The Effects of Agricultural Adaptation on Food Security

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Introduction

- Farmers in rural areas of developing economies deal with numerous uncertainties
- These farmers, while poor, are clever and do the best they can to maximize their welfare
  - Poor but rational (e.g. Schultz, *JPE* 1980)
- Farmers adapt to change
  - They make adjustments in human systems in response to actual or expected changes which moderates harm or exploits beneficial opportunities (adapted from IPCC 2007)

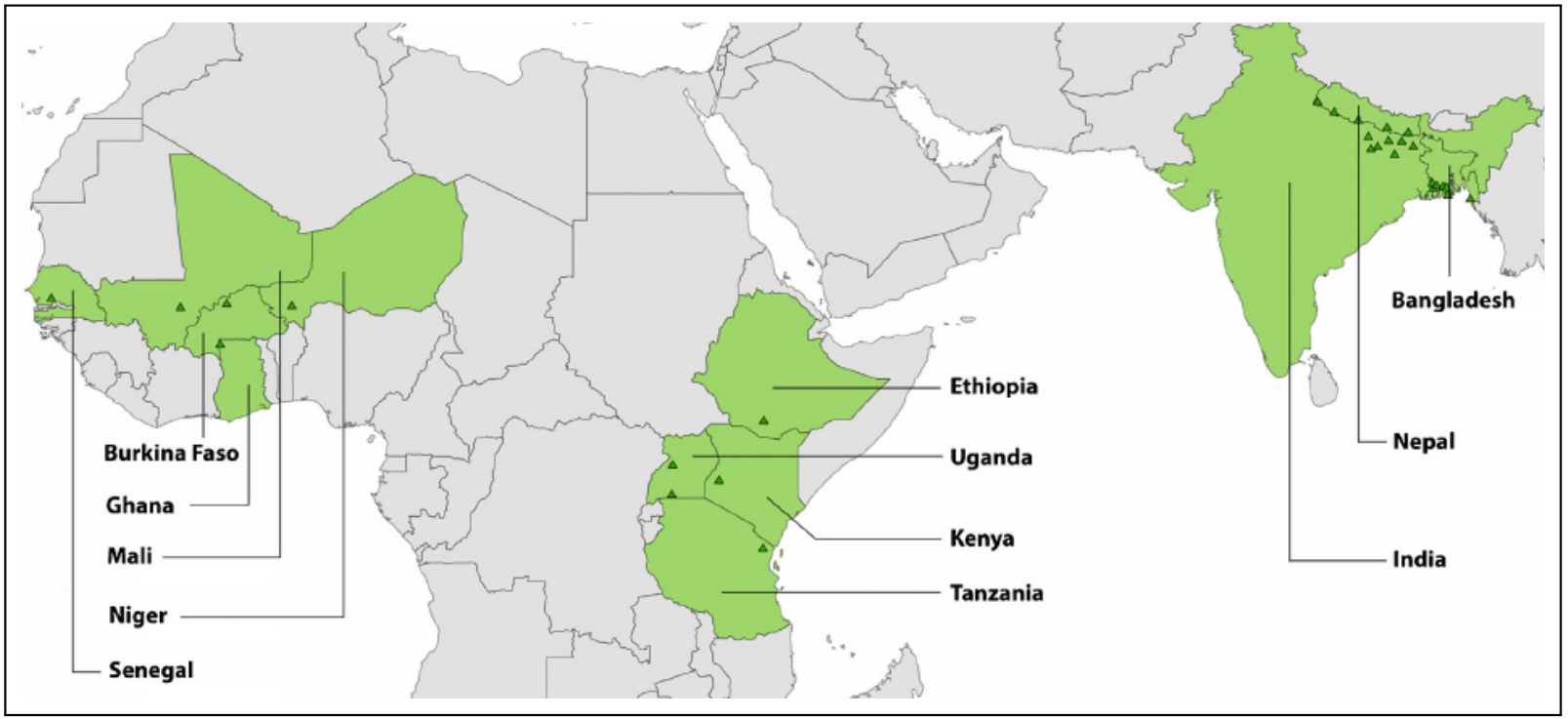
Introduction

- Intuitively, agricultural adaptation is frequently assumed to be welfare improving
- Large literature about the drivers of adaptation (e.g. Di Falco, *Eur Review Ag Econ* 2014)
- Smaller literature on estimating benefits from adaptation
  - Why? Maybe because it is empirically challenging
  - Adaptation affects welfare, but welfare also affects adaptation
  - Adaptation is endogenous in welfare regressions

Contribution

- We contribute to the literature that estimates benefits from adaptation by looking at food security
- We use an IV approach to estimate the effect of agricultural adaptation on food security
  - IV: Adaptation levels of neighbour networks
- External Validity
  - While most of the literature focuses on localized studies, our paper uses data from 3 major food insecure regions of the world (Lobell, *Science* 2008)
  - East Africa
  - West Africa
  - South Asia

Data



Source: Wood et al. 2014, *GEC*

- Source: Climate Change, Agriculture, Food Security research program (CCAFS)
- Survey data of 2,095 households collected from late 2010 to early 2011
- 3 regions, 12 countries, 15 sites, 108 villages

Measuring Food Security (FS)

- Households were asked:

  "identify in which months in a typical year you tend to struggle to find sufficient food, or experience shortages to feed your family".

