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Fertilizer Subsidies in Sub-Saharan Africa: Smart Policy or Political Trap?

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Thomas Jayne's career has been devoted to promoting effective policy responses to poverty in Africa. Jayne is a university foundation professor of agricultural, food, and resource economics at Michigan State University (MSU). He is also visiting professor at the University of Pretoria and adjunct professor at the Indaba Agricultural Policy Research Institute in Lusaka, Zambia. Jayne has played a major role in building MSU's partnerships with African research institutes.

Temporary Subsidies, Savings and the Adoption of Improved Technology

USAID Ag Sector Forum

Michael R Carter

University of California, Davis & NBER
Director, BASIS Assets & Market Access Innovation Lab

25 March 2015

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IFDC

The Problem

- In 2009, SSA farmers used an average of 13 kg/hectare, compared to 94 in other developing countries
- Mozambique is no exception to this pattern–at the national level, most maize farmers use no fertilizer and average less than 1 ton per-hectare
- International Fertilizer Development Center program in Mozambique identified a gaping 2-3 ton/hectare yield gap between what is possible with existing technologies and what farmers currently achieve
- Given the prevalence of poverty in the rural areas of Mozambique, the question is why this failure to adopt a seemingly profitable technology, and what should be done about it

The Problem: Competing Explanations & Solutions

- *Technological*: Poor quality soils are not fertilizer responsive–that is, the yield gap is more apparent than real
  - Tailored soil amendments
  - New seed technologies
- *Economic*: Liquidity, risk and information constraints
  - Smart/Temporary learning subsidies
  - Financial interventions (credit, savings or insurance)
- *Behavioral*: Time inconsistent preferences (or hopelessness)
  - All it takes is a nudge (every year)
- *Hybrid explanations*:
  - Technology-economic (DTMA)
  - Behavioral-economic (economic conditions beget hopelessness–see Laajaj 2014)

Input Subsidies: Temporary or Permanent?

- A number of governments have responded with fertilizer subsidy schemes
- The high opportunity cost of these funds raises question: why subsidize a (supposedly) privately profitable input at all?
- Subsidies can be smart if they can break a low technology trap by:
  - Making technology affordable for low income farmers (*i.e.*, relax liquidity constraints)
  - Sharing the risk of experimentation
  - Reducing learning costs & break the 'let someone else experiment' equilibrium
- Note these are all arguments for *temporary* subsidies
- But will temporary subsidies work & will their impacts persist over time?

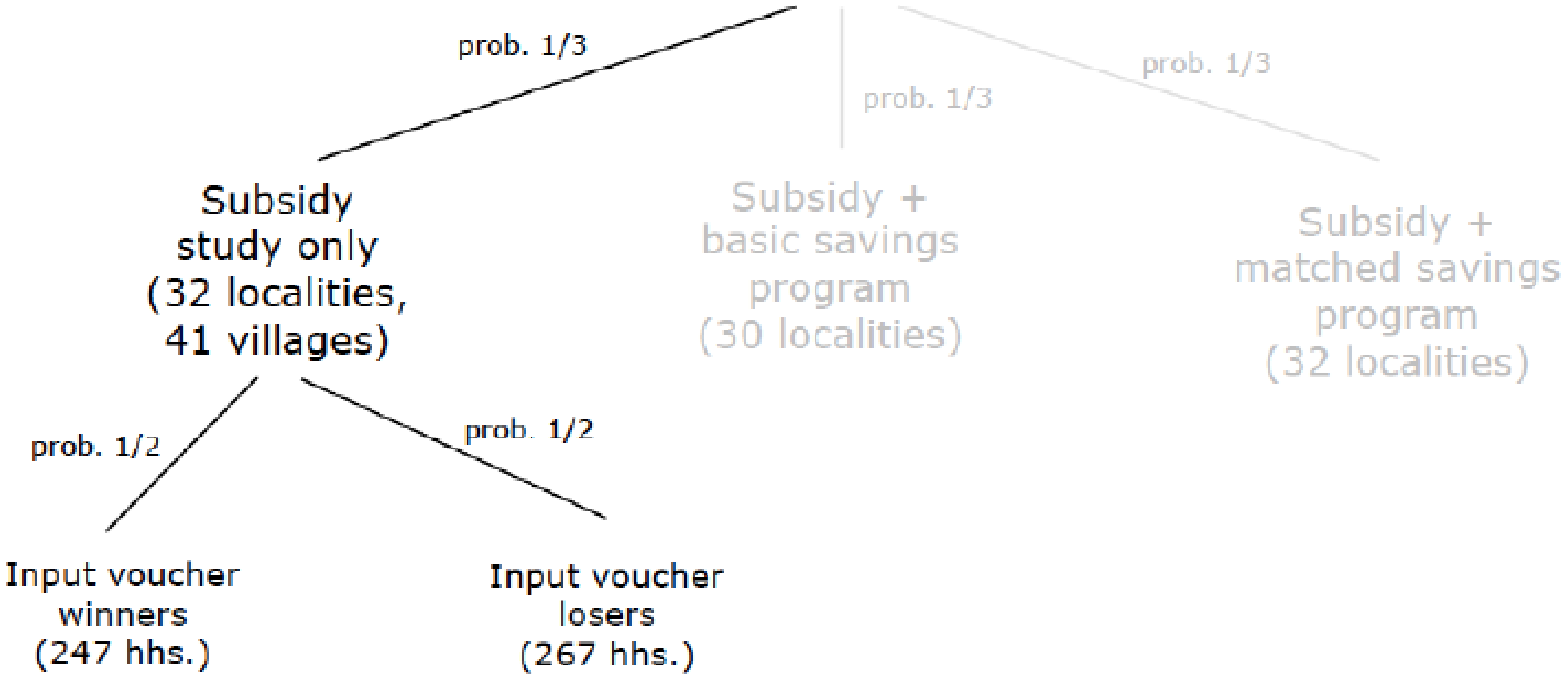
Mozambique Temporary Voucher Program

- Voucher program funded by European Union, implemented by Mozambican government, FAO, and IFDC
- 2 year program 2009-2010 and 2010-2011, 25,000 vouchers of maize and rice in 5 provinces
- Evaluation focuses in Maize vouchers in the Manica Province
- Voucher gave 73% subsidy on package of 12.5 kg of improved seeds (either OPV or hybrid), and 100kg of fertilizer
- Market price of package was about USD 117

Impact Evaluation Design

- Voucher funds available for only 5000 maize farmers in Manica Province
- With the cooperation of the Ministry, 94 localities randomly assigned to one of three treatments:
  1. Subsidy only (41 villages)
  2. Subsidy plus basic savings program with BOM (30 villages)
  3. Subsidy plus plus 'matched savings' with BOM (31 villages)
- Within each village group, individual lottery to determine who got subsidy coupon amongst those who were eligible:
  - 0.5 - 5 hectares in maize
  - Able & willing to make voucher co-pay
- Initially focus only on group 1; return to financial treatment villages later

Impact Evaluation Design



Impact Evaluation Design

- *Sept-Dec 2010:* Random assignment and distribution of vouchers
- *April 2011:* "Baseline" survey to establish voucher use and agricultural outcomes in prior season
- *September 2011:* First follow-up survey to determine short-term voucher impacts
- *September 2012:* Second follow-up survey [no vouchers]
- *August 2013:* Third follow-up survey [no vouchers]

