Productivity Gains and Cropland Allocation at the Extensive and Intensive Margins: Maize Yields and Land Use Choices in Tanzania

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Productivity and Land-Use Choices

- Many development strategies focus on increasing land productivity, in particular via crop-specific strategies aiming to raise yields of major cereal crops (Danda & Murithi, 2015; Lee et al., 2016).

Source: The Global Miller, 2015

- **Theory and Assumptions**:
  - Short term: Yield gains will increase household food security and incomes (Djurfeldt & Djurfeldt, 2013)
  - Medium term: As farmers become more productive, they will specialize in their more productive crop(s), further boosting efficiency, production and incomes (Haggblade, Hazell, & Reardon, 2010)
  - Long term: Relatively less productive farmers will shift to other crops (comparative advantage), or leave farming for other rural or urban employment (Haggblade, Hazell, & Reardon, 2010)

Productivity and Land-Use Choices

Structural Transformation: the transition of a country from low-income status and an economy characterized by low-productivity agriculture contributing the most to national employment and GDP to high-income status and an economy characterized by a smaller, high-productivity agricultural sector and with manufacturing and services accounting for greater shares of employment and incomes (Clark, 1957; Chenery, 1960; Kuznets, 1966; 1973).

- **Land-Use Related Predictions Arising from Theory:**
  - As rural markets develop, farmers will increasingly specialize in those crops for which they hold a comparative advantage (Gollin, Parente, & Rogerson, 2002)
  - Over time, relatively more productive farmers will expand their production while relatively less productive farmers will leave the farming sector (Herrendorf et al., 2013)

Constraints on Smallholder Responses to Productivity-Enhancing Interventions

Household-level constraints

- *Food insecurity* (insufficient production or income to meet family caloric and nutritional needs) (Snapp & Fisher, 2014)
- *Limited time or household labor* (Leonardo et al., 2015; Lalani et al., 2016)

Farm management constraints

- *Incomplete input and labor markets* (Barrett, 2008; Ibom & Devt, 2015)

Geographic and market constraints

- *Climate conditions, seasonality of production* (Alene et al., 2008; Djurfeldt & Djurfeldt, 2013)
- *Remoteness* from markets and roads (McCord et al., 2015)

Risk preferences, information, and attitudes toward change

- *High levels of risk and uncertainty* (Anderson, 2015; Salazar-Espinosa, Jones, & Tarp, 2015)

Research Question

How much is a change in maize yields within a given household associated with changes in land allocation or livelihood strategy?

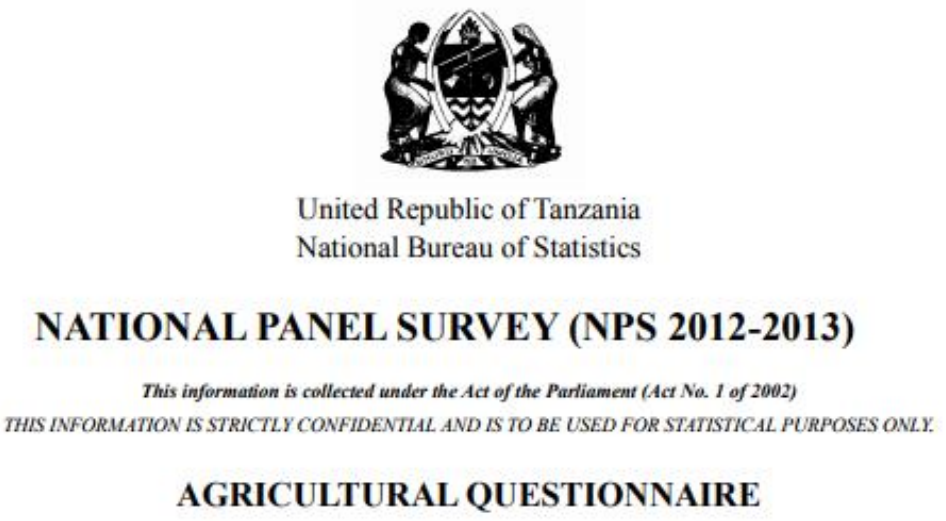
- Differences in farm and household characteristics between **maize yield increasers** and maize yield decreasers
- Differences in farm, household, and maize yield characteristics between **maize area increasers** and maize area decreasers

Possible Decisions:

- *Change the **proportion of farm area** planted to maize*
- ***Expand maize farming onto new land***
- ***Reduce maize farming** or leave farming altogether*

Data: Tanzania National Panel Survey

- Three waves of data were collected as part of the World Bank's Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) in conjunction with the Tanzania National Bureau of Statistics
- The head of household was interviewed soon after main annual harvest
- The survey provided information on household, farm and agro-ecological characteristics that might influence land management decisions over time


United Republic of Tanzania
National Bureau of Statistics

NATIONAL PANEL SURVEY (NPS 2012-2013)

This information is collected under the Act of the Parliament (Act No. 1 of 2002)

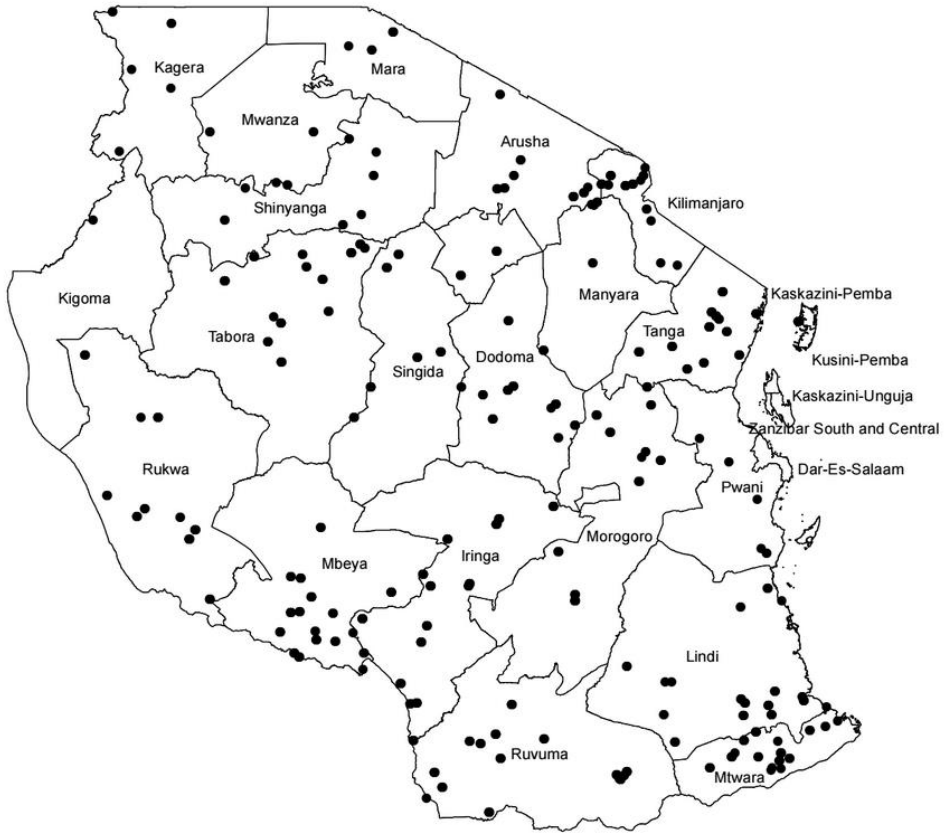
THIS INFORMATION IS STRICTLY CONFIDENTIAL AND IS TO BE USED FOR STATISTICAL PURPOSES ONLY.

