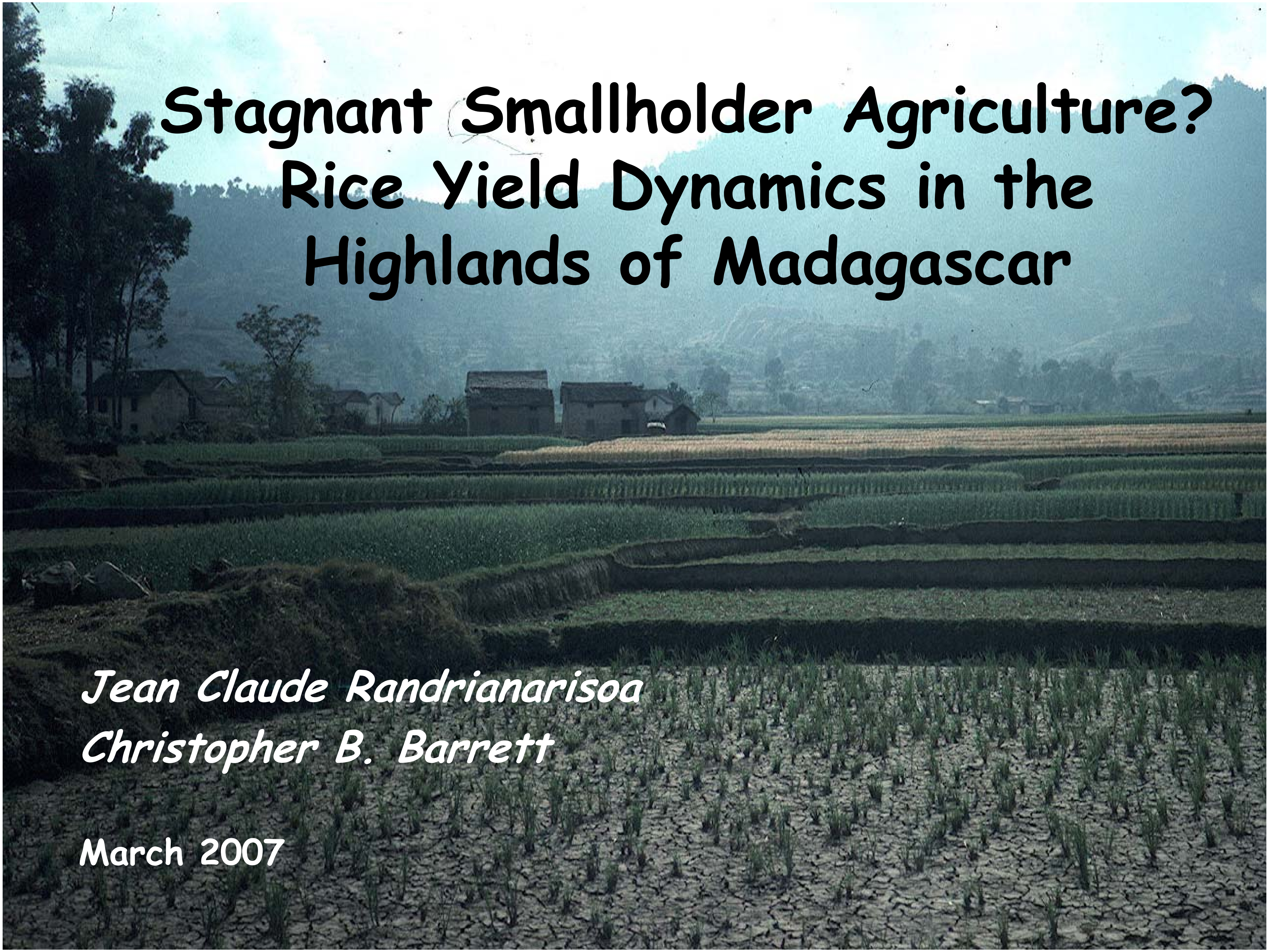

Stagnant Smallholder Agriculture? Rice Yield Dynamics in the Highlands of Madagascar

