Maize marketing boards and sustainable intensification:
Panel survey evidence from Kenya

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Outline

- Motivation
- Approach overview
- Data
- Price expectations
- SI/SFM regression
- Early results
- Questions

SI/SFM

- **Sustainable intensification (SI)**: “a process or system where yields are increased without adverse environmental impact and without the cultivation of more land” (Pretty & Bharucha 2014, p. 1578; see also Royal Society 2009)

- **Soil fertility management (SFM)**: inputs and management practices to enhance soil fertility

- This study: SFM practices with the potential to contribute to SI of maize production in smallholder systems

Motivation: The problem

- The population of sub-Saharan Africa (SSA) is increasing faster than agricultural productivity growth (van Ittersum et al. 2016)
  - Kenya is no exception to this problem
  - Net importer of grain as a result
- Soil fertility depletion is a major cause of low agricultural productivity (Sanchez et al. 1997, others)
  - 3.3% of agricultural GDP in SSA is lost annually because of soil and nutrient loss (Drechsel and Gyiele 1999)
- Given soil fertility challenges, how can governments promote SI
  - how can farmers be supported to adopt SFM

Motivation: Possible solution in SI/SFM

- SFM practices have the potential to reverse the damage
  - Examples: Intercropping maize and legumes, chemical fertilizer, organic fertilizer – alone and combined
- SFM can increase soil carbon content (SCC) (Liebman and Dyck 1993; Snapp et al. 2010)
  - In doing so it also increases the availability of nutrients within the soil as well as those that are applied to the soil in the form of organic or inorganic fertilizer (Marenya & Barrett 2009, Bationo and Mokwunye 1991).
- These practices can increase yields by as much as 50% and also increase HH incomes (Lee 2005, Manda 2016, others)

Motivation: Where marketing boards fit in

- Previous research:
  - Marketing board activities affect maize prices and farmers' maize price expectations in Kenya and Zambia (Jayne, Myers, & Nyoro 2008; Mason, Jayne, & Myers 2015)
  - Increase in expected maize price associated with increases in maize production (Mather and Jayne 2011; Mason, Jayne, & Myers 2015)

- ➔ Marketing boards (including the NCPB in Kenya) may also influence SFM adoption decisions

What are Marketing Boards?

- Quasi governmental organizations that fulfil a specific commodity policy goal
  - Goals are typically to increase prices for farmers and subsidize consumers
    - This is to address the food price dilemma (Timmer et al. 1983)
- Multiple marketing boards operate in Sub-Saharan Africa (SSA) and throughout Asia

Current knowledge gaps and hypothesis

- Though research has been conducted on the NCPB effects on cropping patterns and individual practices, no research has been conducted on SI/SFM adoption
- The effects of marketing boards on the adoption of SFM is unclear
  - Traditionally marketing boards increase the price of maize, which could incentivize farmers to increase production through intensification or extensification
  - Farmers may also act differently and try to maximize the profits from their soil over time choosing not to maximize profits in any individual year, but maximize the stream of income into the future
- We aim to address the question of how the NCPB in particular influences farmers' decision to adopt SFM, which will contribute to our understanding of how output market policies affect adoption of SFM
- In addition to this, the role that prices have played in the adoption decision has been left out of almost all of the research conducted so far on SI adoption

Kenya's maize marketing board: The National Cereals and Produce Board (NCPB)

