Agriculture and International Development: Evidence and Interesting Issues

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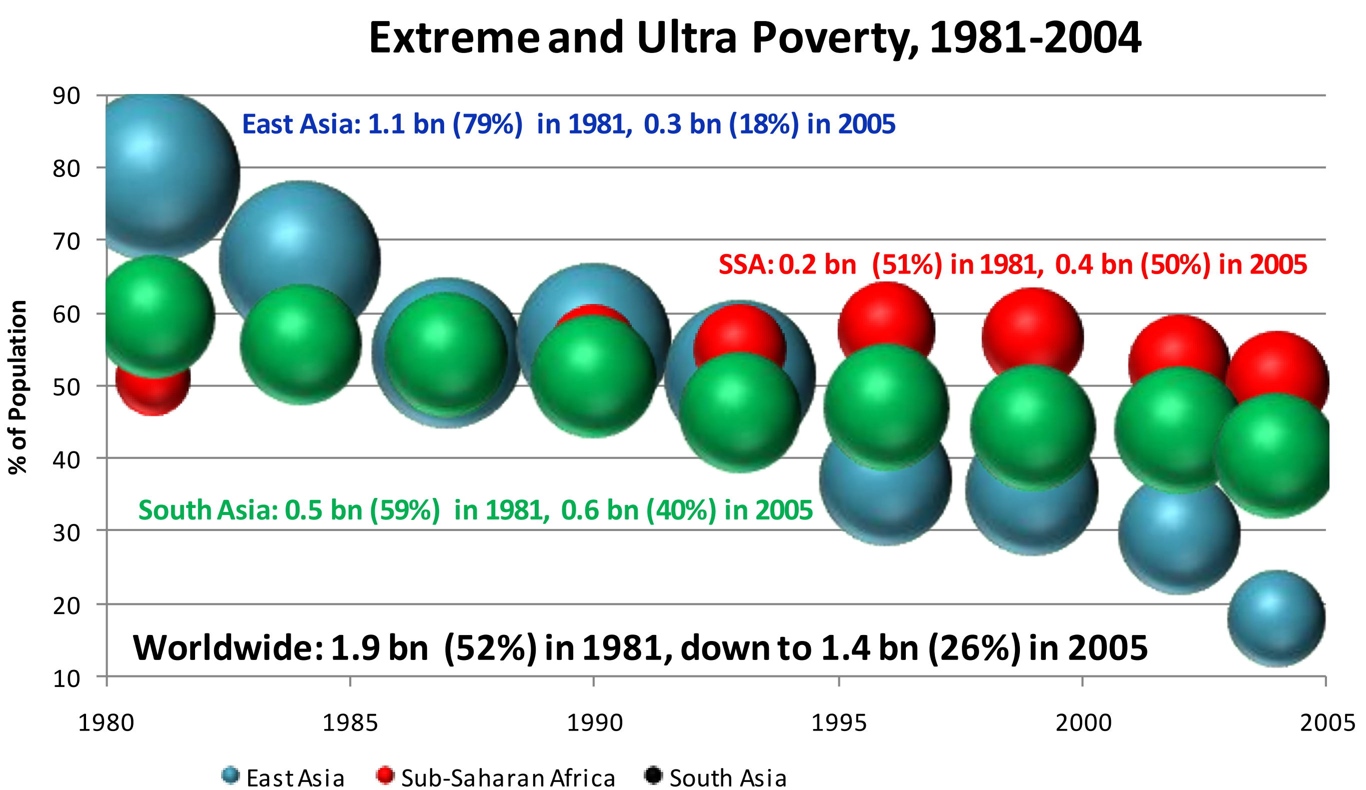
The challenge

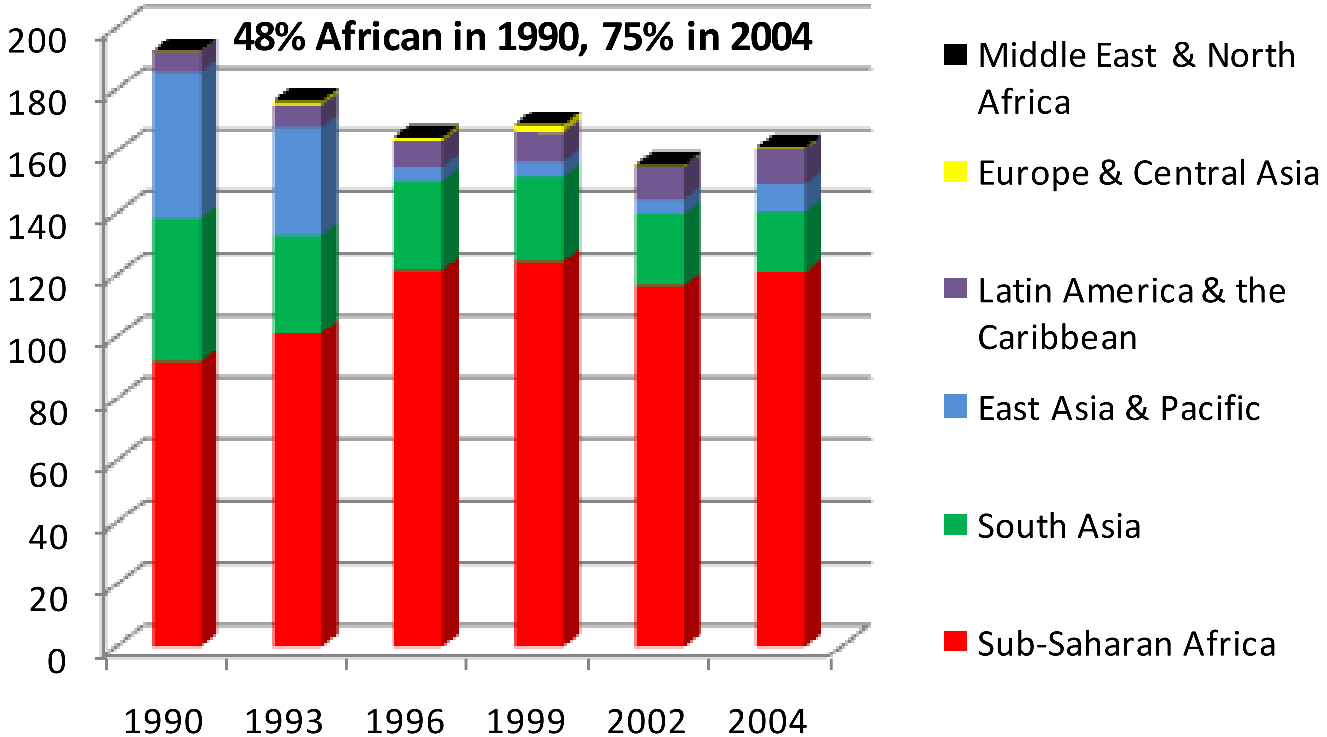
- Extreme poverty has fallen rapidly in east Asia and worldwide, but only proportional gains in South Asia and none in Sub-Saharan Africa, where >50% still live on less than $1.25/day.



Bubble sizes reflect number of people living in extreme poverty (2005US$1.25/day-person) and ultra poverty ($0.54/day-person)

The challenge

- Ultra-poverty is especially persistent and prevalent in sub-Saharan Africa



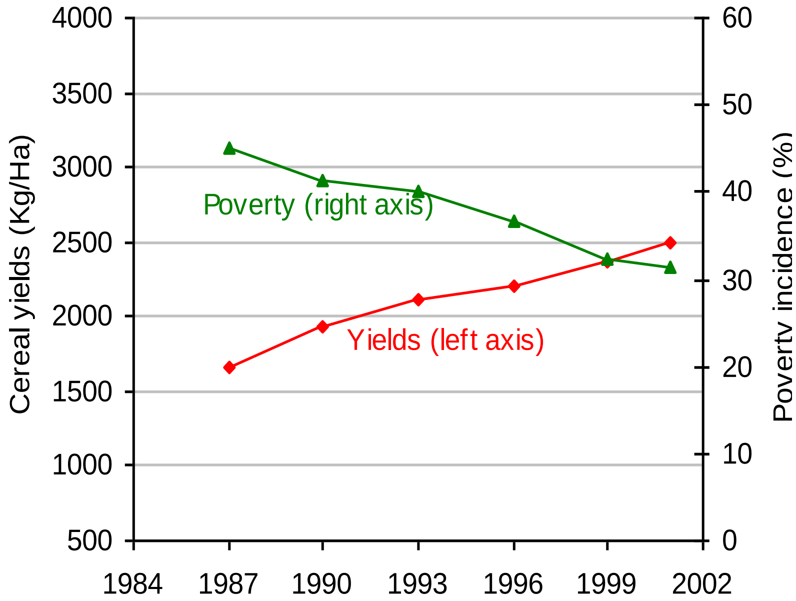
Sources: IFPRI (2007)