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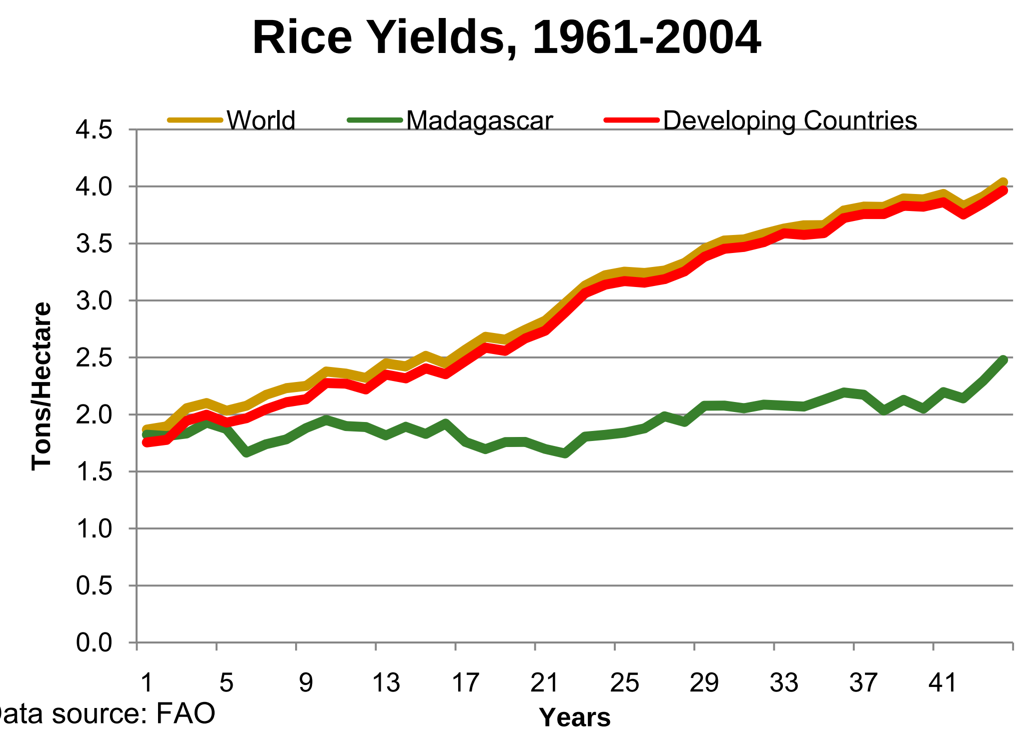
Motivation

- Aggregate time series show stagnation in rice yields in Madagascar, especially compared to other developing countries and world.



Data source: FAO

Motivation

Is stagnation found at micro level as well, in plot-specific longitudinal data?

If not, what sort of convergent or divergent yield dynamics appear in plot-level data? How much is random and how much structural?

Is there important variation across sites and farmer ability groups?