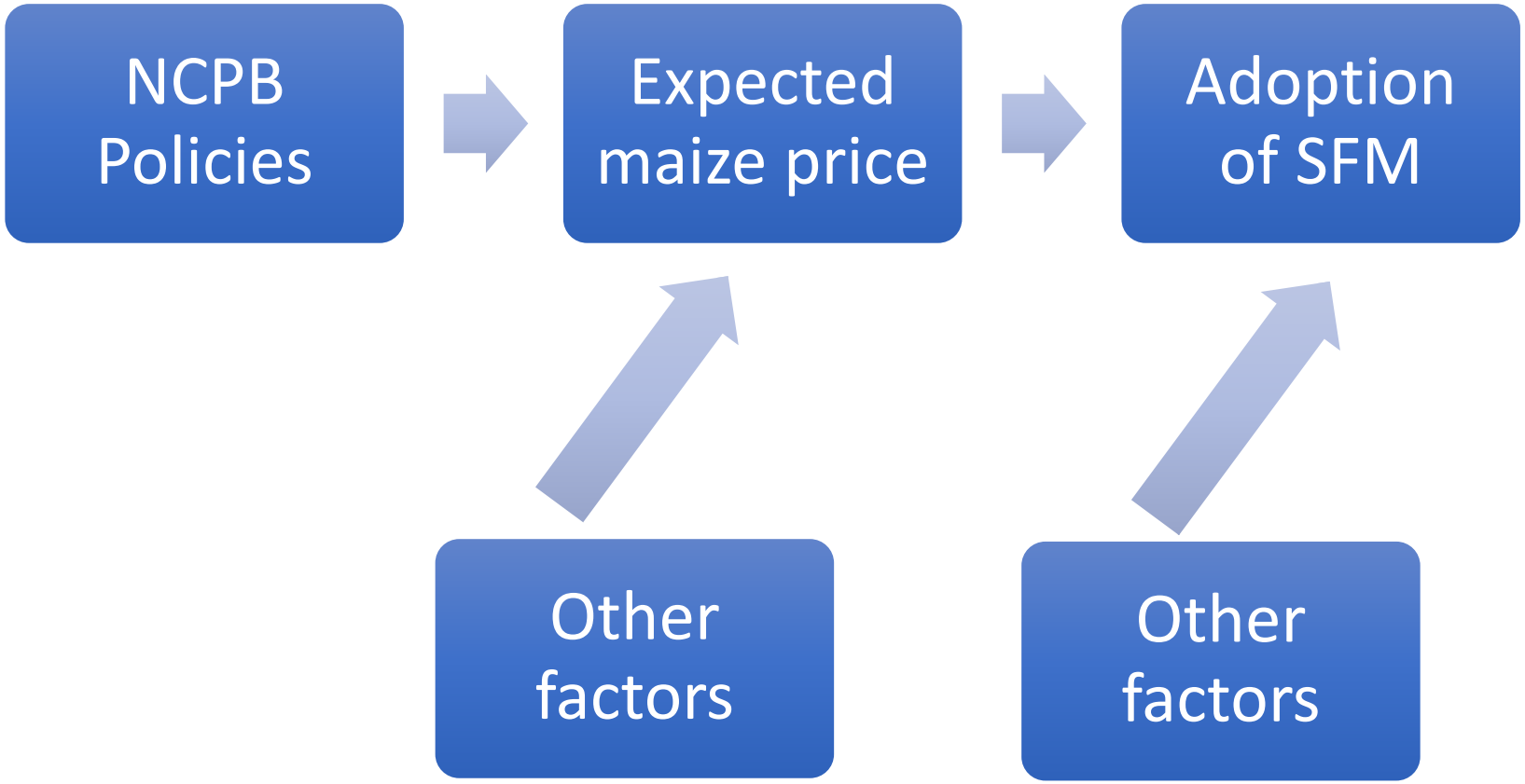
- Primarily purchases maize from traders and large scale farmers at one price across all of Kenya. NCPB purchase price is announced after planting every year.
  - Has some responsibilities as a strategic grain reserve (SGR)
  - Holds stocks of maize dedicated to famine relief
- Purchases occur at depots throughout the country
  - Sellers deliver their maize to depots, where it is weighed, bagged, and accepted.
  - Historically there is some delay in payment for the seller

NCPB Activity

Year	Estimated National Maize Production (000 MT)	NCPB Purchases (000 MT)	NCPB Purchases as percentage of national production	NCPB Sales (000 MT)
1995/96	2699	100.8	3.7%	111.3
1996/97	2160	62.8	2.9%	54.3
1997/98	2214	151.5	6.8%	14.6
1998/99	2400	34.9	1.5%	123.3
1999/00	2322	177.2	7.6%	145.1
2000/01	2160	311.5	14.4%	74.1
2001/02	2776	257.7	9.3%	23.7
2002/03	2441	89.1	3.7%	196.4
2003/04	2714	162.0	6.0%	136.7
2004/05	2459	314.1	12.8%	144.0
2005/06	**2918**	**135.3**	**4.6%**	**375.6**
2006/07	**3248**	**407.2**	**12.5%**	**97.6**
2007/08	**2931**	**32.0**	**1.1%**	**219.6**
2008/09	**2367**	**78.3**	**3.3%**	**308.6**
2009/10	2443			

Maize purchasing

Approach


NCPB Policies
Expected maize price
Adoption of SFM
Other factors
Other factors

Approach: SI/SFM bins at the plot level

Case	Inorganic fertilizer?	Organic fertilizer?	Maize-legume intercrop?	SI category	SI ranking
1	No	No	No	None	0
2	Yes	No	No	Intensification	1
3	No	Yes	No	Sustainable	2
4	No	No	Yes	Sustainable	2
5	No	Yes	Yes	Strong Sustainable	3
6	Yes	Yes	No	SI	4
7	Yes	No	Yes	SI	4
8	Yes	Yes	Yes	SI	4

- Inorganic fertilizer can add nutrients to the soil that are vital to maize growth

- Organic fertilizer does the same, but also adds organic matter to the soil

- Legumes fix nitrogen, provide additional nutritious crops for household consumption, and also provide a good source for crop residues, which can be incorporated into the soil adding to SOM over time

What does intercropping look like?