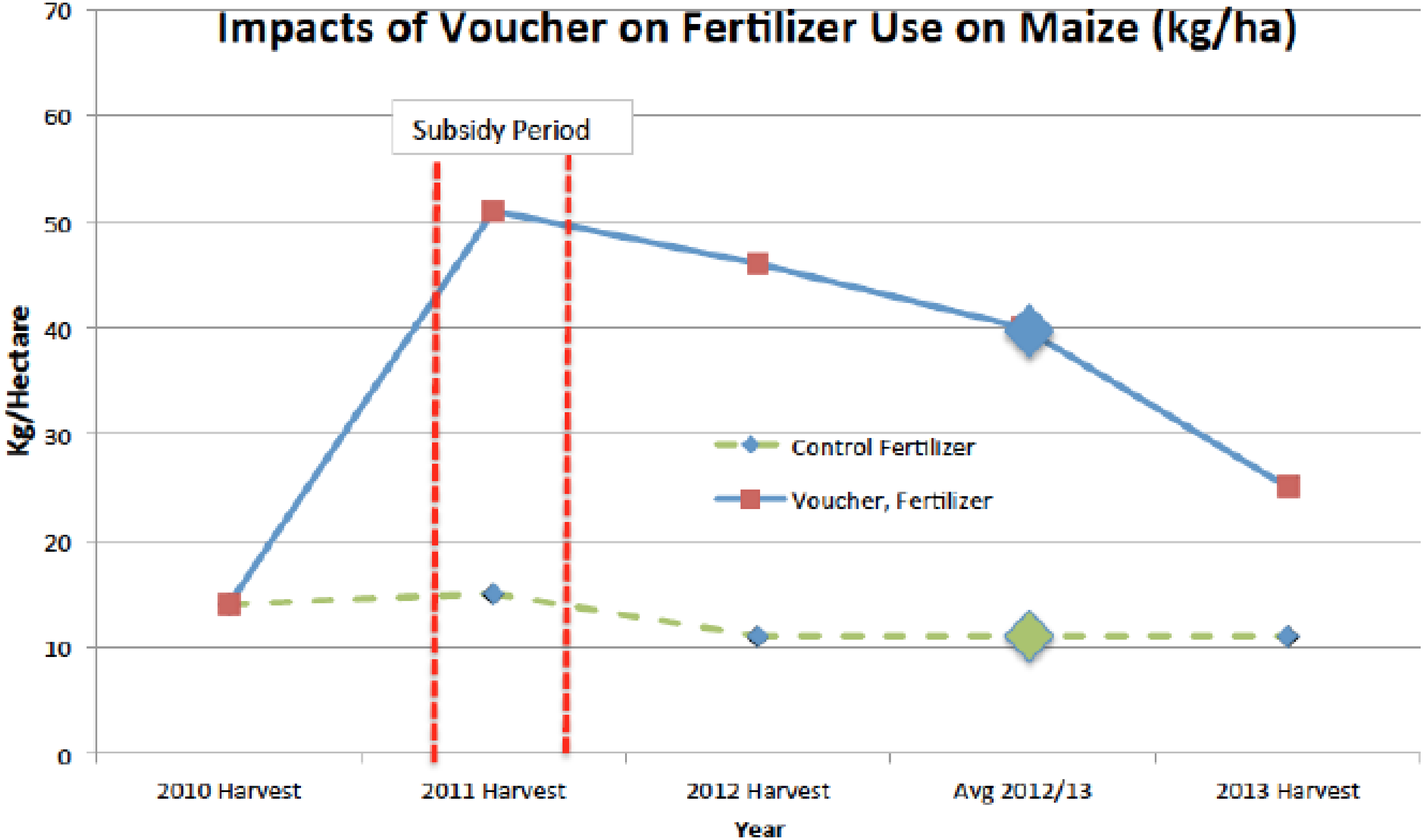
Uptake & Use of Vouchers

- Only about half of lottery winners picked up vouchers, and in the end, a slightly smaller number actually used the vouchers
- In addition, 13% of lottery losers ended up using vouchers
- This partial uptake raises question of whether we are interested in
  - Impacts averaged across all who were offered the program ('intention to treat' impacts) or
  - Impacts averaged across those who participated ("treatment on the treated")
- Focus on the latter as the policy relevant number (*i.e.*, people offered vouchers but who do not use them do not cost the program (much) money)

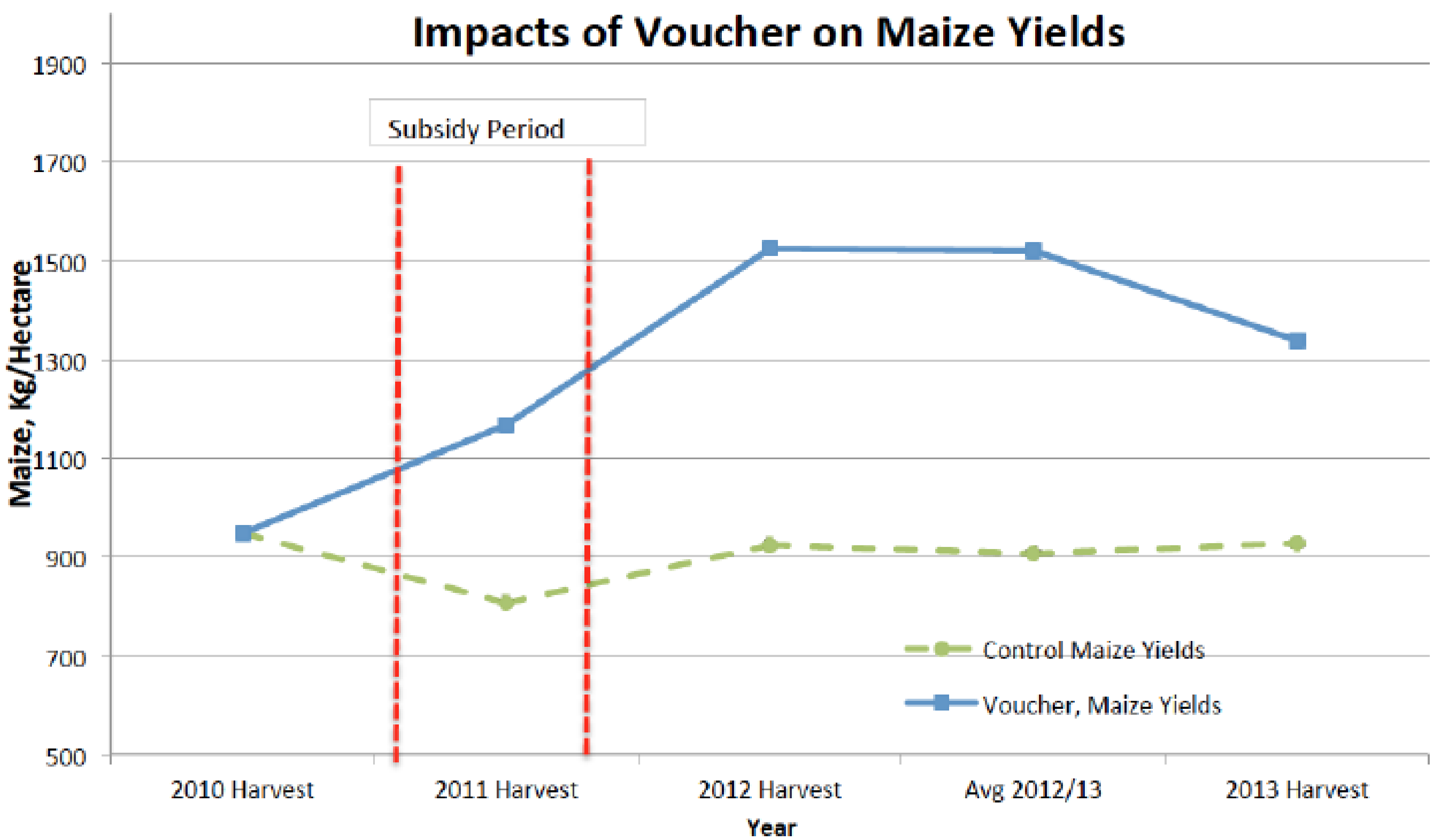
Summary of Analytical Approach

- Confirm baseline balance between treatment and control
- Use standard regression approaches to identify "Intention to Treat" and "Treatment on the Treated" effects (including methods that more or less sensitive to extreme values)
- Analyze following outcome variables in both short and medium term:
  - *Agronomic*
    - Maize-specific outcomes (fertilizer used on maize; maize productivity)
    - Agricultural production outcomes (total fertilizer used; total productivity/income & sales)
  - *Economic*
    - Household living standards (per-capita consumer expenditures, real + imputed)
    - Accumulation of assets and savings
- *Returns to Fertilizer & Learning* from doing and learning from others on returns to fertilizer