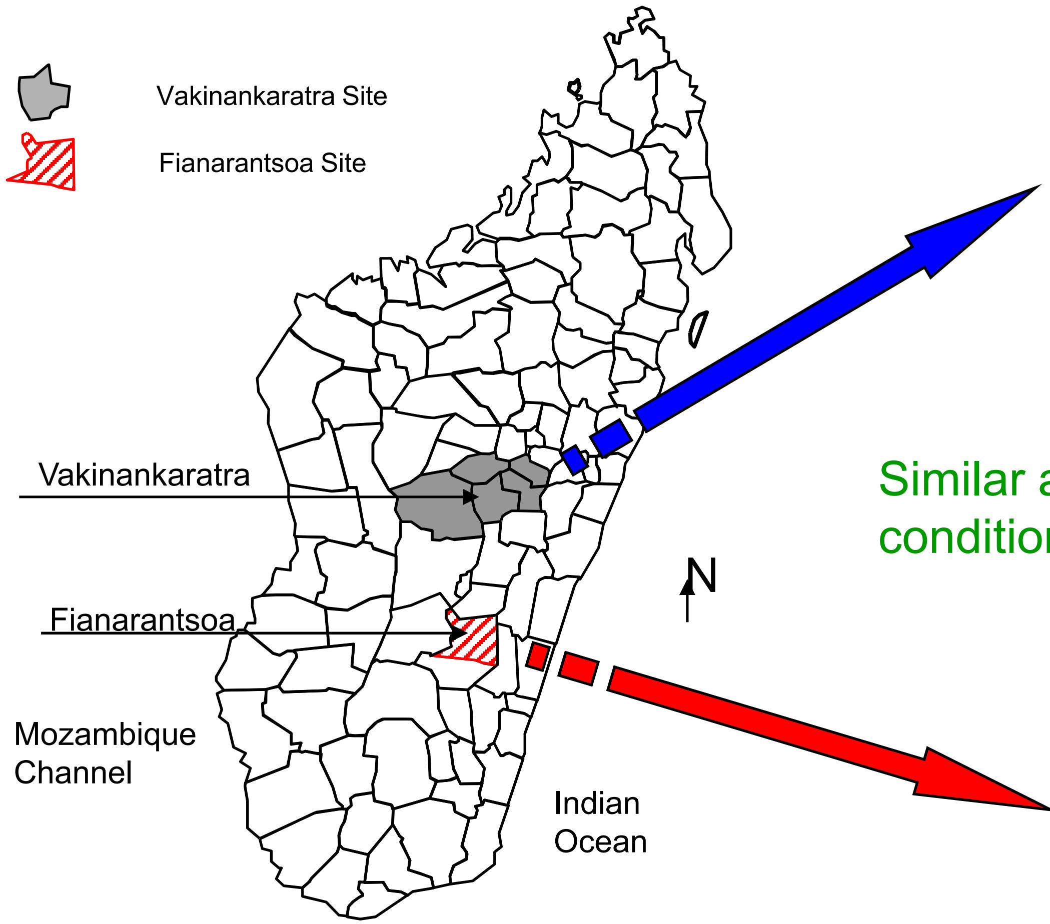
Data

- Continuously cultivated lowland rice plots data collected by the BASIS CRSP project in Madagascar, in 2002 and again in 2003
- Two sites differentiated by poverty level, access to markets and quality of institutions: Vakinankaratra (Antsirabe) and Fianarantsoa
- Combine with commune level data collected by by Cornell ILO project in late 2001

Data: Important Caveats

- Only studies short-term (year-on-year) dynamics
- Ignores whole farm or household (farm + non-farm) dynamics … narrow focus on rice yields
- No accompanying biophysical (e.g., soil quality) data to study coupled dynamics
- Studies two fairly similar systems in Malagasy highlands … not at all nationally representative

Sites



Working institutions
Moderate level of infrastructure
Relatively good soil fertility

Similar agro-climatic conditions (topo., rainfall, etc.)

Weaker institutions
Poor infrastructure
Lower soil fertility

Descriptive Statistics

		Vakinankaratra				Fianarantsoa			
		2002		2003		2002		2003	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Farm characteristics									
Average Yield (plot)	Tons /ha	3.209	2.115	3.346	1.962	2.075	1.401	2.061	1.358
Average plot area	Are	11.98	15.39	13.17	15.45	21.72	20.42	22.23	20.91
Agricultural Asset									
Total land area	Hectare	1.028	1.097	1.028	1.085	1.485	1.296	1.504	1.301
Total rice area	Hectare	0.386	0.484	0.387	0.472	0.645	0.579	0.661	0.574
Zebu – Cattle	Number	0.86	1.68	0.82	1.78	2.26	2.29	2.24	2.41
Idiosyncratic risk									
Plot affected by drought	% yes	14.31		11.79		13.97		13.97	
Plots affected by flood	% yes	11.02		8.51		10.75		6.81	

Is Stagnation Found at Plot Level? Simple Descriptive Evidence

Rice Yield Transition Matrix

Vakinankaratra

% Yield in t/Ha	High 2003	Low 2003
High 2002	32.9% 6.07 → 5.61	16.6% 5.77 → 2.49
Low 2002	19.4% 1.90 → 5.40	31.1% 2.16 → 1.99

Is Stagnation Found at Plot Level? Simple Descriptive Evidence

Rice Yield Transition Matrix Fianarantsoa

% Yield in t/Ha	High 2003	Low 2003
High 2002	38.3% 3.99 → 3.76	12.1% 3.08 → 1.45
Low 2002	12.1% 1.73 → 3.20	37.5% 1.36 → 1.41

25-35% cross the overall site-specific median yield year-on-year!