Approach

- Two stages:
  - Both stages utilize a Correlated Random Effects (CRE) model to remove time constant unobserved heterogeneity
  - 1) Regress the observed sales price of maize on information that a household had available to it at planting time.
    - Then using this regression, predict sale prices for all households (including the households that never sold maize) (Mason et al. 2015, Mather and Jayne 2011)
    - NCPB related variables: Purchases and sales from past years at divisional level, household adjusted purchase price (adjusted using transportation costs per Kg/Km and distance to NCPB depot)
  - 2) Use this expected maize price to determine the effects of the NCPB on the adoption of SFM through a regression of the particular practice.
    - Probit of the individual practices
    - Multinomial logit for the regression of the bins (1 through 8, however some are collapsed due to lack of observations on certain cases)
    - Ordered logit regression for SI ranking(sustainable, intensifying, strong sustainable, etc.)

Data

- Tegemeo Agricultural Policy Research Analysis (TAPRA) household level panel data: 1,540 households in 1997, 1,243 remaining in 2010 survey.
  - Collected in 1997, 2000, 2004, 2007, and 2010 (using 2007 & 2010 due to specific variables needed only being collected in these years)
- Market: Wholesale monthly maize prices collected over the survey
- NPCB: Data provided by the NCPB on purchase price, district level purchases, sales, etc.
- Weather: WorldClim data including rain and temperature
- Soil data: Harmonized World Soil. Database V1.2 dataset

Data

Case	Inorganic fertilizer?	Organic fertilizer?	Maize-legume intercrop	SI category	SI ranking	N= Number of maize plots out of 3,387 plots with maize	Percent of plots	Percent per SI ranking
1	No	No	No	None	0	63	1.9%	1.9%
2	Yes	No	No	Intensification	1	208	6.1%	6.1%
3	No	Yes	No	Sustainable	2	48	1.4%	16.8%
4	No	No	Yes	Sustainable	2	470	14.0%	
5	No	Yes	Yes	Sustainable	3	51	1.5%	
6	Yes	Yes	No	SI	4	519	15.3%	49.8%
7	Yes	No	Yes	SI	4	1,169	34.5%	
8	Yes	Yes	Yes	Strong SI	4	859	25.7%	25.3%
Intercropping with Legumes			N=3,017				89.0%	
Use of inorganic fertilizer			N=2,287				80.1%	
Use of organic fertilizer			N=1,477				51.8%	

Data

Case	Inorganic fertilizer?	Organic fertilizer?	Maize-legume intercrop	SI category	SI ranking	N= Number of maize plots out of 8,915 plots with maize	Percent of plots	Percent per SI ranking
1	No	No	No	None	0	248	2.8%	2.8%
2	Yes	No	No	Intensification	1	510	5.7%	5.7%
3	No	Yes	No	Sustainable	2	131	1.5%	21.9%
4	No	No	Yes	Sustainable	2	1,816	20.4%	
5	No	Yes	Yes	**Strong Sustainable**	**3**	**119**	**1.3%**	**1.3%**
6	Yes	Yes	No	SI	4	1,261	14.1%	68.3%
7	Yes	No	Yes	SI	4	3,190	35.8%	
8	Yes	Yes	Yes	SI	4	1,640	18.4%	
Intercropping with Legumes			N=7,907			88.7%		
Use of inorganic fertilizer			N=5,459			61.2%		
Use of organic fertilizer			N=3,151			35.34%		

Data decisions

- TAPRA survey data includes HHs that dropped out of the survey and then came back; I plan on leaving these out as others have done.
- There are 2 districts in the 1997 & 2000 waves that are dropped in 2004. I plan on leaving these out of all of the analysis. In the 2000 wave many HHs are added to these districts and many fall out of survey.

- Any concern with these decisions?

