สู่การบริหารจัดการความเสี่ยงภาคเกษตรอย่างยั่งยืน ด้วยเทคโนโลยีอวกาศ

Farmers and Pixels: Toward Sustainable Agricultural Finance with Space Technology

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ปรีสาร รักวาทิน

จุฑาทอง จารุมิลินท

GISTDA

สำนักงานอัตราเบี้ยประกันวินาศภัย
IPRB The Insurance Premium Rating Bureau

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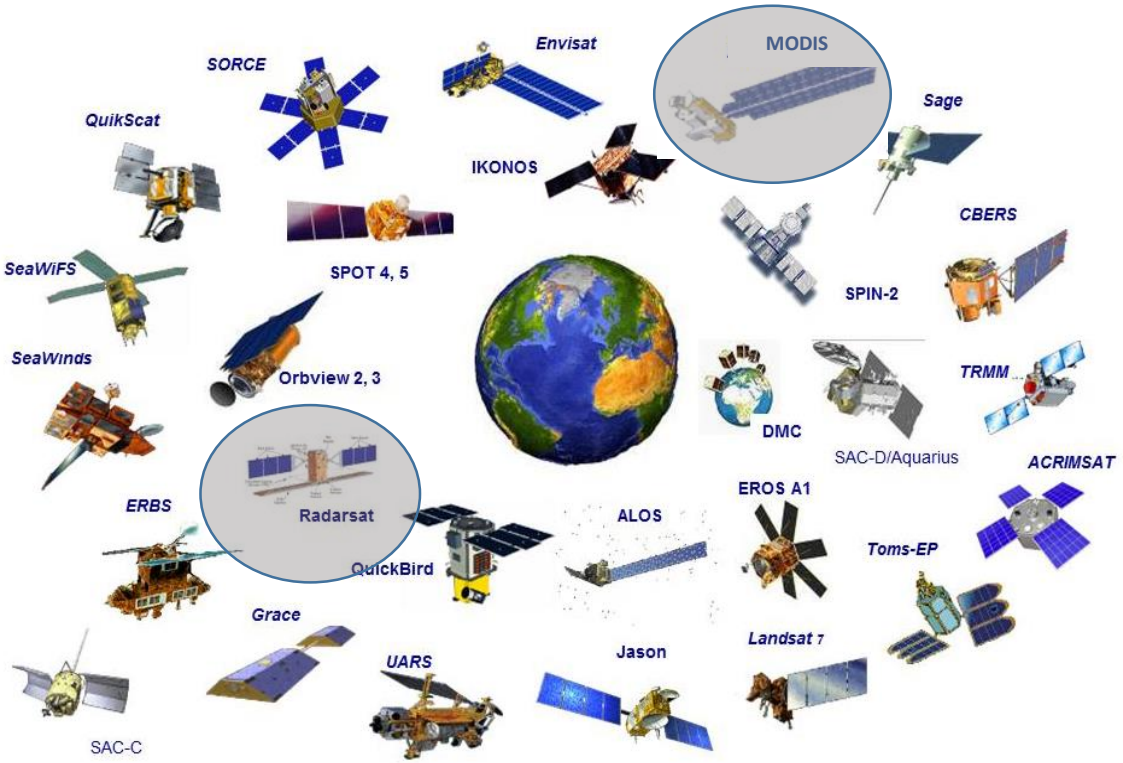
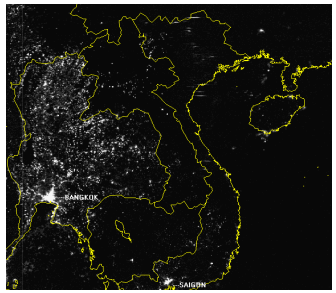
Recent development in space technology

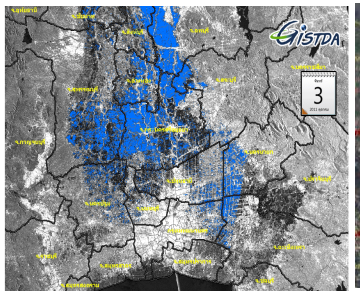


Agriculture

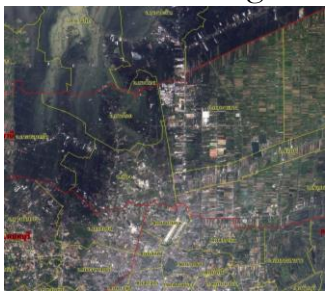
Economic monitor



Disaster



Land use changes



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

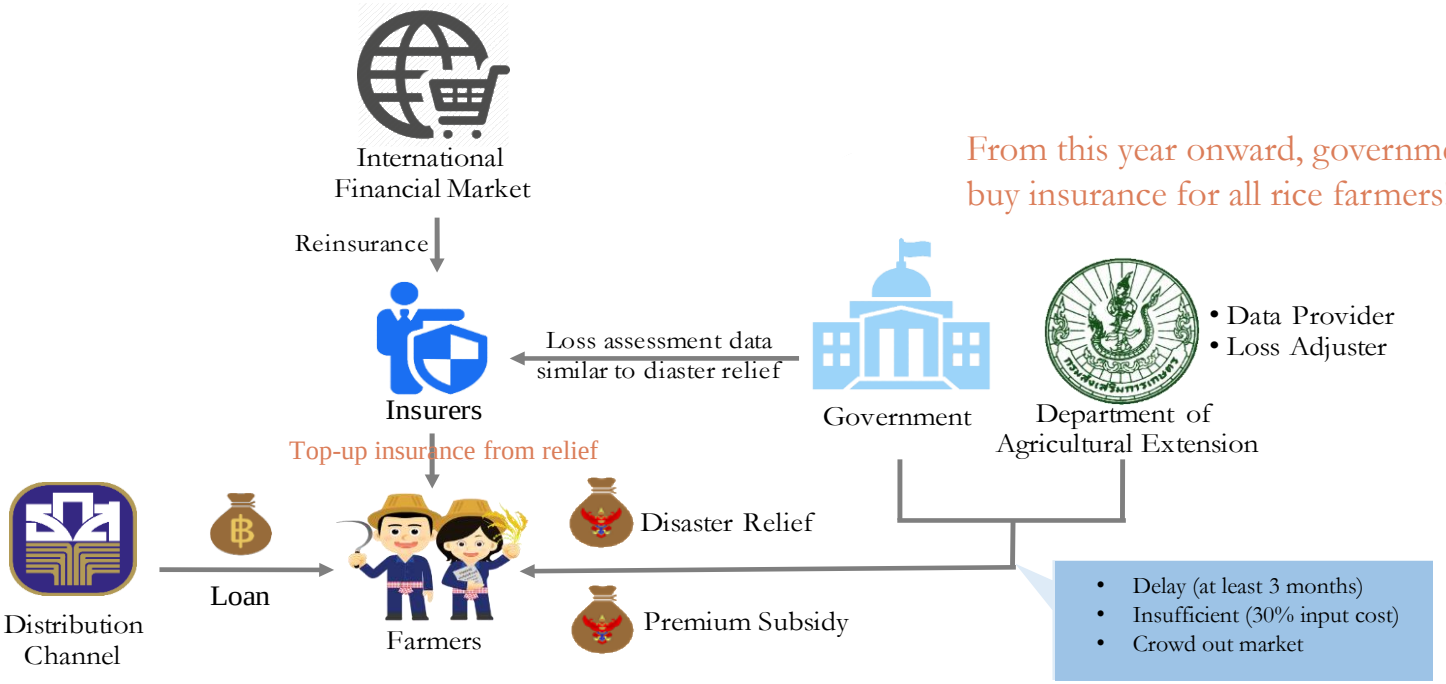
- Lack micro-level risk data
- Lack long historical risk data
- Lack transparency in loss monitoring
- Delay in loss monitoring

Inefficient insurance market

- High cost
- Low value to customer
- Small scale

Less sustainable

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



From this year onward, government will buy insurance for all rice farmers!

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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

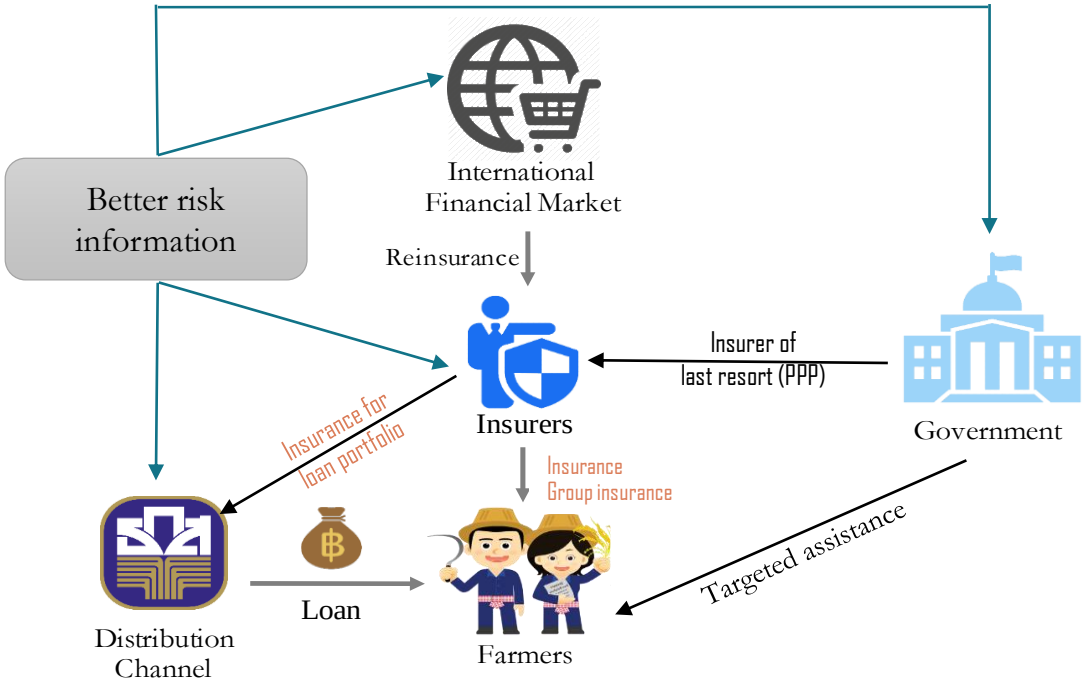
1. Accurate
2. Micro-level
3. Long historical data
4. Transparent
5. Near real time

Healthy insurance market

- Risk-based pricing
- Various designs of insurance → competition among insurers
- Better PPP arrangement