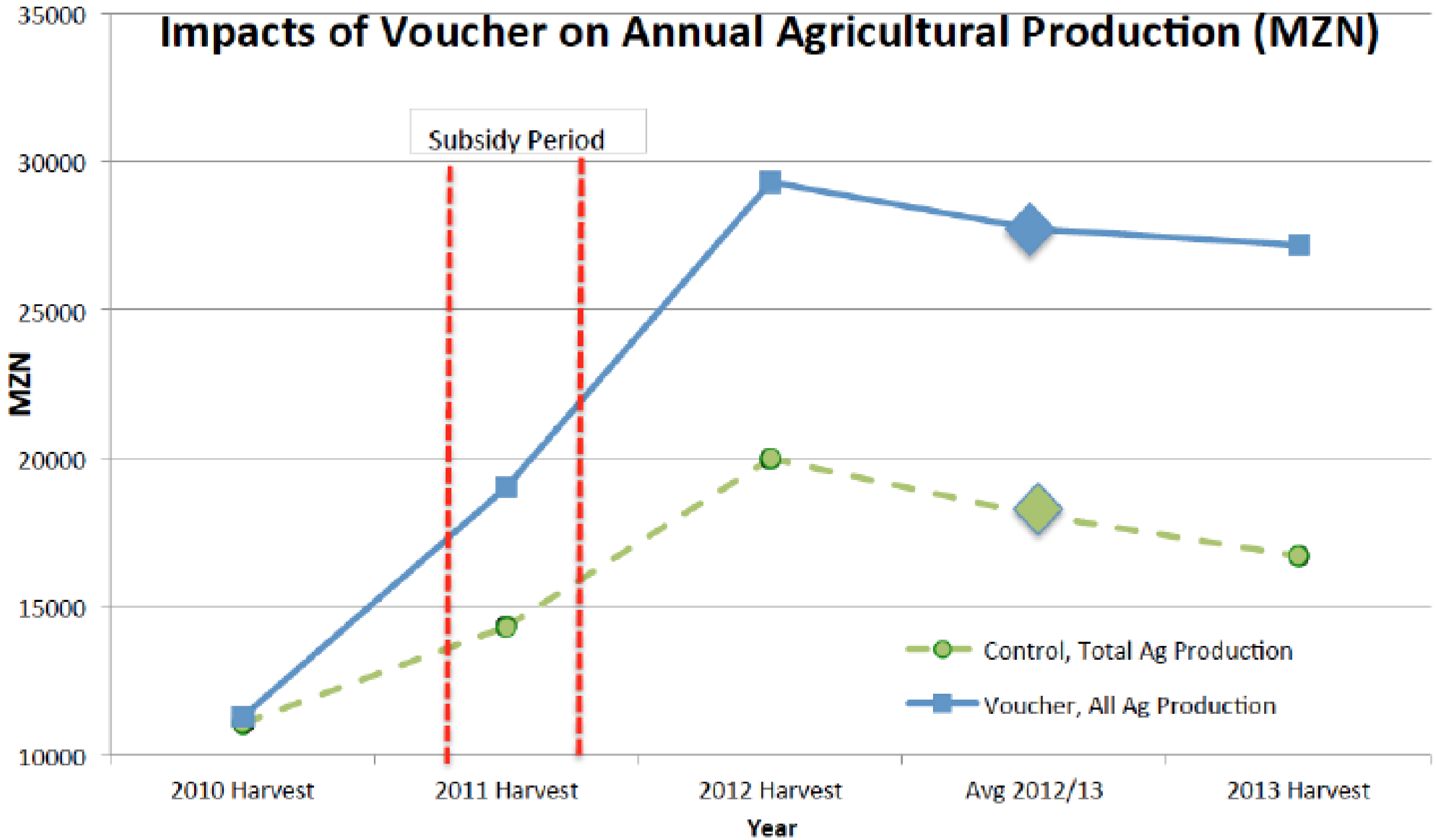
Agronomic Impacts: Maize



Agronomic Impacts: Maize



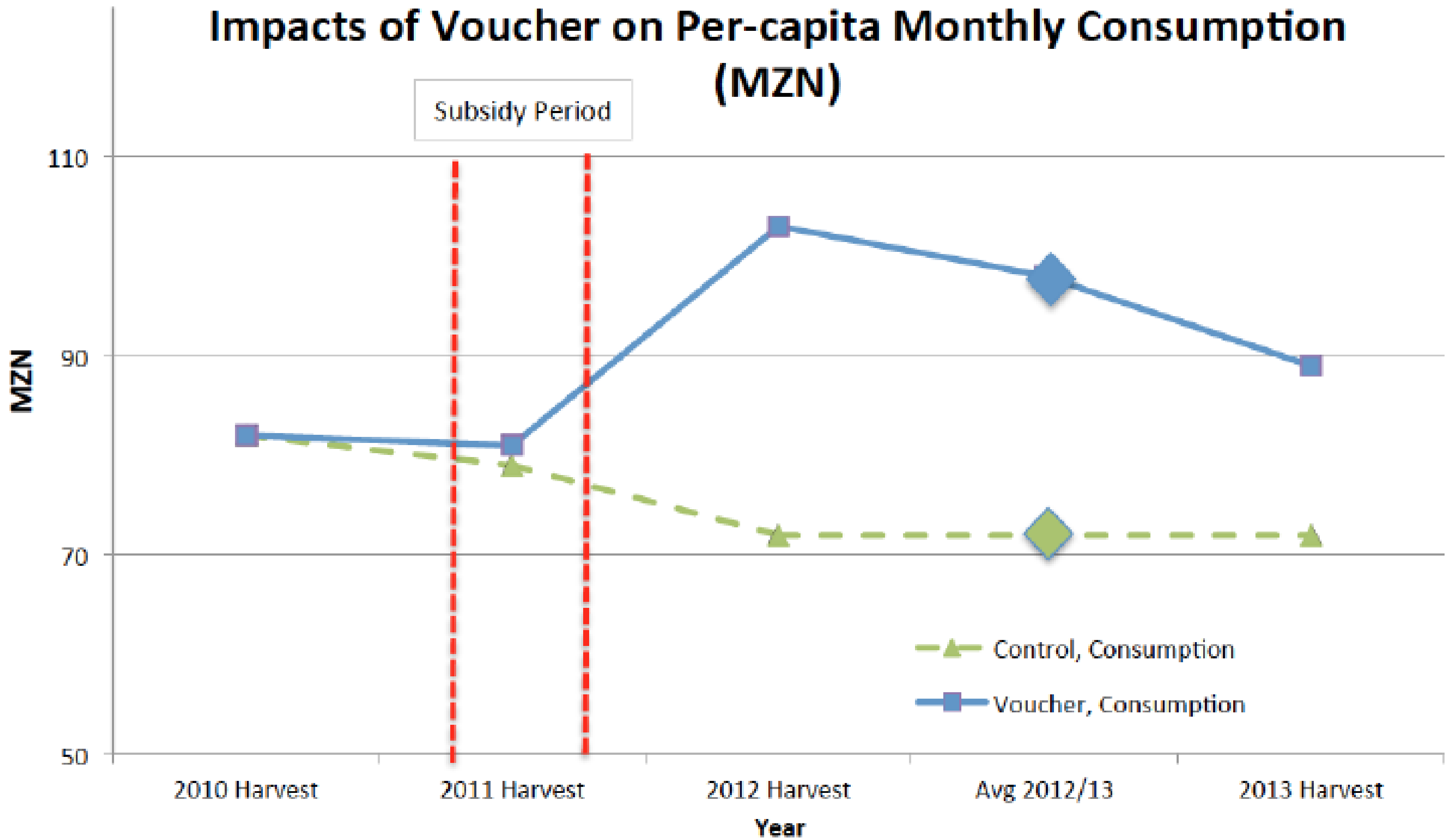
Agronomic Impacts: All Agricultural Activities



Economic Impacts: Living Standards

- Now for the most stringent test: Do these changes result in improved household living standards and reduced rural poverty?
- Initially (2011), no visible impact on total household consumption expenditures
- However, in the 2 post-subsidy years, see an increase in per-capita daily household consumption of 26 MZNS, or 36%

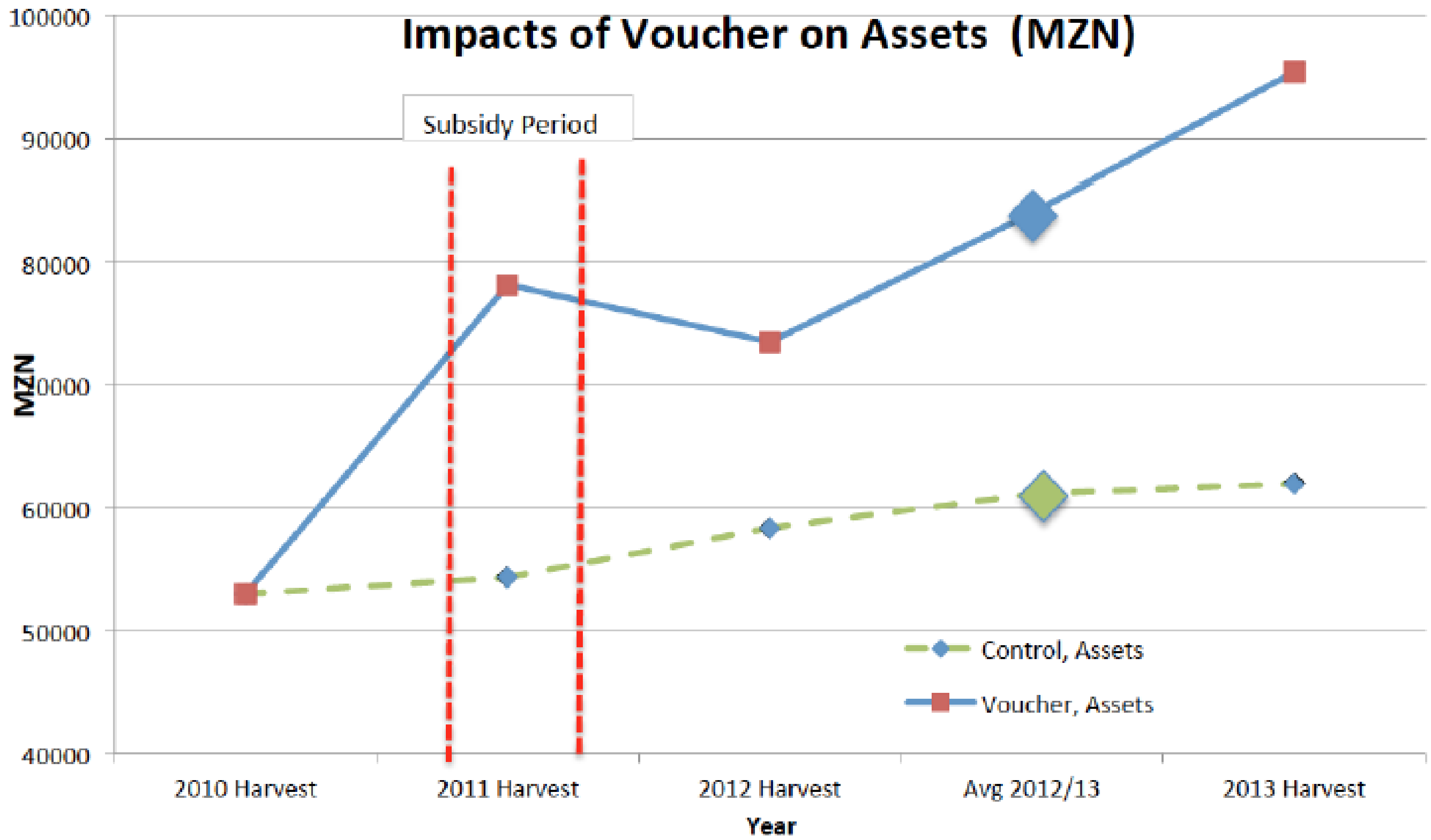
Economic Impacts: Living Standards



Economic Impacts: Living Standards

- With households on average just a bit above conventional poverty lines, an increase of this magnitude implies a substantial reduction in the incidence and depth of poverty
- Also see significant impacts on household assets, savings and food stocks
- Strong impacts, but let's not forget that uptake and usage rate of vouchers was under 50% of lottery winners

Economic Impacts: Assets



Returns to Fertilizer: Learning Impacts

- What explains these strong and persistent effect of a one-time intervention?
- We measured farmers' expected returns to fertilizer under different climatic conditions and found strong learning impacts of the vouchers:
    - Relative to the control group's expectations in 2013, voucher farmers expect an improved seed/fertilizer package to yield on average 2828 kg of maize, which is 51% higher than what the control group expected in 2013
    - If we compare these expectations to baseline (2011) expectations of the control group, we see a 71% increase in expected returns to fertilizer
- We also find that this learning spills over through social networks and that 'indirectly treated' are more likely to persistently use fertilizer

Returns to Fertilizer: Validity of Learning

- Able to use our randomly induced variation in fertilizer use to reliably estimate the impact of fertilizers
- Find that each kg of fertilizer/hectare returns about 20-25 kg of maize per-hectare
- Our analysis of the actual production data shows that on farmers' fields, 100 kg fertilizer would *boost* by yields by 1660 kg/hectare, which is actually about 25% more than what farmers estimate
- This is good news in the sense that farmers' reported expectations are not unrealistic

Financial Interventions: Money Matters

- In a world without deep credit and insurance markets, effectiveness of a voucher program could be shaped by savings interventions that make it safer and cheaper to carry money forward in time:
    1. *Liquidity Effect*: Enhance ability to self-finance post-voucher, full price fertilizer purchases
    2. *Self Insurance Effect*: Enhance the ability to bear post-voucher increased risk due to fertilizer
- Note also that these financial instruments alone could have impacts (especially because learning about fertilizer spills over from others who received vouchers)

Financial Interventions: Programs

- *Basic Savings*: Financial education (saving for consumption smoothing and investment) plus access to mobile Bank (Opportunity Bank of Mozambique)
- *Matched Savings*: Basic Savings plus 25% interest bonus if met savings target (target calibrated on funds needed to purchase seeds & fertilizer)
- For implementation reasons, savings programs were randomized at the village level, while vouchers were randomized within all villages at the individual level
  - Non-voucher recipients could learn from voucher recipients
  - However, non-savings recipients were geographically insulated from beneficiaries of the savings programs

Financial Interventions: Findings, 2012-13

	Living Stds[1]	*Consumption Variability*[2]
Pure Control Group	–	0.453
Voucher Subsidy Only	8.4	0.55
Basic Savings Only	9.1	0.50
Subsidy plus Basic Savings	3.7	0.48
Matched Savings	9.9	0.49
Subsidy plus Matched Savings	8.8	0.45

- Savings interventions do NOT enhance impact of vouchers on mean consumption
- They do allow to offset the added risk associated with agricultural intensification
- Interestingly, savings interventions alone seem to also spur ag investment and growth in mean consumption (but without increased variance penalty)

[1] *% increase over control*

[2] *Standard deviation of log consumption*

Summary: Smart Subsidies

- In summary, we have evidence that temporary subsidies can have sustained impacts
- Strong learning effects seem to explain at least a large part of these sustained impacts
- Temporary subsidies can thus be smart policy–but can they be made even smarter & more effective?

