AGRICULTURE:

Why, Where & When, How and What Next

Nobel Symposium

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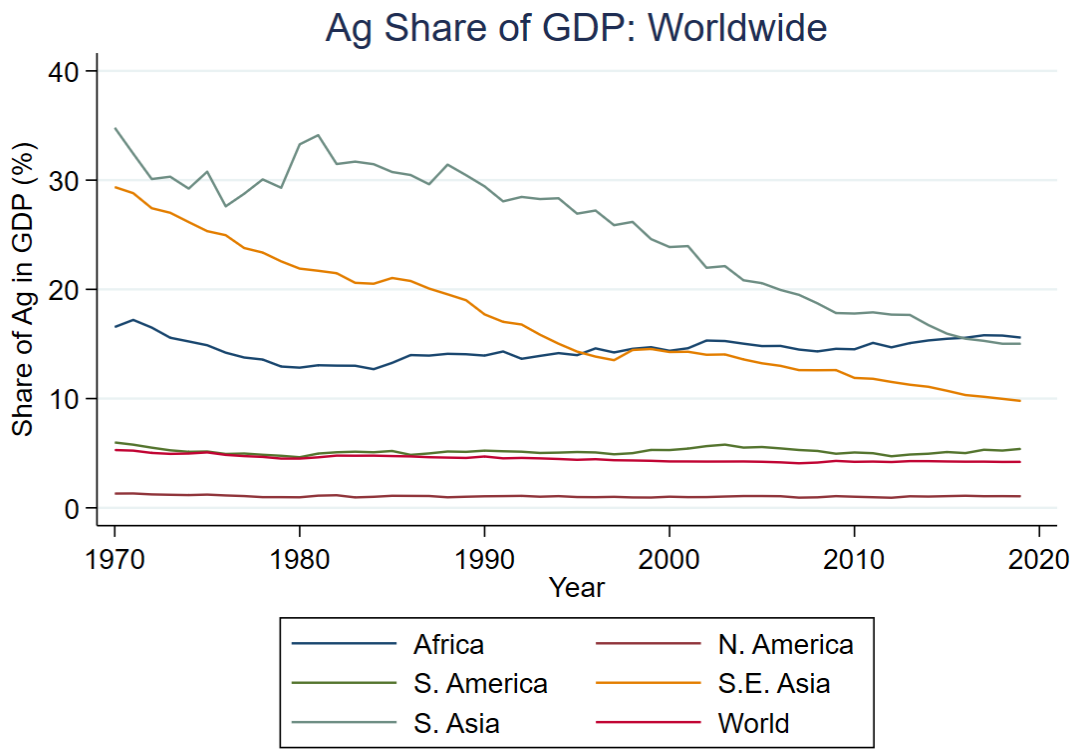
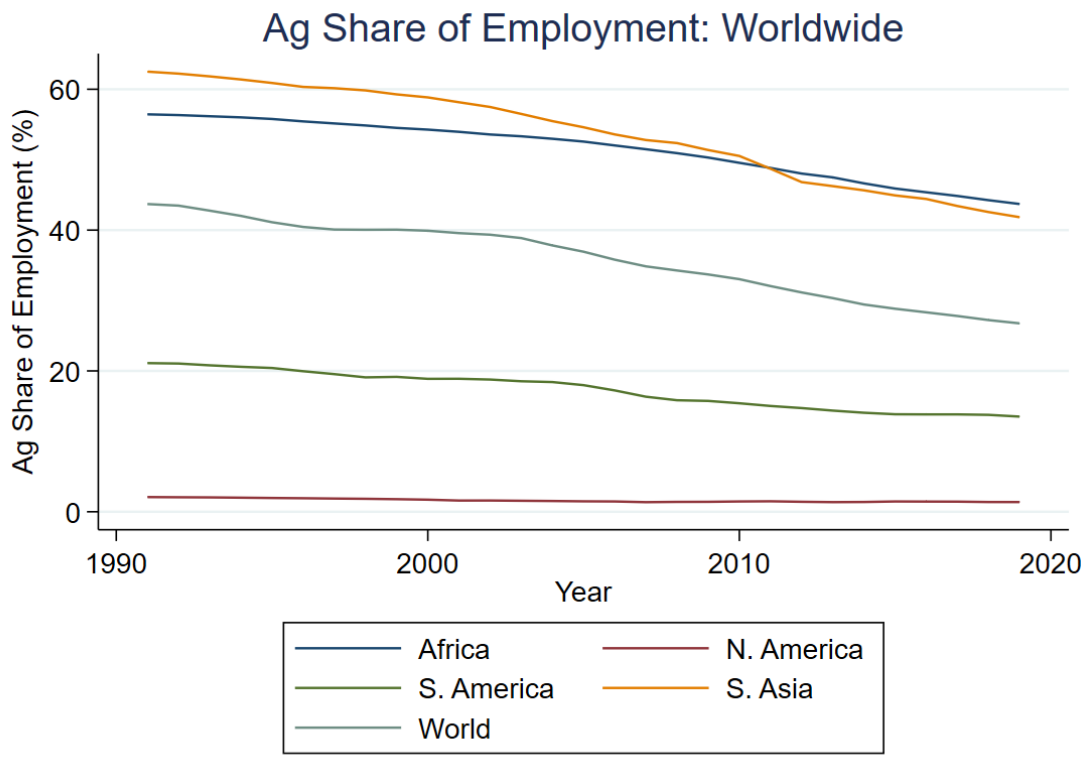
Based on Suri, Udry et al. (2024)[1]