More sustainable

- Active insurance demand
- Well-defined role of government to complement market



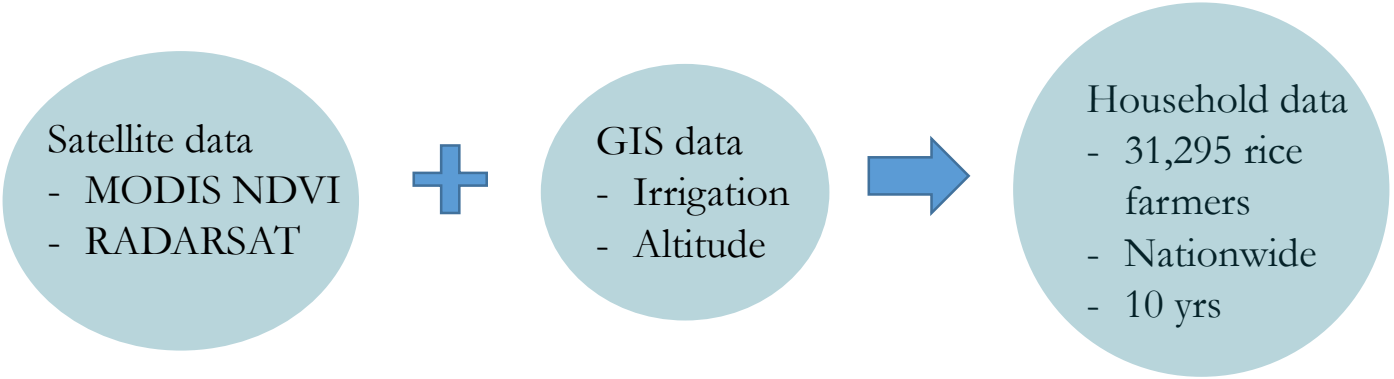
This paper answers two questions

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

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

----------Use rice production as a case study----------

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



1. Detecting rice production
2. Detecting rice production losses

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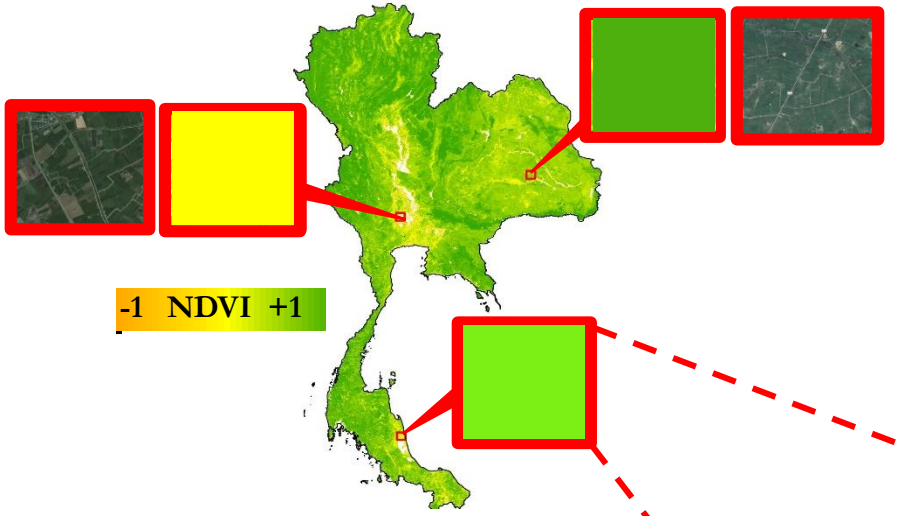
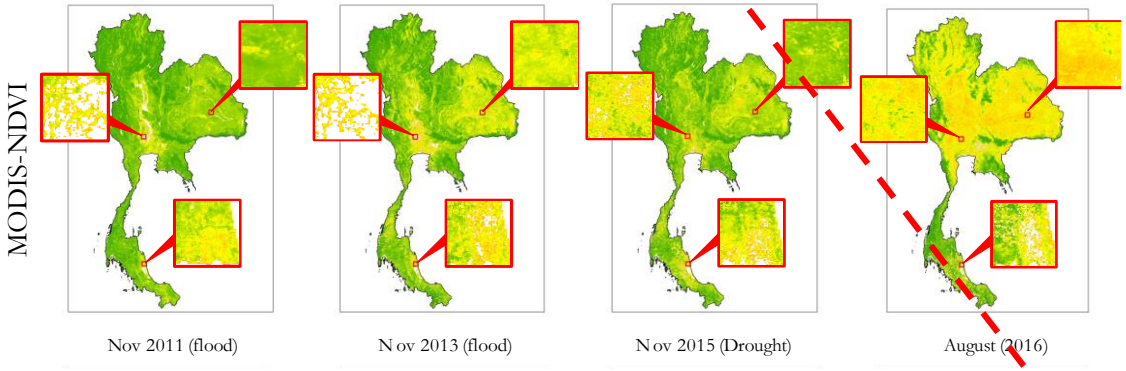
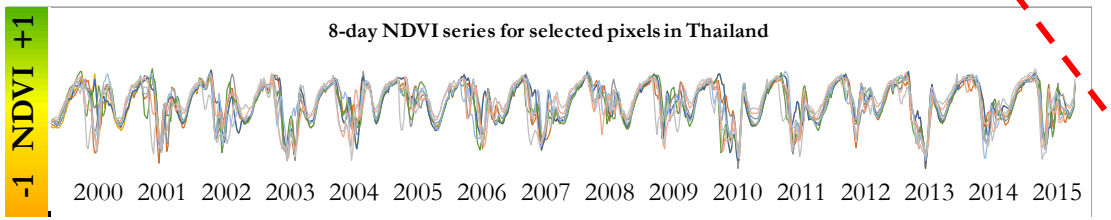
Step 1: Detecting rice production using NDVI



- **Normalized Difference Vegetation Index (NDVI)**
  - Reflect health and cycle of vegetation
  - Cover nationwide
  - 1 pixel reflects area of 250 m^2 or 40 rai
  - 2,260,778 pixels nationwide
  - Every 8 days from 2000-present





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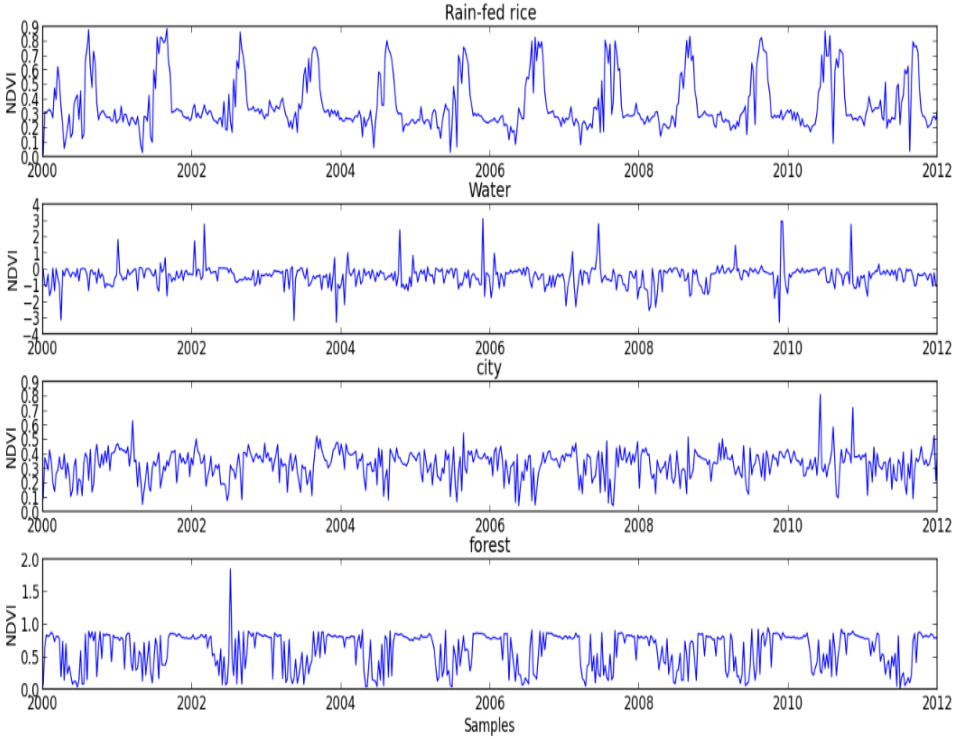
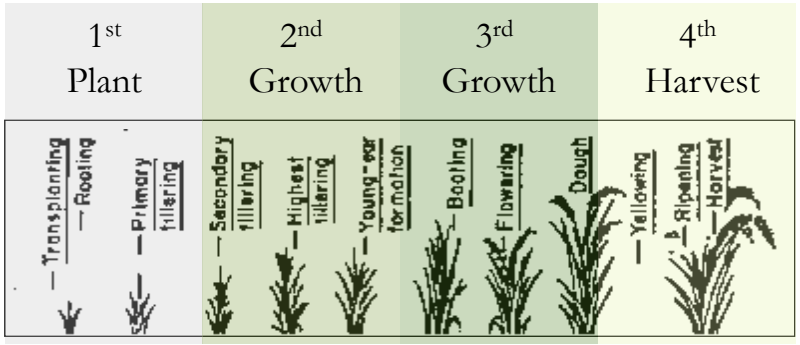
Step 1: Detecting rice production using NDVI

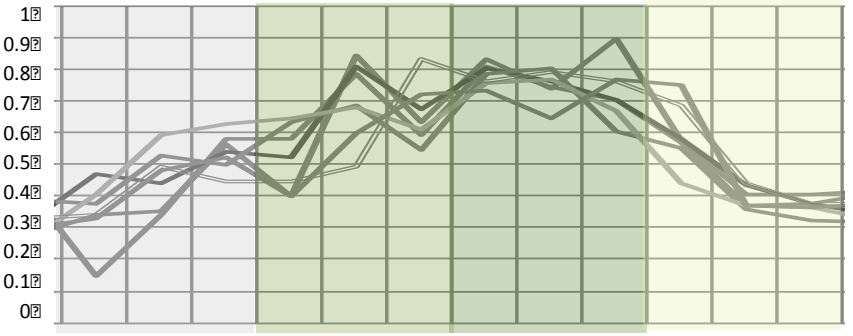
Non-linear estimation model is used to detect pixels with cycle (rice area), start-finish of cycle each year (planting and harvesting dates) based on curvature of NDVI



Rice growth stage (s)



Pattern of NDVI



Rice growth stage from Murphy (1998)

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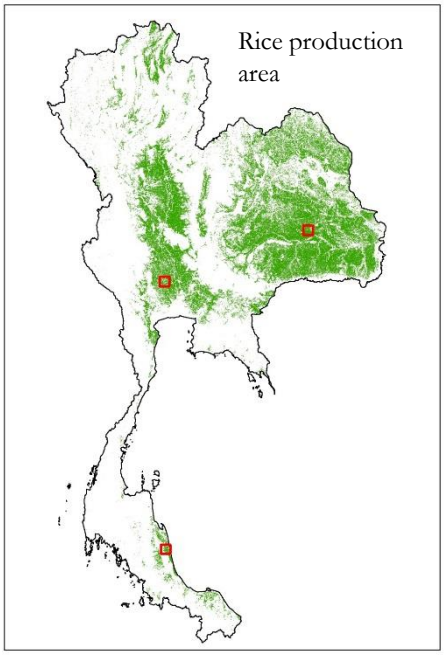
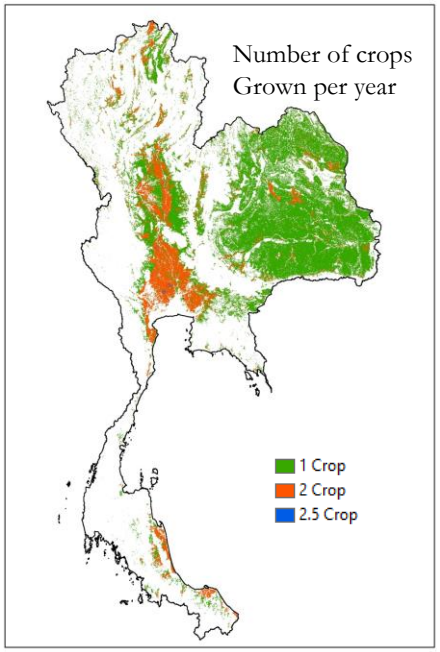
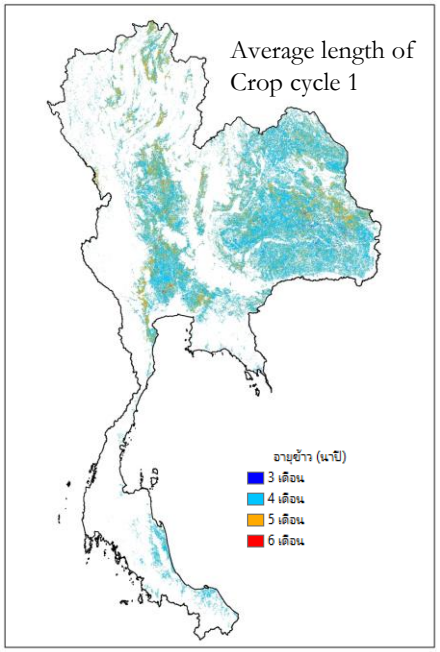
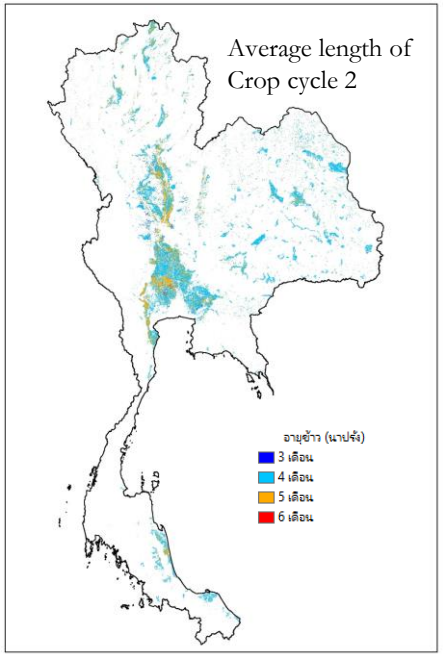
Step 1: Detecting rice production using NDVI