What Sort of Yield Dynamics?

<u>Basic Empirical Framework</u>:
Production function mapping inputs into rice output

$Y = f(A,X,Z)$

where Y is physical output (tons of rice), A is area (hectares), X are other inputs (labor, animal traction, TLU, agr. capital), Z are dummy variables and shocks (irrigation, drought, flood, village)

Put in yield function terms,

$y = g(A, x, Z)$, where $y=Y/A$, $x=X/A$

Empirical Framework

Dynamics

Plot change in yield, Δy, on base period (2002) yield, y^0

Stagnant yields imply a horizontal line with $E[\Delta y]=0$ regardless of y^0

Alternatively, convergence towards a dynamic equilibrium yield (downward sloping) versus multiple equilibrium and a potential yield trap.

Empirical Framework

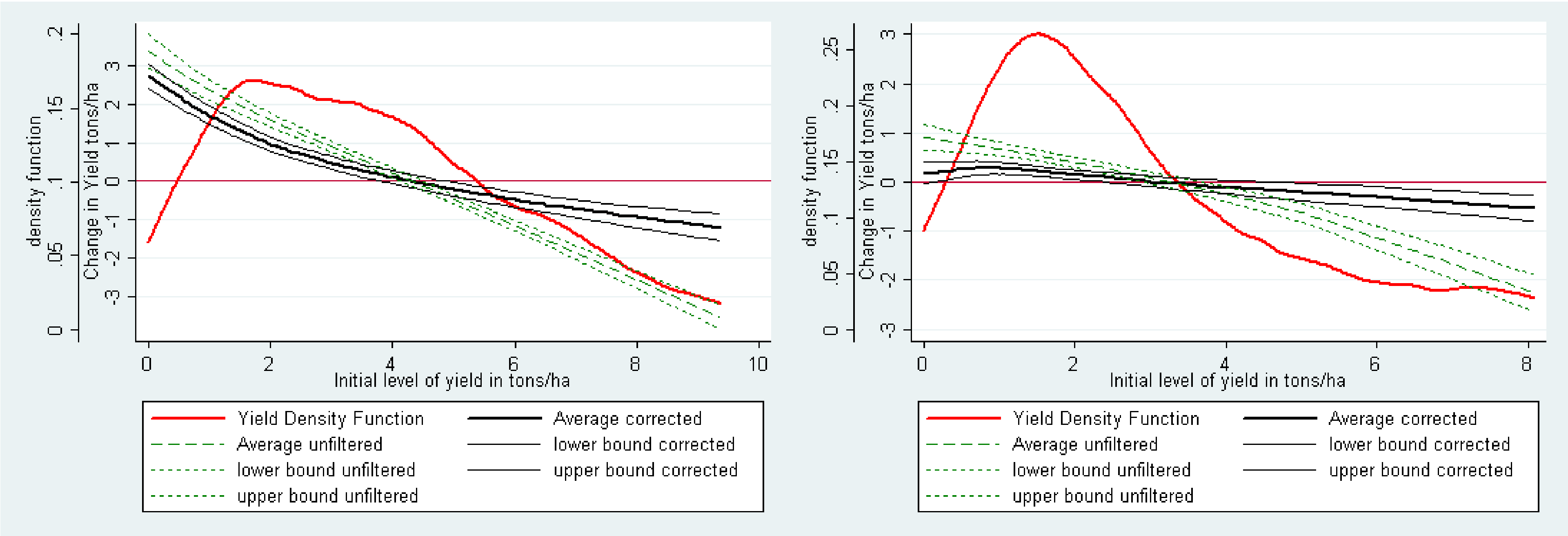
Structural vs. Stochastic Change

Actual yield change includes (i) random fluctuations in yield due to unobserved factors, and (ii) measurement error in yields. These create a regression-to-the-mean effect.

Filter out these elements by estimating expected yield change as function of x, Δx, Z and ΔZ. Use 2^{nd} order exact local approximation (GL form)

Plot structural (i.e., expected) yield changes too.