A key driver

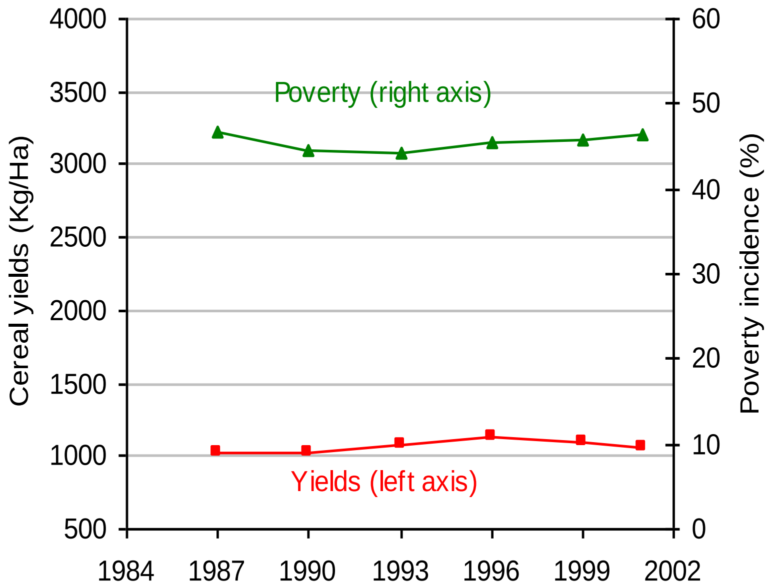
- **Persistent poverty is closely tied to agricultural stagnation**

Cereal yields and extreme poverty move inversely

East Asian progress



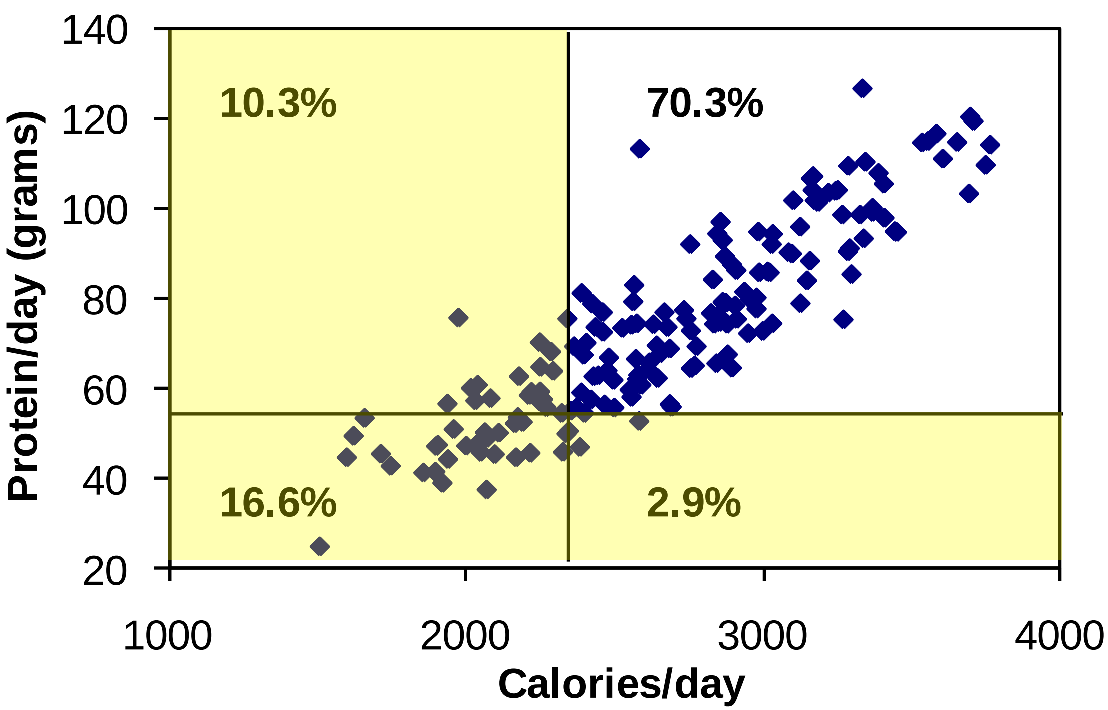
South Asian and African Stagnation



Sources: World Bank (2007)

- **Agricultural stagnation is a key driver of poverty and undernutrition**

Per Capita Nutrient Availability (shaded areas below minima)



The WHO identifies undernutrition as the biggest risk factor for disease and death worldwide … and 30/47 African and South Asian countries have macronutrient *availability* shortfalls .

Poverty traps and Economics of Poverty

The vicious cycle of poverty traps, hunger and related aid traps from

- Low productivity causes poverty
- Poverty causes hunger and natural resource degradation
- But hunger and degraded natural resources also cause poverty

Economics of Poverty

" Most of the people in the world are poor, so if we knew the economics of being poor, we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture we would know much of the economics of being poor."

-- Prof. Theodore W. Schultz Opening remarks of 1979 Nobel Prize in Economics lecture

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Agricultural and rural development

- **In order to break out of poverty traps, we need to stimulate agricultural and rural development**
  - Most ultra-poor live in rural areas and work at least part-time in agriculture → benefit from improvement in productivity of agriculture, rural labors and assets.
  - The ultra-poor spend 65-80% of budget on food. → They are the biggest losers of higher food prices resulted from lower agricultural productivity. → Hence the seriousness of the recent global food price crisis for the poor, including most small farmers!
- **The World Bank estimates that real GDP growth from agriculture is 2.7 times more effective means of reducing extreme poverty than growth in non-agricultural sectors.**
- **No one size fits all approach is viable. But several key principles exist for targeting interventions**

An example from Madagascar:

- **A doubling of rice yields:**
  - reduces the share of food insecure households by 38%
  - shortens the average hungry period by 1.7 months (1/3)
  - increases real unskilled wages by 89% (due to both price and labor demand effects)
  - benefits all the poor: net food seller farmers, unskilled workers, consumers

… indeed, the poorest gain most.

Sources: Minten and Barrett, World Development, 2008

Agricultural and rural development

- **Principle 1: Build productive assets among the poor**

- Multiple assets matter: Human capital (education, health), Natural capital (land, water, livestock, etc.), Financial capital (credit – it takes $ to make $)
- Interventions include
  1) direct provision (e.g., free education) or subsidies for asset accumulation
  2) improve investment incentives

Example of key concern: Even where education is ostensibly “free”, the opportunity cost of a child’s education is often uncertain and highest for the poorest families. Labor market discrimination often a big disincentive to invest in education.

Agricultural and rural development

- **Principle 2: Improve the productivity of the poor's current asset holdings.**

(1) Improved production/processing technologies

(2) More efficient/remunerative marketing channels

Uptake/participation turns on assets, so don't forget #1!

Key concern 1: Agricultural research in SSA

Average RoR ~35%, and ~80% of ultra-poor in agriculture
But only 4% of public expenditures are on agriculture and a small fraction of that goes into research.

Key concern 2: Poor slowest to adopt innovations

Technologies that offer higher expected returns commonly require: accepting greater risk, initial outlays of capital, knowledge and access to information

Principle 3: Improve risk management for the ultra-poor, protecting their assets and livelihoods.

- Regressivity, multidimensionality and context-specificity of uninsured risk exposure make improving risk management a serious challenge.