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

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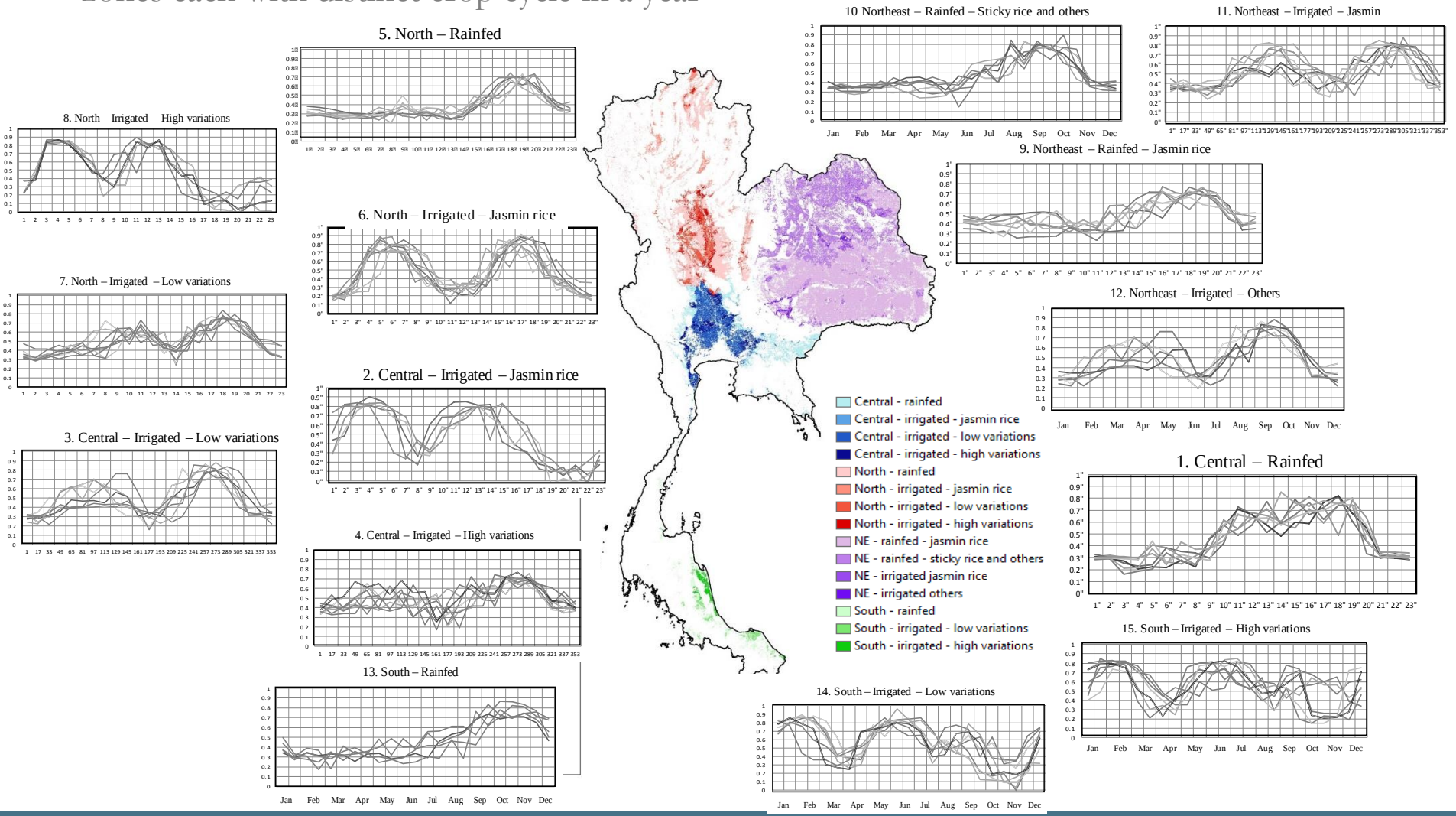
Step 2: Detecting production loss using NDVI and Flood index

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



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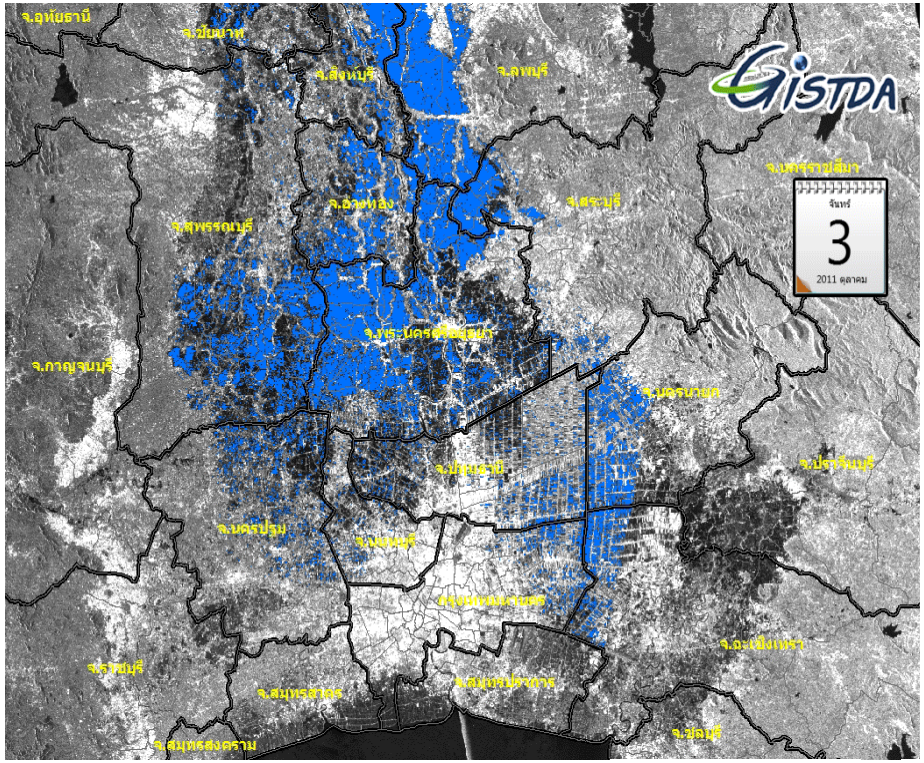
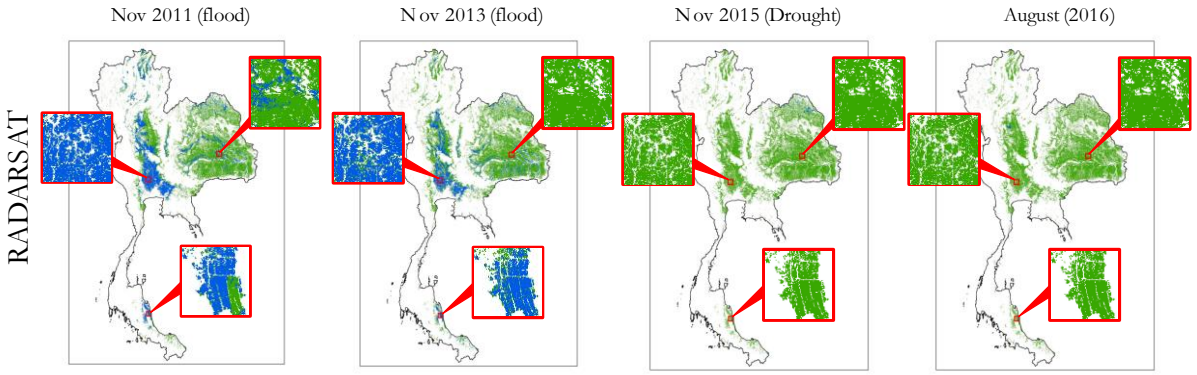
Step 2: Detecting production loss using NDVI and Flood index



❖ **Flood index from RADARSAT**

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

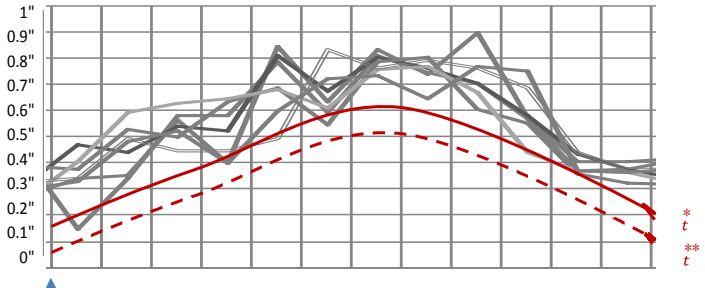


Step 2: Detecting production loss using NDVI and Flood index

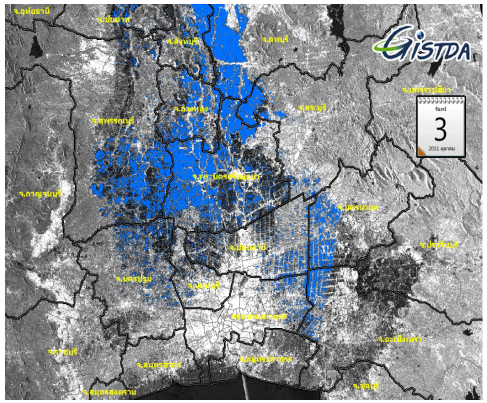
Estimate loss function f ( ) for each production zone that minimizes sum squared errors in