Summary: Making Smart Subsidies Smarter

- Complementary savings interventions have strong risk reduction effect, suggesting that enhance the desirability of sustaining investment in risk-promoting fertilizers
- Perhaps other financial interventions could have helped more
- What could have been done to boost use of the vouchers (& learning) above the modest 50% level?
    - Suspect that for many families, the initial 27% co-investment in the voucher-subsidized package may have been too high or too risky
    - Would fully subsidized vouchers have helped?
    - Would additional financial interventions (credit &, or insurance) have helped?

Summary: Making Smart Subsidies Smarter

- Fertilizer that was used was a 'standard' blend–could we have achieved larger impacts with more appropriate fertilizer blends?
- Both IFDC in Mozambique and BASIS in Kenya & Tanzania are researching this issue
- More generally, average masks heterogeneity that likely reflects differences in soil quality, something which Thom will discuss

Thank You!

Beyond Input Subsidy Programs:

Toward a Holistic and Sustainable Agricultural Growth Strategy in Sub-Saharan Africa

T.S. Jayne, Michigan State University
USAID/Bureau for Food Security
Washington, DC
March 25, 2015

Expenditures of Input Subsidy Programs

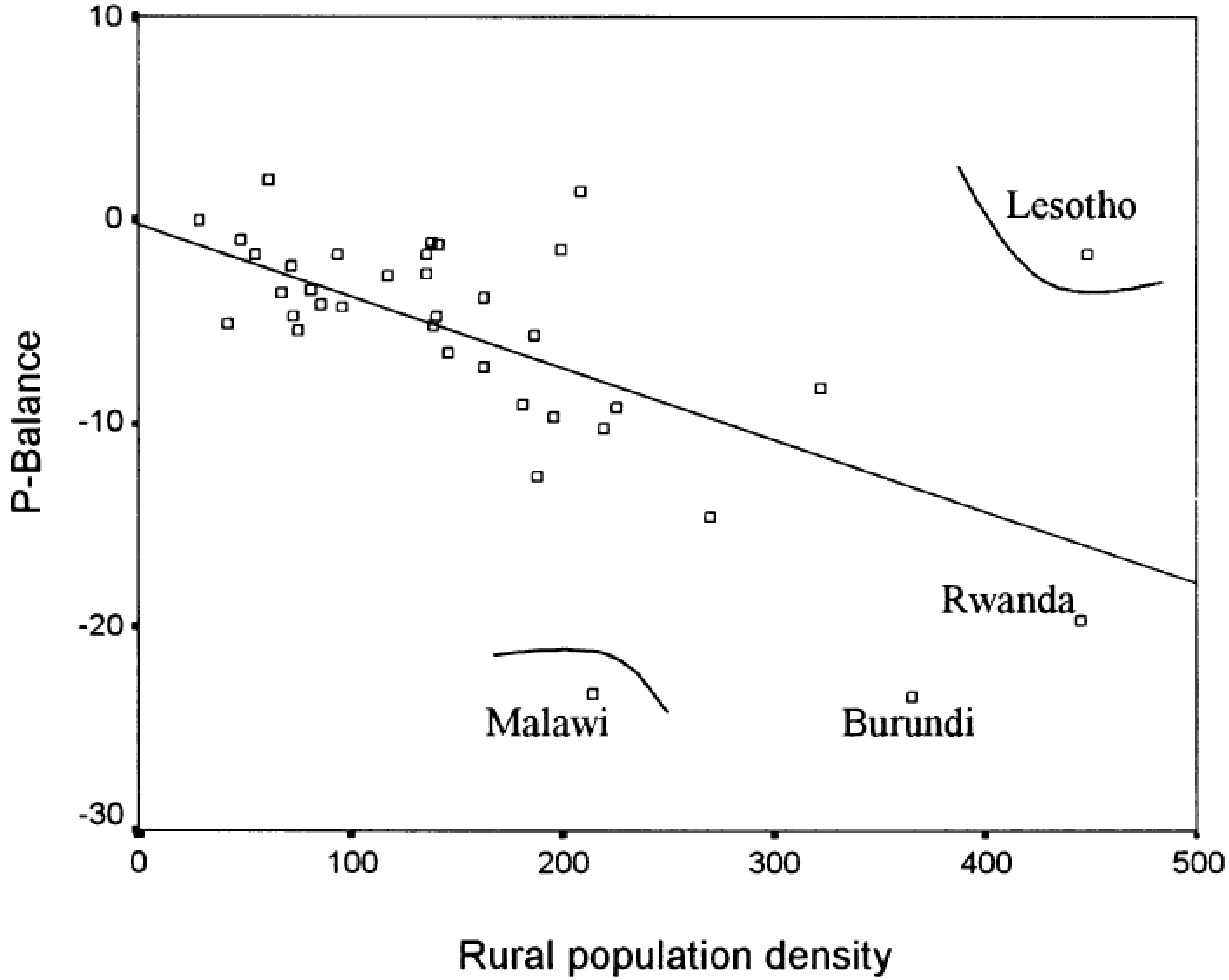
Country	Annual Program Cost (USD million)	% of Ag Budget
Malawi	152 to 275	47 to 71%
Tanzania	92 to 135	39 to 46%
Zambia	101 to 135	21 to 40%
Senegal	36 to 42	26 to 31%
Ghana	53 to 112	20 to 31%
Nigeria	108 to 190??	?? (officially 26%)
Kenya	22 to 81	9 to 26%

Objectives:

1. How to move from a situation where ISPs are the cornerstone of agricultural development to a holistic program of sustainable productivity growth?
2. What would such a holistic program look like?
3. How to achieve it?

Five conclusions:

1. Population growth leading to land scarcity → smaller farm sizes for most rural people
2. Fallows slowly being eliminated in areas of high population density
3. Continuous cultivation with limited nutrient recycling → "soil mining"

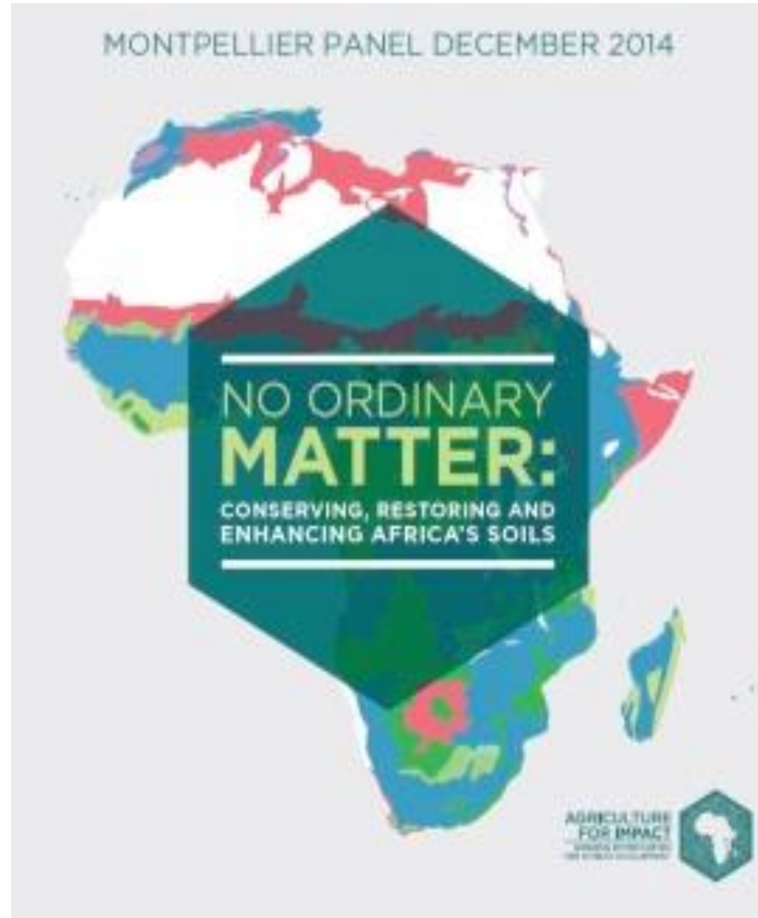


P. Drechsel et al. / Ecological Economics 38 (2001) 251–258

Five conclusions:

1. Population growth leading to land scarcity → smaller farm sizes for most rural people
2. Fallows slowly being eliminated in areas of high population density
3. Continuous cultivation with limited nutrient recycling leading to "soil mining"
4. Soil degradation

- Soil and land degradation a huge concern
  - Major conclusion of Montpellier Panel report
  - Extent of already damaged land:
    - 65% of arable land
    - 30% of grazing land
    - 20% of forests
  - Burden disproportionately carried by smallholders