- Risk reduction tools:
  Improved crops and livestock, better water control, diversification, peace, disease control

- Risk transfer instruments:
  Improved markets, index-based risk finance, global humanitarian response

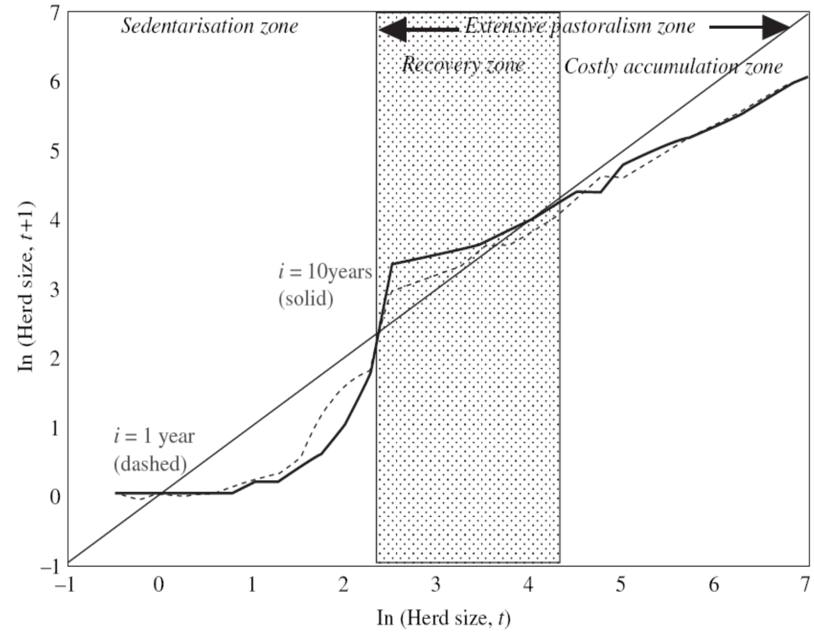
Conclusions

- **There is real reason for hope:**
  - Real agricultural output growth is accelerating in South Asia and Sub-Sahara Africa at long last …
  - Renewed and innovative initiatives and attention in both public aid and private investment in low-income countries.
  - Exciting new innovations in technologies (e.g., micronutrient-rich staple crops, drought-resistant cultivars), advances in finance (e.g., index insurance to pre-finance emergency response and provide a productive safety net), and improvements in policies (e.g., rule of law, global food aid).
- **But there remains much to do to ensure progress.**
- **More research needed for appropriate policies focusing on four key StART principles.**

Insurance and Development

- **Economic costs of uninsured (weather and natural disaster) risk, especially w/ threshold-based poverty traps**

- **Insurance → protect rural livelihoods and escape poverty**
  - Provide safety net to prevent collapse of vulnerable populations
  - Encourage investment and asset accumulation by the poor
  - Induce financial deepening by crowding in credit market and social insurance



Nadaraya-Watson estimates using Epanechnikov kernel with bandwidth (h = 1.5)

- **Insurance → pre-finance effective emergency response and recovery**
  - Timely response enhances resilience to shocks and reduce costs of humanitarian responses/social protection programs

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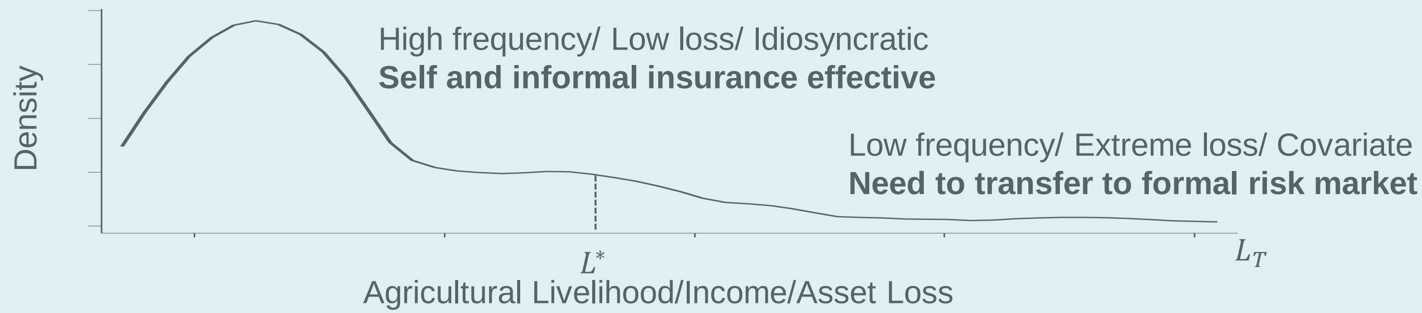
My research

Insurance and Agricultural Risk Management



➢ **Two types of formal agricultural insurance**

Conventional crop insurance

Compensate actual loss, multi-peril or named coverage

- High costs of verifying losses
- Moral hazard and adverse selection
- Existing programs are very costly and largely subsidized

No successful crop insurance in the world, not likely work in rural areas

Index insurance

Compensate specific loss based on objectively measured index NOT actual loss

- Low costs – no farm-level loss verification
- Low incentive problems – insured cannot influence payout probability
- Challenges in minimizing basis risk

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

Developing Index Insurance Program

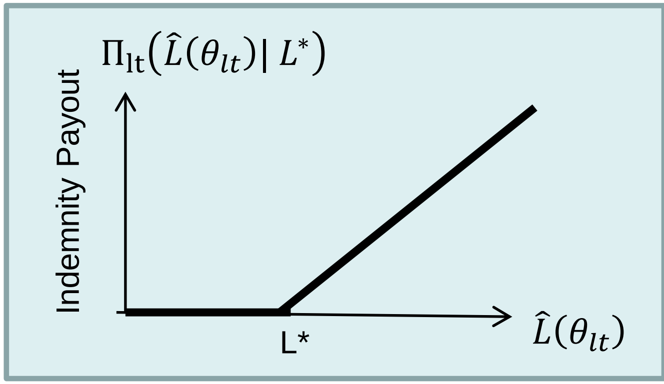
1. **Identify loss to be insured (L_{lt})**
   - Identify uninsured loss by testing simple consumption risk sharing hypothesis (e.g., Townsend 1994), L_{lt} is uninsured if $H_0: c = 0$ is rejected

     $\Delta C_{lt} = a_0 + a_l + a_t + bX_{lt} + cL_{lt} + \varepsilon_{lt}$

2. **Select objectively measured index (θ_{lt})**
   - Highly correlated with loss, available reliably in near-real time, non-manipulable by insured parties, high spatial distribution, at least 20 years historical profiles

3. **Quantify insurable loss from index ($\hat{L}(\theta_{lt})$)**
   - θ_{lt} needs to explain most of the loss variations:

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



4. **Identify optimal contract structure**
   - 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

Developing Index Insurance Program

5. Actuarial pricing

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

  $p_l\left(\hat{L}(\theta_{lt})|\, L^*\right) = E\left(\Pi_{\mathrm{lt}}\left(\hat{L}(\theta_{lt})|\, L^*\right)\right) = \int \Pi_{\mathrm{lt}}\left(\hat{L}(\theta_{lt})|\, L^*\right) df(\,\theta_{lt})$

6. Ex-ante contract evaluation

- Simulated welfare and behavior response impacts using dynamic model/data
- Field experiments to elicit willingness to pay among targeted clients