- We count the number of months they are food secure

- Food Security measure:

  the number of food secure days

Measuring Adaptation

- Households were asked:

  "what changes have you made to your farming practices over the last 10 years?"

  - 46 possible changes
  - Examples: introduced new variety of crops, introduced intercropping, started irrigating, stopped burning, etc.

- Adaptation measure:

  the sum of farming practices that the household has changed w.r.t. any one of their three main crops

Summary Stats: Food Secure Days

Region	Country	Site	Mean	Std Dev
East Africa	Ethiopia	Borana	164	80
	Kenya	Nyando	303	21
	Kenya	Makueni	178	66
	Tanzania	Usambara	199	70
	Uganda	Albertine Rift	285	85
	Uganda	Kagera Basini	243	73
Region Total			***228***	***87***
West Africa	Ghana	Lawra	227	50
	Burkina Faso	Yatenga	245	69
	Mali	Segou	334	33
	Niger	Kollo	248	59
	Senegal	Kaffrine	289	31
Region Total			***269***	***64***
South Asia	Bangladesh	Bagerhat	258	115
	India	Bihar	287	96
	India	Haryana	358	18
	Nepal	Midwestern Terrai	330	63
Region Total			***308***	***90***

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Summary Stats: Adaptation (No of activities changed)

Region	Country	Site	Mean	Std Dev
East Africa	Ethiopia	Borana	4	4
	Kenya	Nyando	11	4
	Kenya	Makueni	17	5
	Tanzania	Usambara	13	5
	Uganda	Albertine Rift	6	5
	Uganda	Kagera Basini	8	5
Region Total			***10***	***6***
West Africa	Ghana	Lawra	11	5
	Burkina Faso	Yatenga	10	6
	Mali	Segou	4	3
	Niger	Kollo	7	4
	Senegal	Kaffrine	10	3
Region Total			***9***	***5***
South Asia	Bangladesh	Bagerhat	3	3
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Summary Stats: Control Variables

	mean	std dev
Access to Information and Human capital		
Access to weather information	0.779	0.415
Membership in farming association(s)	0.447	0.497
Highest level of education attained is primary	0.435	0.496
Highest level of education attained is secondary	0.310	0.463
Highest level of education attained is post-secondary	0.128	0.334
Finance		
Access to agricultural credit	0.144	0.352
Bank account	0.221	0.415
Cash from the government	0.216	0.412
Income from non-farm employment	0.691	0.462
Income from renting out land or machinery	0.136	0.343
Assets		
Count of production-related assets	0.732	1.288
Count of nonproduction-related assets	2.402	1.659
Livestock	0.906	0.293
Motorcycle	0.186	0.390
Car or truck	0.032	0.176
Boat	0.007	0.085

Summary Stats: Control Variables (cont)

	mean	std dev
Farm and Household Characteristics		
Running water	0.095	0.294
Storage facility for crops	0.217	0.412
Planted trees	0.452	0.498
Farm size	1.920	7.630
Household size	10.36	6.111
Female-headed	0.126	0.332
Farming and Crisis Experience		
Farming experience is at least ten years	0.935	0.246
Experienced climate crisis in the last five years	0.721	0.449
Stated Reasons for Adaptation		
Market conditions	0.673	0.469
Climate variability	0.522	0.500
Pests and disease	0.290	0.454
Government/NGO intervention	0.154	0.361
Labor availability	0.439	0.496
Land productivity	0.507	0.500