Five conclusions

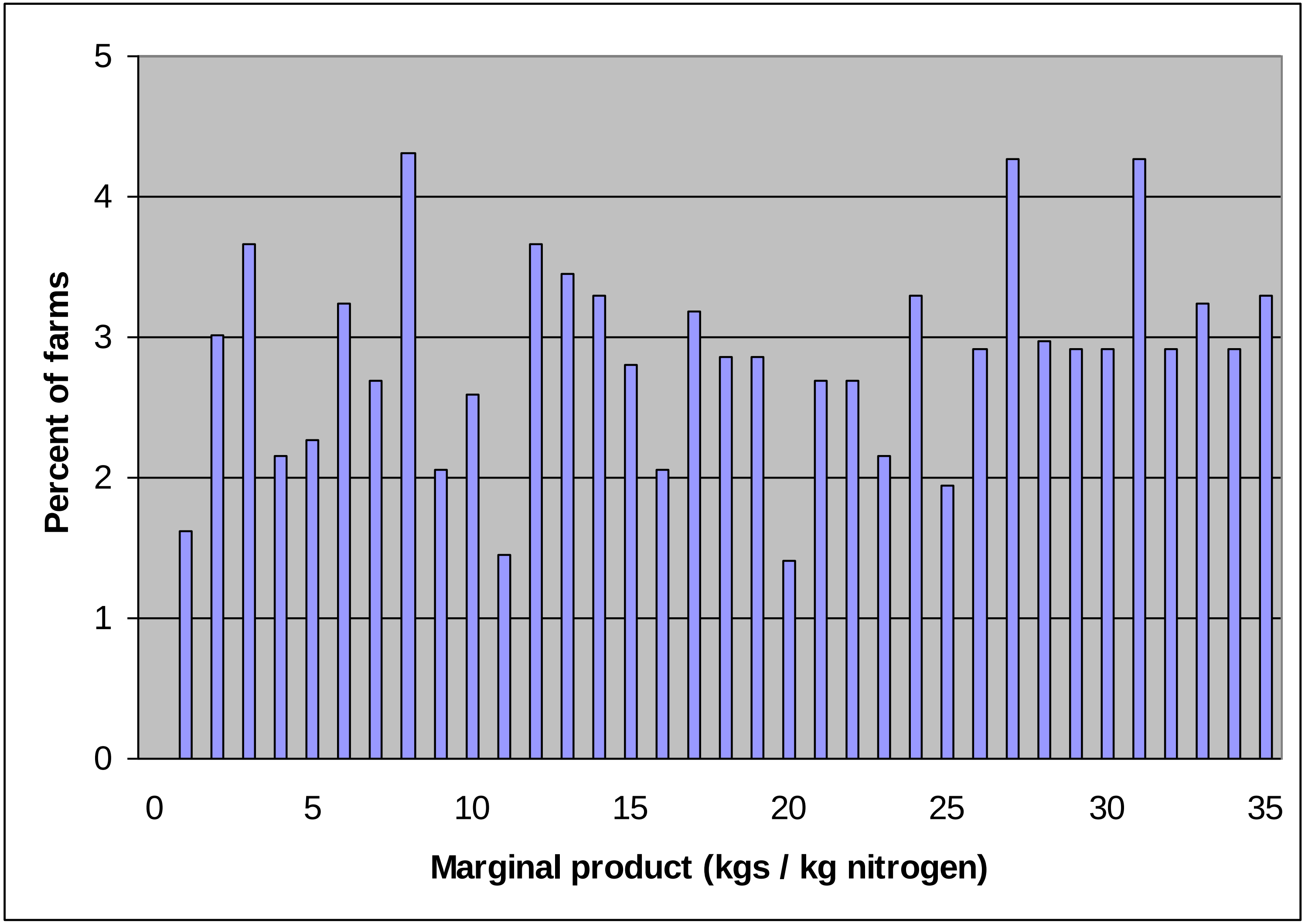
1. Population growth leading to land scarcity → smaller farm sizes for most rural people
2. Fallows slowly being eliminated in areas of high population density
3. Continuous cultivation with limited nutrient recycling → "soil mining"
4. Soil degradation
5. Evidence of low and declining crop response rates to inorganic fertilizer application

Review of maize-fertilizer response rates on farmer-managed fields

Study	country	Agronomic response rate (kgs maize per kg N)
Morris et al (2007)	W/E/S Africa	10-14
Sheahan et al (2013)	Kenya	14-21
Marenya and Barrett (2009)	Kenya	17.6
Liverpool-Tasie (2015)	Nigeria	8.0
Burke (2012)	Zambia	9.6
Snapp et al (2013)	Malawi	7.1 to 11.0
Holden and Lunduka (2011)	Malawi	11.3
Pan and Christiaensen (2012)	Tanzania	8.5 to 25.5
Minten et al (2013)	Ethiopia	11.7

Highly variable crop response rates – even among farmers in same areas in same seasons

Variation in farmers' efficiency of fertilizer use on maize, Agroecological Zone IIa, Zambia



Note: Zone IIa is a relatively high-potential zone suitable for intensive maize production; mean national NUE = 9.6 kgs maize per kg nitrogen (Burke, 2012).

African farming systems in densely settled areas commonly display 4 forms of unsustainable land intensification

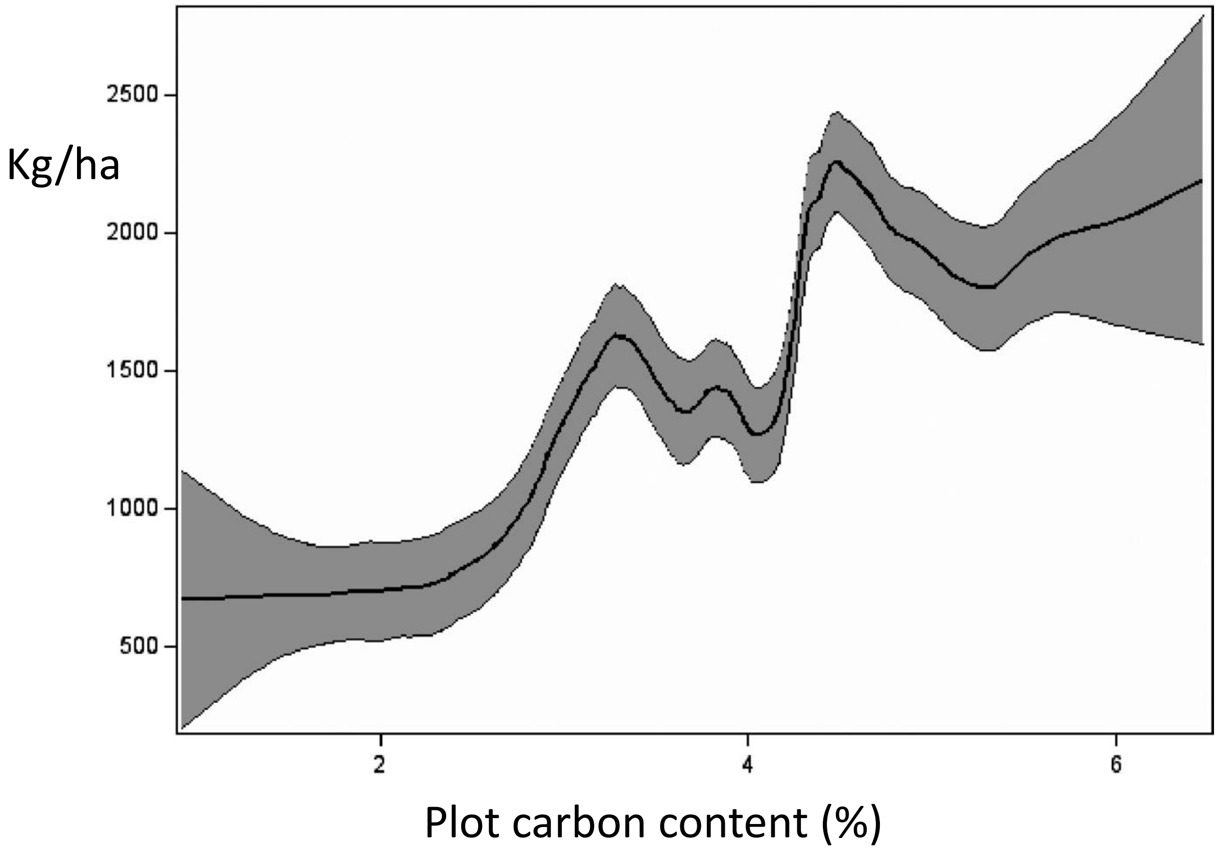
1. Soil mining
2. Inadequate recycling of organic matter → loss of SOC
3. Demise of fallows
4. Limited profitability of using fertilizer at full market prices

Factors depressing NUE of inorganic fertilizer use:

1. Low soil organic matter
   - significant decline in SOM over past 20 years in Malawi (Mpeketula and Snapp)

Fertilizer response rates in degraded areas

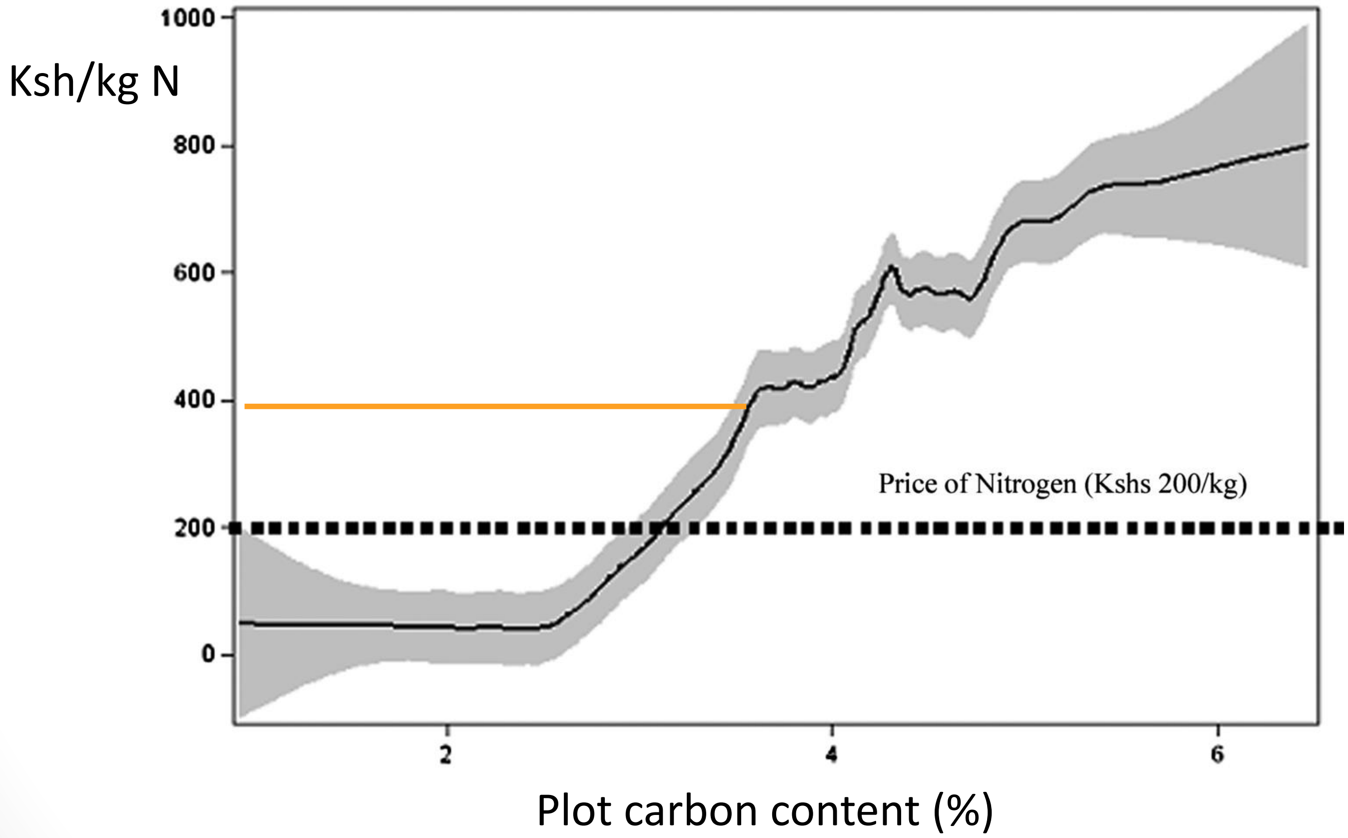
Maize yields as a function of plot soil carbon content



Source: Marenya & Barrett 2009

Fertilizer response rates in degraded areas

Estimated marginal value product of nitrogen fertilizer conditional on plot soil carbon content



Source: Marenya & Barrett 2009

Factors depressing NUE of inorganic fertilizer use:

1. Low soil organic matter
   - significant decline in SOM over past 20 years in Malawi (Mpeketula and Snapp)
2. Acidification

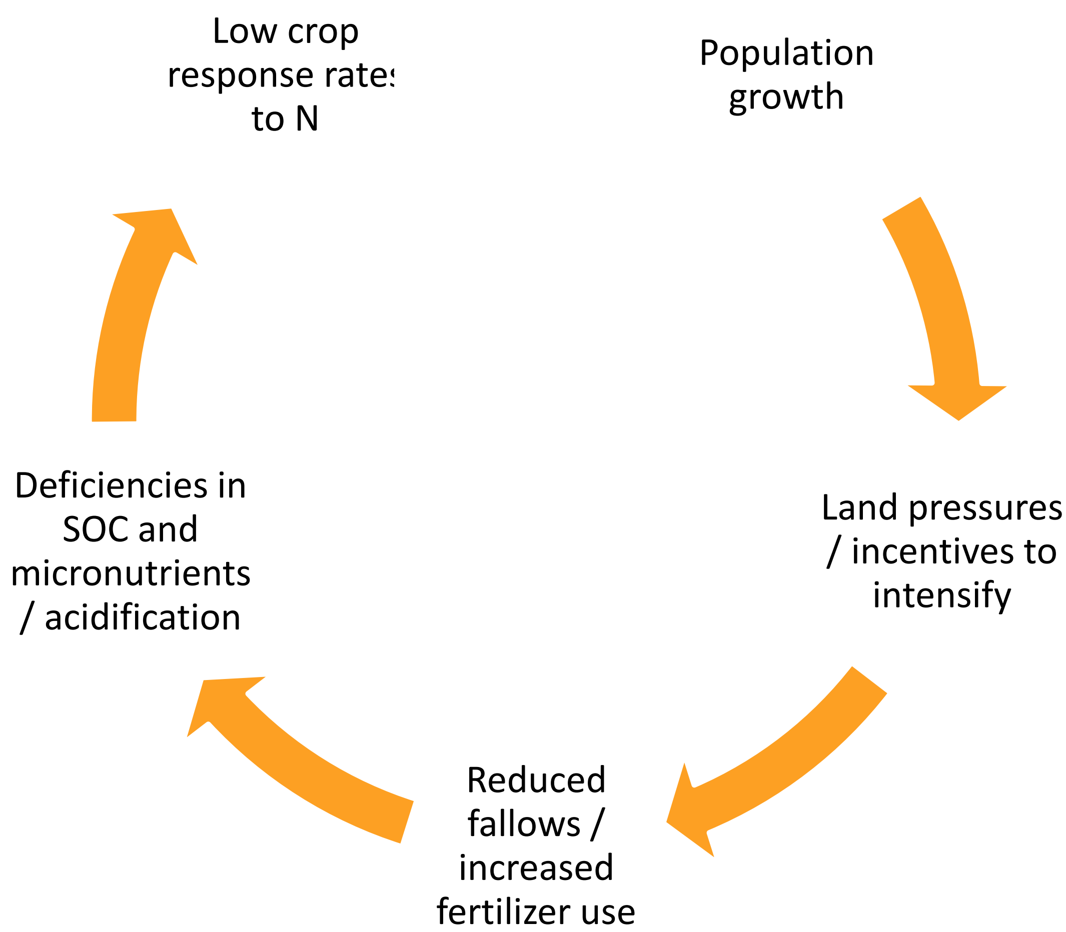

From Larson and Oldham,
Mississippi State University Extension Service, 2008.
4.3
5.3
Source: Burke, 2012

Photo courtesy of Dingi Banda,
Lusaka Province, Zambia

Factors depressing NUE of inorganic fertilizer use:

1. Low soil organic matter
    - significant decline in SOM over past 20 years in Malawi (Mpeketula and Snapp)
2. Acidification
3. Micro-nutrient deficiencies

Everyone agrees that inorganic fertilizer use must go up – why isn't it happening?