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

Pattern of NDVI after detected planting date in each pixel



Flood index from RADARSAT



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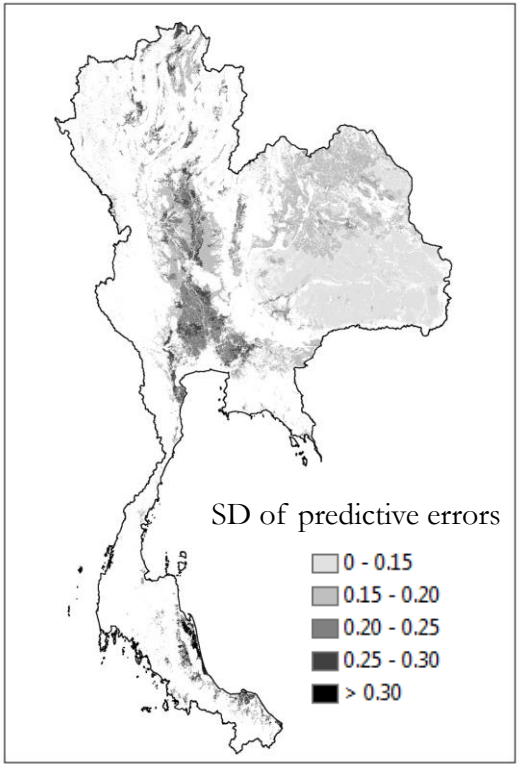
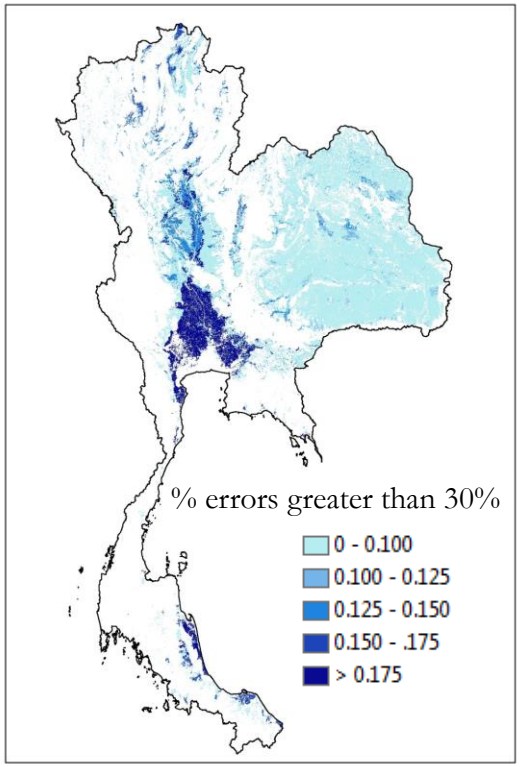
How well can satellite data estimate production losses of farmers?

From predictive errors:

- Satellite data predicts production losses well in rainfed area but less well in the more heterogeneous irrigated areas
- Errors are especially low during the extreme losses (may be suitable for detecting insured loss)

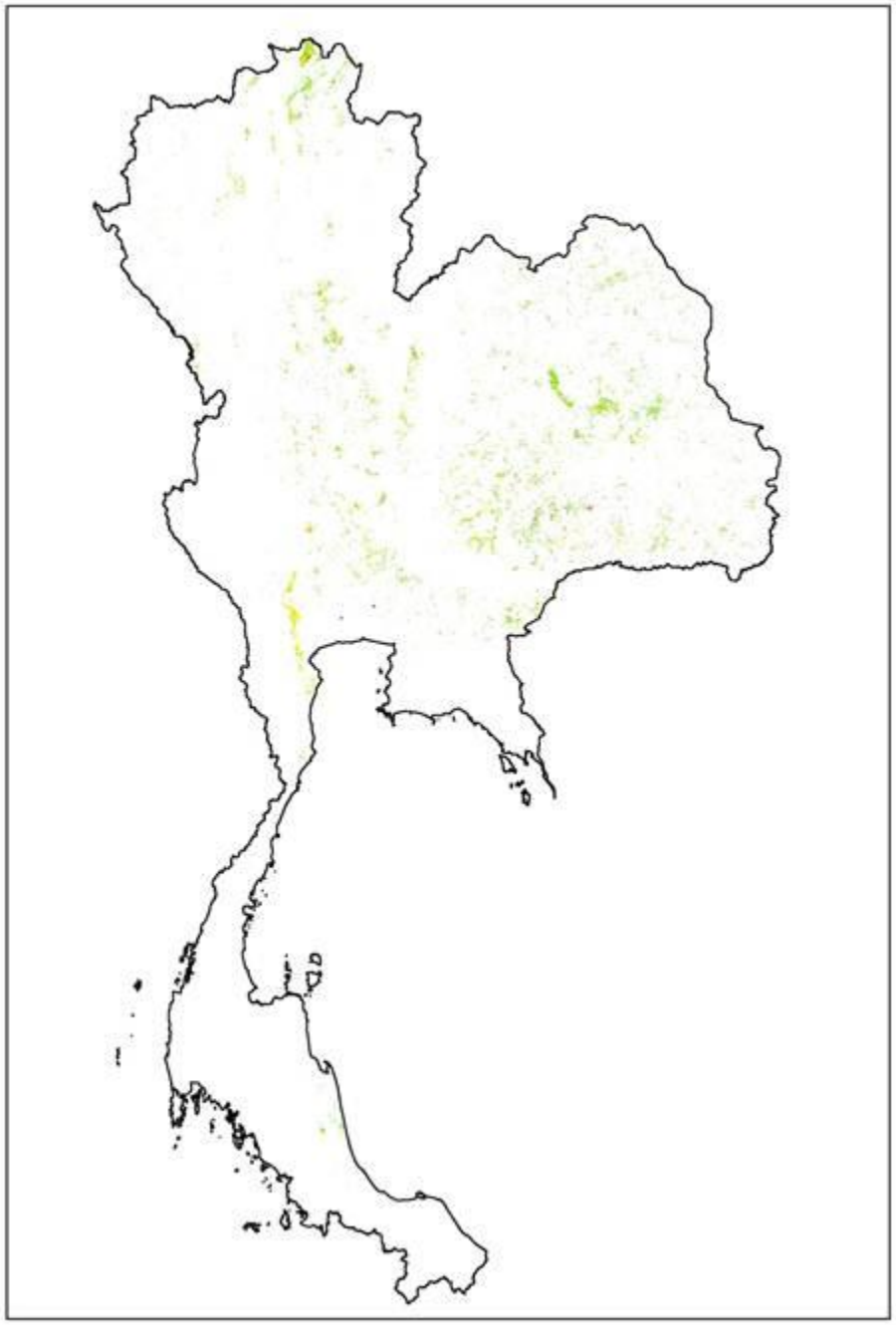




The results imply

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

Satellite-based risk information for rice production at pixel level (2000-2016)



May 2016

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

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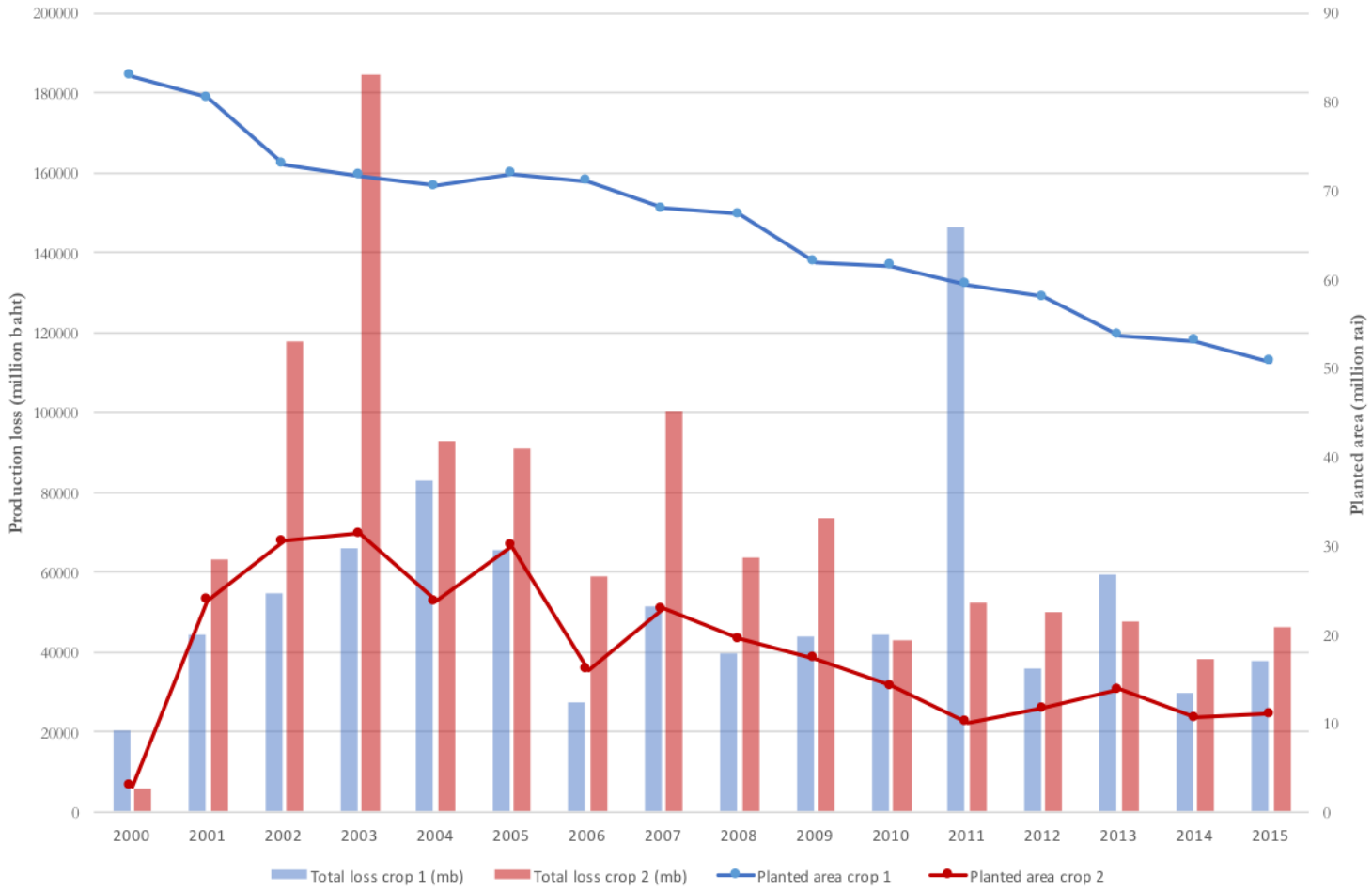
What can we learn from the satellite-based risk information?