AGRICULTURAL QUESTIONNAIRE

- Data collected in three waves: 3,265 (2008) 3,924 (2010) & 5,015 (2012) households
- Representative for the nation as a whole including rural areas
- Since 2010 all accessible farm plots were measured via GPS

Sample of Tanzanian Maize Farmers

- To be included in the sample, households must have:
  - Reported area planted to maize and total maize production quantity for both 2008 and 2010 (to establish yield increasers and decreasers)
  - Responded to the LSMS survey in 2012 (did not have to complete the agricultural module)
- The final sample includes 994 agricultural households cultivating maize in both 2008 and 2010
  - Of these, 850 households were also observed in the 2012 agricultural survey



Tanzania National Panel Survey Sample

Drivers of Land-Management Decisions and Maize Yields

Household Characteristics

- *Gender of household head* (Alene et al., 2008; Snapp & Fisher, 2014)
- *Age and education of household head* (Renkow, Hallstrom, & Karanja, 2004; Eakin et al., 2015)
- *Incomes and food security* (Woldeyohanes, Heckelei, and Surry, 2017)

Time and Labor Allocation

- *Household labor per area of land* (Leonardo et al., 2015; Lalani et al., 2016)
- *Ability to recruit / afford hired labor* (Zingore et al., 2009)

Farm Management Practices

- *Access to improved seed varieties* (Iimi, Humphreys, & Melibaeva, 2015; Bozzola, Smale, & Falco, 2016)
- *Use of fertilizer / agrochemicals / irrigation* (Arslan et al., 2016)
- *Intercropping, fallowing, animal traction* (Temesgen, Fukai, & Rodriguez, 2015)

Market and Agro-ecological Context:

- *Access to input markets and product markets* (Alene et al., 2008; Renkow, Hallstrom, & Karanja, 2004; Snapp & Fisher, 2014)
- *Geography [agro-ecology, political context]* (Alene et al., 2008; McCord et al., 2015)

Analysis Control Variables

Sample Household Characteristics

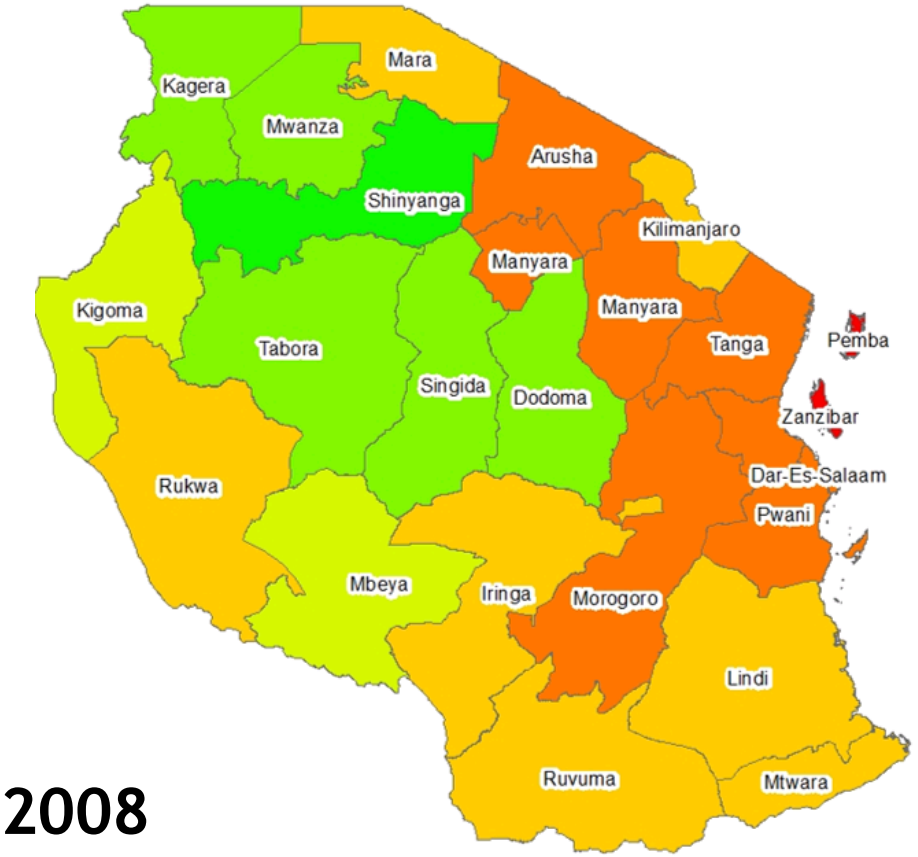
Source: The World Bank

	Variable	N	Mean	Min	Max	Median
Household Characteristics (2010)	Female-headed	802	0.24	0	1	0
	Age of HH head	802	48.99	21	99	47
	Education of HH head	802	4.57	0	13	7
	Number HH members	802	5.47	1	25	5
	Daily consumption per capita	802	3.17	0.57	14.92	2.68
	Number of hungry months	802	0.34	0	11	0

- In total 802 households provided complete responses on all covariates of interest (summary statistics reflect those households appearing in the final regression models).

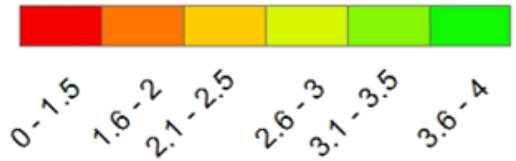
Weighted Summary Statistics: Sample Households

Farm Management Characteristics



2008

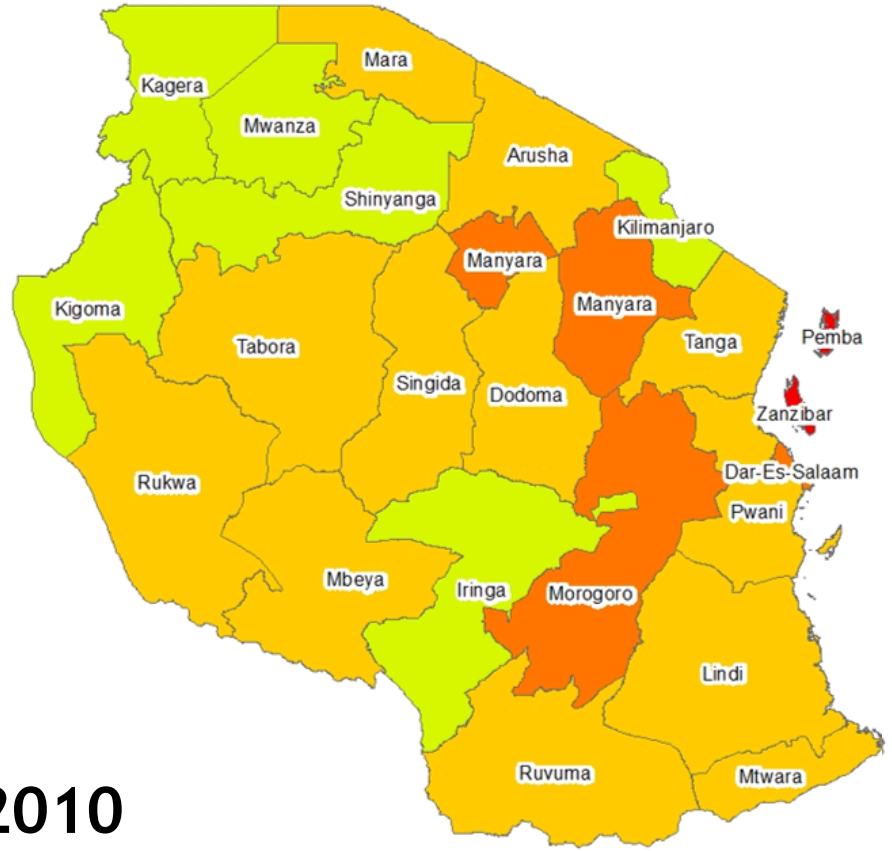
Average Crop Count



	Variable	N	Mean	Min	Max	Median
Farm Management Characteristics	Improved seed	802	0.10	0	1	0
	Organic fertilizer	802	0.18	0	1	0
	Inorganic fertilizer	802	0.21	0	1	0
	Fallowing	802	0.07	0	1	0
	Pesticides / herbicides	802	0.11	0	1	0
	Irrigation	802	0.02	0	1	0
	Intercropping	802	0.74	0	1	1
	Number of crops grown	802	5.13	1	18	4
	Ox implement	791	0.25	0	1	0
	HH labor, days/ha	802	124.4	0	2174	87.32
	Hired labor, days/ha	802	5.38	0	316.7	0
	Extension	802	0.09	0	1	0
	Δ farm size 2008-10, ha	802	0.27	-12.91	13.19	0.08
	Δ farm size 2010-12, ha	802	0.00	-9.15	9.31	0.01
	Log(farmsize), 1000*ha	802	7.35	3.70	9.52	7.41