[1] with J Aker, C Barrett, L Bergquist, M Carter, L Casaburi, R Osei, D Gollin, V Hoffmann, T Jayne, N Karachiwalla, H Kazianga, J Magruder, H Michelson, M Startz, and E Tjernstrom

SOME TRENDS

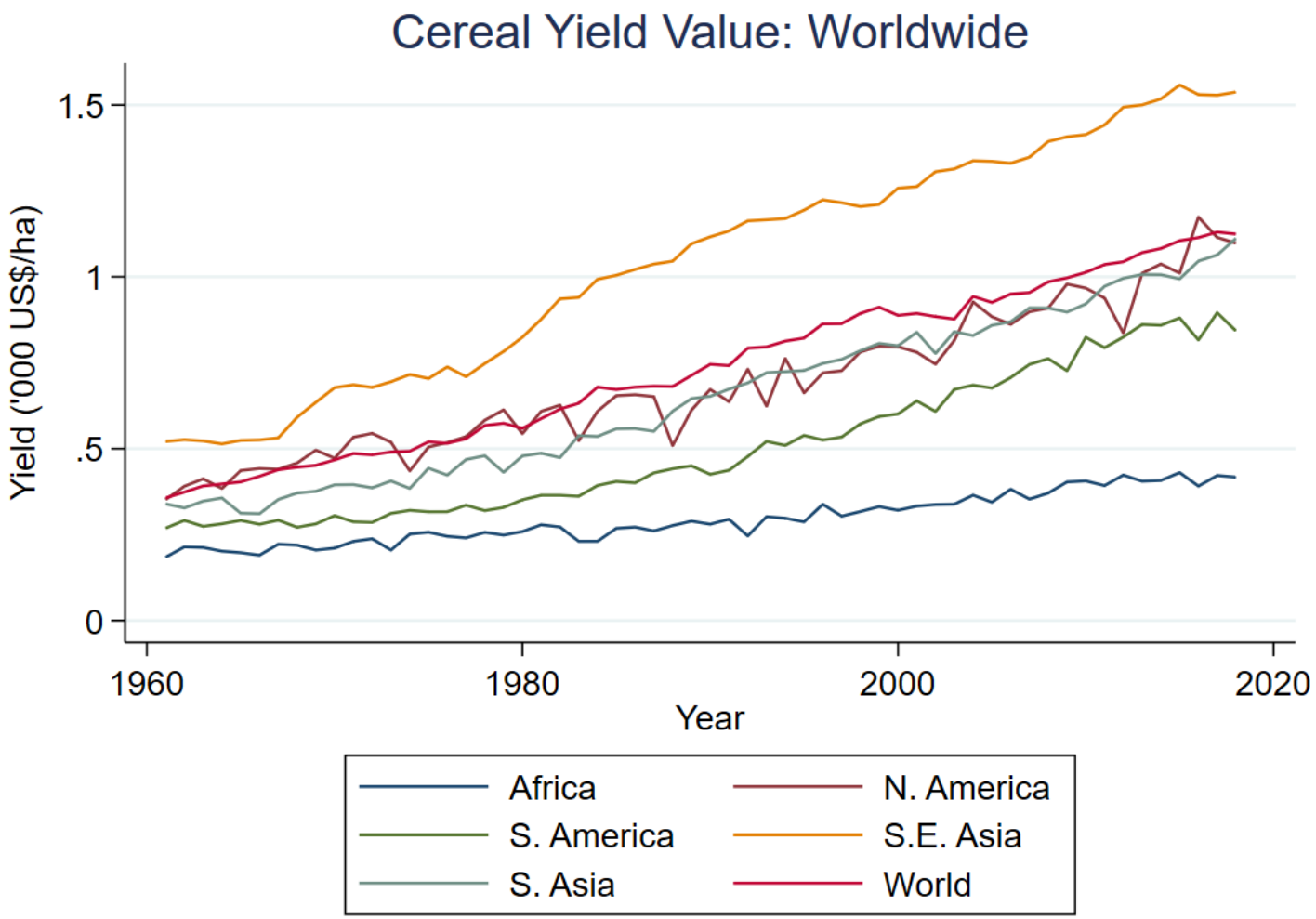
Agriculture an important part of GDP and employment in the developing world