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)

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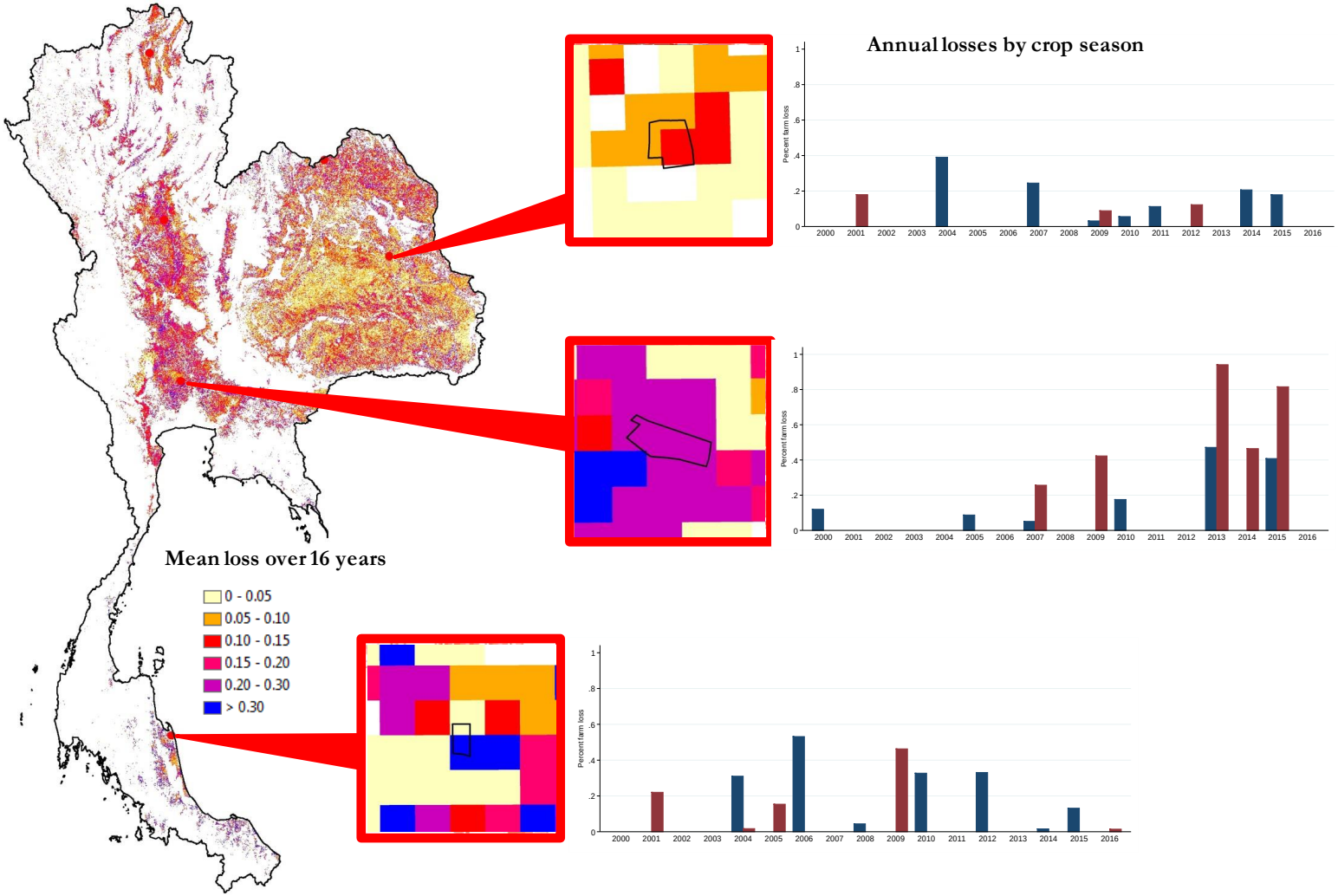
What can we learn from the satellite-based risk information?

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



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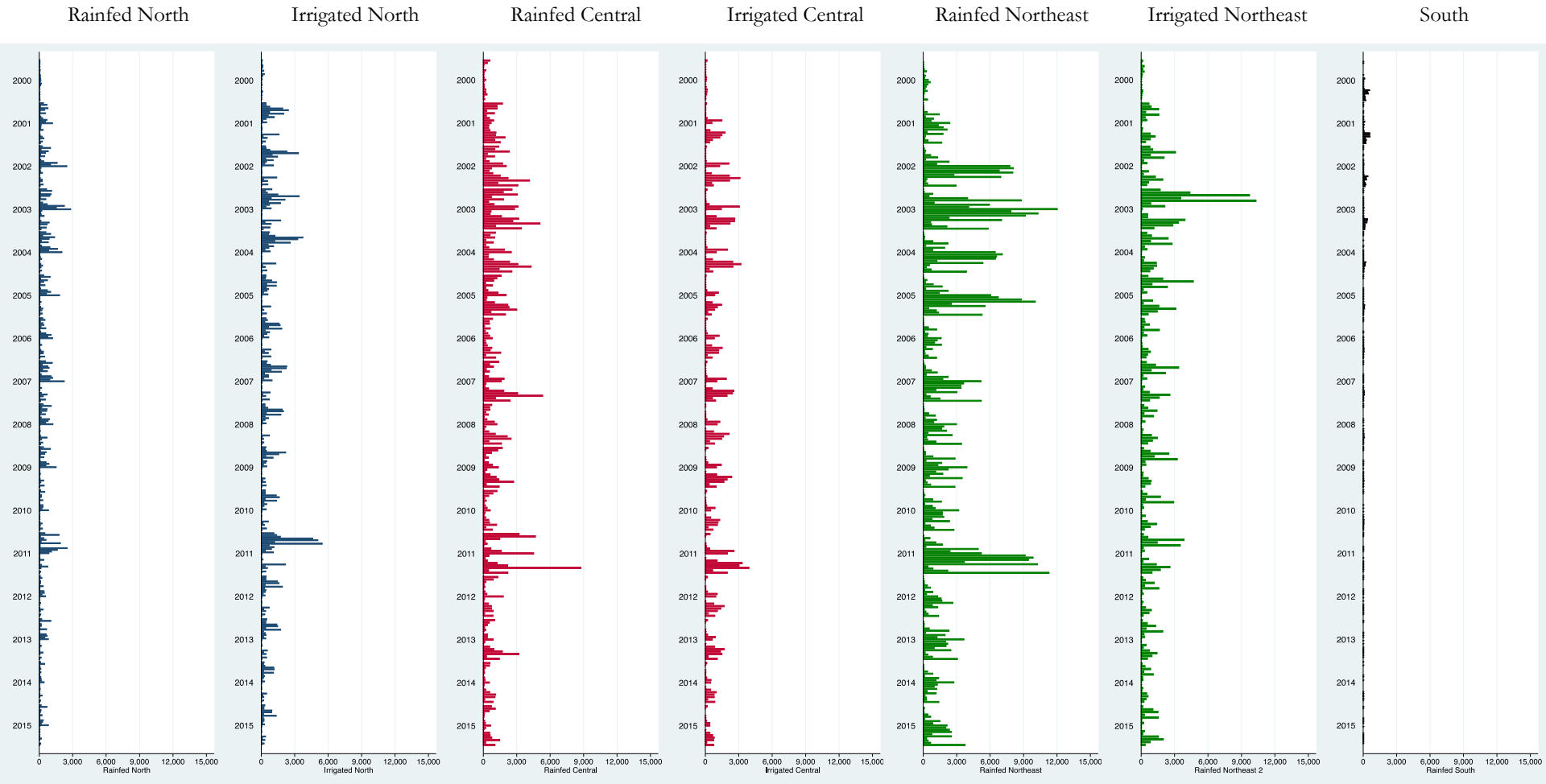
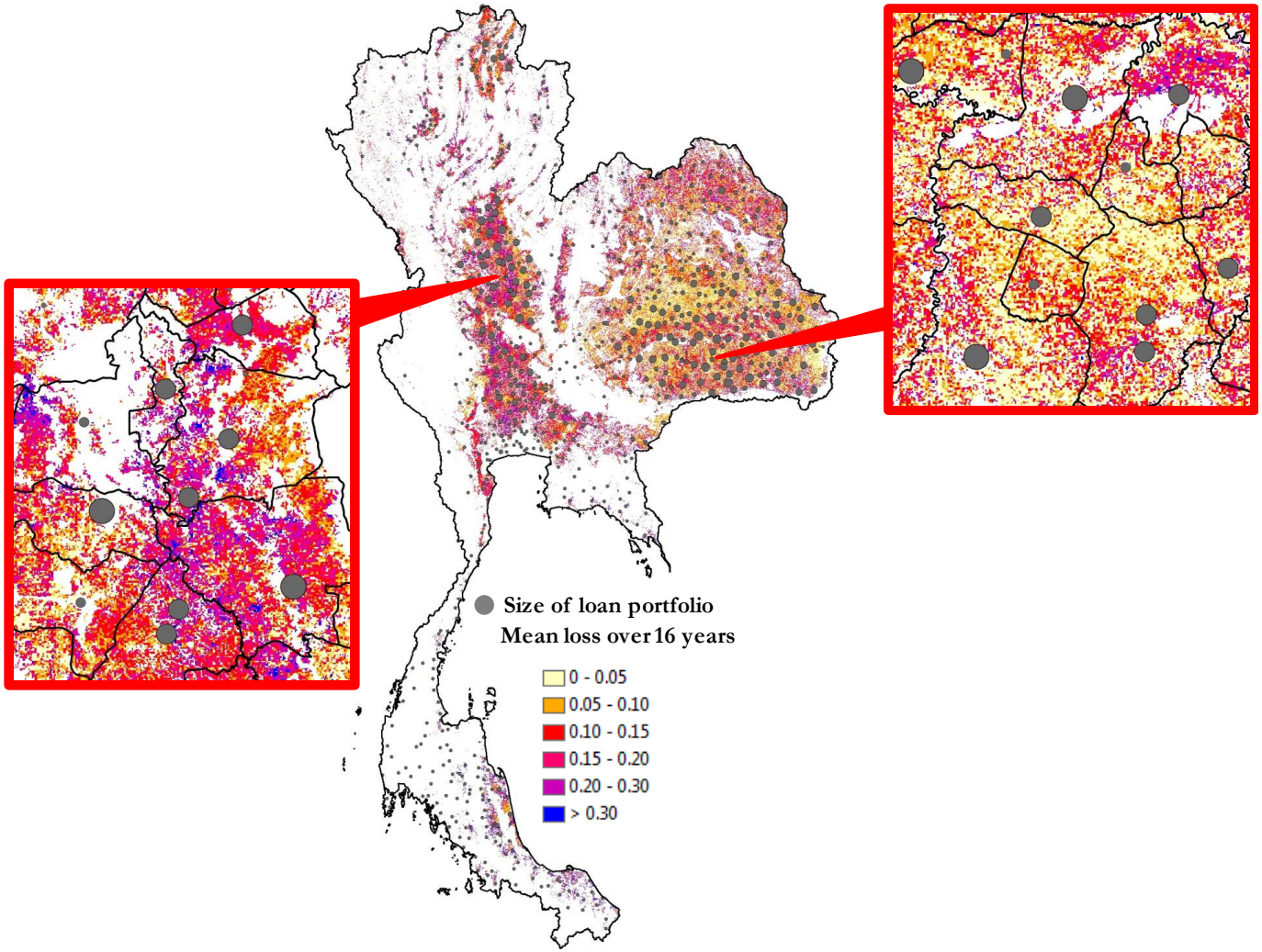
What can we learn from the satellite-based risk information?