Weighted Summary Statistics: Sample Households

Farm Management Characteristics



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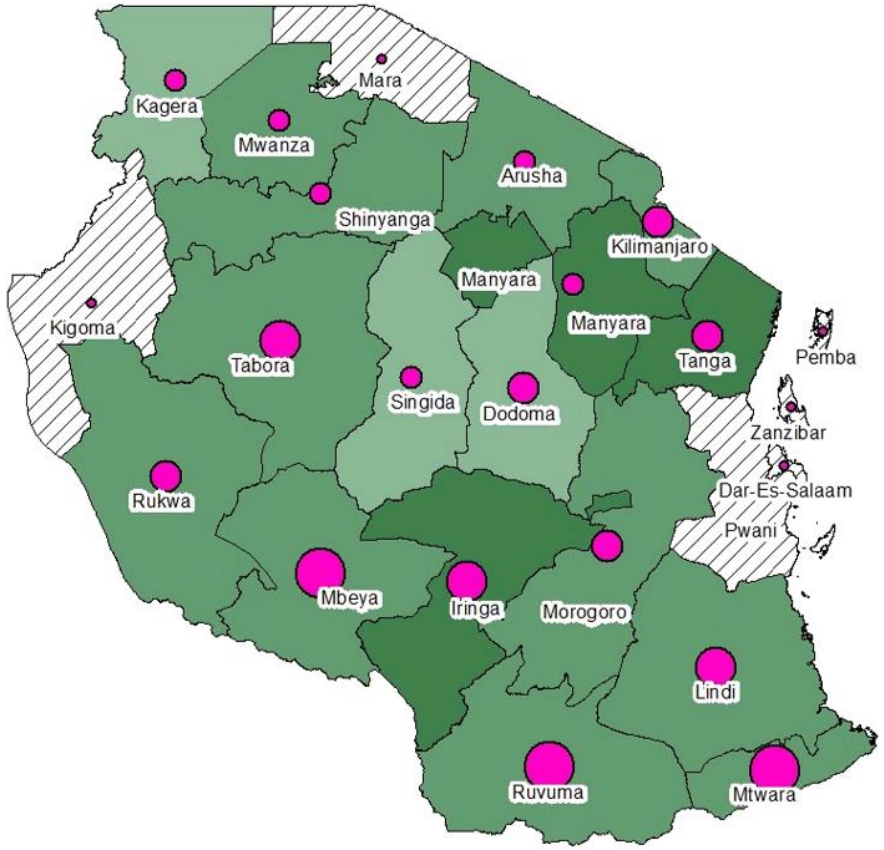
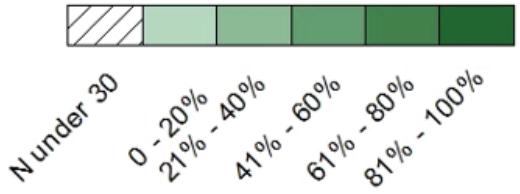
Weighted Summary Statistics: Sample Households

Agro-Ecological & Market Context



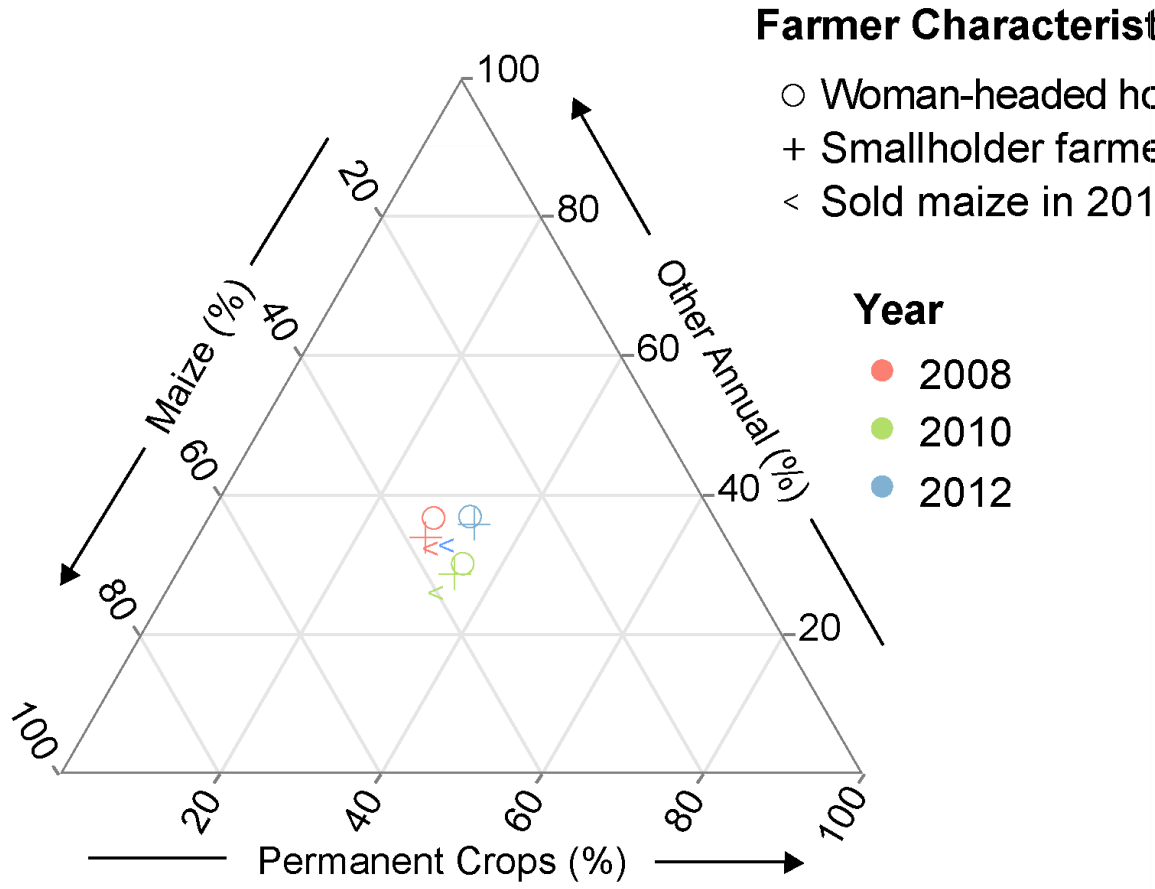
Proportion of Land Area Cultivated with Maize



	Variable	N	Mean	Min	Max	Median
Agro-ecological and Market Characteristics	Annual Rainfall (mm)	802	780.39	287	1921	776
	Mean Temp. (°C)	801	21.99	155	275	220
	Preharvest loss	791	0.33	0	1	0
	Distance to nearest truck road, km	802	20.15	0	135.1	15.9
	Distance to nearest major market, km	802	82.76	1.9	253.2	80
	Crop in storage	802	0.28	0	1	0
	Sold non-maize crop	802	0.49	0	1	0
	Sold perm/fruit crop	802	0.22	0	1	0
	Maize price (internat'l $)	802	0.14	0	2	0
	Quantity of maize sold (tonnes)	802	165.27	0.16	380	240

Weighted Summary Statistics: Sample Households

Farmer Land Allocation Decisions in 2008, 2010, 2012

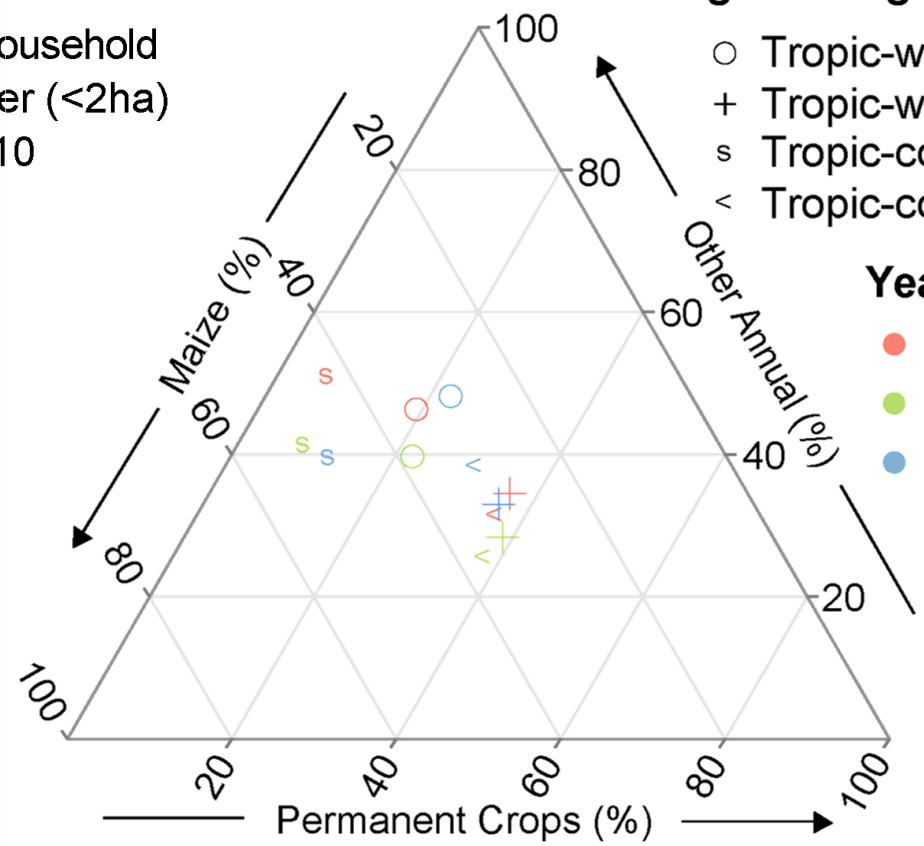


Farmer Characteristics

- ○ Woman-headed household
- \+ Smallholder farmer (<2ha)
- < Sold maize in 2010

Year

- 2008
- 2010
- 2012



Agroecological Zone

- ○ Tropic-warm/semiarid
- \+ Tropic-warm/subhumid
- s Tropic-cool/semiarid
- < Tropic-cool/subhumid

Year

- 2008
- 2010
- 2012

Crop allocation as a proportion of total smallholder farmer land area, 2008-2012.