Empirical Model

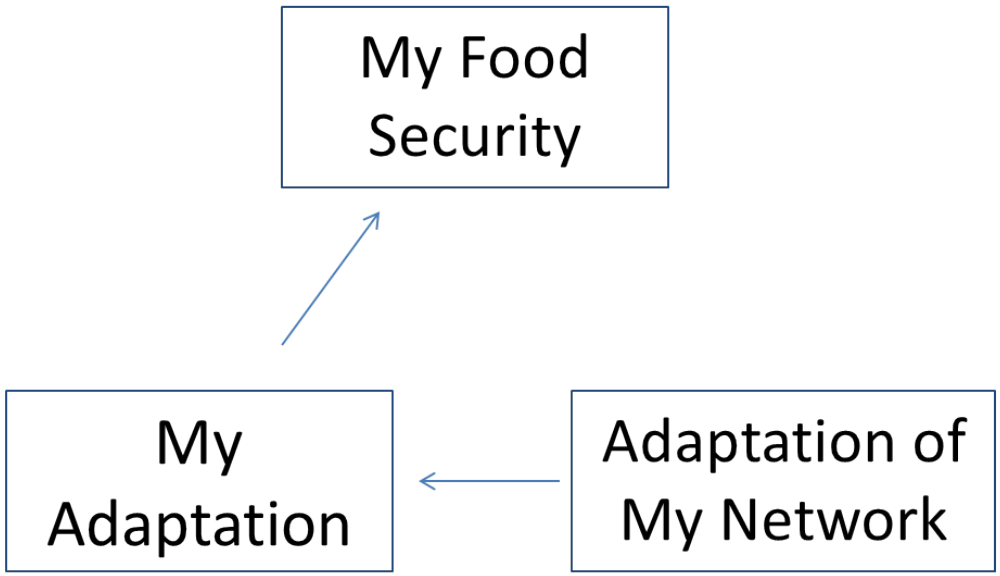
$$FS_{i,v} = \alpha + \beta \text{Adaptation}_{i,v} + \underbrace{\gamma X_{i,v}}_{\text{Controls}} + \underbrace{\sum \delta_j C_j}_{\text{Crop Mix Effect}} + \underbrace{\sum \mu_v V_v}_{\text{Village Effect}} + \varepsilon_{i,v}$$

- Our main interest is to obtain an estimate of β
- Issue:
  - Adaptation $\rightarrow$ Food Security
  - Food Security $\rightarrow$ Adaptation
- OLS delivers biased estimates of β

IV Estimation

- Instrumental Variable:
  - A variable that is correlated with Adaptation ...
  - ... but uncorrelated with unobserved determinants of food security

- Our IV: Adaptation level of neighbour networks



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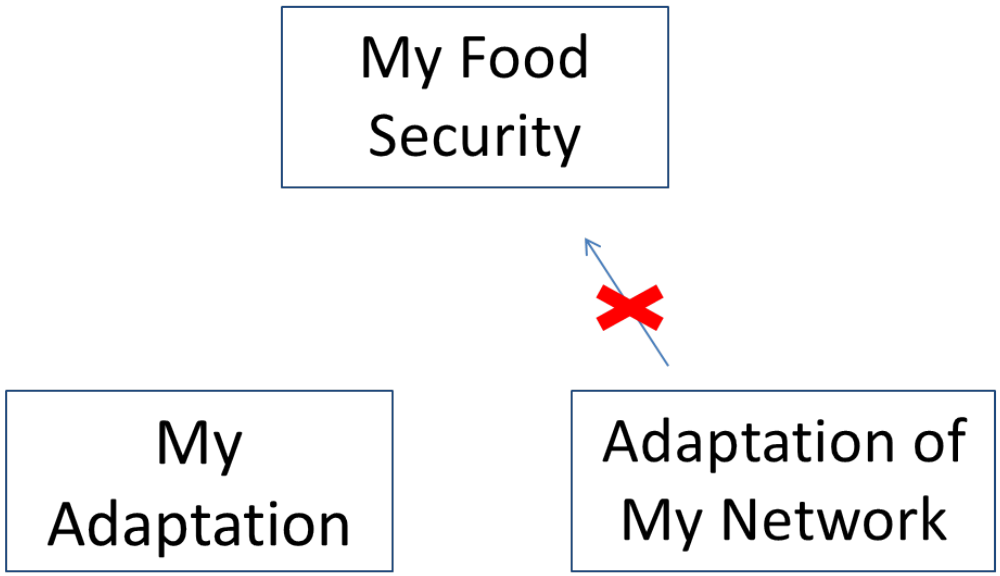