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



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

Production losses and risk can be extracted for each branch of BAAC to understand credit risk of their loan portfolio



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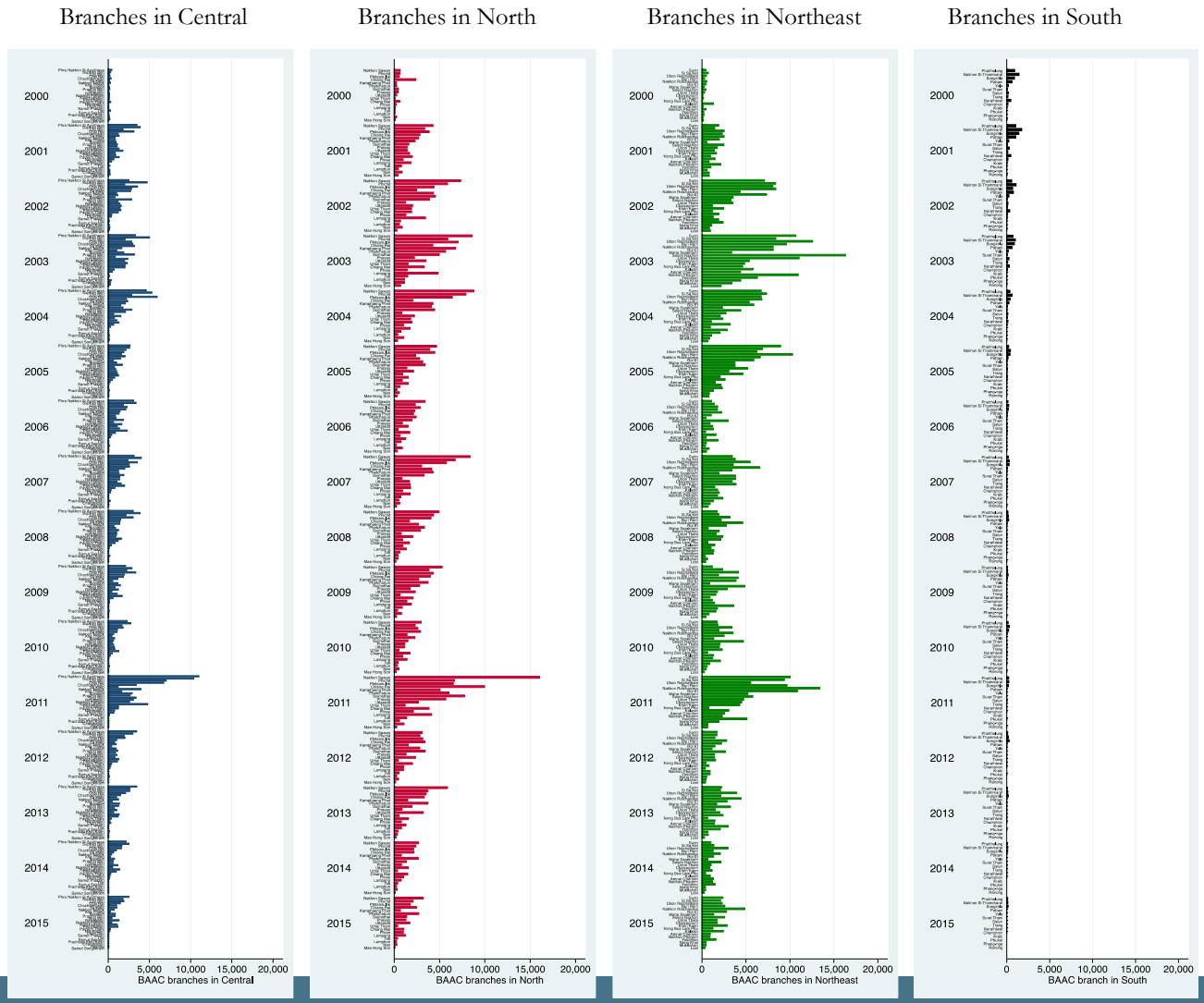
What can we learn from the satellite-based risk information?

Rice production losses appear highly correlated → potential threat to rural financial stability?



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

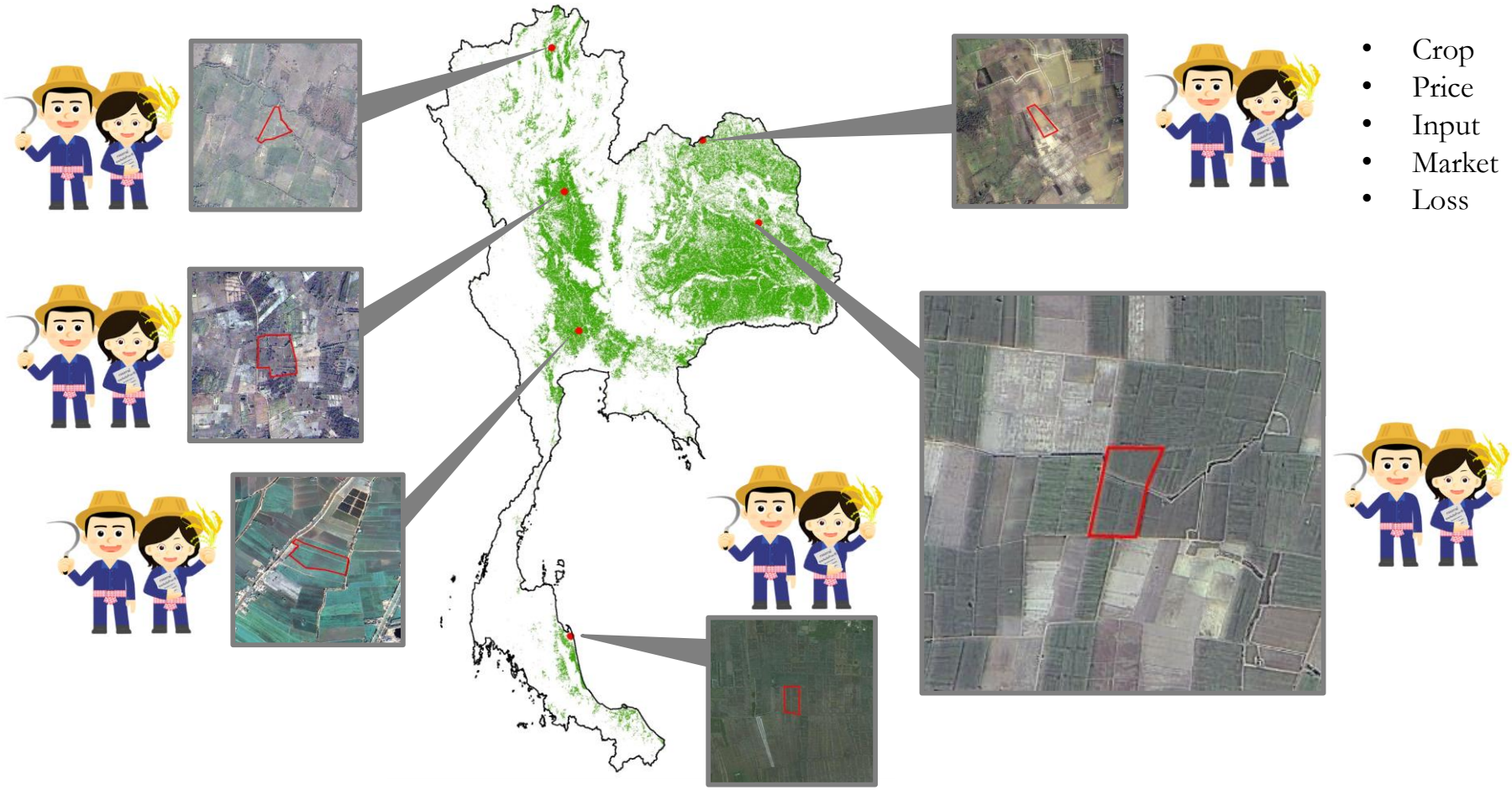
Satellite-based risk information

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

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

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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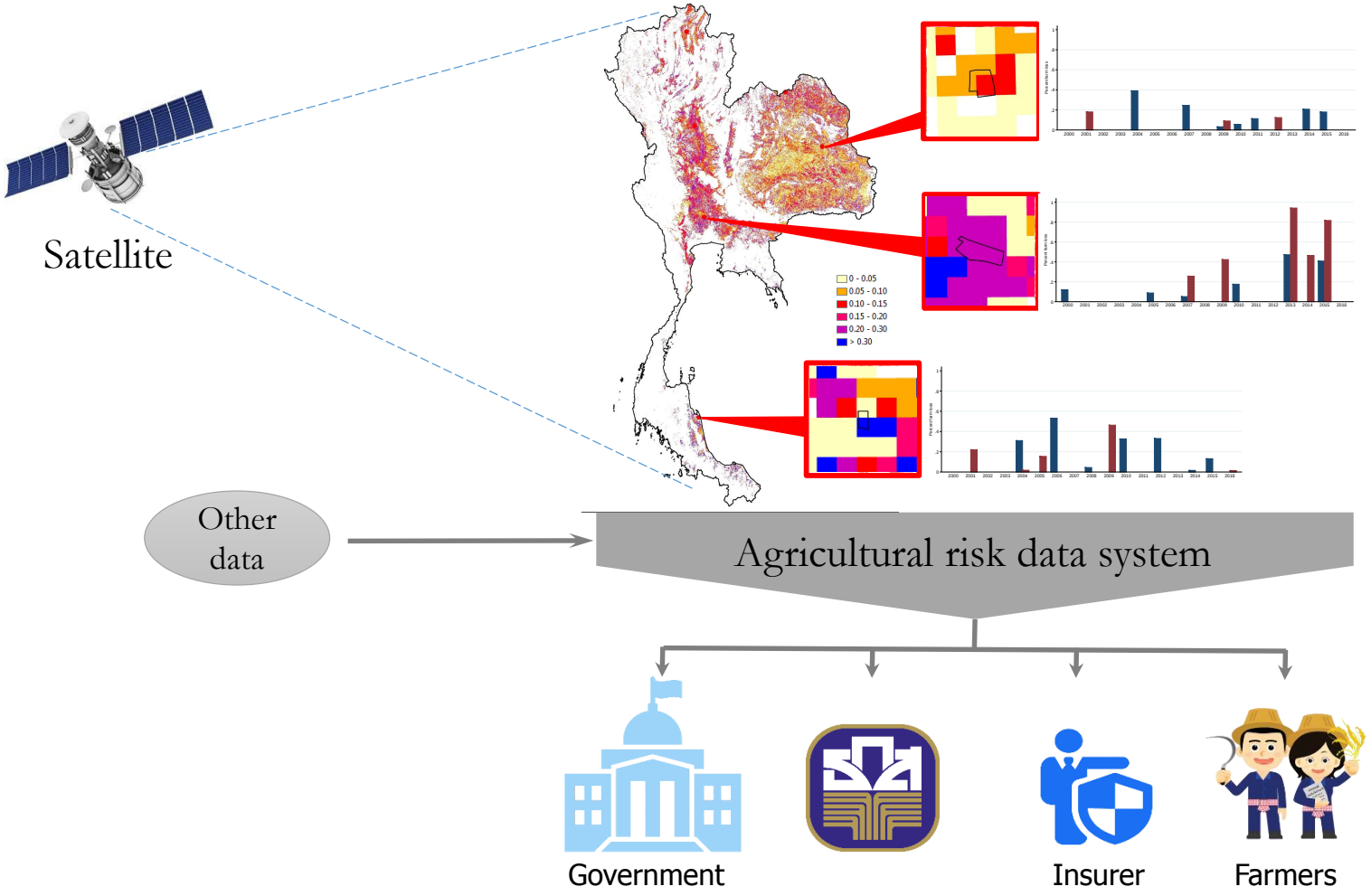
Toward agricultural risk data system

