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Land constraints in Africa and their implications for development

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Some brief background

- ❑ Going to present 1.5 papers from a forthcoming special issue of *Food Policy* on emerging land issues in sub-Saharan Africa
- ❑ Motivation for this special was dissatisfaction
- ❑ Dissatisfaction with the common idea that Africa is land abundant; or that land doesn't impose any constraints on African development
- ❑ My co-editors and I believed this was a fundamentally flawed perspective of African development
- ❑ Land constraints under-emphasized in the academic and policy discourse on ag development in Africa



Some brief background

- Gates Foundation funded a project to explore the importance of land in Africa's development
- 1. Cross-country work testing how African countries have responded to rising land constraints***
- 2. Cross-country work exploring the potential for profitable land expansion**
- 3. Series of case studies examining 1 & 2*
- 4. Various thematic papers on land institutions, mechanization, large farm investments



Outline for today's talk

1. Introduction - motivations and theories
2. Land expansion – draw on different types of data to retrospectively and prospectively assess this issue
3. Agricultural intensification – does Boserup's theory apply in Africa?
4. Nonfarm diversification
5. Demographic responses – desired & achieved rural fertility rates
6. Conclusions



1. Introduction

- ❑ Some 215 years ago, Malthus argued that pop. growth cyclically outstrips agricultural productivity
- ❑ In much of the world, economic history has not been kind to Malthus, because of “induced innovations”
- ❑ But what about Africa?
 1. Very poor and vulnerable; poverty still heavily rural
 2. Mixed success/potential with agric. intensification
 3. Very limited success with industrialization
 4. Population to double by 2050
 5. Land/water is a constraint for many, many Africans



1. Introduction

- ❑ This paper seeks to understand how countries adopt to population pressures & ask “Is Africa different?”
- ❑ Framework based on decomposing growth in farm income:

$$\Delta \ln \frac{\text{Output}}{\text{Pop.}} \equiv \Delta \ln \frac{\text{Land}}{\text{Pop.}} + \Delta \ln \frac{\text{Output}}{\text{Land}}$$

Growth in rural population is the sum of fertility & net migration:

$$\approx \Delta \ln \frac{\text{Output}}{\text{Land}} + \Delta \ln \text{Land} - \Delta \ln \text{fertility} - \Delta \ln \text{migration}$$

Shrinking farm sizes

The diagram illustrates the relationship between farm size and population growth components. A central box labeled "Shrinking farm sizes" has four arrows pointing to the terms in the equation above: $\Delta \ln \frac{\text{Output}}{\text{Land}}$, $\Delta \ln \text{Land}$, $\Delta \ln \text{fertility}$, and $\Delta \ln \text{migration}$. This indicates that shrinking farm sizes influences all four components of the equation.



1. Introduction

- ❑ In terms of data and methods, we make use of FAOSTAT ag production and land data, GIS data, census & survey data on farm sizes, DHS data on rural fertility rates & occupations, some WB data on remittances
- ❑ On methods, our approach is fairly exploratory
- ❑ Establishing causation is an under-recognized problem with Boserup's theory
- ❑ IV not plausible, but we try to at least minimize some of the obvious biases
- ❑ I am not going to focus much on methods or data in the presentation, but we acknowledgeable some of the results we derive are contestable



2. Land expansion

- ❑ If farm sizes are shrinking, why not expand land use?
- ❑ Africa is typically thought of as land abundant
- ❑ In widely cited work on large farm investments, Deininger & Byerlee estimate that Africa has more underutilized arable land than any other continent:
198-446 million hectares
- ❑ Two issues with these statistics
 1. It neglects the heterogeneity within Africa: Congo is land abundant, neighboring Rwanda isn't
 2. Biological, economic and institutional potential of this land is debatable



2. Land expansion

- ❑ Let's focus on the heterogeneity
- ❑ We collected FAO farm census data, augmented it with survey data from MSU and IFPRI, cross-checked it against FAOSTAT data of dubious quality

Region	Period	Hectares per agric. worker (FAO)	Hectares per holding (censuses)
Africa - high density ^b (n=5)	1970s	0.84	1.99
	2000s	0.58	1.23
Africa - low density ^b (n=11)	1970s	1.65	2.65
	2000s	1.37	2.82
South Asia (n=5)	1970s	0.78	2.01
	2000s	0.55	1.19
China & S.E. Asia (n=4)	1970s	0.80	2.08
	2000s	0.68	1.58



2. Land expansion

❑ Retrospective facts:

1. Farm sizes are shrinking in high-density Africa; on par with South Asia, and even smaller than East Asia
2. Farm sizes are unchanged (on average) in low density Africa, but still very small on average. In these countries land may be a constraint, but more likely power (labor, draft, machinery)



2. Land expansion

- ❑ What can we say prospectively about land expansion?
- ❑ We revisit the Deininger-Byerlee analysis
- ❑ They use a simple approach:
 - FAO-IIASA estimates of potential for 9 crops
 - Rural pop. density < 25 people per sq km (“unused”)
 - Forest and non-forest land
 - Travel time to cities < 6 hours
- ❑ Their analysis was perfectly sensible in the context of assessing long run land potential
- ❑ Much more questionable that it says anything about the prospects for smallholders



2. Land expansion

- ❑ Our approach builds on this earlier work:
- ❑ Newer, higher resolution data
- ❑ We develop a simple model of economic potential based on what we think are realizable yields, and plausible impacts of remoteness on prices
- ❑ Allows us to separate what is achievable in the long run (farmers moving towards tech frontier, lack of roads not a binding constraint) versus the short run
- ❑ We specifically focus on smallholder expansion
- ❑ Still working on a large holder model