Legumes in intercrops

Legume	Number of intercropped plots	Proportion of intercropped plots (N=3,017)	Proportion of maize plots (N=3,387)
Beans	2,456	81.4%	72.5%
Pigeon pea	161	5.3%	4.8%
Cowpeas	589	19.5%	17.4%
Ground nuts	57	1.9%	1.7%
Soy beans	31	1.0%	0.9%
Green grams	136	4.5%	4.0%

Legumes in intercrops

Legume	Number of intercropped plots	Proportion of intercropped plots (N=7,907)	Proportion of maize plots (N=8,915)
Beans	6,429	81.3%	72.1%
Pigeon pea	358	4.5%	4.0%
Cowpeas	1,405	17.7%	15.8%
Ground nuts	148	1.9%	1.7%
Soy beans	46	0.6%	0.5%
Green grams	289	3.7%	3.24%

Maize price expectation

- $P_{it_h} = \beta_0 + \beta_1 \boldsymbol{NCPB}_{t-1_p} + \beta_2 \boldsymbol{market}_{rt-1_p} + \beta_3 \boldsymbol{HH}_{it-1_p} + \beta_4 \boldsymbol{Weather}_{rt-1_p} + c_i + u_{it}$
  - h subscripts represent information only know after the harvest
  - p subscripts represent information only know at planting
  - i subscript represents HH level variable
  - r subscript represents local level variable
- NCPB Variables of interest:
  - Previous years purchase prices
  - Previous years quantity of purchases at division level
- This results in us being able to generate an expected price for all HHs
- Number of sales observed from 2007 to 2010 at the household level: 1,039 out of 2,518 observed HHs

Maize price expectation results (CRE-POLS)

Explanatory Variables	coefficient	aster	pval
Farmgate NCPB maize price (t-1, real 2010 Ksh/kg)	**0.080**	*	**0.059**
NCPB purchases of maize at divisional level (MT, t-1)	**0.005**	**	**0.044**
Hunger season average wholesale price of maize (real 2010 Ksh/kg)	-1.130	***	0.003
Plentiful season average wholesale price of maize (real 2010 Ksh/kg)	1.257	***	0.003
Village median land rental rate (real 2010 Ksh/acre/year)	0.0003		0.157
=1 if female-headed HH	0.280		0.346
Village level average CAN price per Kg (real 2010 Ksh)	-0.003		0.956
Village level average DAP price per Kg (real 2010 Ksh)	-0.049		0.388
Village median farm wage (real 2010 Ksh/hour)	0.036		0.539
Age of the HH head (years)	0.018		0.591
Education of the HH head (years)	0.004		0.967
Number of prime age adults (age 15 to 59)	0.243	*	0.088
Distance in kms from HH to nearest market place for farm produce	-0.033		0.483
Km to the nearest motorable road	-0.183		0.32
Km to the nearest place to get extension advice	-0.002		0.976
Total landholdings owned as of previous survey (acres)	-0.032	*	0.08
=1 if the HH had stores in the prior survey	-0.392		0.188
=1 if the HH had a cart in the prior survey	-0.596		0.2
=1 if the HH had a bike in the prior survey	0.379		0.146
=1 if the HH had a motorcycle in the prior survey	0.709		0.671
=1 if the HH had a car in the prior survey	-1.245		0.182
=1 if the HH had a truck in the prior survey	-2.193	*	0.099
=1 if the HH had a radio in the prior survey	-0.665		0.156
=1 if the HH had a tv in the prior survey	-0.266		0.344
assets in previous survey (real 2010 1000s*Ksh)	-0.00036		0.334
Main season rain (mm) t-1	-0.007	**	0.023
Fraction of 20 day periods with <40mm rain for main season t-1	-7.489	***	0
Year is 2010 (=1)	1.114		0.152

- Dependent variable is the observed sale price per Kg after planting.
  - Determinants are lagged from previous survey or previous year
- Selection bias/incidental truncation in sellers of maize suggests no bias