Tanzania National Panel Survey/LSMS-ISA Data

Analysis: Outcome Variables

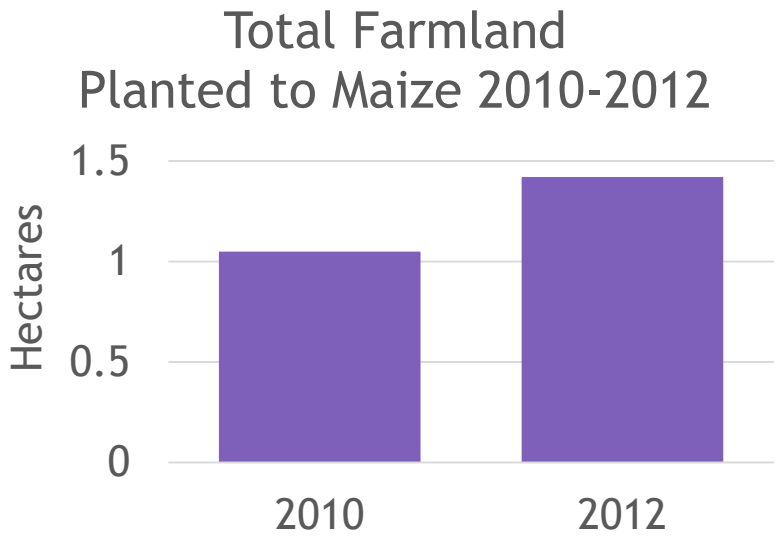
$$\textbf{Maize yield:}\ \frac{\sum \textbf{Quantity maize harvested}}{\sum \textbf{Area maize planted}}$$

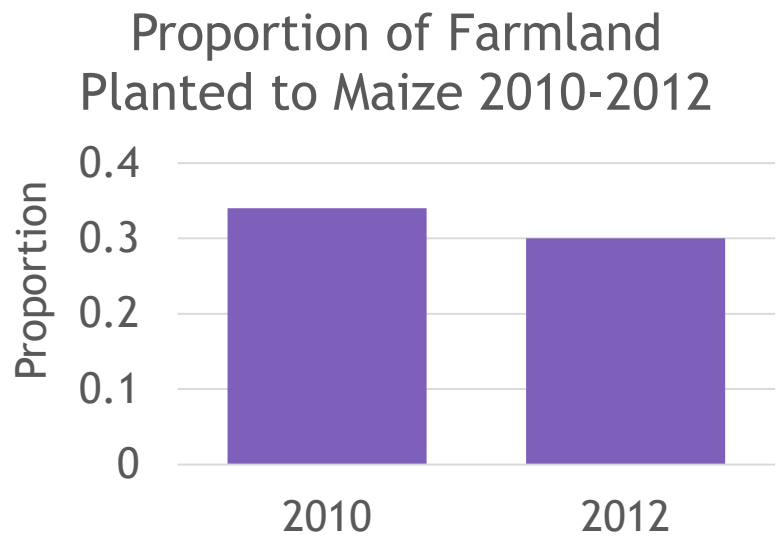
$$\textbf{Maize yield increaser:}\ \frac{\sum \textbf{Quantity harvested in 2010}}{\sum \textbf{Area planted in 2010}} - \frac{\sum \textbf{Quantity harvested in 2008}}{\sum \textbf{Area planted in 2008}} > 0$$

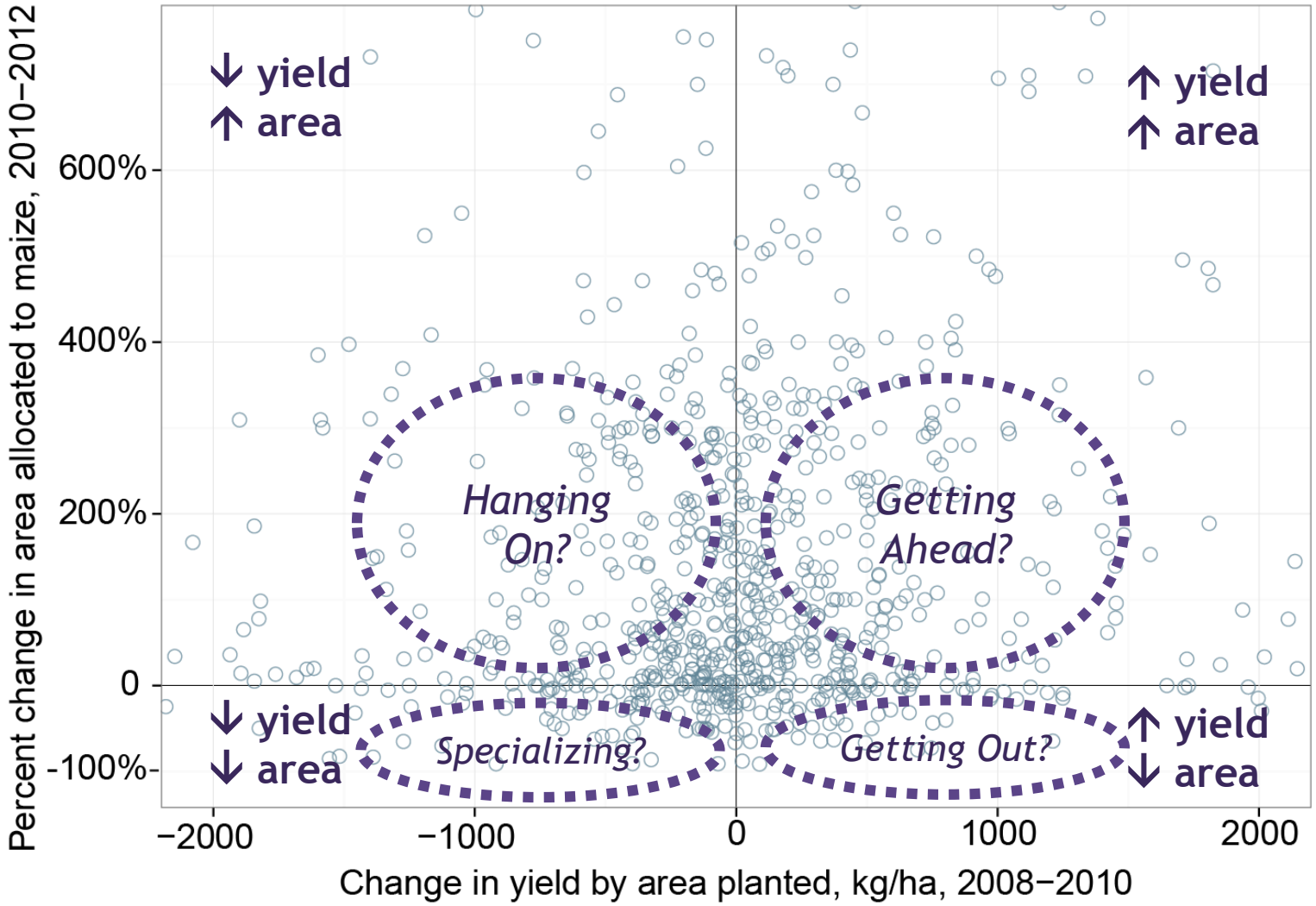
$$\textbf{Maize area increaser:}\ \sum \textbf{Area maize planted in 2012} - \sum \textbf{Area maize planted in 2010} > 0$$

Tanzania National Panel Survey/LSMS-ISA Data

Analysis: Outcome Variables







Weighted Summary Statistics: Sample Households

Household Characteristics

- Maize yield increasers are, on average, wealthier and experience fewer hungry months
- Age, education, and household size are not associated with being classified as a maize yield increaser or decreaser

		Maize Yield Increasers					Maize Yield Decreasers				
Household Characteristics		N	Mean	Min	Max	Median	N	Mean	Min	Max	Median
	Female-headed household	405	0.26	0	1	0	394	0.21	0	1	0
	Age of household head, years	405	48.96	22	99	48	394	49.09	21	90	46
	Education of household head, years	405	4.67	0	13	7	394	4.46	0	13	7
	Number of household members	405	5.48	1	25	5	394	5.46	1	15	5
	Daily consumption per capita, international $	405	3.26	0.57	14.9	2.71	394	3.08	0.61	11.84	2.66
	Number of hungry months	405	0.29	0	7	0	394	0.39	0	11	0

Weighted Summary Descriptive Statistics: Maize Yield Increasers versus Maize Yield Decreasers (2008-2010)