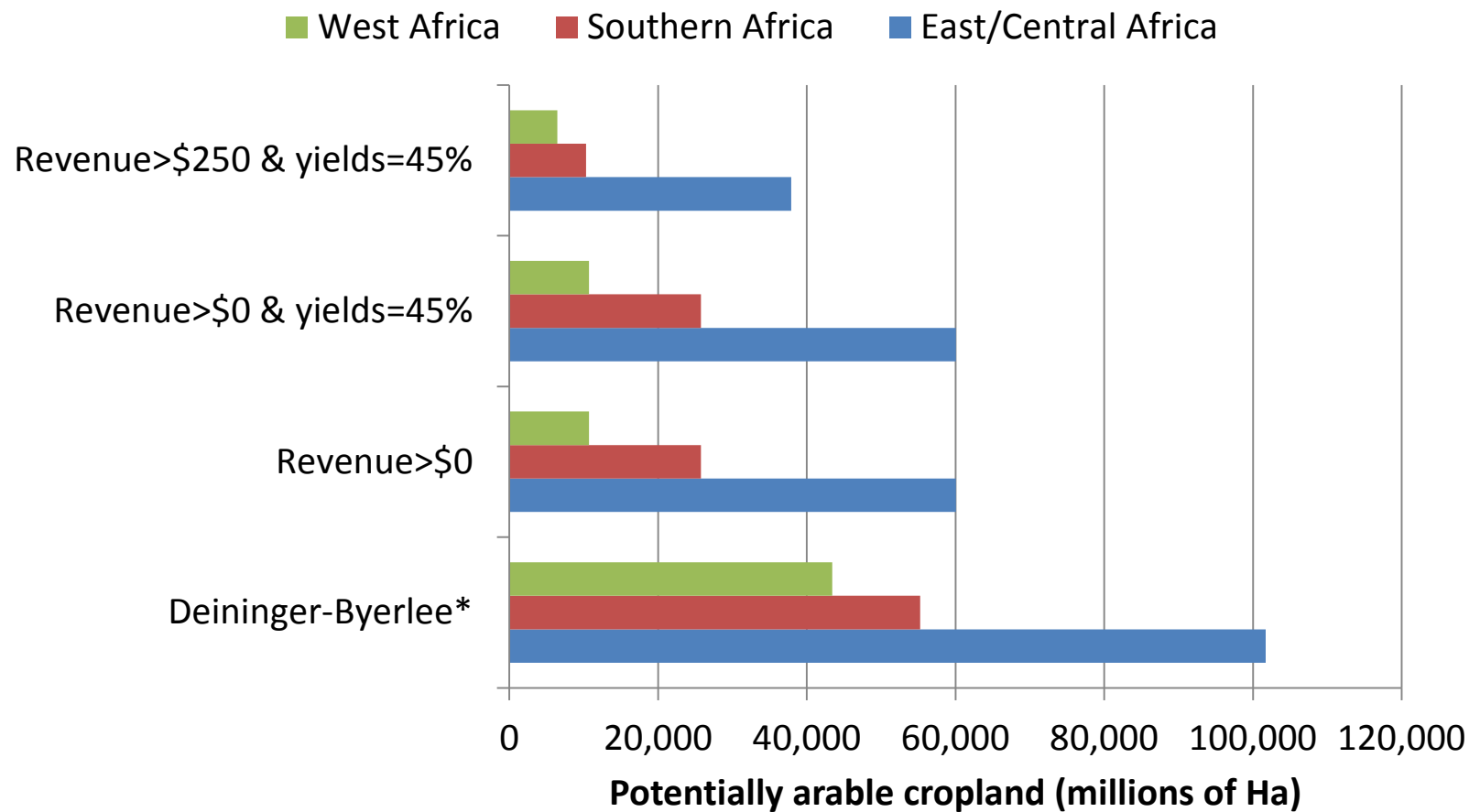


2. Land expansion

- ❑ The economic model is based:
 1. IIASA estimates of crop yields
 2. Assumptions of low intermediate inputs
 3. Farmers achieve 40% of potential yields
 4. Distance decay function of prices
 5. Cost of production data from Zambia
- ❑ We also discuss other constraints: tsetse fly, malaria, institutional barriers, etc
- ❑ But these are not yet in the model



F1. Potential cropland under different assumptions



Notes: These estimates apply to non-forested area



2. Land expansion

- ❑ The unused land is in a handful of countries
- ❑ In the Deininger-Byerlee approach, 50% of potentially arable cropland is in the two Congos, Madagascar, Central African Republic
- ❑ Tightening the criteria pushes this to 70%, then 86%
- ❑ So there's some obvious institutional constraints to international migration, and even intra-national migration in ethnically diverse countries
- ❑ Sizeable costs to land preparation in some contexts
- ❑ Focus groups in country studies emphasized malaria, tsetse fly and isolation as most important constraints



2. Land expansion

- ❑ Prospective “facts”:
 1. In the long run, Africa is land abundant, but most of this potentially arable cropland is in a few countries
 2. In the short run, very few African countries have the infrastructure in place to facilitate land expansion
 3. Disease burdens, costs of transition to new areas also would appear to be major constraints
- ❑ These facts are consistent with declining farm sizes in many African countries, including countries with apparent land abundance (e.g. Madagascar, DRC)