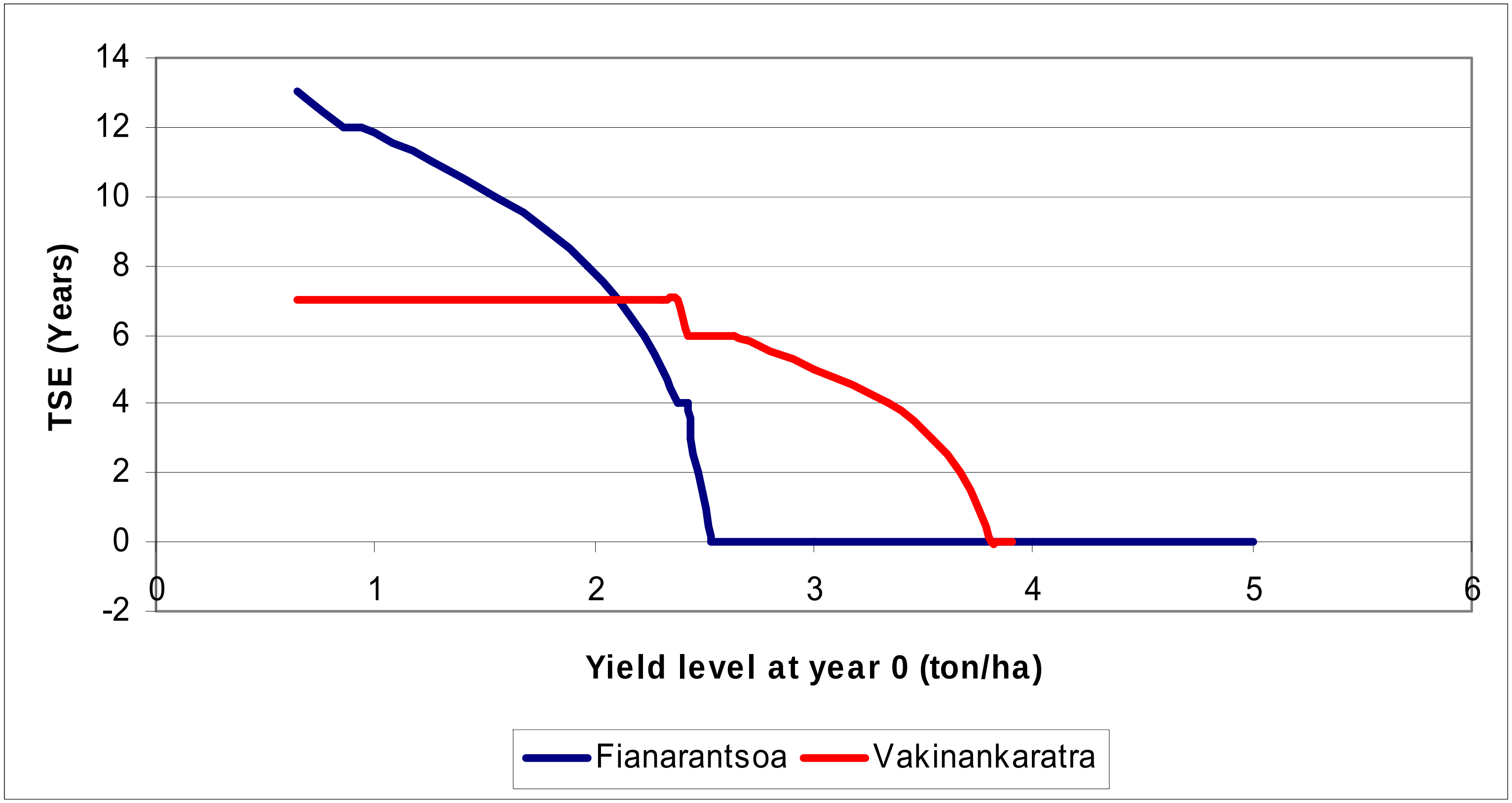
Estimated Stochastic and Structural Rice Yield Dynamics



Vakinankaratra	Fianarantsoa
Steady-state: 4.26 T/ha (3.84-4.48)	Steady-state: 3.05 T/ha (2.15-4.05)
only 8% in eqln interval	35% in eqln interval
mode/majority below	mode/majority below

Semi-stagnant yields in Fianarantsoa, but not in Vakinankaratra

Time to Achieve Steady-State Yield



When asset loss or other structural factors cause yield loss, slow recovery

Are Dynamics Different Based on Farmer Ability?