7. Develop education and extension tools for pilot sale

- Simplified products, financial educational tools, targeted learning network

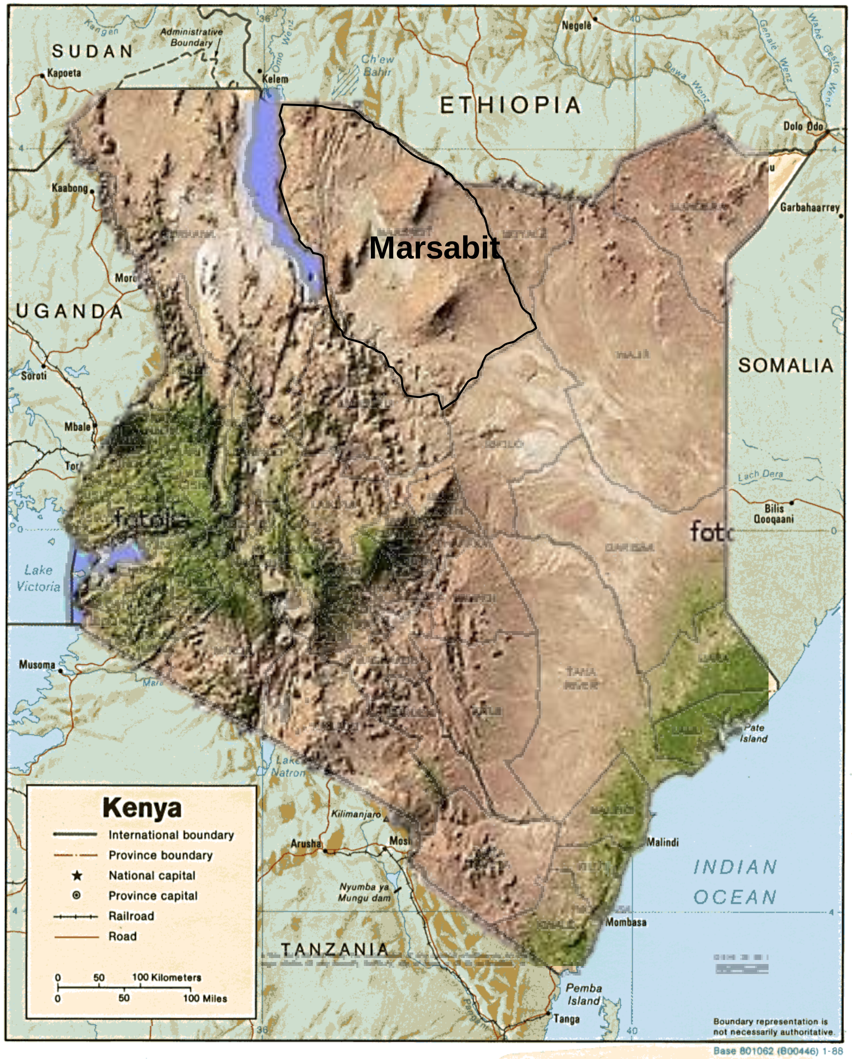
8. Identify cost effective delivery mechanisms

- Delivery through mobile technology, local financial institutions, network groups

9. Long-term micro-level impact assessment

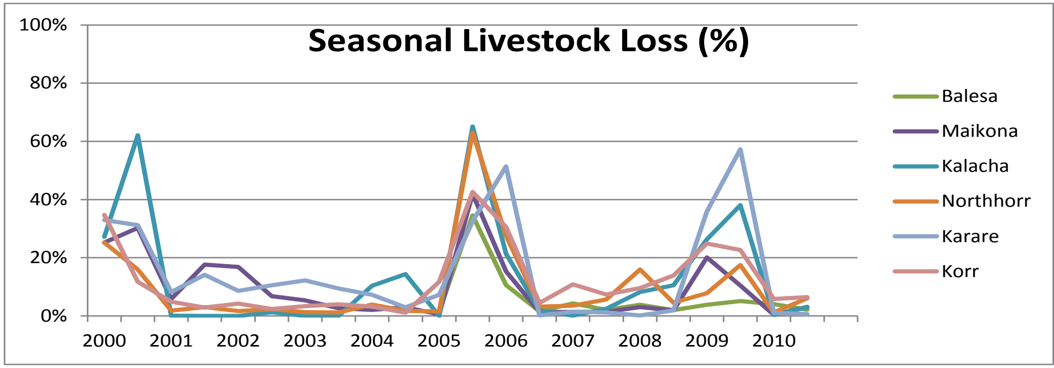
- Randomized survey and experiments to elicit demand, impacts on welfare, induced behavior responses from control and treatment groups

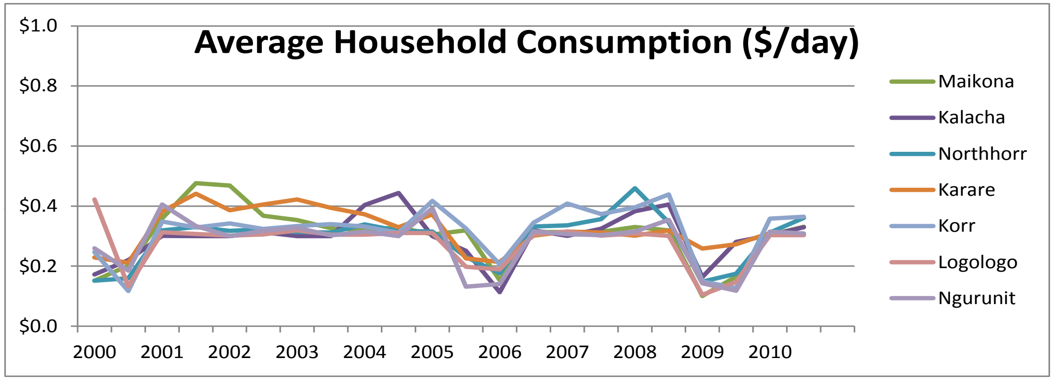
Satellite vegetation based livestock insurance in Kenya



(1) Identify loss to be insured:
Catastrophic livestock losses from drought as key uninsured risk in this area

- Observed household welfare co-move with livestock losses





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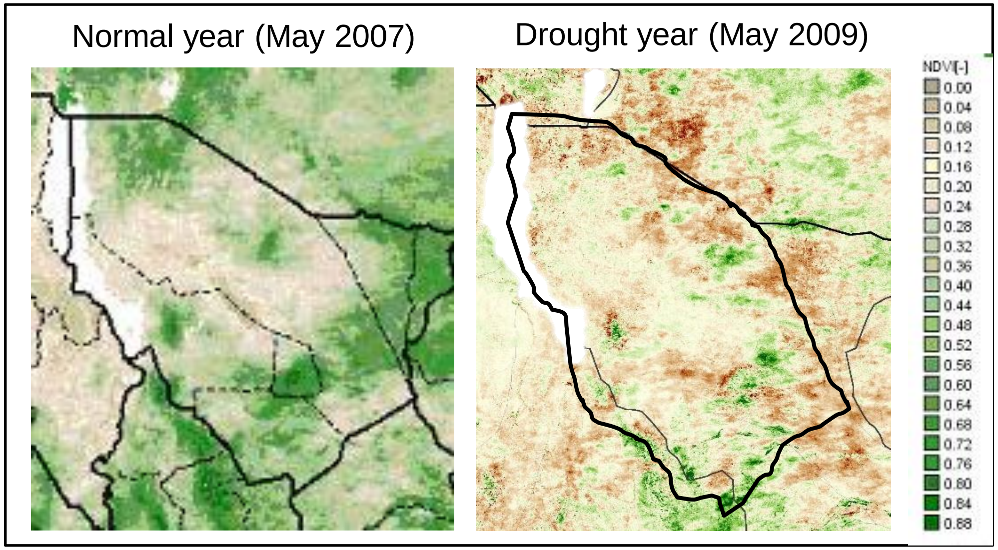
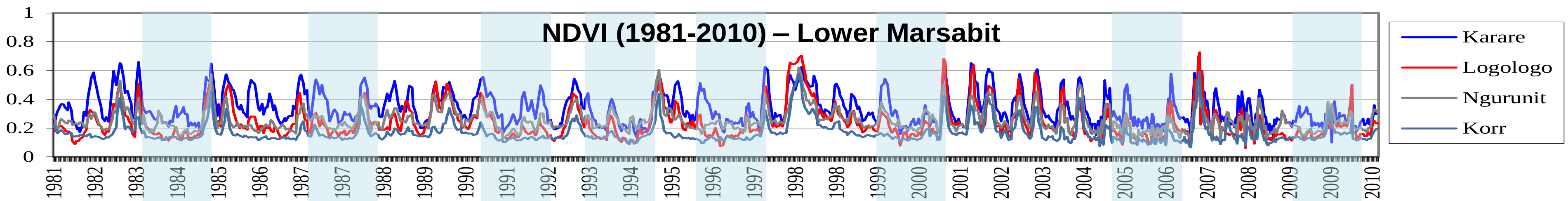
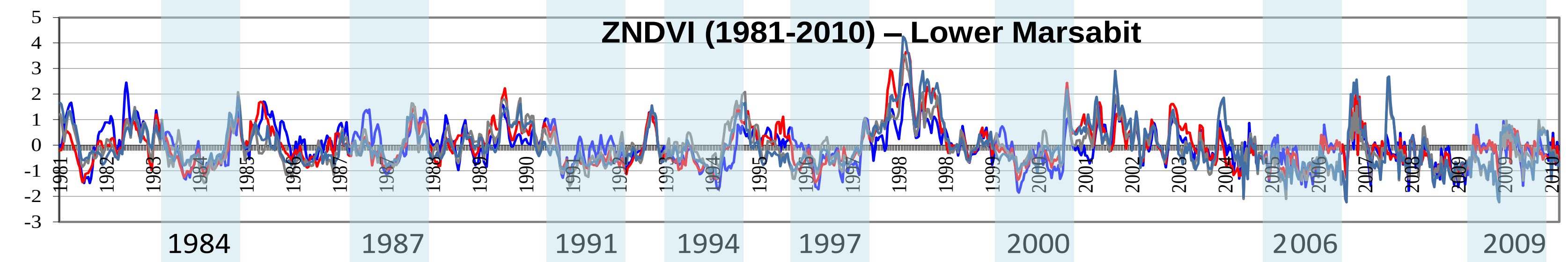