3. Agricultural intensification

- ❑ Boserup (1965) was the first to hypothesize that as land constraints bind, farmers endogenously intensify production techniques
- ❑ von Thunen (1818) had similar hypothesis with respect to market access
- ❑ Binswanger and colleagues attempted to generalize these theories, and gave supporting evidence
- ❑ But they were also cautious to emphasize that very rapid population growth may not induce successful intensification



3. Agricultural intensification

- ❑ Many potential indicators of intensification
- ❑ In the framework above, the most welfare-relevant indicator of intensification is just output per hectare
- ❑ Boserup focused more on cropping intensity, and the ag-econ profession & CGIAR focus a lot at yields and other modern inputs, particularly fertilizers & seeds
- ❑ Binswanger et al. emphasize labor-saving inputs, including draught animals, pesticides, herbicides
- ❑ But switching to high value crops is obviously also a potentially important adaptation, especially in SSA.
- ❑ All of these are to some extent measurable in FAO data



3. Agricultural intensification

- ❑ Data is measured in 10 year periods over 1977, 1987, 1997 and 2007
- ❑ Econometric framework is basic:
$$\Delta \ln \frac{\text{inputs}}{\text{land}} = \varepsilon \Delta \ln \frac{\text{Pop.}}{\text{Land}} + \varepsilon_{SSA} \Delta \ln \frac{\text{Pop.}}{\text{Land}} \cdot \text{Africa} + \mu \cdot \text{Africa}$$
- ❑ First differences to get rid of fixed effects, but μ picks up Africa-specific trends
- ❑ The interaction term tests whether Boserupian intensification is somehow different in Africa
- ❑ But I almost never find this is significant
- ❑ Obviously still caveats, such as policy unobservables



Table 3. First differenced regressions of intensification indicators against agricultural population density, with SSA interaction terms

Y vars	Capital per pha	Non-land capital pha	Cattle pha	Nitrogen pha	Cereal output pha
$\Delta \ln$ density	0.16***	0.17***	0.48***	0.99***	-0.04
	(0.03)	(0.06)	(0.09)	(0.32)	(0.10)
SSA trend	-0.03	0.09	-0.17	-1.15**	0.00
	(0.05)	(0.08)	(0.14)	(0.50)	(0.15)
Y vars	Crop intensity	Nonfood output (%)	Non-cereal output pha	Crop output pha	Total output pha
$\Delta \ln$ density	0.35***	0.25*	0.24**	0.36***	0.35***
	(0.10)	(0.13)	(0.11)	(0.10)	(0.09)
SSA trend	-0.02	-0.32	-0.16	-0.18	-0.07
	(0.16)	(0.20)	(0.16)	(0.15)	(0.13)



3. Agricultural intensification

- ❑ So Boserup's theory is broadly supported by the data, seemingly holds as well in Africa as other regions
- ❑ But two key differences are the very low rates of fertilizer use and irrigation in African countries
- ❑ Several theories out there to explain fertilizer use
 1. African soils fundamentally poor (Voortman et al.)
 2. Nutrient mining, low organic matter (Drechsel et al.)
 3. Less irrigation
 4. Lower quality seeds
 5. Supply side factor (e.g. transport costs)