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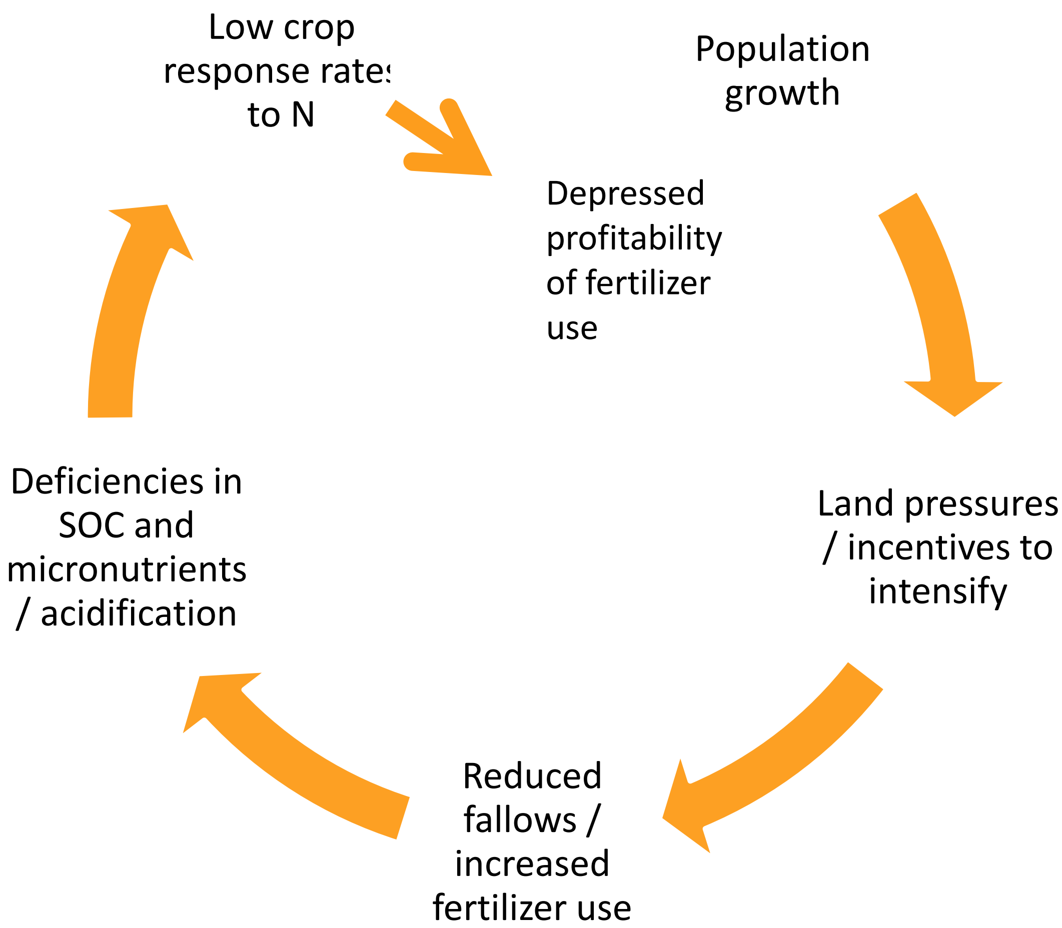
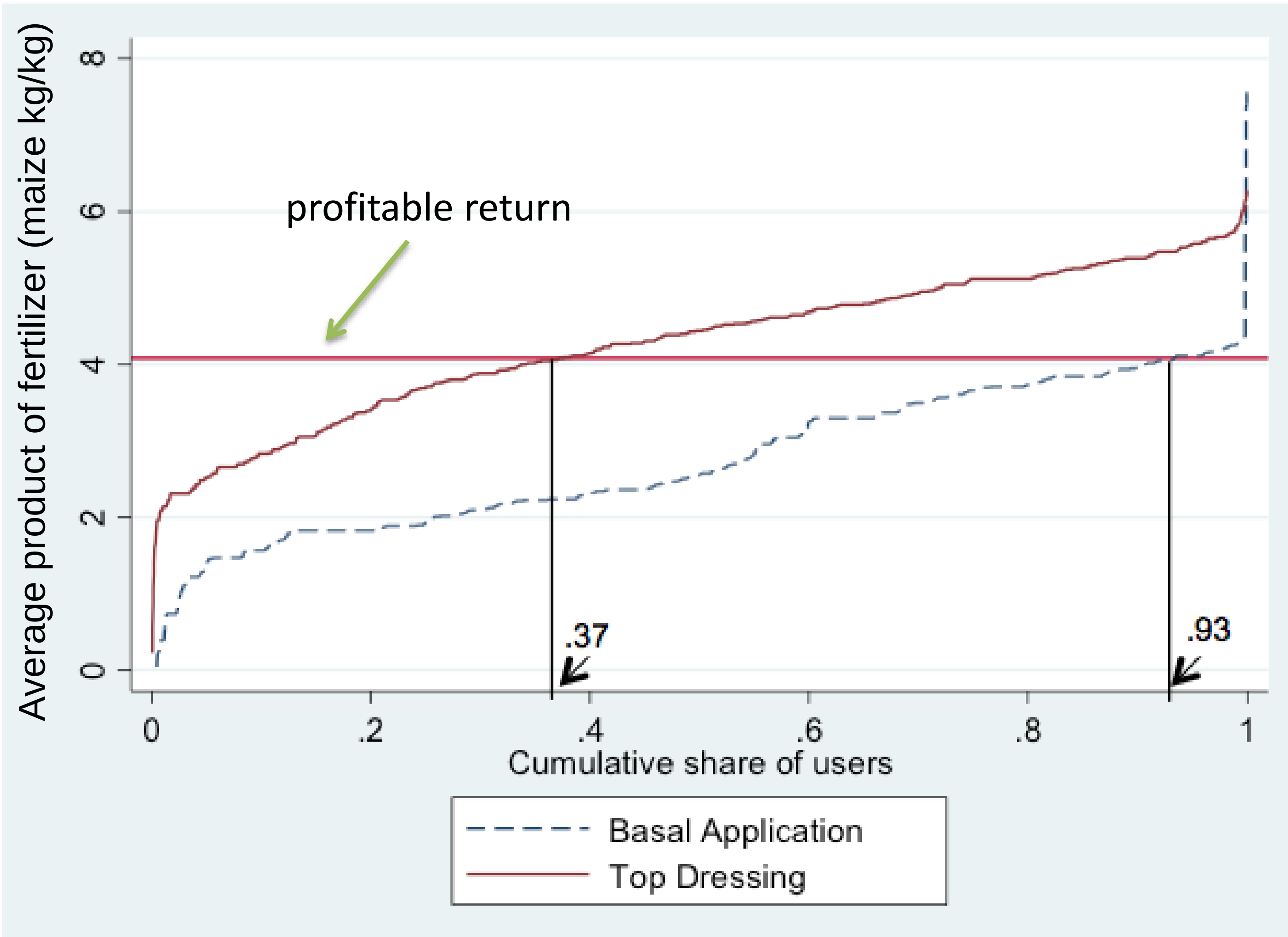


Cumulative distribution of average product of fertilizer used in Zambia (2004,2008)



Source: Burke, 2012

Factors affecting N use efficiency

1. Soil organic carbon
2. Acidification (pH) – mainly affects basal
3. Micronutrients
4. Soil moisture – N response on irrigated > rainfed fields
5. Timing of fertilizer application
6. Timely and sufficient weeding
7. Rotation of crops on a given plot
8. Contours / ridging to prevent erosion on sloped fields

- → Fixation with N
- → ISPs need to be part of a more holistic approach so that N can get sufficiently high crop response

Focus on making inputs profitable → effective demand

Profitable use (main drivers):

- output price
- input prices
- crop response rates

Elements of a holistic strategy:

1. R&D (national ag research systems)
2. Extension programs / soil testing
3. Programs to help farmers restore soil quality
4. Conservation agricultural practices
5. Physical infrastructure
6. Reducing costs in input supply chains
7. More appropriate fertilizer use recommendations

Oft-asked policy question:

- Given that ISPs will continue, what concrete guidance can be identified to improve their effectiveness?
- We identify 3 proposals:
  1. Holistic approach that regards ISP as one component of an integrated sustainable intensification campaign
  2. Target poor farmers to achieve more equitable development impacts
  3. Redouble political will to reduce corruption

Proposal 1: Raise public investment in agronomic research and extension programs to enable farmers to use fertilizer more efficiently

Proposal 2: Reconsider targeting guidelines to achieve more equitable development impacts

FISP fertiliser received (2010/11 crop season) and expected maize sales, 2011, by farm size category

Total area cultivated (maize + all other crops)	Number of farms	% of farms	% of farmers receiving FISP fertilizer	kg of FISP fertilizer received per farm household	% of farmers expecting to sell maize	Expected maize sales (kg/farm household)
	(A)	(B)	(C)	(D)	(E)	(F)
0-0.99 ha	616,867	41.9%				
1-1.99 ha	489,937	33.3%				
2-4.99 ha	315,459	21.4%				
5-9.99 ha	42,332	2.9%				
10-20 ha	6,626	0.5%				
Total	1,471,221	100%				

Source: MACO/CSO Crop Forecast Survey, 2010/11

FISP fertiliser received (2010/11 crop season) and expected maize sales, 2011, by farm size category

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2-4.99 ha	315,459	21.4%	45.1%			
5-9.99 ha	42,332	2.9%	58.5%			
10-20 ha	6,626	0.5%	52.6%			
Total	1,471,221	100%	28.6%			

Source: MACO/CSO Crop Forecast Survey, 2010/11

FISP fertiliser received (2010/11 crop season) and expected maize sales, 2011, by farm size category

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5-9.99 ha	42,332	2.9%	58.5%	309.7		
10-20 ha	6,626	0.5%	52.6%	345.6		
Total	1,471,221	100%	28.6%	77.1		

Source: MACO/CSO Crop Forecast Survey, 2010/11

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Total	1,471,221	100%	28.6%	77.1		

Source: MACO/CSO Crop Forecast Survey, 2010/11

Proposal 3: greater political will for ensuring that the subsidies go to the intended beneficiaries

- Currently 1/3 of state resources for ISPs are diverted (Malawi and Zambia), more in other cases (pre-2011 Nigeria)

Ranking of Alternative Investments: Meta-Study Evidence from Asia and Africa

	The Economist	IFPRI study
Policies		
Infrastructure investment		
Agricultural R&D		
Agricultural extension services		
Credit subsidies		
Fertilizer subsidies		
Irrigation		

Ranking with respect to ***agricultural growth:*** Evidence from Asia

	The Economist	IFPRI
Policies	1	
Infrastructure investment	3	1
Agricultural R&D	2	2
Agricultural extension services	5	
Credit subsidies	7	3
Fertilizer subsidies	6	4
Irrigation	4	5

Ranking with respect to ***poverty reduction:*** Evidence from Asia

	The Economist	IFPRI
Policies	1	
Infrastructure investment	2	1
Agricultural R&D	3	2
Agricultural extension services	4	3
Credit subsidies	7	4
Fertilizer subsidies	5	6
Irrigation	5	5

Conclusions

1. ISPs are a powerful tool to quickly raise food production….
2. But if they account for too large a share of agricultural spending, they can crowd out other public investments required for sustainable development
3. Spending a large share of the ag budget on ISPs may *not be the most effective way* to promote the welfare of it citizens, but it is a *highly demonstrable way* to do so.

Conclusions

4. ISPs would be more effective if adequate resources were allocated to complementary public investments
5. More balanced public expenditure patterns could more effectively promote national policy objectives
6. There are concrete steps for improving ISP effectiveness – related to
   - governance and political commitment
   - More holistic approach to sustainable intensification

Thank you

Survey data vs. researcher-managed trials

Reasons why researcher-managed trials tend to show 2-3 times higher NUE than in farmer-managed survey data:

1. trials often non-randomly select farmers known to extension agents, often “master farmer” types
2. Trials often instruct farmers to follow strict protocols that most farmers cannot adhere to on their own plots
3. “observer effect”
4. Trials often entail throwing out observations in which the plot incurred damage due to insects, disease, monkeys, flooding, etc

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Contact Us: agrilinks@agrilinks.org

OR

Julie MacCartee, USAID/BFS jmaccartee@usaid.gov

Upcoming Events

April 15th: Agrilinks Twitter Chat

April 23rd: Joint Agrilinks + Microlinks Seminar

Agrilinks and the AG Sector Council Seminar Series are products of the USAID Bureau for Food Security under the Feed the Future Knowledge-Driven Agricultural Development (KDAD) project.