Farm Management Characteristics

		Maize Yield Increasers					Maize Yield Decreasers				
	Variable	N	Mean	Min	Max	Median	N	Mean	Min	Max	Median
Farm Management Characteristics	Δ farm size 2008-2010, ha	405	-0.04	-12.91	8.08	-0.06	394	0.58	-8.7	13.19	0.24
	Δ farm size 2010-2012, ha	405	0.08	-8.4	8.11	0.04	394	-0.08	-9.15	9.31	-0.02
	Log of farm size, 1000*ha	405	7.21	3.7	9.35	7.27	394	7.49	4.49	9.52	7.52
	Improved maize seed	405	0.11	0	1	0	394	0.10	0	1	0
	Organic fertilizer	405	0.20	0	1	0	394	0.17	0	1	0
	Inorganic fertilizer	405	0.24	0	1	0	394	0.19	0	1	0
	Fallowing	405	0.08	0	1	0	394	0.06	0	1	0
	Pesticides and/or herbicides	405	0.12	0	1	0	394	0.10	0	1	0
	Irrigation	405	0.01	0	1	0	394	0.03	0	1	0
	Intercropping	405	0.73	0	1	1	394	0.75	0	1	1
	Number of crops grown	405	5.38	1	17	5	394	4.88	1	18	4
	Ox-related farm implement	399	0.20	0	1	0	389	0.29	0	1	0
	Household labor, days/ha	405	149.34	1.36	2174.53	98.37	394	99.4	0	803.09	69.83
	Hired labor, days/ha	405	6.20	0	316.68	0	394	4.55	0	135.94	0
	Extension advice	405	0.10	0	1	0	394	0.08	0	1	0

Weighted Summary Descriptive Statistics: Maize Yield Increasers versus Maize Yield Decreasers (2008-2010)

Agro-ecological and Market Factors

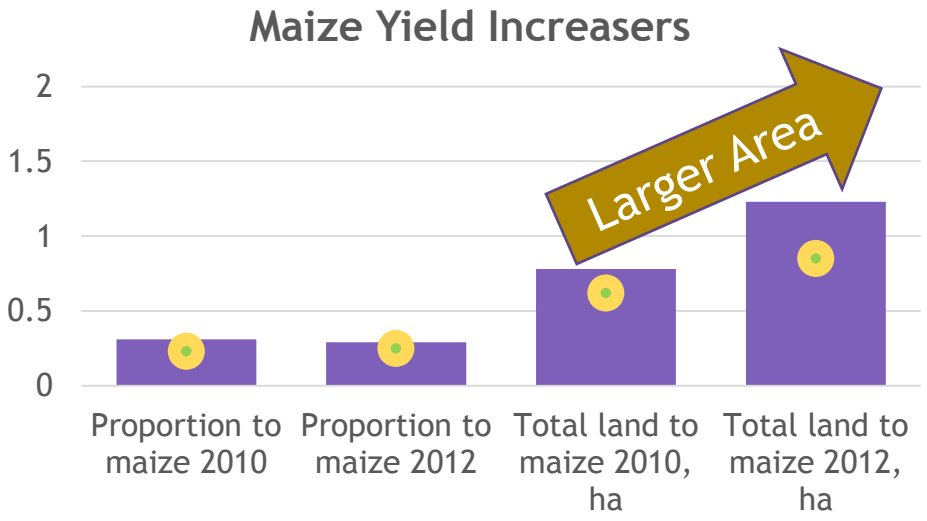
- Maize yield increasers sell more maize on average, but at lower local market prices

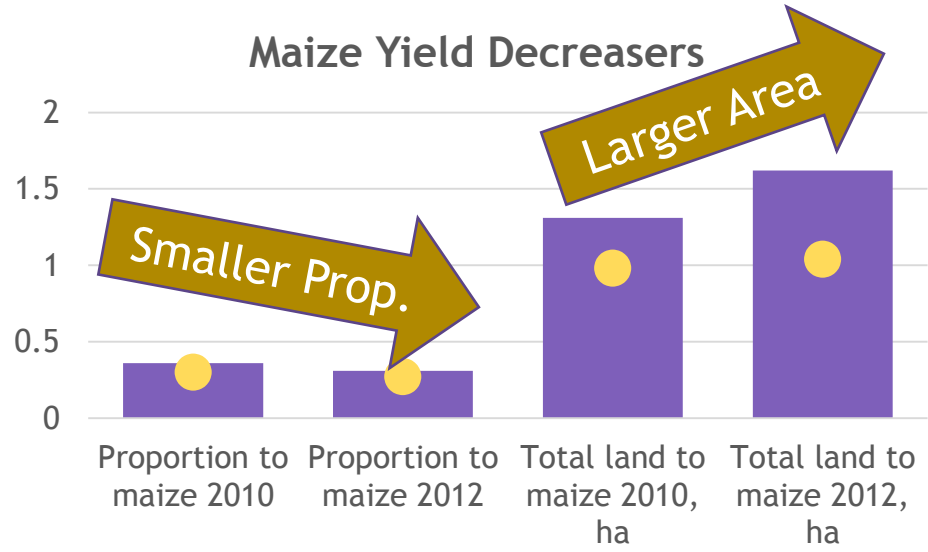
		Maize Yield Increasers					Maize Yield Decreasers				
		N	Mean	Min	Max	Median	N	Mean	Min	Max	Median
Agro-ecological and Market Factors	Rainfall in July 2009-June 2010 (mm)	405	769.8	287	1921	766	394	789.5	287	1476	778
	Average temperature, ° C*10	405	219.57	155	267	220	393	220.15	156	275	221
	Preharvest loss	405	0.34	0	1	0	383	0.31	0	1	0
	Distance to nearest truck road, km	405	20.76	0	135.1	17.1	394	19.4	0	134.6	13.7
	Distance to nearest major market, km	405	81.19	1.9	253.2	76.4	394	84.06	1.9	252.2	82
	Crop in storage	405	0.30	0	1	0	394	0.26	0	1	0
	Sold crop besides maize	405	0.50	0	1	0	394	0.49	0	1	0
	Sold any permanent/fruit crop	405	0.23	0	1	0	394	0.20	0	1	0
	Household price, international $[1]	405	155.03	0.17	380	210	394	175.91	0.16	380	250
	Quantity of maize sold, tonnes	405	0.16	0	2	0	394	0.11	0	1.68	0

Weighted Summary Descriptive Statistics: Maize Yield Increasers versus Maize Yield Decreasers (2008-2010)

Land Use Choices

● Median response





		Maize Yield Increasers					Maize Yield Decreasers				
Land Use		N	Mean	Min	Max	Median	N	Mean	Min	Max	Median
	Proportion to maize 2010	405	0.31	0.01	1	0.23	394	0.36	0.01	1	0.3
	Proportion to maize 2012	405	0.29	0	1	0.25	394	0.31	0	1	0.27
	Total land to maize 2010, ha	405	0.78	0.02	3.97	0.62	394	1.31	0.06	9.22	0.98
	Total land to maize 2012, ha	405	1.23	0	10.43	0.85	394	1.62	0	11.94	1.04

Weighted Summary Descriptive Statistics: Maize Yield Increasers versus Maize Yield Decreasers (2008-2010)

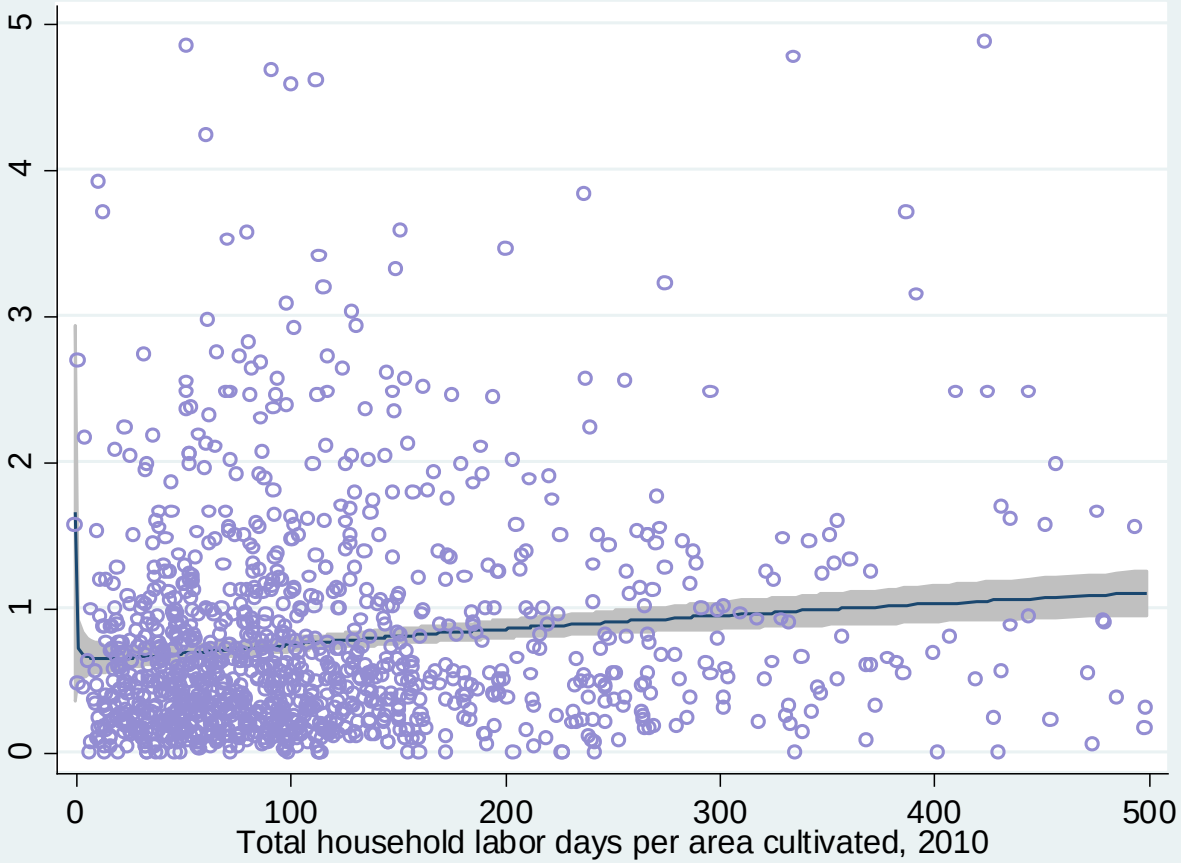
Analysis: Empirical Models

- Probit Regression Models
  - Model **increase in maize yield over time** (1/0)
- OLS and Probit Regression
  - Model farmers' **land allocation decisions in 2012** as a function of the observed change in maize yield from 2008 to 2010