(2) Selecting index: NASA MODIS Normalized difference vegetation index (NDVI) as index

- Indication of availability of vegetation over rangeland
- Spatiotemporal rich (1×1 km^2)
- Available in near-real time every 15 day (1982-present)



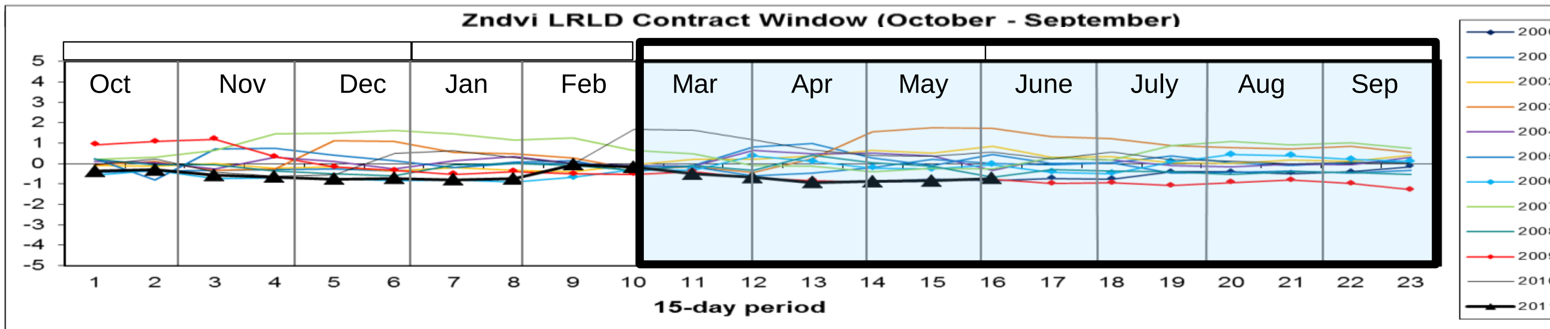


Historical Droughts

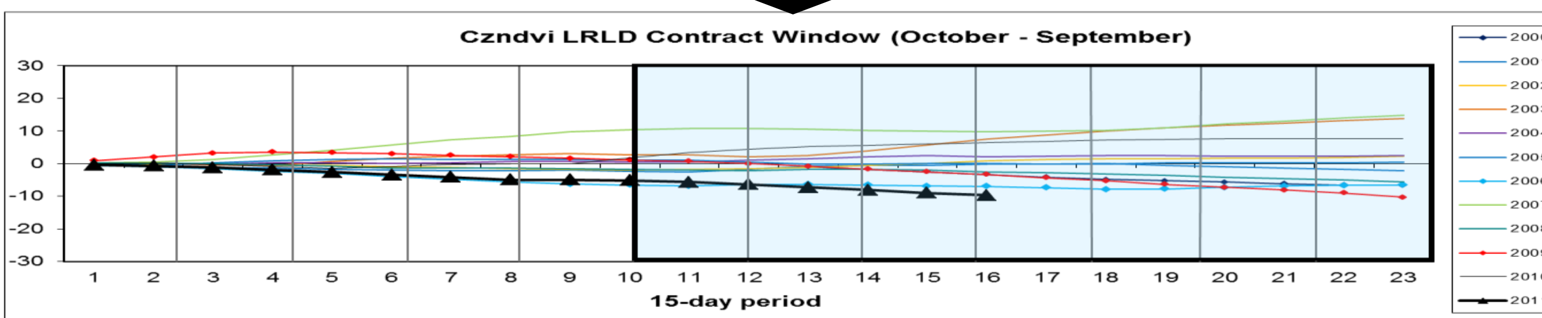
Satellite vegetation based livestock insurance in Kenya

(3) Quantify insurable loss from index: construct predicted livestock loss from the empirical model: $M_{lt} = M(ZNDVI_{lt}) + \varepsilon_{lt}$

$ZNDVI_{lt}$



$Cumulative\ ZNDVI_{lt}$



Regime switching model for zone-specific, seasonal mortality prediction:

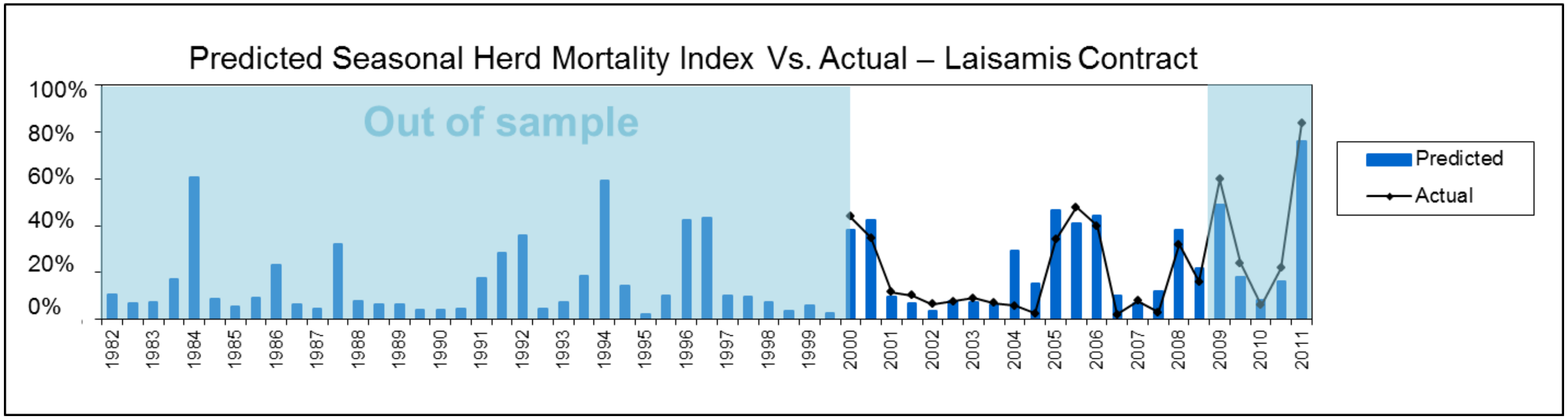
$$M_{lt} = \begin{cases} M_1\big(X(ndvi_{lt})\big) + \varepsilon_{1lt} & if\ Czndvi\_pos_{lt} \geq \gamma \quad (good\ climate\ regime) \\ M_2\big(X(ndvi_{lt})\big) + \varepsilon_{2lt} & if\ Czndvi\_pos_{lt} < \gamma \quad (bad\ climate\ regime) \end{cases} \Rightarrow \widehat{M}(ZNDVI_{lt})$$

Satellite vegetation based livestock insurance in Kenya

(3) Quantify insurable loss from index: construct predicted livestock loss from the empirical model: $M_{lt} = M(ZNDVI_{lt}) + \varepsilon_{lt}$

Predictive Performance of predicted livestock loss, $\widehat{M}(ZNDVI_{lt})$

- Out-of-sample prediction errors within +-10% (especially in the bad year)
- Predict historical droughts well