Additional Information

Regression Approach

- Reduced form (ITT):

$$y_{iv} = \alpha^I + \beta^I Z_{iv} + \theta_v^I + \varepsilon_{iv}^I \qquad (1)$$

- Inverse hyperbolic sine transformation:

$$sinh^{-1}(y) = ln(y + (y^2 + 1)^{0.5})$$

- Will also look at average treatment on the treated:

$$y_{iv} = \alpha^T + \beta^T \hat{F}_{iv} + \theta_v^T + \varepsilon_{iv}^T$$

  where $\hat{F}$ is use of the coupon instrumented with Z_{iv}
- These ATT estimates are the policy relevant impacts

Impacts on Fertilizer Use

	Dependent variat	Fertilizer on maize (kg)	Fertilizer on maize (kg/ha)	Fertilizer on other crops (kg)	Fertilizer on all crops (kg)	Value of fertilizer on all crops (MZN)
***Panel B* : Outcomes in levels**						
2011 season	Treatment	17.16***	12.28*	3.294	22.72**	636.0**
		[5.12]	[6.94]	[6.492]	[8.897]	[251.0]
	N	510	505	504	503	503
	Mean, cont. grp.	22.32	15.41	29.08	51.85	1456
2012 season	Treatment	6.37*	13.36	14.46**	17.98**	505.3**
		[3.40]	[9.03]	[6.858]	[7.539]	[211.6]
	N	457	449	456	452	452
	Mean, cont. grp.	18.83	10.68	18.61	39.86	1116
2013 season	Treatment	7.50	5.76*	3.179	12.84*	358.3*
		[5.48]	[3.23]	[6.203]	[6.698]	[187.7]
	N	473	471	472	470	470
	Mean, cont. grp.	17.90	11.19	26.76	45.01	1259
Average, 2012-2013 seasons	Treatment	8.65*	11.82*	9.060	19.13***	534.5***
		[4.34]	[6.21]	[5.531]	[6.385]	[179.6]
	N	495	493	496	495	495
	Mean, cont. grp.	18.48	10.65	21.78	41.31	1156

IHST Direct Impacts on Fertilizer Use

	Dependent variab	Fertilizer on maize (kg)	Fertilizer on maize (kg/ha)	Fertilizer on other crops (kg)	Fertilizer on all crops (kg)	Value of fertilizer on a crops (MZN
***Panel A* : Outcomes in inverse hyperbolic sine transformation (IHST)**						
2011 season	Treatment	0.76***	0.67***	0.040	0.61***	0.98**
		[0.19]	[0.20]	[0.15]	[0.22]	[0.36]
	N					
	Mean, cont. grp.	510	505	504	503	503
2012 season	Treatment	0.32**	0.31**	0.38**	0.46***	0.70***
		[0.13]	[0.12]	[0.15]	[0.15]	[0.24]
	N	457	449	456	452	452
	Mean, cont. grp.	0.71	0.59	0.90	1.37	2.48
2013 season	Treatment	0.31**	0.26**	0.18	0.28	0.42
		[0.13]	[0.11]	[0.15]	[0.17]	[0.29]
	N	473	471	472	470	470
	Mean, cont. grp.	0.70	0.61	1.13	1.44	2.55
Average, 2012-2013 seasons	Treatment	0.36***	0.34***	0.32**	0.47***	0.72***
		[0.12]	[0.10]	[0.12]	[0.14]	[0.24]
	N	495	493	496	495	495
	Mean, cont. grp.	0.70	0.60	0.98	1.37	2.44

Impacts on Agricultural Production
IHST estimates

	Dependent variable:	Maize production (kg)	Maize yield (kg/ha)	Other crop production (MZN)	Production, al crops (MZN)
Panel A : Outcomes in inverse hyperbolic sine transformation (IHST)					
2011 season	Treatment	0.050	0.23**	-0.26	0.0037
		[0.074]	[0.086]	[0.28]	[0.093]
	N	460	457	470	460
	Mean, cont. grp.	7.14	6.29	5.51	9.11
2012 season	Treatment	0.087	0.25**	0.81***	0.14
		[0.096]	[0.12]	[0.30]	[0.097]
	N	442	436	462	442
	Mean, cont. grp.	7.17	6.37	6.09	9.19
2013 season	Treatment	0.13	0.14*	0.45**	0.19**
		[0.081]	[0.079]	[0.22]	[0.074]
	N	468	466	475	468
	Mean, cont. grp.	7.19	6.38	6.71	9.22
Average, 2012-2013 seasons	Treatment	0.11	0.19**	0.62***	0.16**
		[0.071]	[0.077]	[0.19]	[0.069]
	N	492	491	496	492
	Mean, cont. grp.	7.17	6.37	6.40	9.21

Impacts of Consumption, Savings & Assets

	Dependent variable:	Per capita daily consumption (MZN)	Total savings (MZN)	Durable goods (MZN)	Livestock (MZN)	Food stocks (MZN)	Total asse and saving (MZN)
Panel A*: *Outcomes in inverse hyperbolic sine transformation (IHST)							
2011 season	Treatment	0.0072	0.20	0.33	-0.020	0.10	0.12
		[0.042]	[0.25]	[0.25]	[0.23]	[0.20]	[0.13]
	N	469	470	470	470	470	470
	Mean, cont. grp.	4.34	6.25	8.00	8.99	7.61	10.3
2012 season	Treatment	0.14***	0.66**	0.10	0.44	0.34	0.17
		[0.036]	[0.27]	[0.19]	[0.27]	[0.25]	[0.12]
	N	462	462	462	462	462	462
	Mean, cont. grp.	4.24	5.14	8.34	8.73	7.46	10.3
2013 season	Treatment	0.050	0.43	0.10	0.70*	0.22	0.26**
		[0.053]	[0.27]	[0.23]	[0.35]	[0.14]	[0.12]
	N	475	475	475	475	475	475
	Mean, cont. grp.	4.26	6.42	8.28	8.48	8.18	
Average, 2012-2013 seasons	Treatment	0.095**	0.51**	0.12	0.60**	0.30*	0.22*
		[0.036]	[0.20]	[0.19]	[0.29]	[0.15]	[0.11]
	N	496	496	496	496	496	496
	Mean, cont. grp.	4.26	5.78	8.30	8.59	7.81	10.4

Learning from Others

Network size & composition

A. Size of social network

	Count	Share
0	154	30.0%
1	83	16.1%
2	65	12.6%
3	38	7.4%
4	44	8.6%
5	26	5.1%
6	18	3.5%
7	16	3.1%
8	17	3.3%
9	10	1.9%
10	11	2.1%
11	10	1.9%
12	6	1.2%
13 or more	16	3.1%
Total	514	100.0%
Addendum:		
5 or more	130	25.3%

B. Number of voucher winners in social network

	Count	Share
0	226	44.0%
1	94	18.3%
2	77	15.0%
3	42	8.2%
4	30	5.8%
5	17	3.3%
6	12	2.3%
7	5	1.0%
8	4	0.8%
9	1	0.2%
10	4	0.8%
11	0	0.0%
12	0	0.0%
13 or more	2	0.4%
Total	514	100.0%
Addendum:		
5 or more	45	8.8%

Note: Social network size defined as number of study participants in the same village with whom respondent talked about agriculture in the previous season (2009-2010) at "moderately" or "a lot" (as opposed to "a bit" or not at all). Respondents asked on average about social network links to 11.5 other individuals in their village.

Learning from Others

- Estimate impacts of voucher winning in the social network on fertilizer use (Y_{iv}) for study participant i in village v, via the following modified version of the standard ITT regression equation:

$$Y_{iv} = \alpha + \beta Z_{iv} + \sum_{k=1}^{5+} \gamma_k W_{iv}^k + \sum_{k=1}^{5+} \lambda_k S_{iv}^k + \theta_v + \varepsilon_{iv}, \quad (2)$$

  where the indicator variables W_{iv}^k for the respondent having one, two, three, four, or five or more voucher winners in his or her social network; S_{iv}^k is the same for total social network size
- This specification assumes it is the total number of messages that you receive which matters (consistent with a Bayesian way of thinking about learning)
- Logic here is to control for "gregariousness" as number of treated members will spuriously be correlated with number of people you know (which may correlate with ...)

Learning from Others

ITT impacts of network on fertilizer use

Dependent variable:		Fertilizer used (inverse hyperbolic sine transformation)			
		2011 season	*2012 season*	*2013 season*	*Average, 2012-13 seasons*
Panel A* : *Fertilizer on maize					
Treatment		0.79***	0.34**	0.33**	0.38***
		[0.21]	[0.14]	[0.14]	[0.12]
1 voucher winner	(γ_1)	-0.54*	0.31	0.38	0.31
in social network		[0.31]	[0.30]	[0.23]	[0.26]
2 voucher winners	(γ_2)	0.0067	1.12***	0.80**	0.97***
in social network		[0.40]	[0.35]	[0.36]	[0.34]
3 voucher winners	(γ_3)	-0.52	1.11**	0.86*	1.00**
in social network		[0.62]	[0.45]	[0.47]	[0.44]
4 voucher winners	(γ_4)	-0.046	1.42**	0.45	0.93
in social network		[0.71]	[0.67]	[0.59]	[0.56]
5 or more voucher winners	(γ_{5+})	-0.0094	1.36**	1.03**	1.22**
in social network		[0.55]	[0.52]	[0.48]	[0.49]
N		510	457	473	495
Mean, cont. grp.		0.95	0.71	0.70	0.70
P-val. of F-test: joint signif of all γ_k coefficients		0.13	0.07	0.32	0.11

IV Estimates of Returns to Fertilizer

		4A REGRESSIONS IN LEVEL		4.B INVERSE HYPERBOLIC SINE TRANSFORMATION (IHST)	
		4A.1	4A.2	4A.3	4A.4
		Maize Production (kg)	Yield (kg/ha)	Maize Production (kg)	Yield (kg/ha)
2011	Fertilizer (kg)	11.8		0.07	
		[11.8]		[0.12]	
	Fertilizer (kg/ha)		14.2*		0.33**
			[8.1]		[0.15]
	Observations	450	447	450	447
2012	Fertilizer (kg)	30.3		0.30	
		[39.5]		[0.32]	
	Fertilizer (kg/ha)		21.3*		0.85*
			[12.8]		[0.48]
	Observations	434	429	434	429
2013	Fertilizer (kg)	58.8		0.41	
		[45.1]		[0.30]	
	Fertilizer (kg/ha)		28.4		0.51
			[22.3]		[0.40]
	Observations	462	460	462	460
Avg 2012-2013	Fertilizer (kg)	36.1		0.31	
		[24.5]		[0.21]	
	Fertilizer (kg/ha)		21.1**		0.57**
			[9.4]		[0.27]