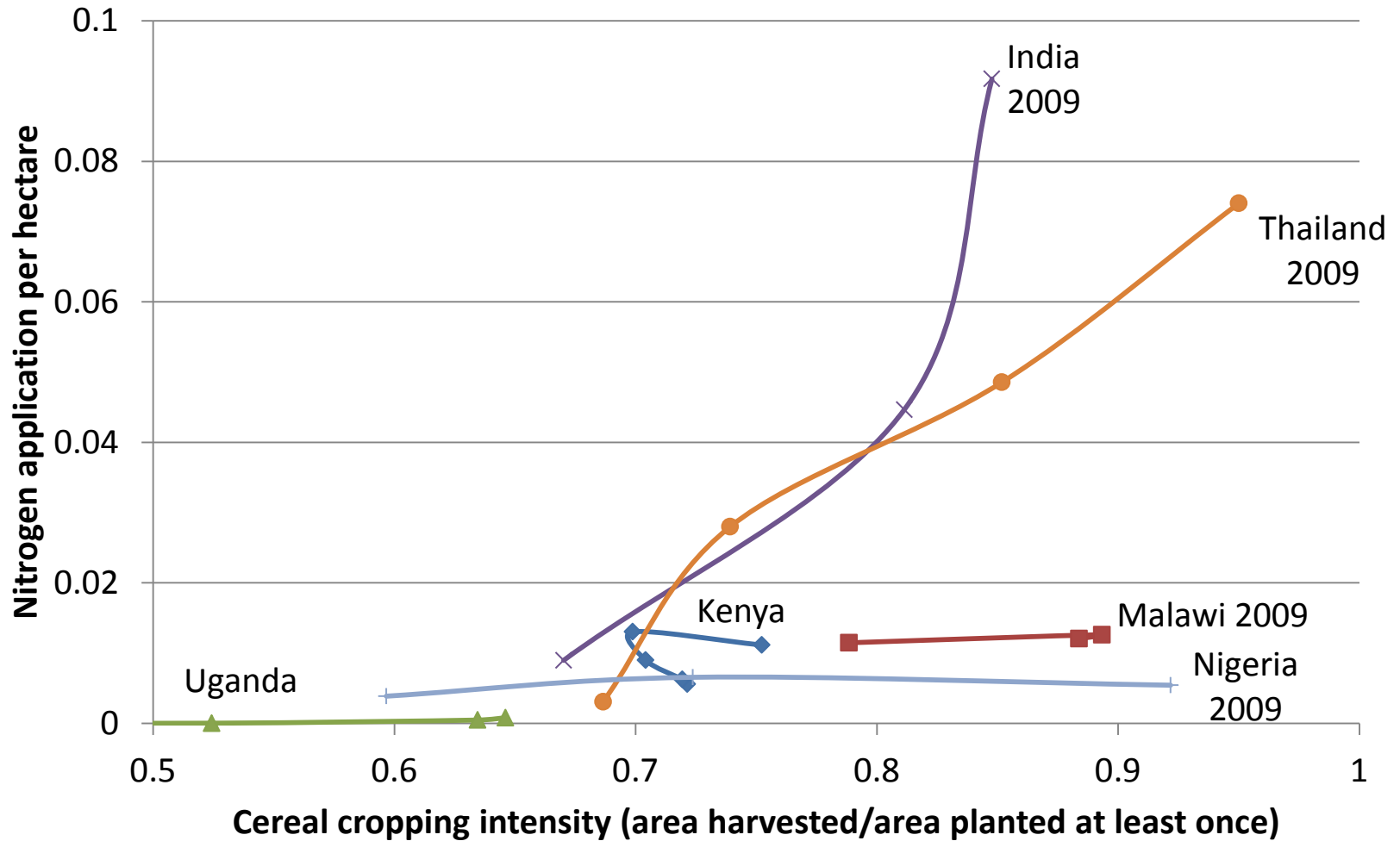


3. Agricultural intensification: Fertilizers

- ❑ All of these constraints may be relevant, but a particularly disturbing trend is the combination of increased cropping intensity and low fertilizer use
- ❑ Drechsler et al & Barrett type work is fairly convincing on this point
- ❑ FAO data – limited as they – also point to this disturbing trend