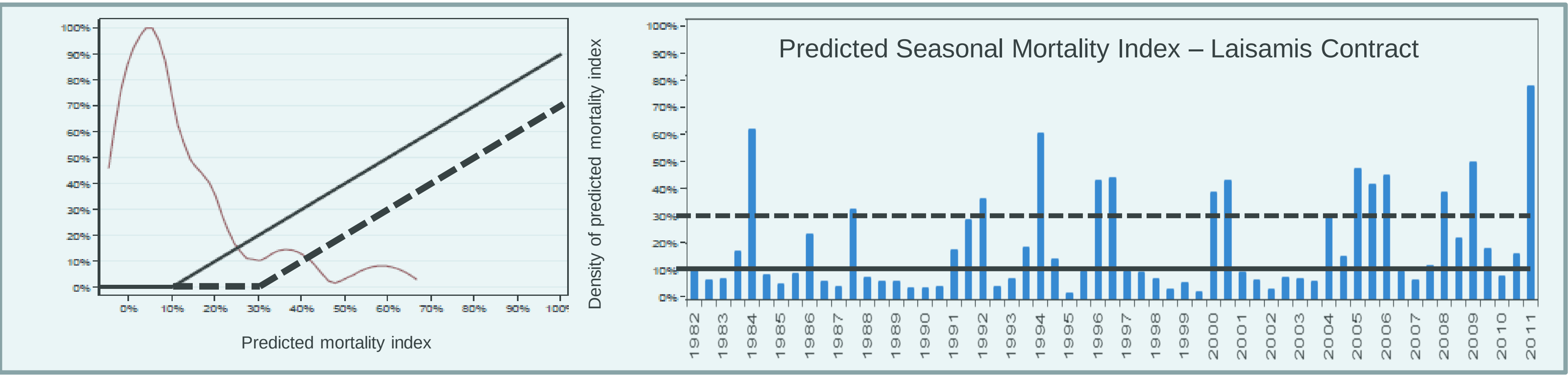


Satellite vegetation based livestock insurance in Kenya

(4) Identify optimal contract structure

- **Insurable loss:** Area average livestock loss indicated by $\widehat{M}(ZNDVI_{lt})$
- **Seasonal indemnity payment:**

$$\Pi_{lt}\left(\widehat{M}(\theta_{lt})|\, M^{*}, TLU, P_{TLU}\right) = max\left(\widehat{M}(ZNDVI_{lt}) - M^{*}, 0\right) \times TLU \times P_{TLU}$$



- **Coverage:** Division level, annual contract (covers two seasonal payouts)

(5) Actuarial fair premium:
(% of sum insured)

Strike (M^{*})	10%	30%
Fair premium rate	6.8%	3.2%
Pr($\widehat{M_l}(NDVI) > M^{*}$)	34.5%	19.8%

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Satellite vegetation based livestock insurance in Kenya

(6) Ex-ante contract evaluation: simulations of stochastic dynamic model based on observed household dynamic data

Pastoral production function:

$$f(H_{it}, X_{it}) = \begin{cases} f_L(H_{it}, X_{it}) + b_{it} & if \quad H_{it} \leq H^* \\ f_H(H_{it}, X_{it}) & if \quad H_{it} > H^* \end{cases}$$

Herd dynamics with stochastic environment:

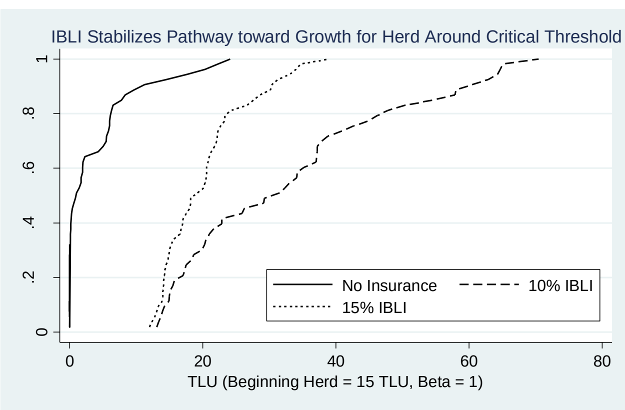
$$H_{it+1} = (1 + g(NDVI_t, \varepsilon_{it}) - m(NDVI_t, \varepsilon_{it}))\, H_{it} + i_{it}$$

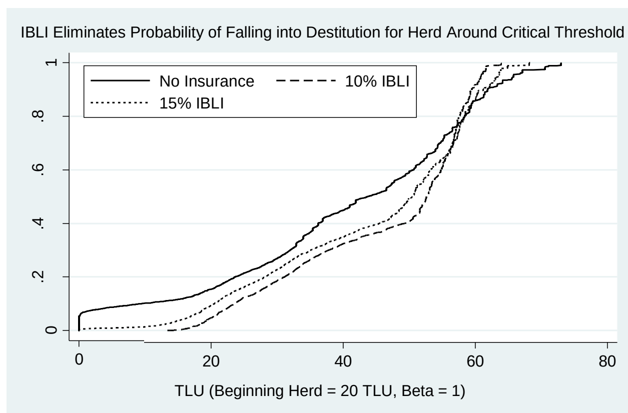
Household budget constraint:

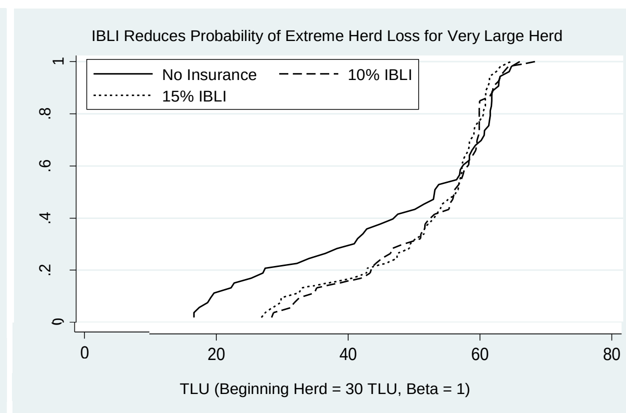
$$c_{it} + i_{it} \leq f(H_{it}, X_{it}) + (W_{it} - W_{it+1}) + (\pi - \rho) h_{it} H_{it}$$

Household Intertemporal problem:

$$V(H_{it}) = \max_{c_{it}, h_{it}} u(c_{it}) + \delta_i E\left(V(H_{t+1}) | \Gamma_i(NDVI_t, \varepsilon_{it}, \pi_t)\right)$$







- In most case, insured herd SOSD uninsured herd: insurance reduces prob. of extreme loss
- Contract seems to be effective despite the existence of basis risk!

Satellite vegetation based livestock insurance in Kenya

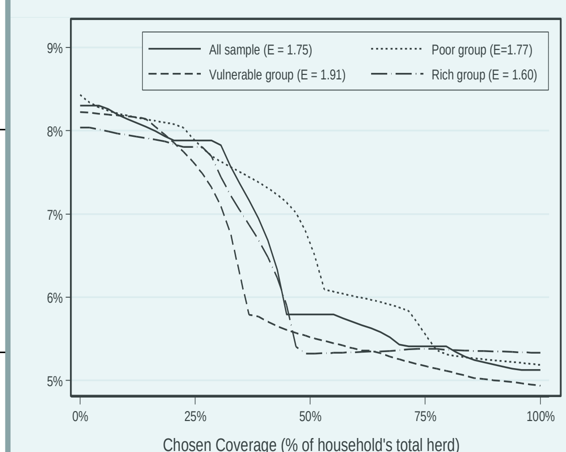
(6) Ex-ante contract evaluation: Willingness to pay experiments (210 hhs)