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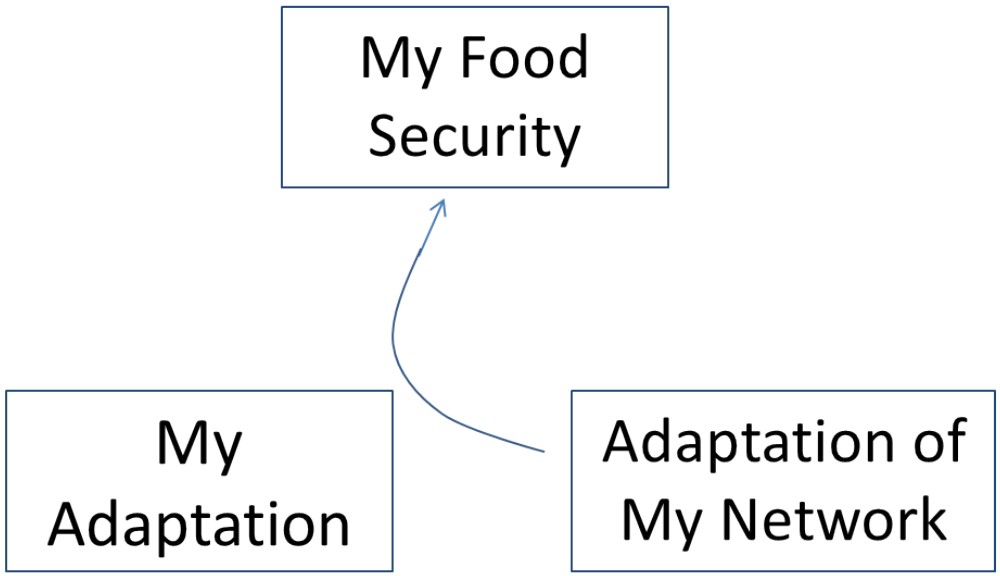

Two Statistical Tests

1. Test of endogeneity
   - H_o: Number of changed practices is exogenous
   - Reject null hypothesis that the number of changed practices is exogenous (p=0.0026)
2. Test of overidentifying restrictions
   - Joint H_o: Instruments are uncorrelated with the error term, and instruments are correctly excluded from the estimated equation
   - Fail to reject null hypothesis that our instruments are valid (p=0.6357)

Estimates of the Food Security Regression Model

	OLS	GMM/IV
Constant	171.155***	196.077***
	(29.409)	(26.676)
Adaptation	1.401**	5.520***
	(0.509)	(1.672)
Access to Information and Human capital		
Access to weather information	1.880	-2.787
	(4.511)	(4.256)
Membership in farming association(s)	0.383	-1.613
	(3.442)	(3.130)
Highest level of education attained is primary	9.172	6.708
	(5.280)	(4.823)
Highest level of education attained is secondary	0.973	-0.649
	(5.956)	(5.474)
Highest level of education attained is post-secondary	5.889	9.799
	(7.498)	(7.413)
Finance		
Access to agricultural credit	-0.602	-2.201
	(4.500)	(4.462)
Bank account	10.844	11.290*
	(5.558)	(5.617)
Cash from the government	15.633***	10.271*
	(4.187)	(4.538)
Income from non-farm employment	-3.152	-4.105
	(3.587)	(3.784)
Income from renting out land or machinery	0.710	-0.339
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Estimates of the Food Security Regression Model (cont)

	OLS	GMM/IV
ASSETS		
Count of production-related assets	-1.644	-2.623
	(1.835)	(1.941)
Count of nonproduction-related assets	6.679***	5.312**
	(1.600)	(1.617)
Livestock	9.971	7.881
	(6.410)	(5.940)
Motorcycle	-0.566	-2.308
	(4.839)	(4.378)
Car or truck	-6.170	-9.442
	(8.055)	(7.472)
Boat	25.811	43.812
	(20.628)	(27.437)
FARM AND HOUSEHOLD CHARACTERISTICS		
Running water	7.563	-6.137
	(6.127)	(7.591)
Storage facility for crops	3.756	1.326
	(4.457)	(4.869)
Planted trees	-2.257	-3.822
	(3.618)	(3.669)
Farm size	7.914***	11.161***
	(2.271)	(3.124)
Household size	-0.519*	-0.600*
	(0.250)	(0.236)
Female-headed	-2.507	-4.801
	(5.492)	(5.250)

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	OLS	GMM/IV
Farming and Crisis Experience		
Farming experience is at least ten years	14.799*	10.176
	(7.390)	(8.331)
Experienced climate crisis in the last five years	-12.868***	-11.438**
	(3.785)	(3.657)
Stated Reasons for Adaptation		
Market conditions	-11.344**	-20.408***
	(4.169)	(5.702)
Climate variability	9.230*	3.304
	(4.242)	(5.029)
Pests and disease	-6.039	-12.798**
	(4.113)	(4.964)
Government/NGO intervention	-4.257	-8.905
	(4.386)	(5.529)
Labor availability	-0.152	-6.807
	(3.632)	(4.152)
Land productivity	-9.618*	-13.536***
	(3.837)	(3.898)
F-statistic of the first-stage regression		160.85

Robust standard errors are reported in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