$$\text{Outcome} = \beta_0 \left[+ \Delta\text{yield} \cdot \beta_{\Delta\text{yield}}\right] + \text{Household} \cdot \beta_1 + \text{Farm} \cdot \beta_2 + \text{Geography} \cdot \beta_3$$

- Control Variables
  - Household characteristics (gender, age, education, food security, and household consumption)
  - Farm management (input use, crop mix, labor)
  - Geography and market context

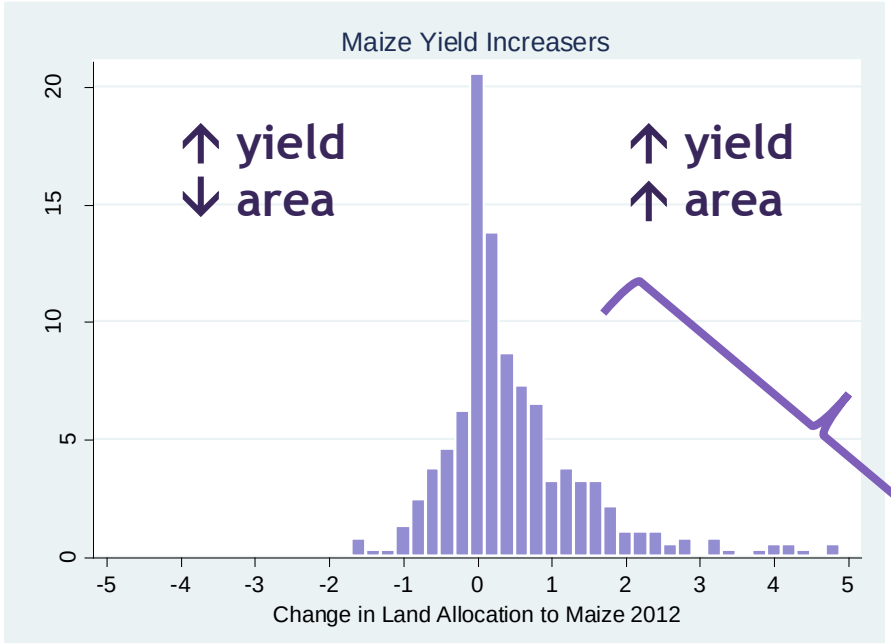
"Yield Increasers"



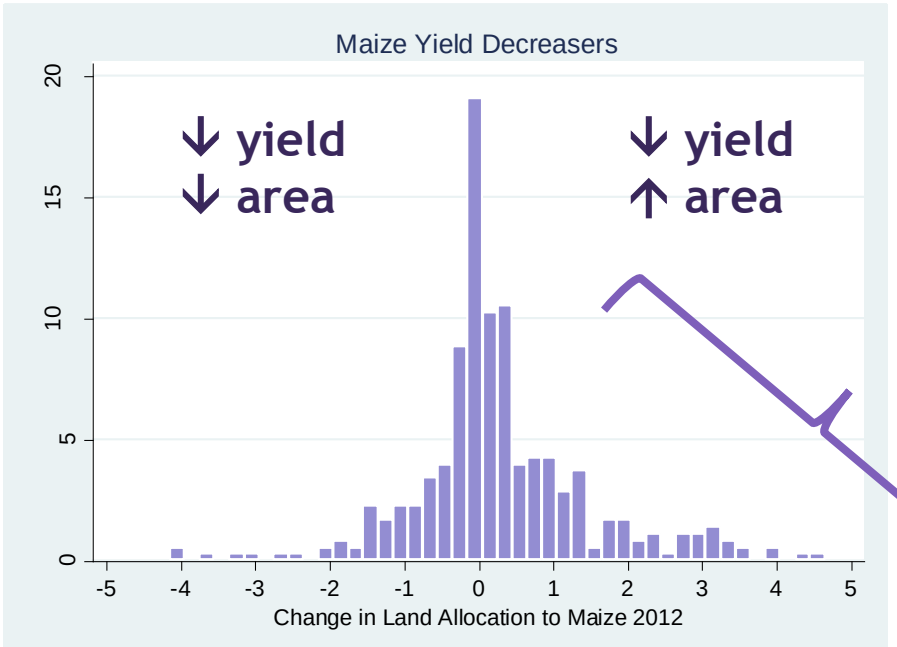
- More likely to see increasing yields from 2008-10:
  - Households with more access to HH labor
  - Households with market access (maize sellers)
- Less likely to see increasing yields from 2008-10:
  - Food insecure HHs
  - Intercropping HHs
  - **HHs expanding land cropped**

"Area Increasers"

- More likely to see increasing **area** from 2010-12:
  - Female-headed HHs
  - More educated HHs
  - HHs with market access and higher local maize prices
  - **HHs experiencing higher yields over 2008-10**
- Less likely to see increasing area from 2010-12:
  - HHs using improved seed [small N, and may reflect intensification]