F2. Trends in fertilizer use and cropping intensity

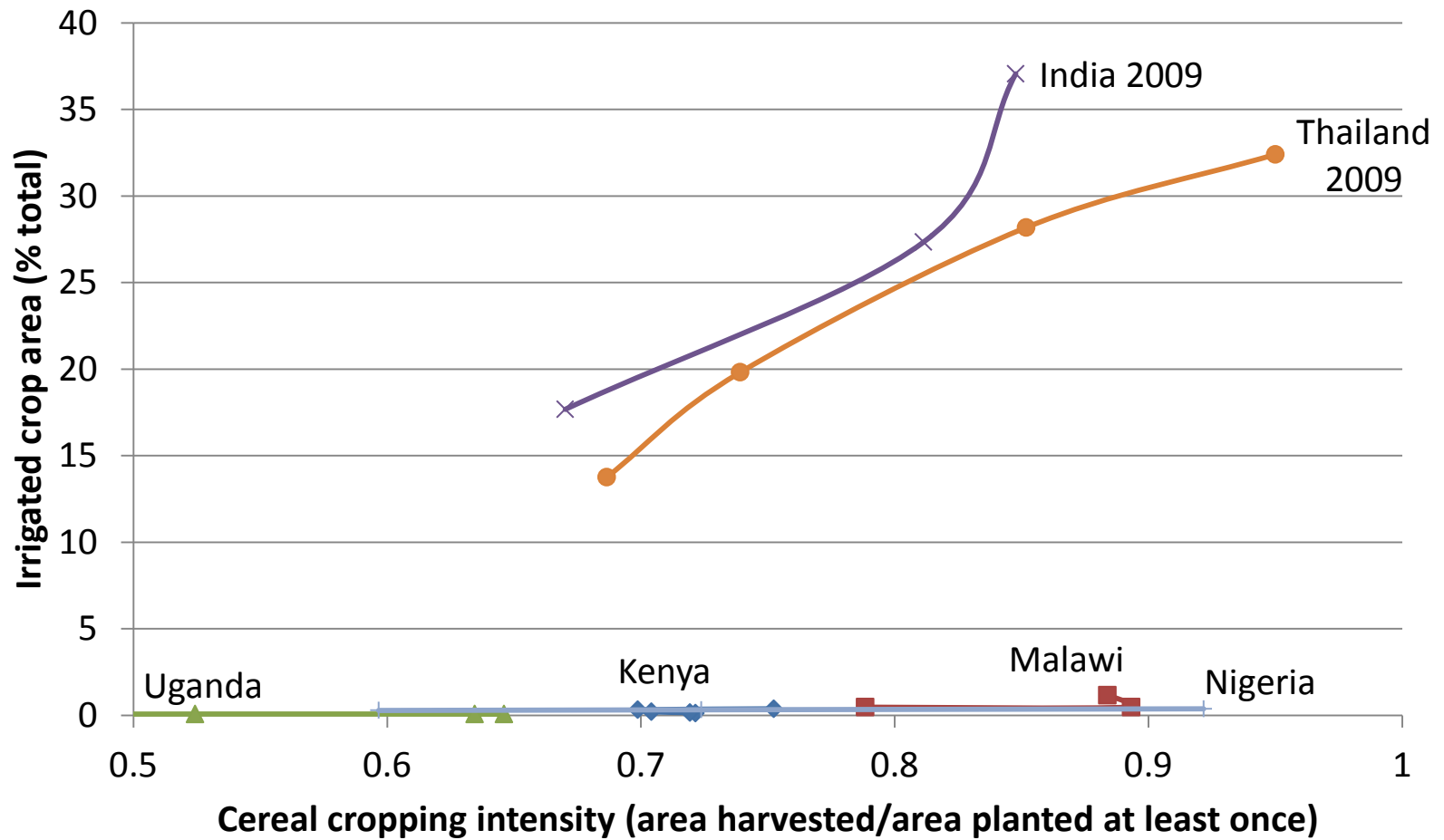


3. Agricultural intensification: Irrigation

- ❑ Irrigation is surely another fundamental difference between small farm Africa and small farm Asia
- ❑ Irrigation accounts for a fraction of cropland in Africa, and estimates of irrigation potential vary widely
- ❑ Hydrological estimates suggest irrigation potential in Africa is good, but economic estimates suggest the potential is limited (You et al 2009)
- ❑ Irrigation is not the low hanging fruit it was in Asia



F3. Trends in Irrigation and cropping intensity



3. Agricultural intensification

- ❑ Finally, what are the welfare implications of intensification?
- ❑ The elasticity of gross farm output per hectare with respect to population density is about 0.35
- ❑ In other words, as farm sizes shrink by 1%, gross farm output per hectare increases by 0.35%, and farm output per capita decreases by 0.65%
- ❑ This is gross farm income – elasticity of net farm income will vary between 0 and 0.35
- ❑ Case study estimates suggest the elasticity for net farm income is close to zero



3. Agricultural intensification

- ❑ So, on average, intensification helps prevent catastrophic income loss
- ❑ But without other drivers of income growth it would not be strong enough to prevent major declines in income



4. Nonfarm diversification

- ❑ Much neglected in 1980s literature on Boserup
- ❑ Subsequent literature on rural non-farm (RNF) sector shows non-farm income is big in rural areas of LDCs
- ❑ But not much specific literature looking at pop density
- ❑ Often suggested there is a U-shaped relationship between farm size and RNF employment: landless poor are pushed into RNF, rich are pulled in
- ❑ Do high density rural areas see more out-migration?
- ❑ Difficult to tell with domestic migration, but int. migration boomed in last 20 years; e.g. remittances now 22% of rural income in Bangladesh.



Table 9. Speculative estimates of rural nonfarm employment shares for men and women in the 2000s

<u>High density Africa</u>			<u>Low density Africa</u>			<u>Other LDCs</u>		
Country	W	M	Country	W	M	Country	W	M
Benin	50.4	23.7	Burkina Faso	12.9	8.1	BGD	53.4	44.5
Congo (DRC)	14.0	23.5	Chad	13.7	9.6	Bolivia	71.4	25.9
Ethiopia	34.3	9.7	Cote d'Ivoire	31.7	22.1	Cambodia	36.0	
Kenya	47.1	37.3	Ghana	50.1	26.6	Egypt	69.4	
Madagascar	17.8	15.3	Mali	44.6	16.0	Guatemala	79.1	
Malawi	41.5	36.0	Mozambique	5.2	23.0	Haiti	24.0	19.0
Nigeria	65.5	37.0	Niger	60.2	35.8	India	22.4	
Rwanda	7.3	14.2	Senegal	63.7	37.1	Indonesia	59.2	39.5
Sierra Leone	25.2	20.1	Tanzania	7.2	10.5	Nepal	90.5	34.2
Uganda	15.5	20.3	Zambia	30.1	19.5	Philippines	16.2	42.6



Table 11. Elasticities between RNF employment indicators and rural population density for women and men

Regression No.	R1	R2	R3	R4	R5	R6
Sample	Women	Women	Women	Men	Men	Men
Population density	0.47	0.09	0.15	-0.33	-0.32	-0.31
Density*Africa	-0.19**	-0.22**	-0.15*	0.03	-0.02	-0.02
Africa dummy	-0.25	0.1	0.04	-0.43	0.09	0.09
Sec. educ. by gender		0.03	0.11		0.35***	0.35***
Road density		0.14*	0.15**		0.17*	0.17*
Electricity		0.20**	-0.07		0.09	0.09
Ag. Output/worker, log			0.46***			0.01
No. Obs.	162	122	95	74	74	74
R-square	0.2	0.53	0.24	0.55	0.55	0.55



4. Nonfarm diversification

- ❑ We also know that structural transformation has been very slow in Africa, particularly lack of a manufacturing sector
- ❑ And contrary to UN estimates, demographers have suggested that rural-urban migration has not been unusually quick in Africa
- ❑ Thus there are little signs of modern industrial or service sectors pulling rural labor into cities
- ❑ What about international labor markets?
- ❑ Very important for South Asian countries, and also Philippines, Vietnam