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Summary of Results

- From data: average household has 263 food secure days

- From our estimates (on average):

$$\underbrace{196}_{\text{Baseline}} + \underbrace{50}_{\text{Adaptation}} + \underbrace{3}_{\substack{\text{Bank}\\\text{Account}}} + \underbrace{2}_{\substack{\text{Cash}\\\text{Govt}}} + \underbrace{13}_{\substack{\text{Nonprod}\\\text{Assets}}} + \underbrace{22}_{\substack{\text{Farm}\\\text{Size}}} = 286 \text{ days}$$

$$- \underbrace{6}_{\substack{\text{HH}\\\text{Size}}} - \underbrace{8}_{\substack{\text{Climate}\\\text{Crisis}}} - \underbrace{13}_{\substack{\text{Market}\\\text{Conditions}}} - \underbrace{3}_{\substack{\text{Pests and}\\\text{Diseases}}} - \underbrace{6}_{\substack{\text{Land}\\\text{Productivity}}} = 250 \text{ days}$$

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Thank you

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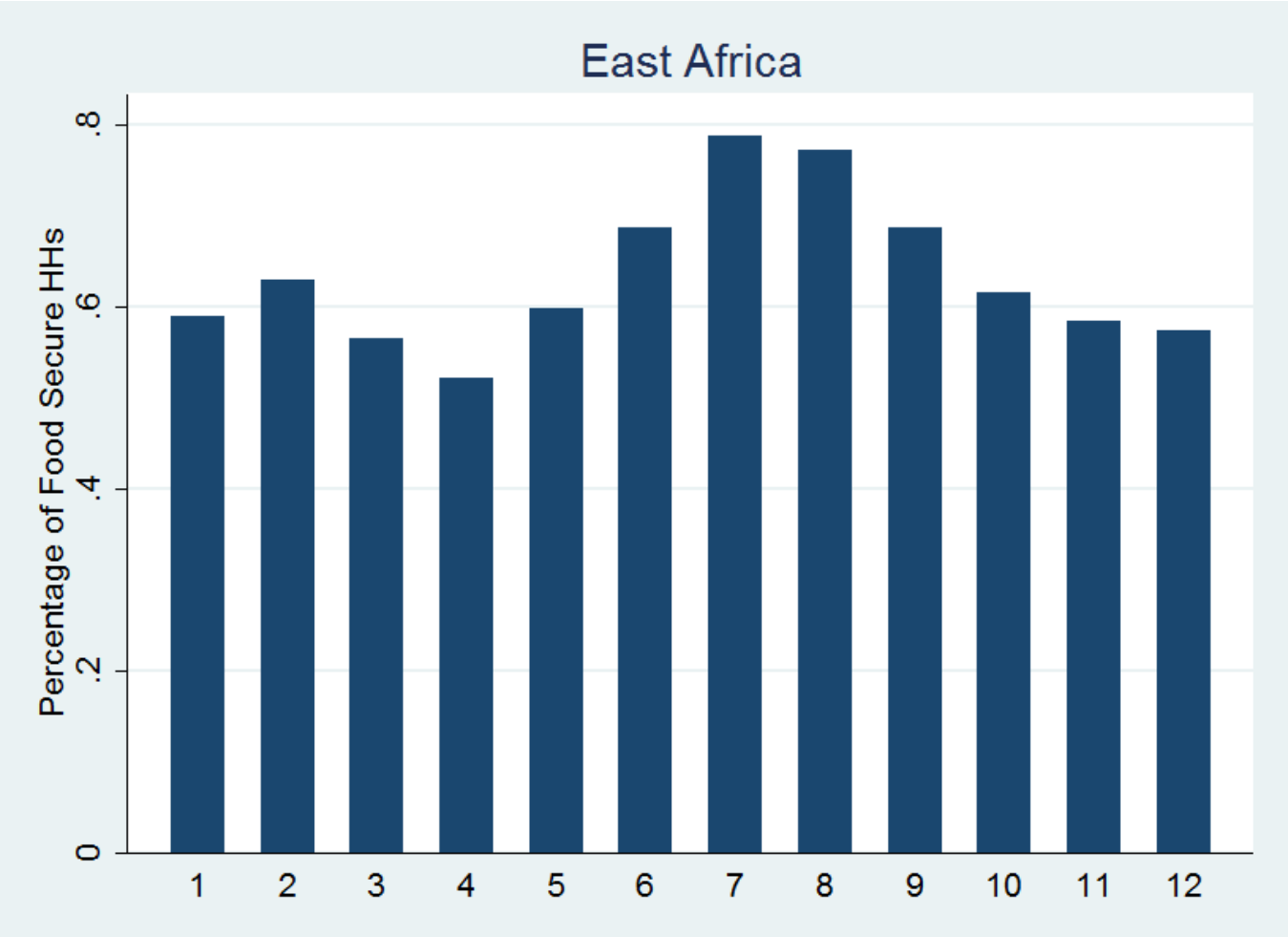
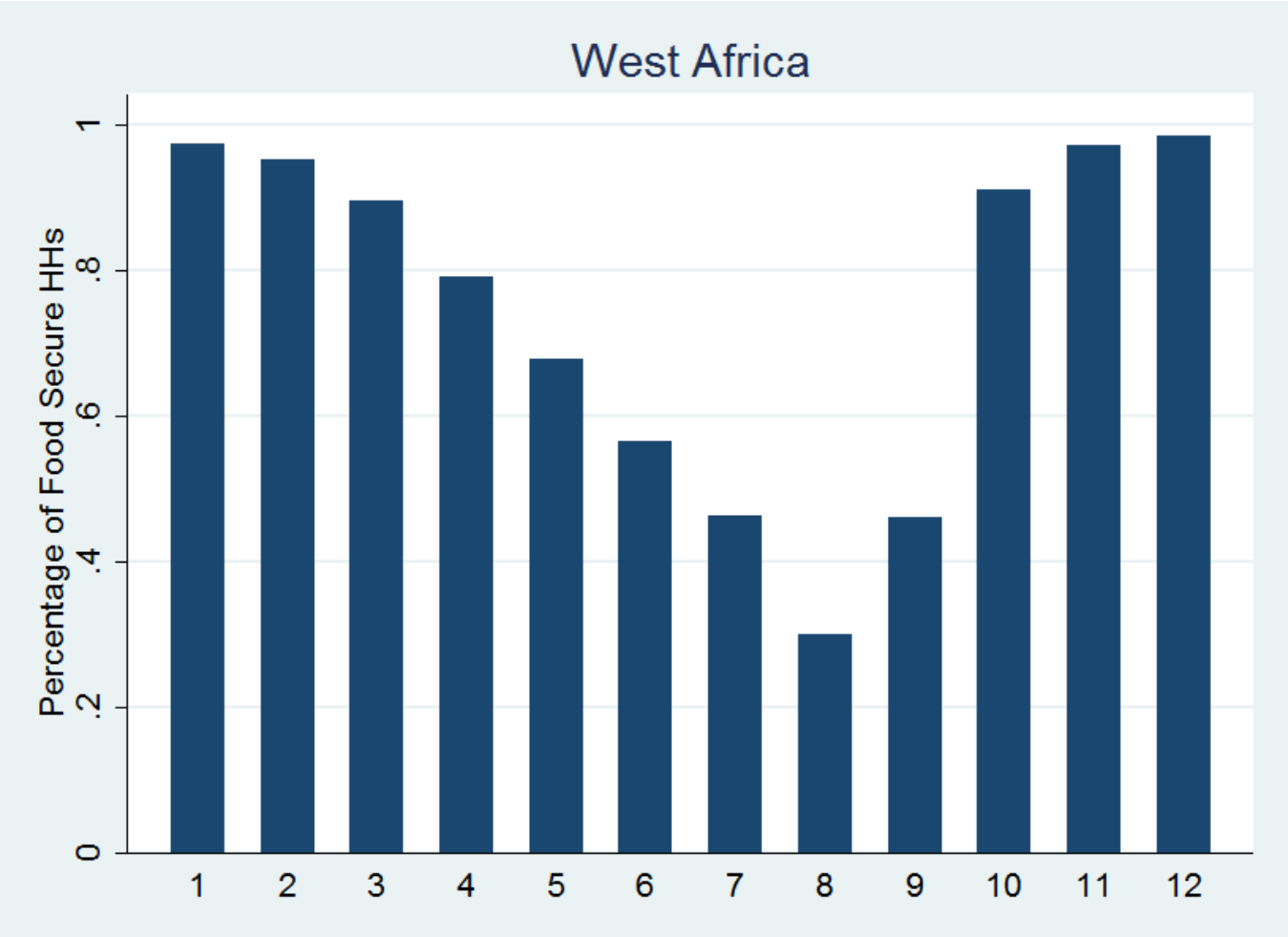
Future Research: look at FS over the year