Older, more educated, wealthier, more market access

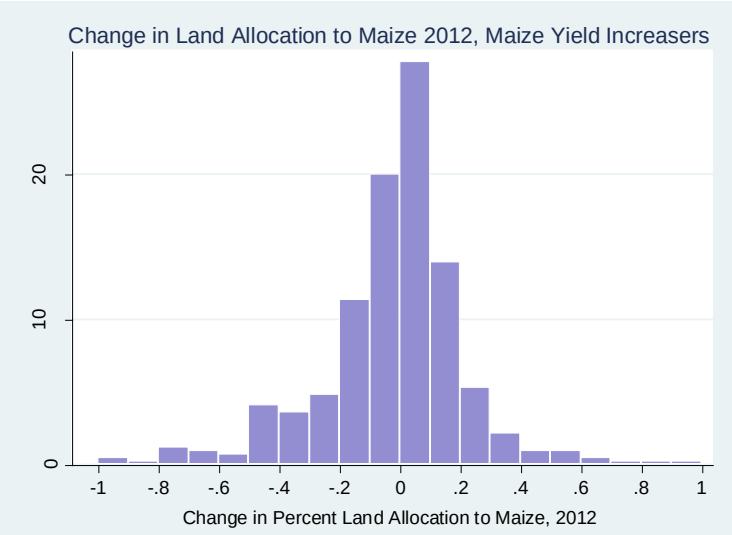


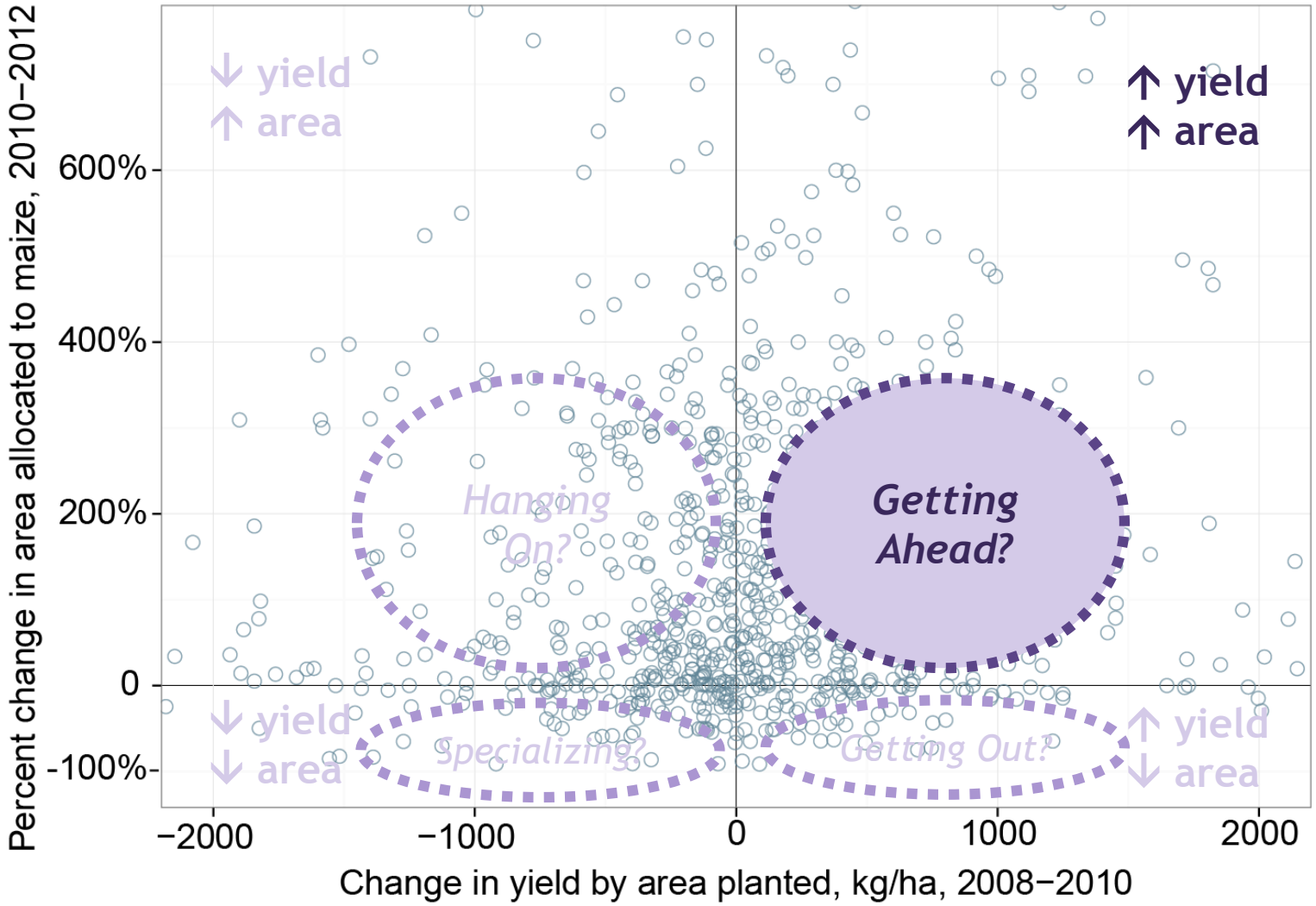
Poor model explanatory power;

Market access and prices

"Proportion Increasers"

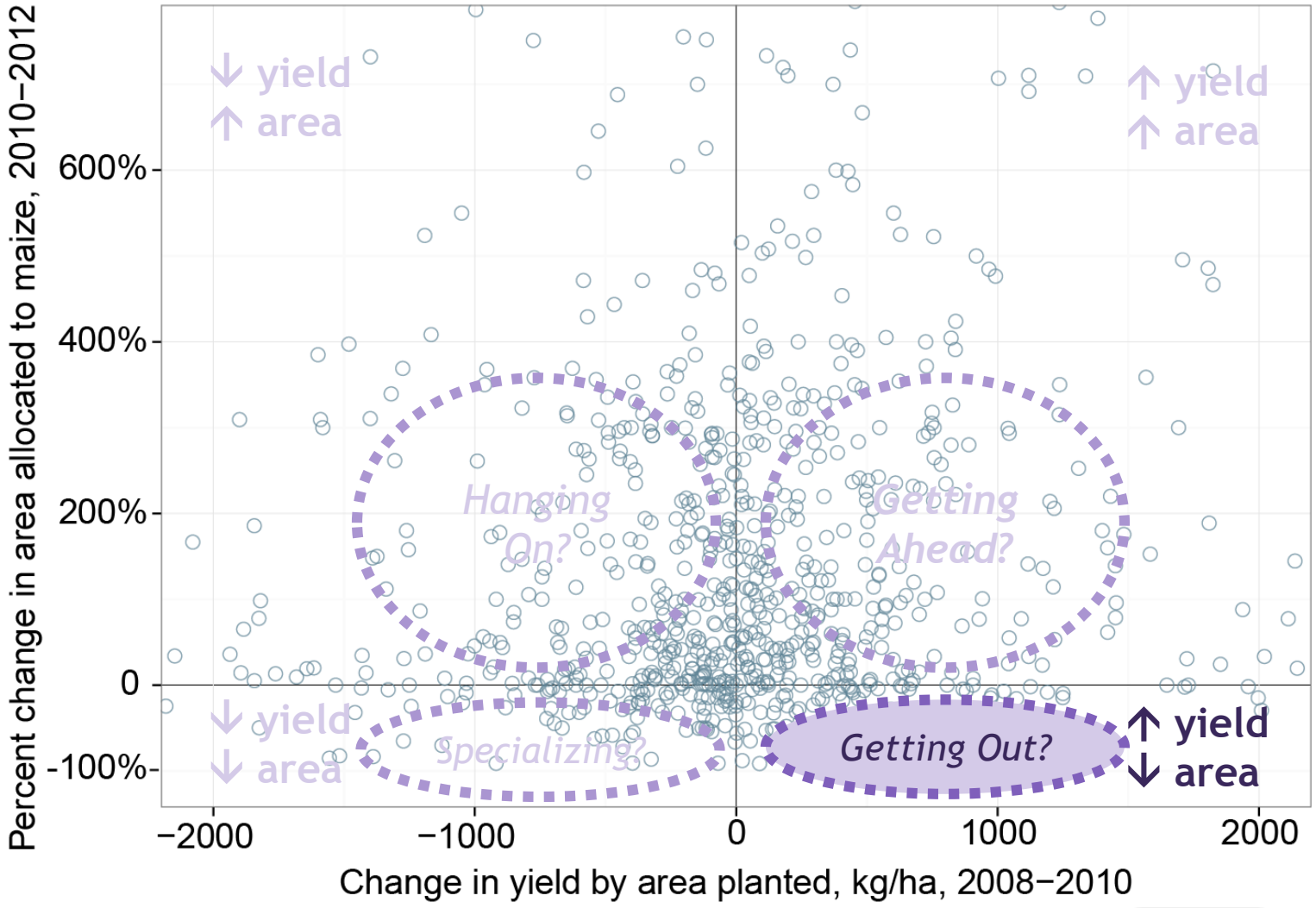
- More likely to see increasing **proportion** from 2010-12:
  - HHs with higher local maize prices
  - **HHs experiencing higher yields over 2008-10**





"Proportion Increasers"

- More likely to see increasing **proportion** from 2010-12:
  - HHs with higher local maize prices
  - **HHs experiencing higher yields over 2008-10**
- Less likely to see increasing proportion from 2010-12:
  - **HHs with higher incomes (consumption)**
  - **HHs with crop in storage**
  - **HHs with market access**



Key Findings

- Maize yield in a previous year is related to maize land allocation decisions both as a land area value and when considering a household's area share to maize.
  - However, experiencing a previous increase in maize yield does not have a consistent relationship with later maize allocation decisions.
  - Ability to increase farm size on the extensive margin is associated with a greater magnitude increase in maize allocation (in hectares, and as a proportion) than is maize yield alone.

- Many high-yielding and high-potential-yielding farmers may respond to an increase in maize yields by diversifying away from maize, or by leaving farming.
  - Interventions targeting "specializing" farmers?
  - Interventions targeting "getting out" farmers?

} *Non-crop-specific strategies*

Evans School Policy Analysis & Research Group (EPAR)

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EPAR uses an innovative student-faculty team model to provide rigorous, applied research and analysis to international development stakeholders. Established in 2008, the EPAR model has since been emulated by other UW schools and programs to further enrich the international development community and enhance student learning.

Please direct comments or questions about this research to Principal Investigators C. Leigh Anderson and Travis Reynolds at epar.evans.uw@gmail.com.