	1	2	3	4	5	6	7
Contract Coverage	100% Compulsory Coverage				Insured Chooses Coverage level		
Model (Dependent Variable)	Probit (Willing to purchase = 1)				Ordered Probit (0, 25%, 50%, 75%, 100%)		
Premium rate	-0.146***	-0.140***	-0.143***	-0.135***	-0.453***	-0.452***	-0.454***
	(0.036)	(0.033)	(0.039)	(0.036)	(0.046)	(0.0455)	(0.045)
Preference							
Discount rate	-0.184	-0.177	-0.190	-0.165	-0.085	-0.106	-0.077
	(0.158)	(0.157)	(0.139)	(0.149)	(0.225)	(0.224)	(0.231)
Risk aversion	-0.085	-0.083		-0.085	-0.303*		-0.308**
	(0.123)	(0.112)		(0.120)	(0.156)		(0.150)
Risk aversion × Have bank account		1.247***		1.249***	0.0448		0.042
		(0.180)		(0.234)	(0.0328)		(0.034)
Ambiguity aversion	-0.005		-0.037	-0.029		-0.0340	-0.001
	(0.031)		(0.031)	(0.035)		(0.169)	(0.137)
Ambiguity aversion × Have bank account			0.0376	0.0375		0.0309	0.237
			(0.034)	(0.034)		(0.0583)	(0.547)
Loss experience and perception							
Probability of m_it>200% mean_i	0.771***	0.728***	0.705**	0.687**	1.524**	1.440**	1.533**
	(0.284)	(0.282)	(0.281)	(0.274)	(0.617)	(0.606)	(0.598)
Experienced very bad long rain 2008	0.143**	0.135**	0.107	0.119*	0.208	0.164	0.207
(=1 if yes)	(0.067)	(0.065)	(0.069)	(0.071)	(0.199)	(0.207)	(0.212)
Expected livestock loss in 2009	0.708	0.679	0.690	0.629	1.568***	1.631***	1.559***
	(0.520)	(0.498)	(0.524)	(0.532)	(0.317)	(0.320)	(0.326)
Basis risk (% false negative when area	-0.497***	-0.475***	-0.488***	-0.459***	-0.179	-0.155	-0.174
Average loss trigger 10% strike)	(0.164)	(0.154)	(0.173)	(0.152)	(0.239)	(0.238)	(0.235)
Wealth and credit constraint							
Ln (total livestock)	-0.225***	-0.216***	-0.216***	-0.206***	-0.379***	-0.374***	-0.377***
	(0.017)	(0.018)	(0.016)	(0.015)	(0.119)	(0.124)	(0.122)
Ln (non-livestock productive assets)	0.038***	0.036***	0.036***	0.035***	0.0663***	0.0610***	0.068***
	(0.007)	(0.007)	(0.005)	(0.006)	(0.0168)	(0.0158)	(0.016)
Landholding	0.050*	0.048**	0.045*	0.044*	-0.0280	-0.0154	-0.026
	(0.026)	(0.024)	(0.027)	(0.025)	(0.0557)	(0.0654)	(0.060)
Credit constrained (=1 if yes)	0.225***	0.215***	0.175*	0.180*	0.268	0.182	0.262
	(0.083)	(0.078)	(0.094)	(0.094)	(0.214)	(0.220)	(0.211)
Financial experience and literacy							
Have bank account (=1 if yes)	0.337***	0.158	0.327***	0.155	0.0310	0.0729	-0.137
	(0.022)	(0.136)	(0.017)	(0.152)	(0.409)	(0.376)	(0.788)
Belong to active network (=1 if yes)	0.321***	0.300***	0.306***	0.289***	0.483**	0.452*	0.503**
	(0.037)	(0.030)	(0.047)	(0.038)	(0.234)	(0.241)	(0.256)
Head education (=1 if yes)	-0.033*	-0.032*	-0.040**	-0.037*	-0.0550*	-0.0380	-0.054*
	(0.019)	(0.017)	(0.019)	(0.019)	(0.0312)	(0.0316)	(0.031)

Demand determinants

- (+) familiarity with fn. product
- (+) with interacting financial experience with risk aversion
- (+) perceived loss profile
- (+) expected loss
- (+) wealth (wealth eff.)
- (-) perceived basis risk
- (+) credit constraint (buffer stock)

Premium Vs. Chosen Coverage



Modest demand exists at 20%+fair
Less elastic among the rich

Satellite vegetation based livestock insurance in Kenya

(7) Develop education and extension tools: using experimental games with real incentives

- Replicate the pastoral livelihood in the community
- Teach how this insurance work and how it will affect herd dynamics
- The game also allows us to study hh's behavior responses from insurance!

Satellite vegetation based livestock insurance in Kenya

(8) Identify cost effective delivery mechanisms to remote clients using mobile technology

- The contract has been commercialized in northern Kenya since 2010
- Contracts sold to among 10% of populations in the first year
- Local insurance company underwrites the contract with Swiss Re

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Satellite vegetation based livestock insurance in Kenya

(9) Long-term micro-level impact assessment

- 4-year panel household survey, baseline (2009) with annual repeat
- **Challenges:** (i) cannot randomize eligibility for insurance
  (ii) low uptake reduces power of estimating avg. treatment effects
- **Hence quasi-experiment with encouragement design:** use IV approach with multiple instruments (to generate variation in insurance purchase)
- **We randomize 3 instruments:**

  (1) Insurance education (e_{it})
  (2) Eligibility for cash transfer (t_{it})
  (3) Discount coupon at 0-60% (d_{it})

	Cash transfer	No cash transfer
Educated	4 sites	4 sites
Not educated	4 sites	4 control sites

- **Survey instruments**: welfare, Induced behavior responses, formal/informal access to credit, social insurance, environmental impacts
- **Empirical estimations** of demand determinants and impacts of insurance:

$$First\ stage: \quad D_{it} = \gamma_0 + \gamma_1 e_{it} + \gamma_2 t_{it} + \gamma_3 d_{it} + \varepsilon_{it}$$

$$Second\ stage: \quad \Delta Y_{it} = \rho_0 + \rho_1 D_{it} + \rho_2{}' X_{it} + D_{it} X_{it}{}' \rho_3 + \delta_i + \varepsilon_{it}$$

Stay tuned!

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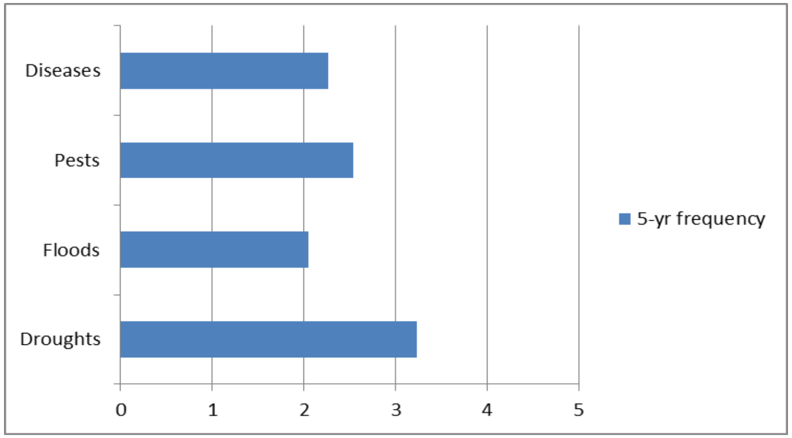
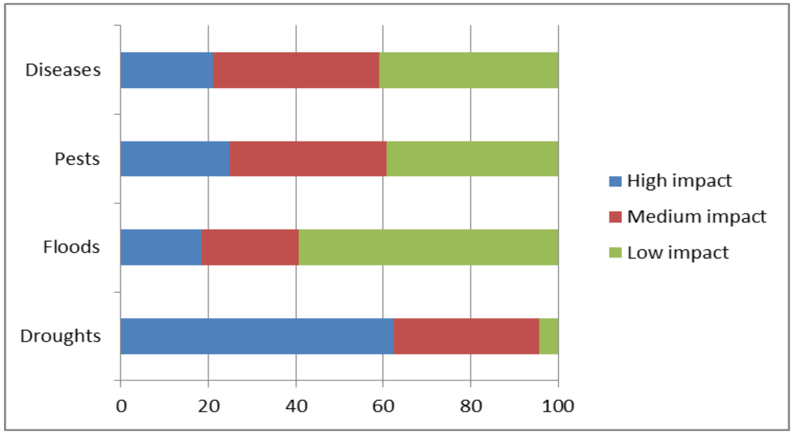
IBLI official site: http://livestockinsurance.wordpress.com/

Existing agricultural risk management in Thailand

➢ Agricultural households largely uninsured from covariate shocks





Source: สำนักงานเศรษฐกิจการคลัง

➢ Current agricultural risk management system

Self/ informal insurance

pre: water and land mng.
diversifications, etc.
post: formal/informal credit

Issues: Not sufficient for managing covariate shocks

Marketed index insurance

Drought insurance for maize (7 provinces since 2007)
Drought insurance for rice (Khon Kaen since 2010, 14 provinces since 2011)