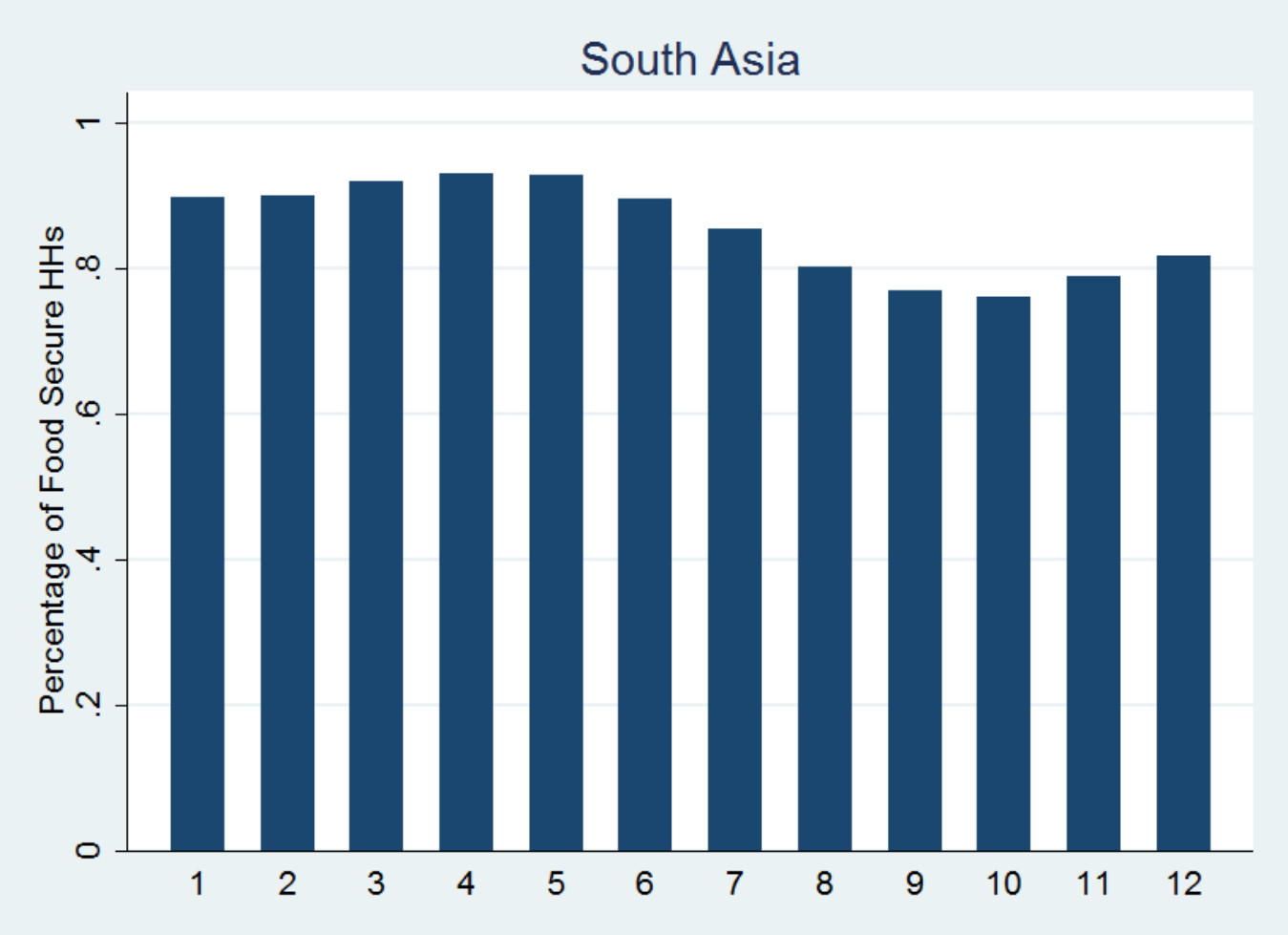
- Average: 65% of HHs are food secure
- Most Vulnerable Month: April

Future Research: look at FS over the year



- Average: 75% of HHs are food secure
- Most Vulnerable Month: August

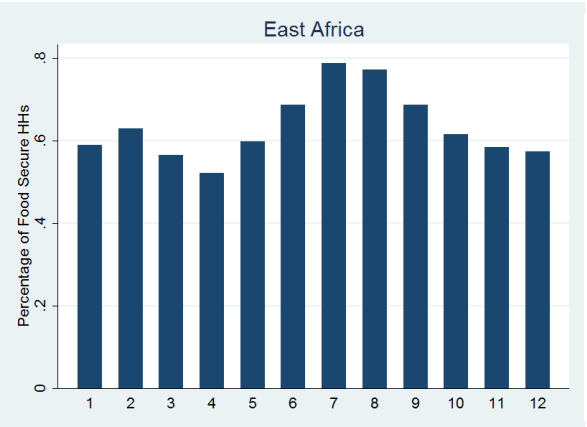
Future Research: look at FS over the year