Figure 6. National remittances earnings (% GDP) and rural population density

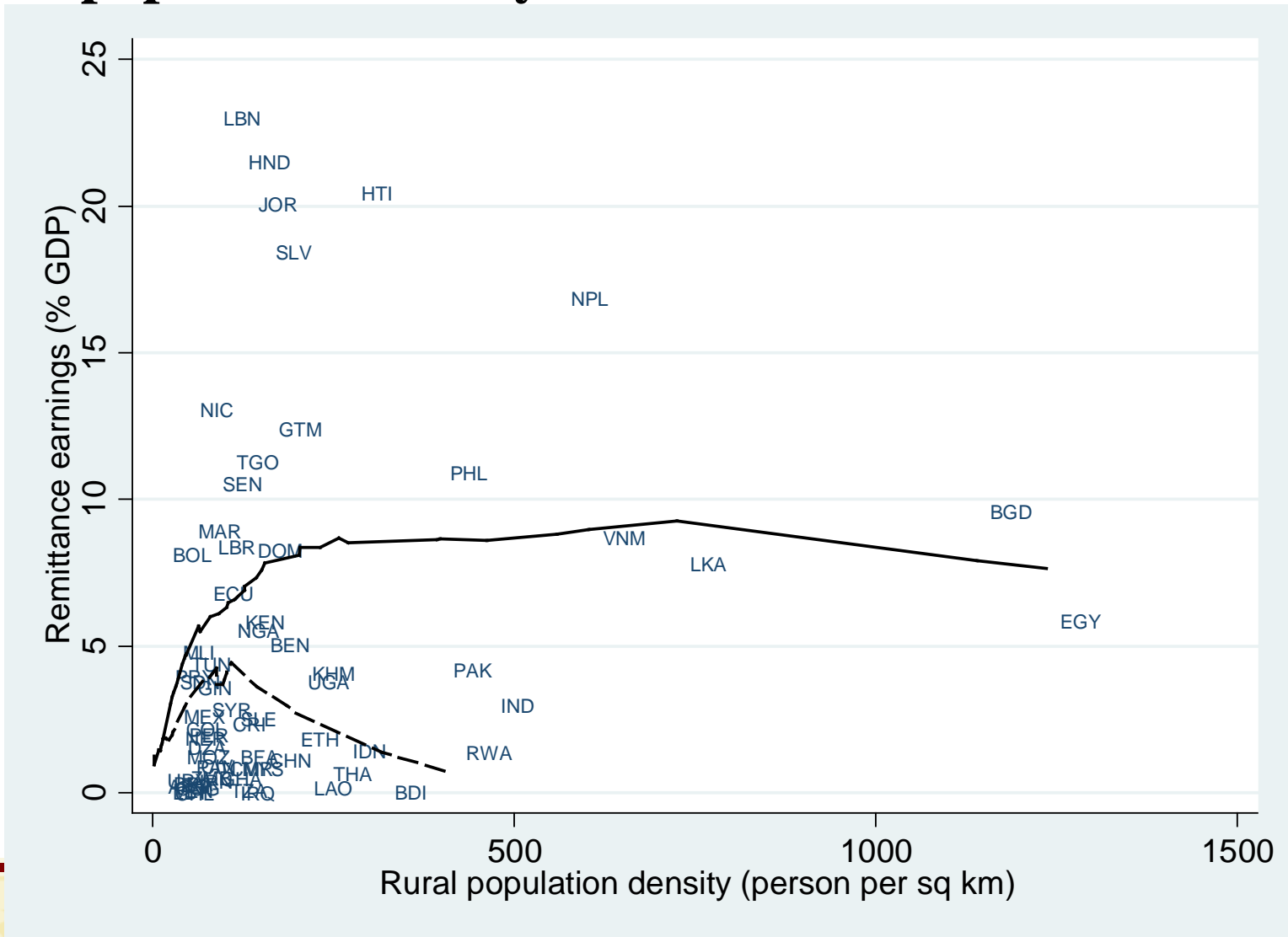


Table 11. Estimating elasticities between national remittance earnings (% GDP) and population density

Estimator	Robust
Structure	First difference
Density variable	Rural
Population density	1.17***
Population density*Africa	-1.22**
Total population	-0.82
Lagged remittances	-0.24***
Lagged population density	0.06
1987-97 dummy	-0.06
1997-2007 dummy	0.24*
Number of observations	159
R-square	0.22



4. Nonfarm diversification

- ❑ The nonfarm sector isn't looking like much of a release valve in Africa
- ❑ This poses a number of questions
- ❑ Is more investment needed in rural infrastructure and services?
- ❑ Why is industrialization floundering?
- ❑ To what extent can Africa tap into overseas labor markets more?



5. Reducing rural fertility rates

- ❑ Reducing fertility rates is a response to land constraints that is entirely consistent with Becker-type theories of fertility as a choice variable
- ❑ Yet not really examined in ag. or dev. Economics
- ❑ We ask 2 questions
 - 1) Do land constraints reduce *achieved* fertility rates?
 - 2) Do land constraints reduce *desired* fertility rates?
- ❑ A difference between desired & achieved fertility rates is termed the “unmet need for contraception”.
- ❑ Suggests scope for policy interventions