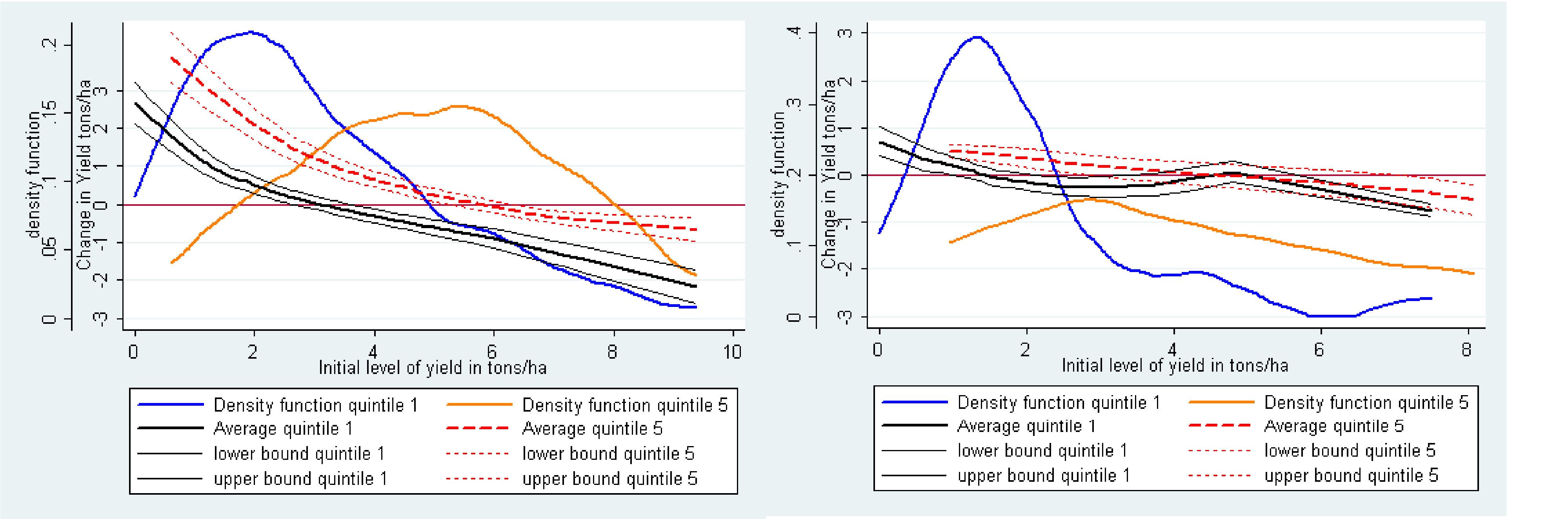
Method:

Estimate production frontier with time-invariant technical inefficiency to proxy for farmer ability.

Efficiency improved by farmer education and local security and health care.

Estimate dynamics separately by inefficiency quintile to see if there are important differences

Heterogeneous Rice Yield Dynamics



<u>Vakinankaratra</u>
3.0 T/ha (least efficient)
5.6 T/ha (most efficient),
with uniformly more rapid
convergence to steady-state

<u>Fianarantsoa</u>
1.5-6.0 T/ha stagnant (least)
4.2-6.0 (most efficient)
Both groups have wide intervals
and slow convergence

Site seems to matter more than farmer ability

Preliminary Conclusions

Aggregate level yield stagnation masks considerable micro (plot)-level dynamics

- a bit of this is truly stochastic, but much is structural, i.e., predictable based on changes in underlying household or location-specific characteristics

- big geographic differences between more developed area (Vakinankaratra), where steady-state yields are higher, convergence is much faster and farmer ability matters, versus less developed area (Fianarantsoa), where yields are lower, convergence slower and farmer ability makes little difference.

Preliminary Conclusions

There seems significant room for yield growth even within present technology set: roughly 1 ton/hectare in each site between current mean and steady-state yield

Change in factors of production, especially labor and livestock, are the big factors affecting expected yields. Thus household-level asset protection and asset building strategies may play a central role in improving staple grain productivity.

Thank you for your time and comments!