Maize price expectation results

VARIABLES	1 Maize price expectation	2 aster	3 pval	4 Bootstrap	5 aster	6 pval
Farmgate NCPB maize price (t-1, real 2010 Ksh/kg)	**0.080**	*	**0.059**	**0.080**	**	**0.047**
NCPB purchases of maize at divisional level (MT, t-1)	**0.005**	**	**0.044**	**0.005**	**	**0.035**
Hunger season average wholesale price of maize (real 2010 Ksh/kg)	-1.130	***	0.003	-1.130	***	0.001
Plentiful season average wholesale price of maize (real 2010 Ksh/kg)	1.257	***	0.003	1.257	***	0.001
Village median land rental rate (real 2010 Ksh/acre/year)	0.0003		0.157	0.0003		0.147
=1 if female-headed HH	0.280		0.346	0.280		0.354
Village level average CAN price per Kg (real 2010 Ksh)	-0.003		0.956	-0.003		0.955
Village level average DAP price per Kg (real 2010 Ksh)	-0.049		0.388	-0.049		0.415
Village median farm wage (real 2010 Ksh/hour)	0.036		0.539	0.036		0.515
Age of the HH head (years)	0.018		0.591	0.018		0.616
Education of the HH head (years)	0.004		0.967	0.004		0.966
Number of prime age adults (age 15 to 59)	0.243	*	0.088	0.243	*	0.077
Distance in kms from HH to nearest market place for farm produce	-0.033		0.483	-0.033		0.499
Km to the nearest motorable road	-0.183		0.32	-0.183		0.334
Km to the nearest place to get extension advice	-0.002		0.976	-0.002		0.978
Total landholdings owned as of previous survey (acres)	-0.032	*	0.08	-0.032		0.125
=1 if the HH had stores in the prior survey	-0.392		0.188	-0.392		0.168
=1 if the HH had a cart in the prior survey	-0.596		0.2	-0.596		0.183
=1 if the HH had a bike in the prior survey	0.379		0.146	0.379		0.128
=1 if the HH had a motorcycle in the prior survey	0.709		0.671	0.709		0.678
=1 if the HH had a car in the prior survey	-1.245		0.182	-1.245		0.18
=1 if the HH had a truck in the prior survey	-2.193	*	0.099	-2.193		0.177
=1 if the HH had a radio in the prior survey	-0.665		0.156	-0.665		0.168
=1 if the HH had a tv in the prior survey	-0.266		0.344	-0.266		0.345
assets in previous survey (real 2010 1000s*Ksh)	-0.00036		0.334	0.000		0.357
Main season rain (mm) t-1	-0.007	**	0.023	-0.007	**	0.014
Fraction of 20 day periods with <40mm rain for main season t-1	-7.489	***	0	-7.489	***	0
Year is 2010 (=1)	1.114		0.152	1.114		0.137
Residuals from the tobit of quantity sold				0.000		0.208

Stage two SI/SFM NCPB effects at plot level

- $\text{Category}_{lt} = \beta_0 + \boldsymbol{p}_{\boldsymbol{it}}^{\boldsymbol{e}}\beta_1 + \boldsymbol{HH}_{\boldsymbol{it}}\beta_2 + \boldsymbol{prices}_{\boldsymbol{it}}\beta_3 + c_i + u_{it}$
  - l subscripts represent information only know after the harvest
  - i subscript represents HH level variable
- **HH** will include soil characteristic variables, extension, and other determinants.
- **Prices** will include wages, input costs, etc.