Figure 3. Rural fertility rates and rural population density

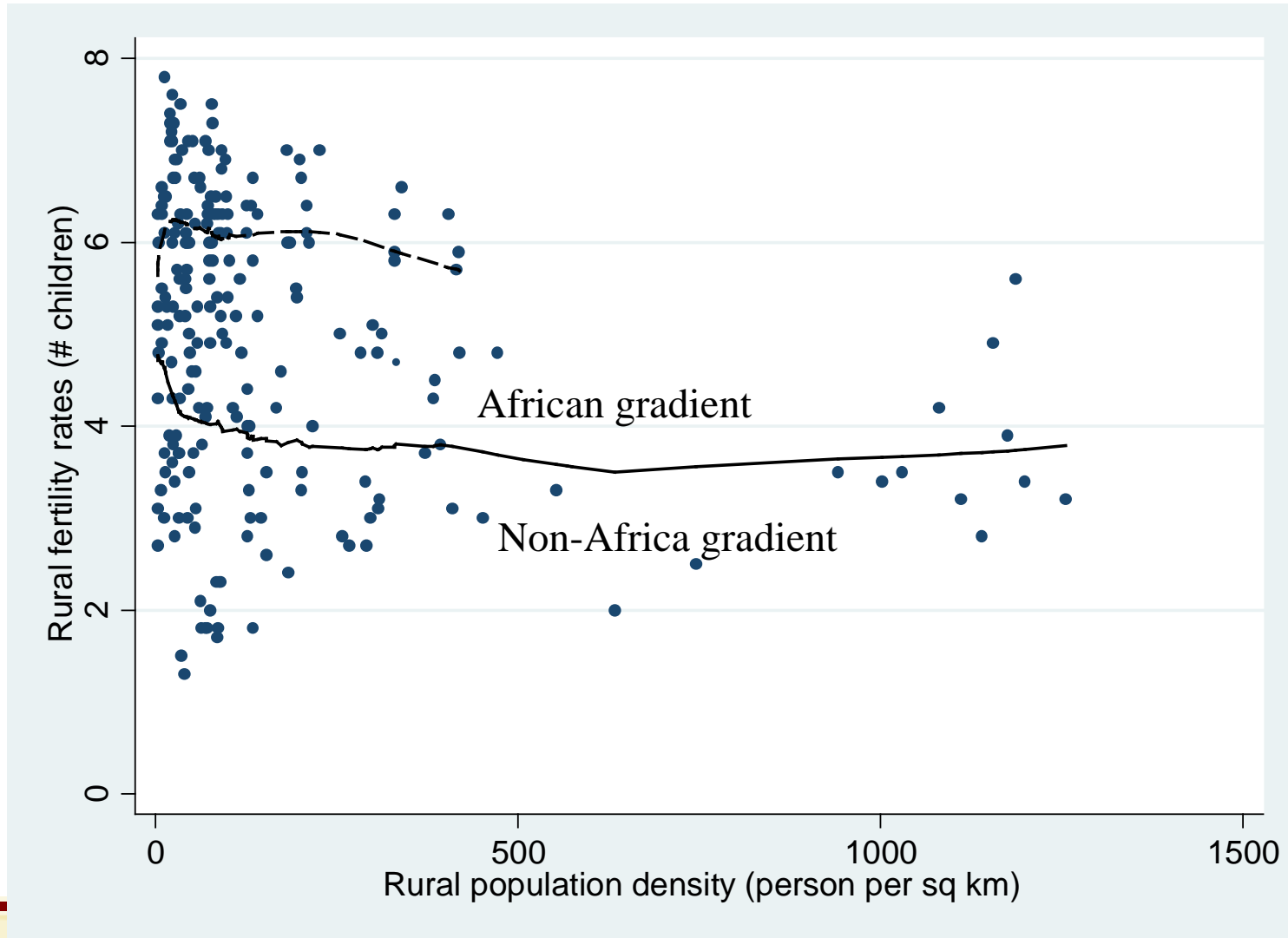


Table 8. Elasticities between rural fertility indicators & rural population density

Regression number	1	2	3	4
Dependent variable	Actual fertility	Actual fertility	Desired fertility	Desired fertility
Model	Linear	Log-log	Linear	Log-log
	b/se	b/se	b/se	b/se
Pop density (per 100 m ²)	-0.14***	-0.09***	-0.11***	0.00
Density*Africa	0.05	0.09***	-0.34***	-0.07***
Female sec. education (%)	-0.02***	-0.05***	-0.01**	-0.08***
Ag. output per worker, log	-0.58***	-0.13***	0.01	0.06***
Africa dummy	1.25***	-0.15	2.13***	0.67***
Number of observations	165	165	164	164
R-square	0.75	0.76	0.77	0.81



5. Reducing rural fertility rates

- ❑ So high density African countries have a huge unmet demand for contraception
- ❑ Suggests that family planning interventions in these countries would be efficacious
- ❑ Existing literature suggests there is a big demographic dividend to reducing fertility rates quickly (Bloom & Williamson 1998)
- ❑ Asian countries also saw family planning as a response to land pressures



6. Conclusions

- ❑ Land pressures are severe in much of Africa, esp. high density SSA, where small farms are getting smaller, and will presumably continue to get smaller
- ❑ Yet history shows that rural people are generally resourceful in adapting to mounting land constraints (though Boserupian intensification is only part of it)
- ❑ The question we posed is whether Africa is different
- ❑ In many ways, the answer is yes . . .



6. Conclusions

Adaptation 1 - Land expansion

- Available land very isolated
- Disease burdens make land expansion unattractive
- Potentially arable cropland highly concentrated in a few countries, several beset by conflict
- Potential for smallholder expansion pretty limited in the short to medium term
- Seems to explain the clustering of Africa's rural populations in high density areas



6. Conclusions

- ❑ **Adaptation 2- Agricultural Intensification**
- ❑ African agriculture has increased cropping intensity, but without increase use of fertilizers or irrigation
- ❑ Fertilizer literature points to nutrient mining and low returns to chemical fertilizer as a result
- ❑ Caught in a poor soils poverty trap?
- ❑ Irrigation potential uncertain, but less than Africa
- ❑ How much more can cropping intensity be increased without larger irrigation investments?



6. Conclusions

- ❑ **Adaptation 3 – Nonfarm diversification**
- ❑ Appears that the nonfarm sector doesn't just grow without engines: education, infrastructure, agriculture, manufacturing
- ❑ Boom in overseas migration and implications for rural development remittances is new & unexpected.
- ❑ 20 years ago, BGD and Pakistan were regarded as too big to benefit from remittances. Not true now.
- ❑ Why isn't Africa getting more remittances?