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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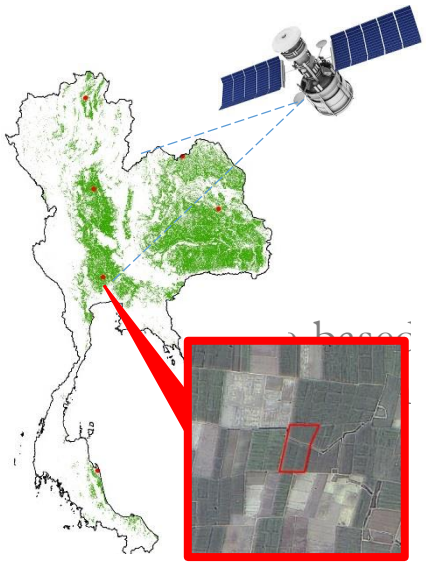
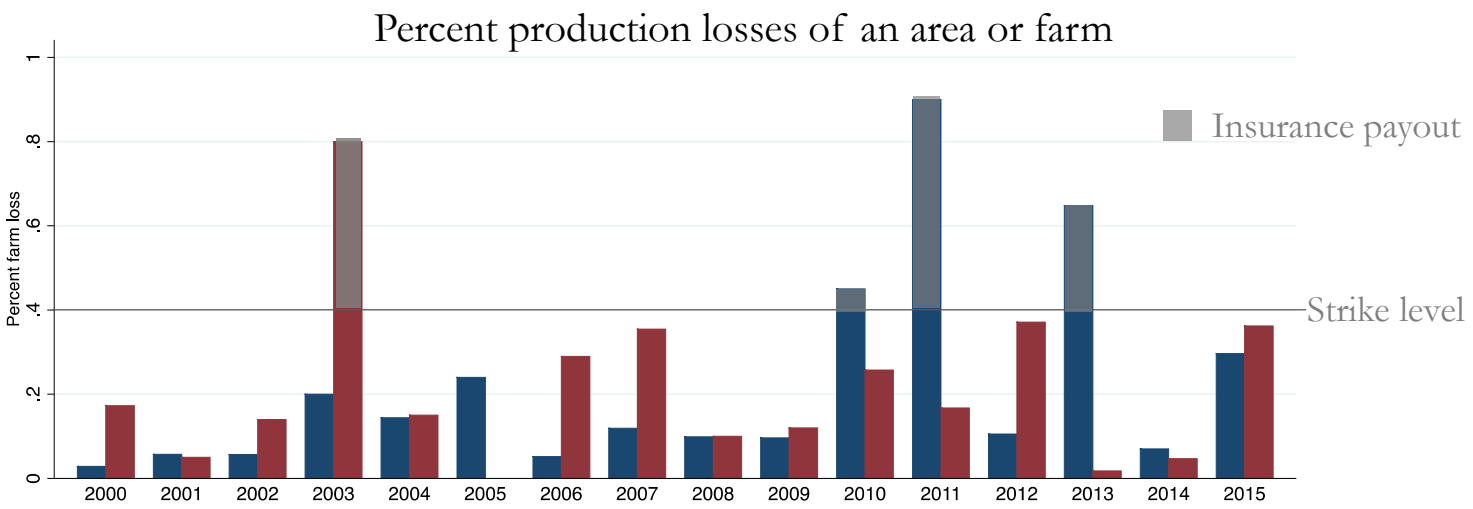
Better risk information for better design of agricultural insurance programs

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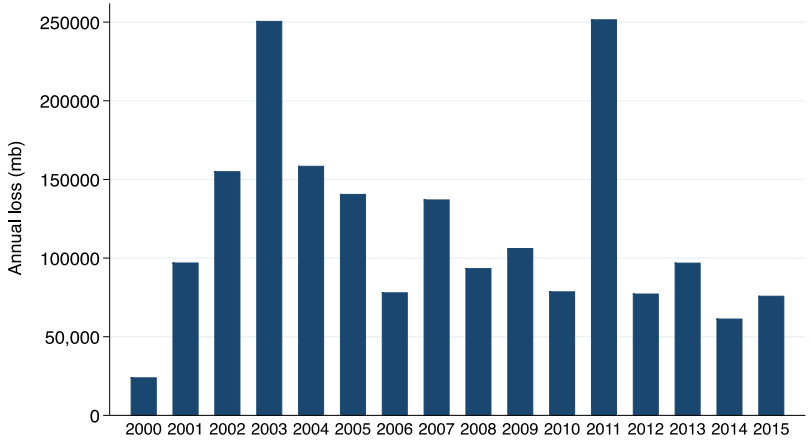
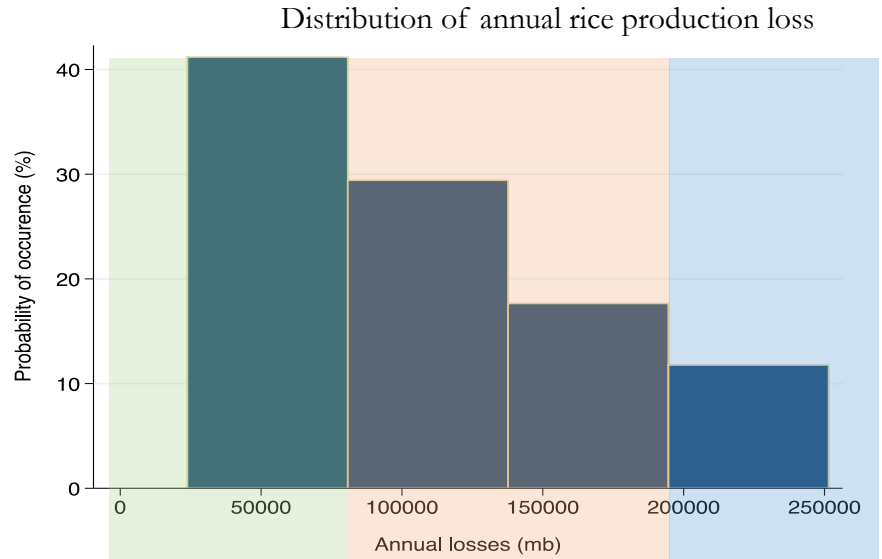
Better risk information for better design of PPP in agricultural risk management of the country

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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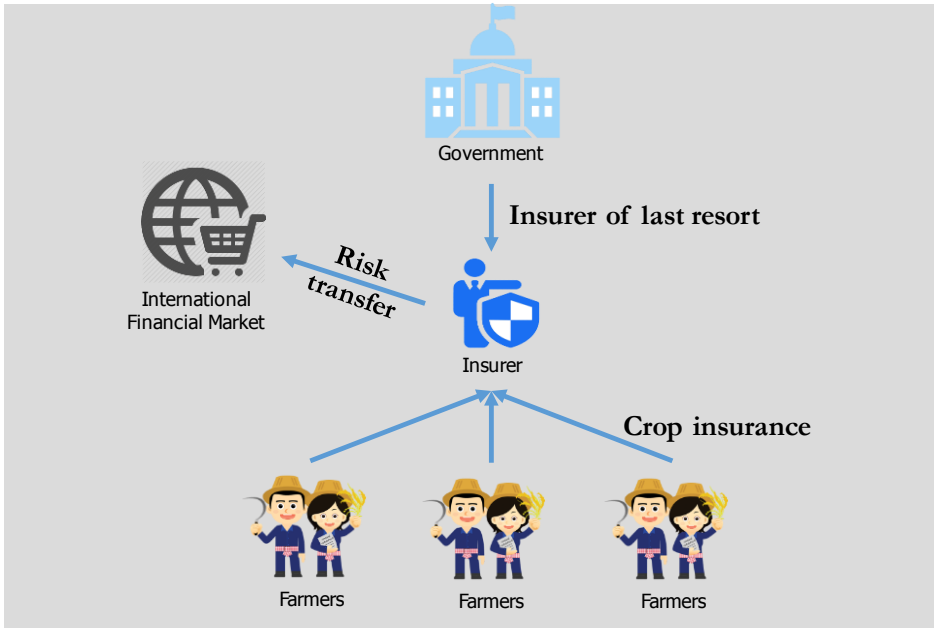
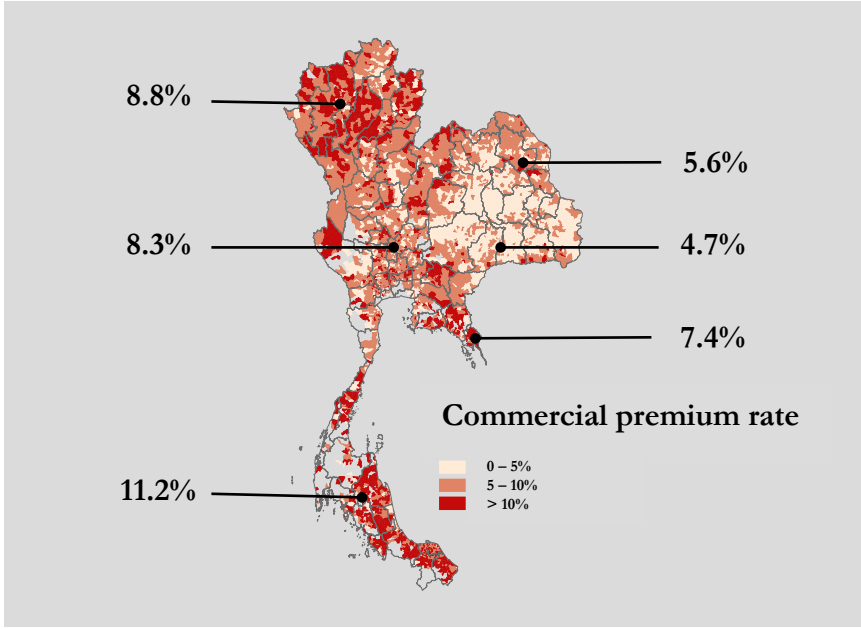
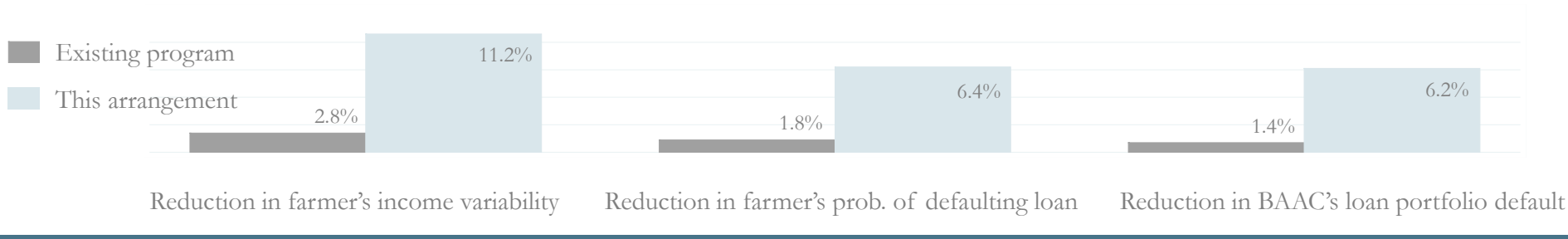
Possible insurance and PPP arrangements