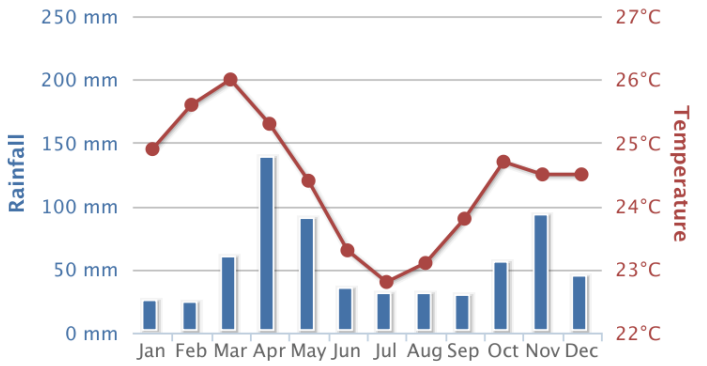


- Average: 85% of HHs are food secure
- Most Vulnerable Month: October

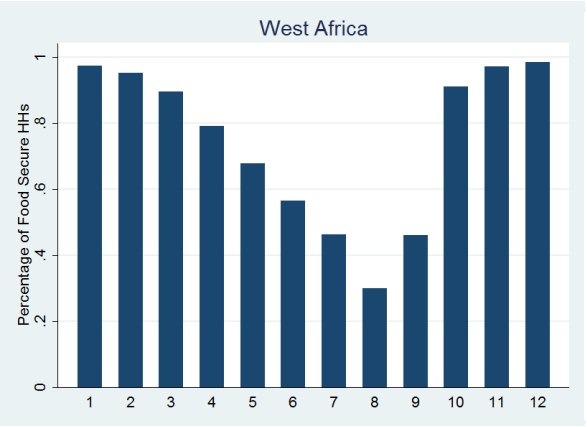
Future Research: Why? Crop? Weather?

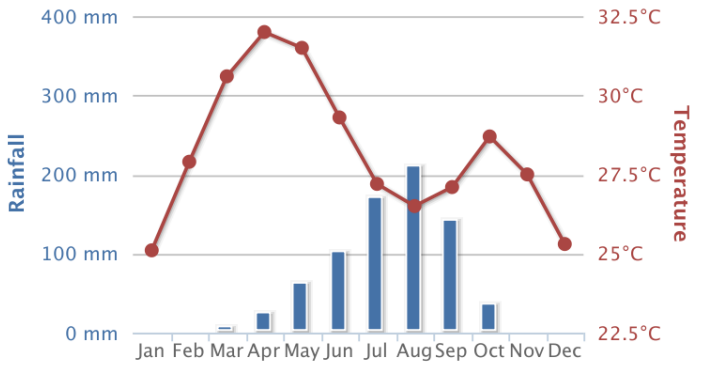
East Africa:
Millet, Cabbage



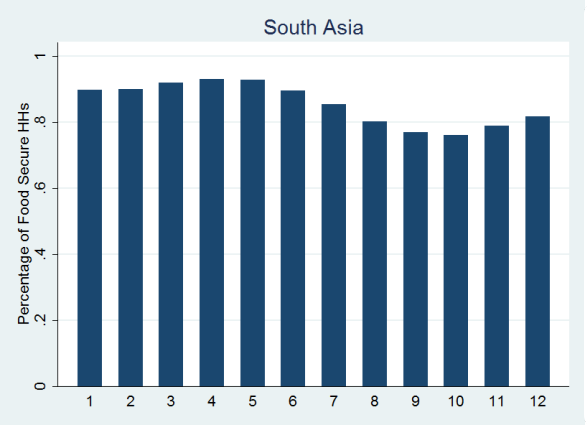


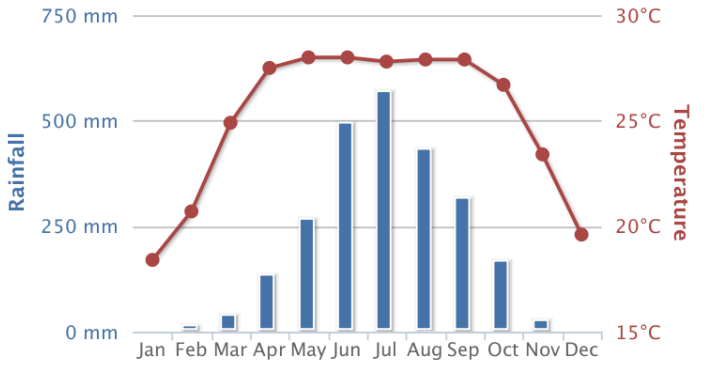
West Africa:
Sweet Potato, Millet





South Asia:
Rice, Banana





Thank you

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