Issues: basis risks, awareness no impact assessment

Government supports

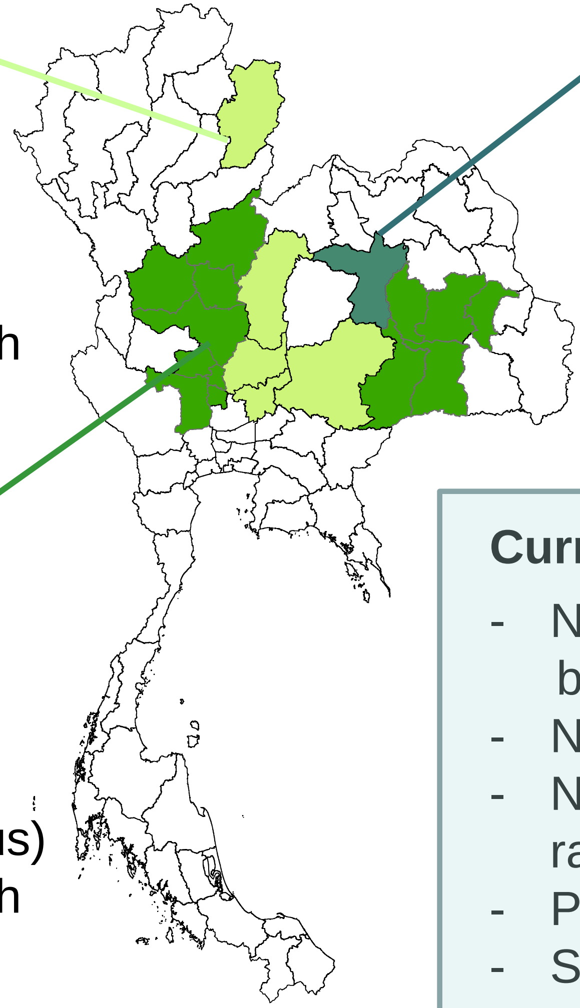
Disaster relief program (compensate for total or partial losses based on local verification)

Issues: not sufficient delay in payment, Induced moral hazard

Three Index Insurance Piloted in Thailand

(1) Drought insurance for maize since 2007

- WB, BAAC, GIA
- 7 provinces
- Cum. rainfall (25 radius) at 3 stages of crop growth
- 80-day coverage



(2) Drought insurance for rice since 2010

- JBIC, BAAC, Sompo
- Only in Khon Kaen
- Simple cum. rainfall (25 radius)
- 3-month coverage

(3) Drought insurance for rice since 2011

- TRF, BAAC, GIA
- 14 provinces
- 15 consecutive days of deficient rainfall (25 radius) at 3 stages of crop growth
- 63-day coverage

Current issues

- No micro-level analysis of basis risk
- No rigorous impact evaluation
- Need educational tools to raise awareness
- Product complications
- Scalability

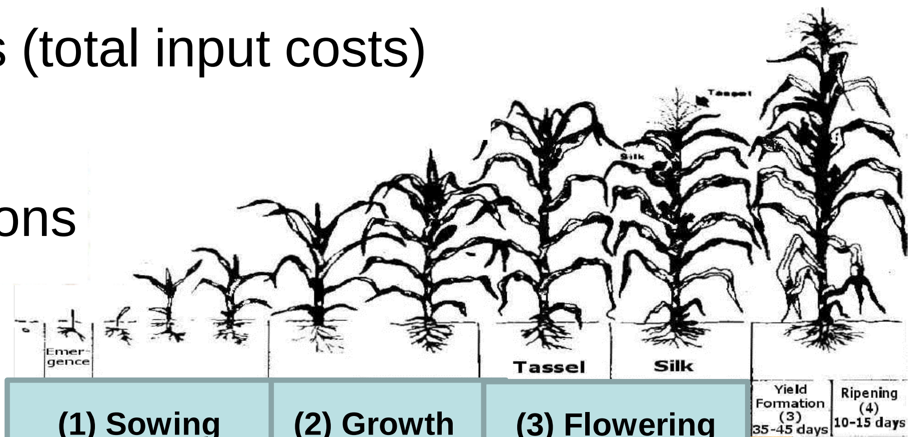
Australian National University

Interesting Issues in Thailand

(1) Drought index insurance for maize

- World Bank models, BAAC distributes, GIA underwrites
- **Piloted** since 2007, in 7 provinces (as of 2010)
- **Index:** cumulative rainfall at station (25 radius eligibility)
- **Contract:** 80-day coverage at 3 stages of crop growth
- **Payout** = sum of 3 stages payouts (total input costs)
  - Max payout: 1170-2815 Baht/rai
- **Premium:** 100 baht/rai for all stations
  - Adverse selection?

Year	Insured farmers	Areas (Rais)	Premium (MB)	Sum Insured (MB)	Payout (MB)
2007	35	962	0.08	1.3	-
2008	338	7,238	0.71	7.6	0.12
2009	817	13,454	1.35	13.3	0.82
2010	2,535	45,918	4.59	58.6	-



(1) Sowing (30 days)	(2) Growth (20 days)	(3) Flowering (30 days)
Trigger1 (mm) Payout/tick 1 Max payout 1	Trigger2 (mm) Payout/tick 2 Max payout 2	Trigger3 (mm) Payout/tick 3 Max payout 3

Source: BAAC

(2) Drought index insurance for rice (JBIC)

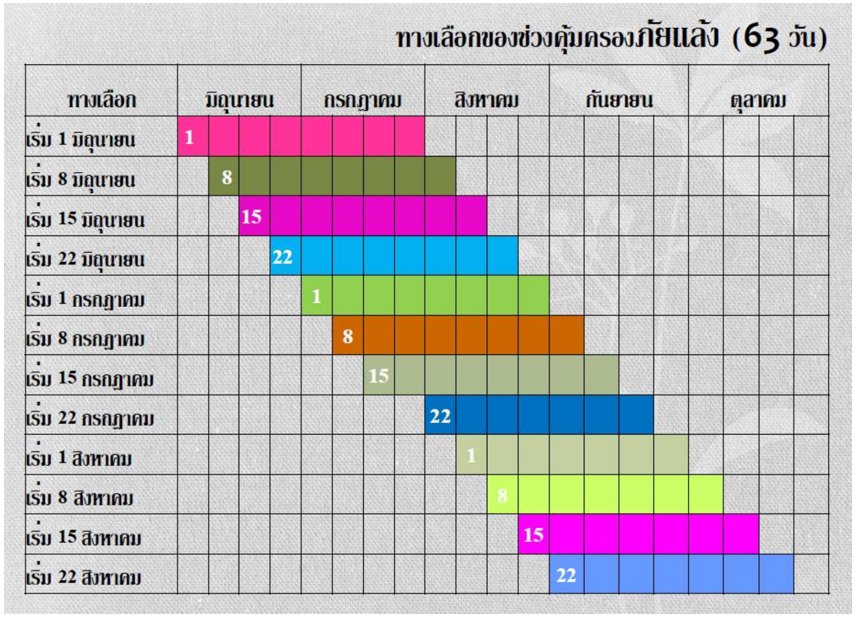
- JBIC models, BAAC distributes, Sompo Japan underwrites
- **Piloted** since 2010, in Khon Kaen
- **Index:** cumulative rainfall at station (25 radius eligibility)
- **Contract:** 3-month coverage from July-September
- **Payout:** 15% of principle if drought (3-month cum. Rain < upper threshold)
  40% of principle if severe drought (cum. Rain < lower threshold)
- **Premium:** 4.64% of principle
- **Quite popular since the first year**: simple contract

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

Source: BAAC

(3) Drought index insurance for rice (TRF)

- TRF funded project (Chada et al.), BAAC distributes, GIA underwrites
- **Piloted** since 2011, in 14 provinces in the North, NE and Central
- **Index:** 15-consecutive day deficient rainfall at station (10 radius eligibility)
- **Contract:** Chosen 63-day coverage
- **Payout** = total input costs (~1,577 Baht)
  if deficient rain (rain<0.1mm) occurs for
  15-consecutive days
- **Premium?**



Source: http://www.map.nu.ac.th/insurance/

Interesting Issues in Thailand

Prospects for Index Insurance in Thailand

➢ **Interesting research questions**

- The optimal contract design as part of existing risk management system (complementarities with self-, informal-insurance, government programs)
- Impact assessment on welfare, productive investments, existing risk management mechanisms
- Designs of financial educational tools
- Viability of flood index insurance (e.g., using satellite imagery?) as part of overall flood management system