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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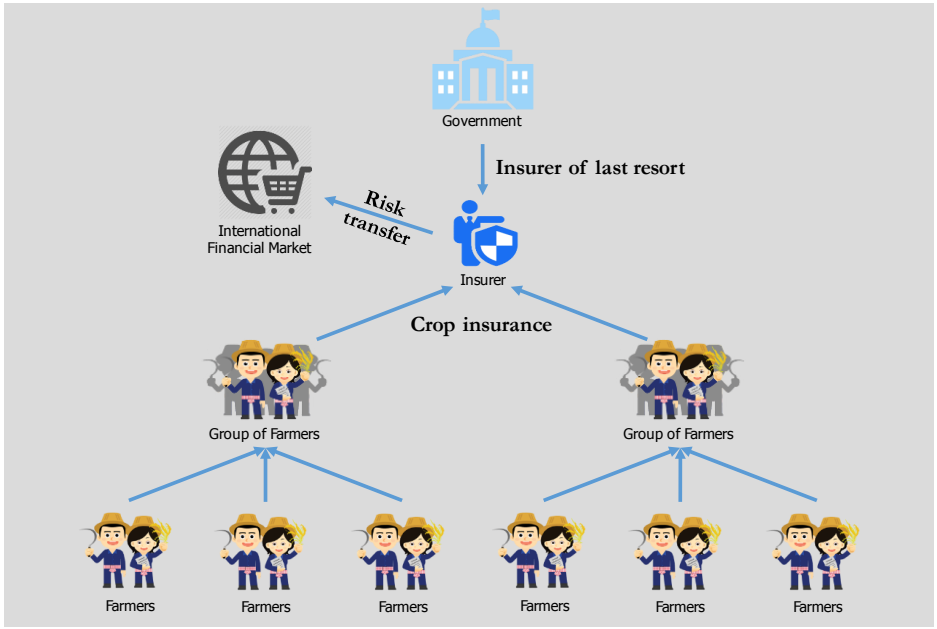
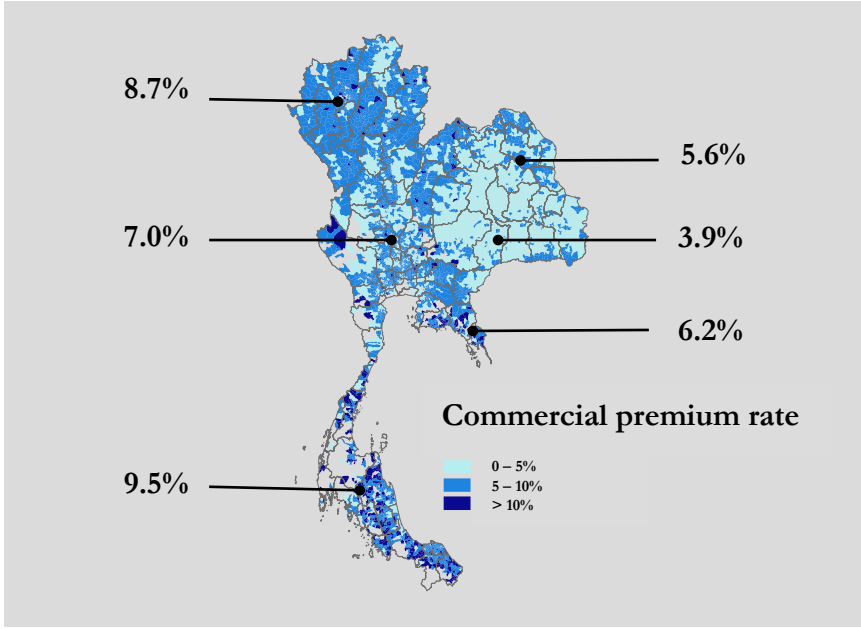
Possible insurance and PPP arrangements

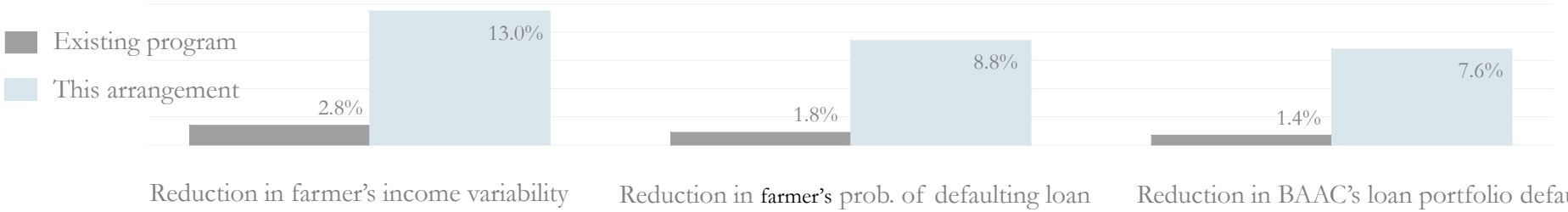
Crop income insurance for cooperatives with government as insurer of last resort





❖ **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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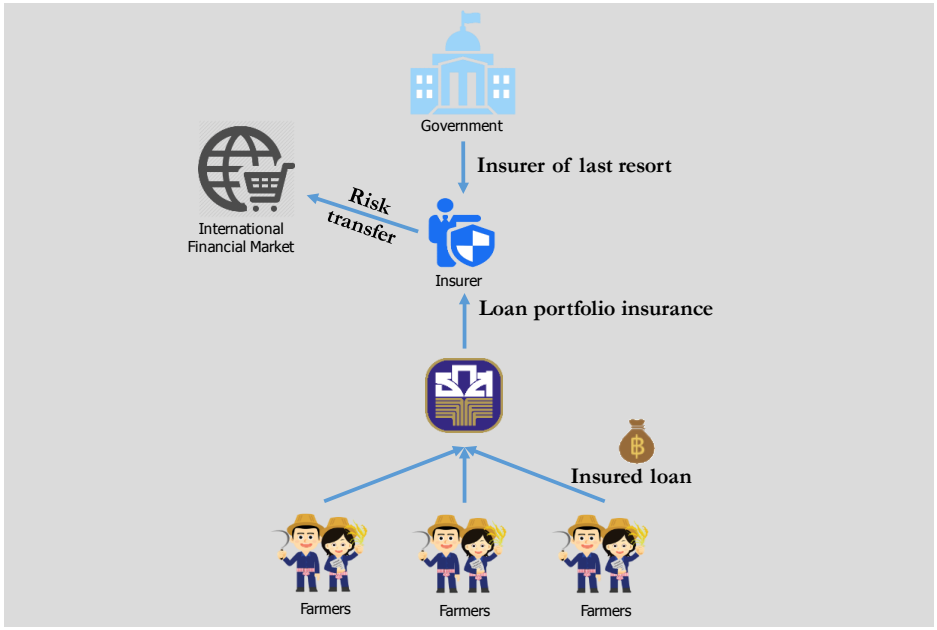
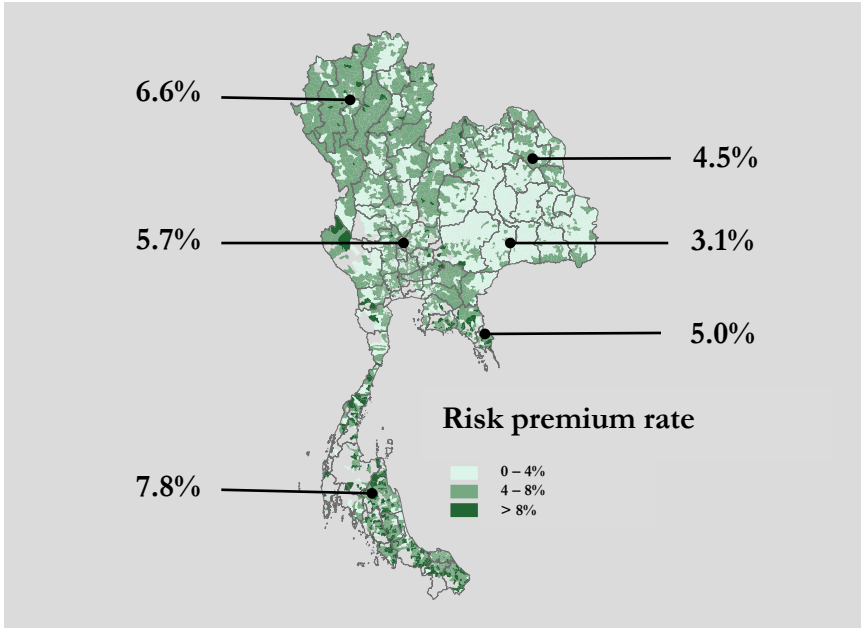
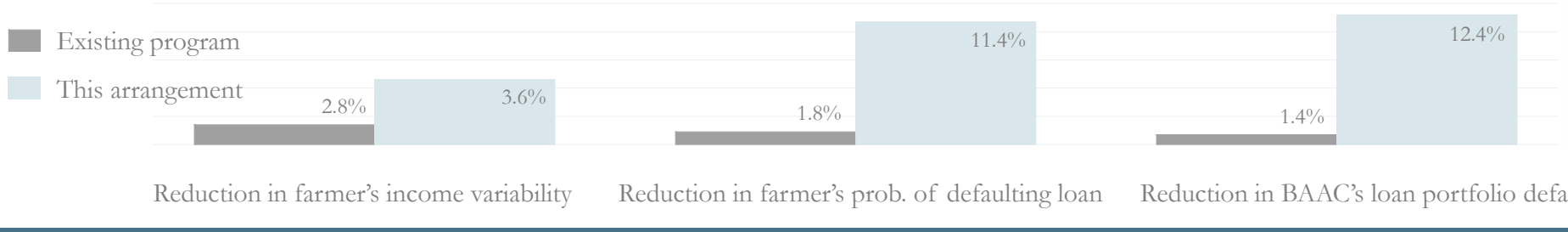
Possible insurance and PPP arrangements

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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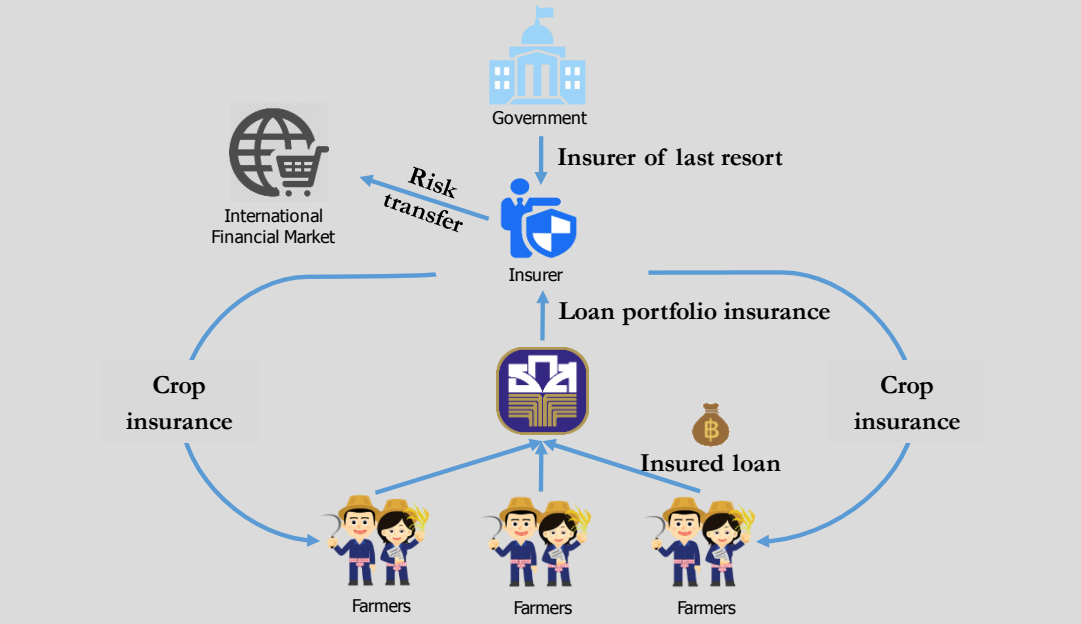
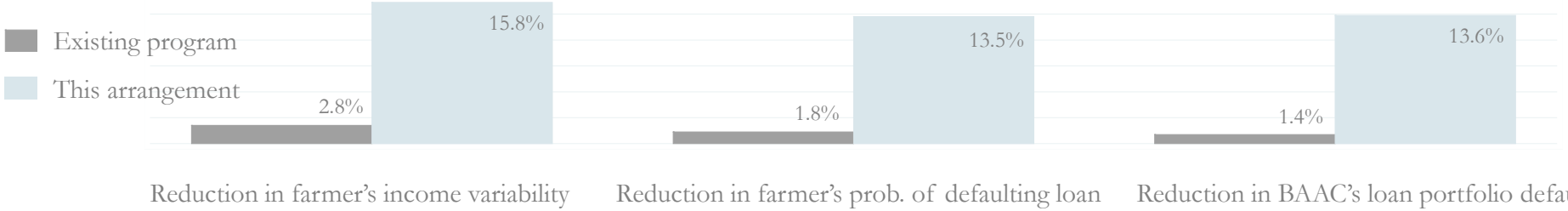
Possible insurance and PPP arrangements

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

Ways forward and policy implications

This 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

Next steps

- Invest in data
- Institutional arrangements to get all parties to benefit from data (e.g., for this case, reform of agricultural risk of the country, laws, risk infrastructure, financial literacy, etc.)