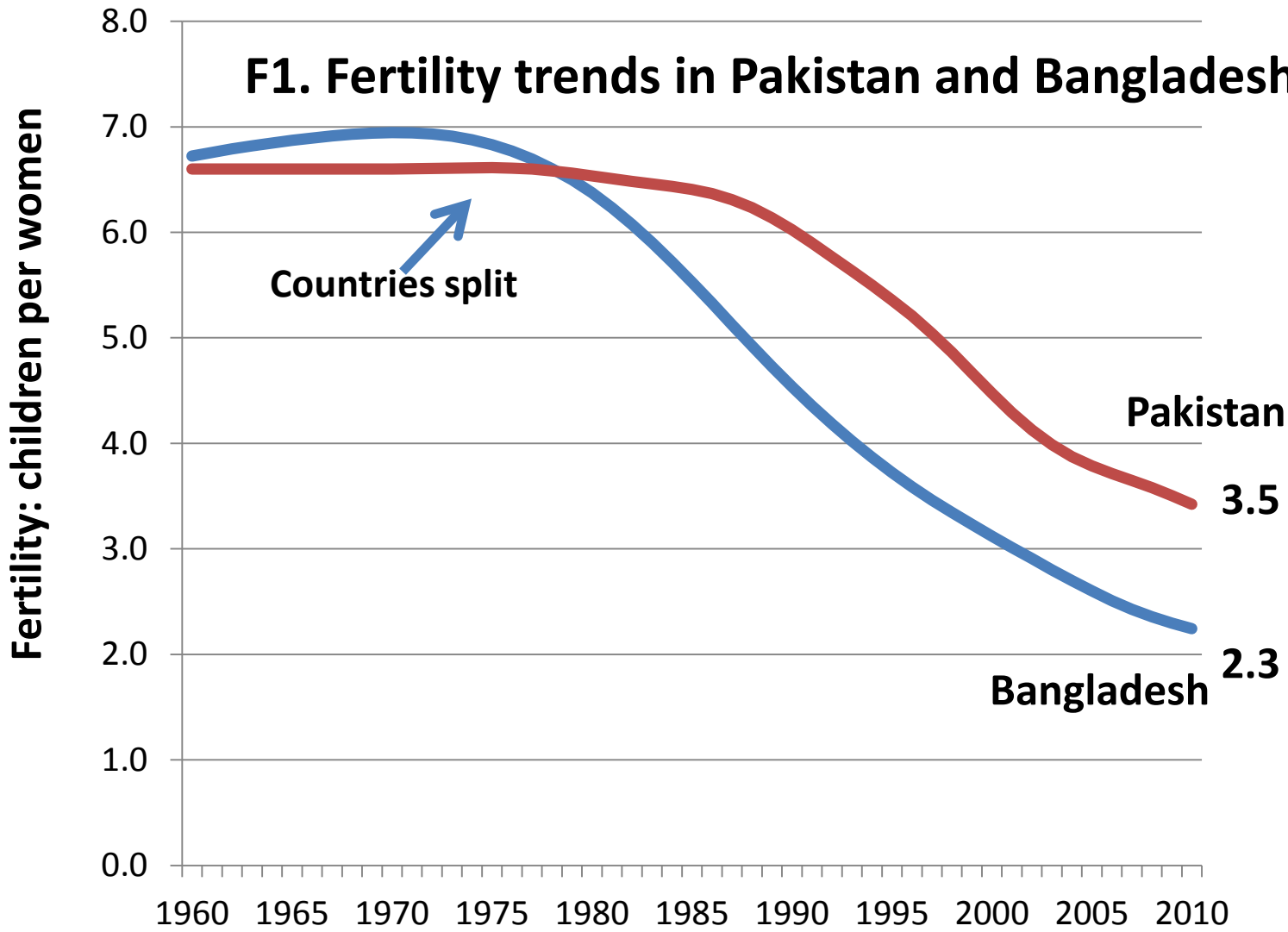


6. Conclusions

- ❑ **Adaptation 4- Reducing fertility rates**
- ❑ Higher densities (smaller farms) appear to lead to a desired reduction in fertility in Africa
- ❑ But desired reductions are not met by access to contraceptive technologies (broadly defined)
- ❑ High-density East Africa now shows mixed policies
- ❑ Ethiopia & Rwanda are investing in family planning (*), but Museveni (Uganda) has resisted family planning (“population growth is a great resource”)
- ❑ Asian experience suggests FP yields high returns



F1. Fertility trends in Pakistan and Bangladesh



6. Conclusions

- ❑ So, four adaptations to land constraints,
- ❑ What are the implications for dev. strategies?
- ❑ Should we be thinking about typologies of countries?
(Land constrained vs land abundant)
- ❑ Within land abundant countries, what should be the balance between smallholder and largeholders?
- ❑ Within land constrained countries, what's the right balance between farm and nonfarm investments?
- ❑ In some high density areas there are likely diminishing returns to further agricultural investments



6. Conclusions

- ❑ These considerations suggest we probably do need to re-think the relevance of Asian Green Revolutions for Africa
- ❑ Soil fertility and irrigation potential very different
- ❑ Very late transition towards fertility decline
- ❑ Not strong engines of nonfarm growth
- ❑ Diversity of land endowments >> targeted focus on land expansion, not just closing yield gaps (what are the lessons from land expansion elsewhere?)



- Thank you