CRE-Probit of individual practices

	Maize legume Intercrop			Chemical fertilizer			Organic fertilizer		
	margins dy/dx	aster	pval	margins dy/dx	aster	pval	margins dy/dx	aster	pval
calculated price expectation	**0.005**		**0.629**	**0.011**		**0.324**	**-0.041**	***	**0.004**
Cowpeas price (real 2010 Ksh/kg, regional wholesale, t-1)	0.0000	***	0.01	0.0001	***	0.001	-0.0001	***	0
Bean price (real 2010 Ksh/kg, regional wholesale, t-1)	0.0001	***	0	-0.0001	*	0.099	0.0002	***	0
=1 if HH farmed land owned by the government, communally, or by a co-op	-0.090		0.376	-0.199	**	0.04	0.141		0.296
=1 if HH farmed land owned by relative	0.142	***	0.003	-0.107		0.144	0.232	***	0.003
=1 if HH owns land, but doesn't hold the deed	0.107	***	0	-0.130	***	0	0.272	***	0
=1 if HH owns land and holds the deed	0.116	***	0	-0.121	***	0	0.249	***	0
Village level average CAN preice per Kg (real 2010 Ksh)	0.003		0.26	-0.002		0.432	0.003		0.344
Village level average DAP preice per Kg (real 2010 Ksh)	0.001		0.868	-0.003		0.371	-0.003		0.524
=1 if female-headed HH	-0.014		0.39	-0.010		0.635	-0.003		0.892
Age of the HH head (years)	-0.002		0.192	0.003	*	0.099	-0.005	**	0.031
Village median farm wage (real 2010 Ksh/hour)	-0.012	***	0	-0.005	*	0.074	0.005		0.131
Village median land rental rate (real 2010 Ksh/acre/year)	-0.000004		0.615	0.00002	*	0.087	-0.00001		0.582
Number of prime age adults (age 15 to 59)	-0.002		0.652	0.007		0.332	-0.001		0.947
Km to the nearest place to get extension advice	-0.002		0.365	-0.003		0.292	0.002		0.372
Distance in kms from HH to nearest market place for farm produce	-0.001		0.444	-0.003		0.166	-0.004	*	0.07
Education of the HH head (years)	0.002		0.544	0.006		0.219	-0.010	*	0.07
plot size in acres	0.008	*	0.096	0.048	***	0	-0.041	***	0
Total landholdings owned as of previous survey (acres)	-0.00004		0.979	0.003		0.275	-0.001		0.648
TLU as of previous survey	0.002		0.577	0.003		0.493	0.005		0.438
Nutrient availability	-0.023	**	0.034	0.014		0.333	0.025		0.17
Main season rain (mm) t-1	0.0003	**	0.04	0.0003	*	0.054	-0.0004	**	0.013
Fraction of 20 day periods with <40mm rain for main season t-1	-0.286	**	0.015	0.089		0.511	-0.688	***	0
HH received subsidized fertilizer through NAAIAP in 2008	-0.002		0.981	0.019		0.832	-0.014		0.882
HH received subsidized fertilizer through NAAIAP in 2009	0.048		0.303	0.237	***	0.008	0.013		0.807
HH received subsidized fertilizer through NAAIAP in 2010	-0.036		0.539	0.037		0.656	-0.032		0.686
Year is 2010 (=1)	0.279	***	0.002	-0.126		0.208	0.575	***	0

Next steps

- Continue refining models
- Use ordered logit regression with dependent variable being the SI ranking
- Use multinomial logit with cases as dependent variables

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References

- Bationo, André, and A. U. Mokwunye. "Role of manures and crop residue in alleviating soil fertility constraints to crop production: With special reference to the Sahelian and Sudanian zones of West Africa." *alleviating soil fertility constraints to increased crop production in West Africa*. Springer Netherlands, 1991. 217-225.
- Drechsel, Pay, and Lucy A. Gyiele. *The economic assessment of soil nutrient depletion: Analytical issues for framework development*. Internat. Board for Soil Research and Management, 1999.
- Jayne, Thomas S., Robert J. Myers, and James Nyoro. "The effects of NCPB marketing policies on maize market prices in Kenya." *Agricultural Economics*38.3 (2008): 313-325.
- Lee, David R. "Agricultural sustainability and technology adoption: Issues and policies for developing countries." *American Journal of Agricultural Economics* 87.5 (2005): 1325-1334.
- Liebman, Matt, and Elizabeth Dyck. "Crop rotation and intercropping strategies for weed management." *Ecological applications* 3.1 (1993): 92-122.
- Manda, Julius, et al. "Adoption and impacts of sustainable agricultural practices on maize yields and incomes: evidence from Rural Zambia." *Journal of Agricultural Economics* 67.1 (2016): 130-153.
- Marenya, Paswel P., and Christopher B. Barrett. "Soil quality and fertilizer use rates among smallholder farmers in western Kenya." *Agricultural Economics*40.5 (2009): 561-572.
- Mason, Nicole M., Thomas S. Jayne, and Robert J. Myers. "Smallholder supply response to marketing board activities in a dual channel marketing system: The case of Zambia." *Journal of Agricultural Economics* 66.1 (2015): 36-65.
- Mather, David Len, and Thomas S. Jayne. *The impact of state marketing board operations on smallholder behavior and incomes: the case of Kenya*. Michigan State University, Department of Agricultural, Food, and Resource Economics and Department of Economics, 2011.
- Pretty, Jules, Camilla Toulmin, and Stella Williams. "Sustainable intensification in African agriculture." *International journal of agricultural sustainability* 9.1 (2011): 5-24.
- Royal Society. "Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture." (2009). 14964-14969.
- Sanchez, Pedro A., et al. "Soil fertility replenishment in Africa: an investment in natural resource capital." *Replenishing soil fertility in Africa* replenishingsoi (1997): 1-46.
- Snapp, Sieglinde S., et al. "Biodiversity can support a greener revolution in Africa." *Proceedings of the National Academy of Sciences* 107.48 (2010): 20840-20845.
- Timmer, C. Peter, et al. *Food policy analysis*. Vol. 1983. Baltimore: Johns Hopkins University Press, 1983.