Probit Regression for Maize Yield Increase (1 = Increase in Maize Yield from 2008 to 2010).		
	Coefficients	Marginal Effects
Household characteristics		
Female-headed household	0.204 (0.127)	0.070 (0.043)
Age of household head, years	-0.000 (0.003)	-0.000 (0.001)
Education of household head, years	-0.005 (0.018)	-0.002 (0.006)
Number of Household Members	0.018 (0.025)	0.006 (0.009)
Daily consumption per capita 2010, international $	0.018 (0.029)	0.006 (0.010)
Number of hungry months 2010	-0.092** (0.039)	-0.032** (0.014)
Farm management characteristics		
Improved maize seed 2010	0.106 (0.169)	0.037 (0.058)
Organic fertilizer 2010	0.193 (0.163)	0.067 (0.056)
Inorganic fertilizer 2010	-0.014 (0.144)	-0.005 (0.049)
Fallowing 2010	0.008 (0.195)	0.003 (0.067)
Pesticides and/or herbicides 2010	-0.055 (0.195)	-0.019 (0.067)
Intercropping 2010	-0.356*** (0.119)	-0.122*** (0.040)
Number of crops grown 2010	0.020 (0.021)	0.007 (0.007)
Ox-related farm implement 2010	-0.179 (0.144)	-0.062 (0.050)
Household labor 2010, days/ha	0.002*** (0.001)	0.001*** (0.000)
Hired labor 2010, days/ha	-0.001 (0.003)	-0.000 (0.001)
Extension advice 2010	0.102 (0.174)	0.035 (0.060)
Agroecological and market factors		
Rainfall July 2009-June 2010 (mm)	0.000 (0.000)	0.000 (0.000)
Average temperature 2010, ° C*10	0.002 (0.003)	0.001 (0.001)
Pre-harvest loss 2010	-0.001 (0.002)	-0.000 (0.001)
Distance to nearest truck road, km	-0.001 (0.001)	-0.000 (0.000)
Distance to nearest major market, km	0.065 (0.117)	0.022 (0.040)
Crop in storage 2010	0.113 (0.114)	0.039 (0.039)
Sold crop besides maize 2010	0.147 (0.120)	0.051 (0.041)
Sold any permanent/fruit crop 2010	-0.090 (0.125)	-0.031 (0.043)
Household price 2010, international $[1]	-0.001 (0.001)	-0.000 (0.000)
Quantity of maize sold 2010, tonnes	0.613** (0.269)	0.211** (0.091)
Land use		
Change in farm size 2008-2010, ha	-0.113*** (0.029)	-0.039*** (0.010)
Log of farm size 2010, 1000*ha	-0.050 (0.084)	-0.017 (0.029)
Constant	-0.733 (0.968)	
N	842	842
Pseudo R-squared	0.129	
Standard errors in parentheses. The regressions include clustering at the district level, regional fixed effects, and panel weighting. [1]Median price reported by cluster if missing		
* p<0.1, ** p<0.05, *** p<0.01		

"Yield Increasers"

- More likely to see increasing yields from 2008-10:
  - Households with more access to HH labor
  - Households with market access (maize sellers)

"Area Increasers"

- More likely to see increasing **area** from 2010-12:
  - Female-headed HHs
  - More educated HHs
  - HHs with market access and higher local maize prices
  - **HHs experiencing higher yields over 2008-10**
- Less likely to see increasing area from 2010-12:
  - HHs using improved seed [small N, and may reflect intensification]

Probit Regression for Maize Area Increase (1 = Increase in Area Allocated to Maize from 2010 to 2012).

	Coefficients	Marginal Effects
Household characteristics		
Female-headed household	0.235** (0.091)	0.084*** (0.033)
Age of household head, years	-0.053 (0.126)	-0.019 (0.045)
Education of household head, years	0.007* (0.004)	0.003* (0.001)
Number of Household Members	0.015 (0.017)	0.005 (0.006)
Daily consumption per capita 2010, international $	0.014 (0.025)	0.005 (0.009)
Number of hungry months 2010	0.037 (0.030)	0.013 (0.011)
Farm management characteristics		
Improved maize seed 2010	-0.307* (0.174)	-0.110* (0.061)
Organic fertilizer 2010	0.073 (0.133)	0.026 (0.048)
Inorganic fertilizer 2010	-0.047 (0.130)	-0.017 (0.047)
Fallowing 2010	0.041 (0.199)	0.015 (0.071)
Pesticides and/or herbicides 2010	0.150 (0.161)	0.054 (0.057)
Intercropping 2010	-0.039 (0.112)	-0.014 (0.040)
Number of crops grown 2010	-0.004 (0.022)	-0.002 (0.008)
Ox-related farm implement 2010	-0.051 (0.134)	-0.018 (0.048)
Household labor 2010, days/ha	-0.000 (0.000)	-0.000 (0.000)
Hired labor 2010, days/ha	0.002 (0.003)	0.001 (0.001)
Extension advice 2010	0.015 (0.166)	0.005 (0.060)
Agroecological and market factors		
Rainfall July 2009-June 2010 (mm)	-0.000 (0.000)	-0.000 (0.000)
Average temperature 2010, ° C*10	-0.003 (0.002)	-0.001 (0.001)
Pre-harvest loss 2010	0.003 (0.003)	0.001 (0.001)
Distance to nearest truck road, km	-0.001 (0.001)	-0.000 (0.000)
Distance to nearest major market, km	0.019 (0.114)	0.007 (0.041)
Crop in storage 2010	-0.078 (0.119)	-0.028 (0.042)
Sold crop besides maize 2010	0.297*** (0.090)	0.106*** (0.031)
Sold any permanent/fruit crop 2010	-0.029 (0.151)	-0.010 (0.054)
Household price 2010, international $[1]	0.001** (0.001)	0.000*** (0.000)
Quantity of maize sold 2010, tonnes	0.136 (0.215)	0.049 (0.077)
Land use		
Change in farm size 2008-2010, ha	-0.040 (0.035)	-0.014 (0.012)
Log of farm size 2010, 1000*ha	0.090 (0.079)	0.032 (0.028)
Yield		
Increased maize yield 2008-2010	0.235** (0.091)	0.084*** (0.033)
Constant	-1.209 (0.966)	
N	778	778
Pseudo R-squared	0.067	

Standard errors in parentheses. The regressions include clustering at the district level, regional fixed effects, and panel weighting.
[1]Median price reported by cluster if missing
* p<0.1, ** p<0.05, *** p<0.01

"Prop. Increasers"

- More likely to see increasing **proportion** from 2010-12:
  - HHs facing crop losses
  - HHs with higher local maize prices
  - **HHs experiencing higher yields over 2008-10**
- Less likely to see increasing proportion from 2010-12:
  - HHs with higher incomes (consumption)
  - HHs with crop storage
  - HHs with market access

Probit Regression for Maize Proportion Increase (1 = Increase in Proportion Allocated to Maize from 2010 to 2012).		
	Coefficients	Marginal Effects
Household characteristics		
Female-headed household	-0.102 (0.141)	-0.036 (0.050)
Age of household head, years	0.003 (0.003)	0.001 (0.001)
Education of household head, years	-0.029 (0.024)	-0.010 (0.008)
Number of Household Members	-0.023 (0.022)	-0.008 (0.008)
Daily consumption per capita 2010, international $	0.067** (0.031)	0.024** (0.011)
Number of hungry months 2010	0.005 (0.038)	0.002 (0.014)
Farm management characteristics		
Improved maize seed 2010	0.034 (0.141)	0.012 (0.050)
Organic fertilizer 2010	-0.053 (0.132)	-0.019 (0.047)
Inorganic fertilizer 2010	0.059 (0.144)	0.021 (0.051)
Fallowing 2010	-0.113 (0.189)	-0.040 (0.067)
Pesticides and/or herbicides 2010	-0.010 (0.148)	-0.003 (0.053)
Intercropping 2010	0.062 (0.117)	0.022 (0.041)
Number of crops grown 2010	0.017 (0.019)	0.006 (0.007)
Ox-related farm implement 2010	-0.079 (0.139)	-0.028 (0.050)
Household labor 2010, days/ha	0.000 (0.000)	0.000 (0.000)
Hired labor 2010, days/ha	0.001 (0.002)	0.000 (0.001)
Extension advice 2010	0.206 (0.162)	0.073 (0.057)
Agroecological and market factors		
Rainfall July 2009-June 2010 (mm)	-0.001 (0.000)	-0.000 (0.000)
Average temperature 2010, ° C*10	0.002 (0.003)	0.001 (0.001)
Pre-harvest loss 2010	0.006** (0.002)	0.002** (0.001)
Distance to nearest truck road, km	0.002 (0.001)	0.001 (0.000)
Distance to nearest major market, km	0.087 (0.115)	0.031 (0.041)
Crop in storage 2010	-0.272** (0.138)	-0.097** (0.048)
Sold crop besides maize 2010	-0.053 (0.105)	-0.019 (0.037)
Sold any permanent/fruit crop 2010	-0.046 (0.136)	-0.016 (0.049)
Household price 2010, international $[1]	0.001* (0.001)	0.000* (0.000)
Quantity of maize sold 2010, tonnes	-0.487* (0.276)	-0.173* (0.098)
Land use		
Change in farm size 2008-2010, ha	-0.024 (0.032)	-0.009 (0.011)
Log of farm size 2010, 1000*ha	0.023 (0.087)	0.008 (0.031)
Yield		
Increased maize yield 2008-2010	0.334*** (0.105)	0.119*** (0.036)
Constant	-0.988 (1.031)	
N	842	842
Pseudo R-squared	0.084	
Standard errors in parentheses. The regressions include clustering at the district level, regional fixed effects, and panel weighting. [1]Median price reported by cluster if missing		
* p<0.1, ** p<0.05, *** p<0.01		