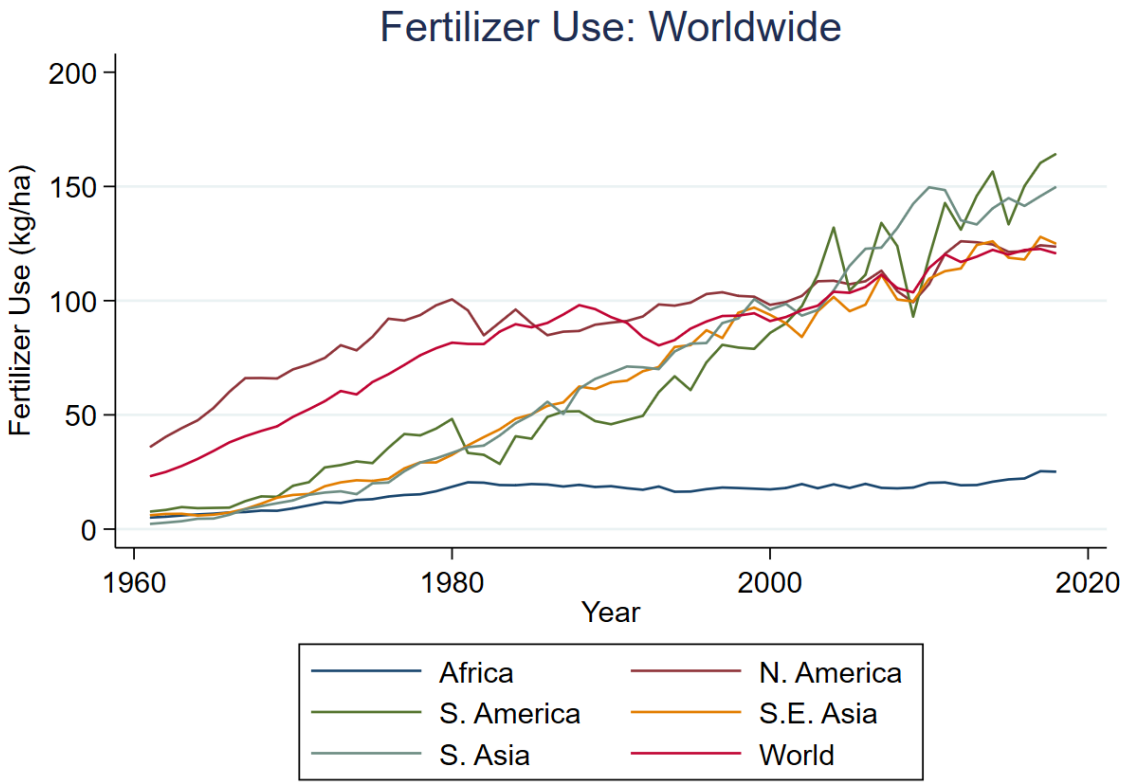
SOME TRENDS

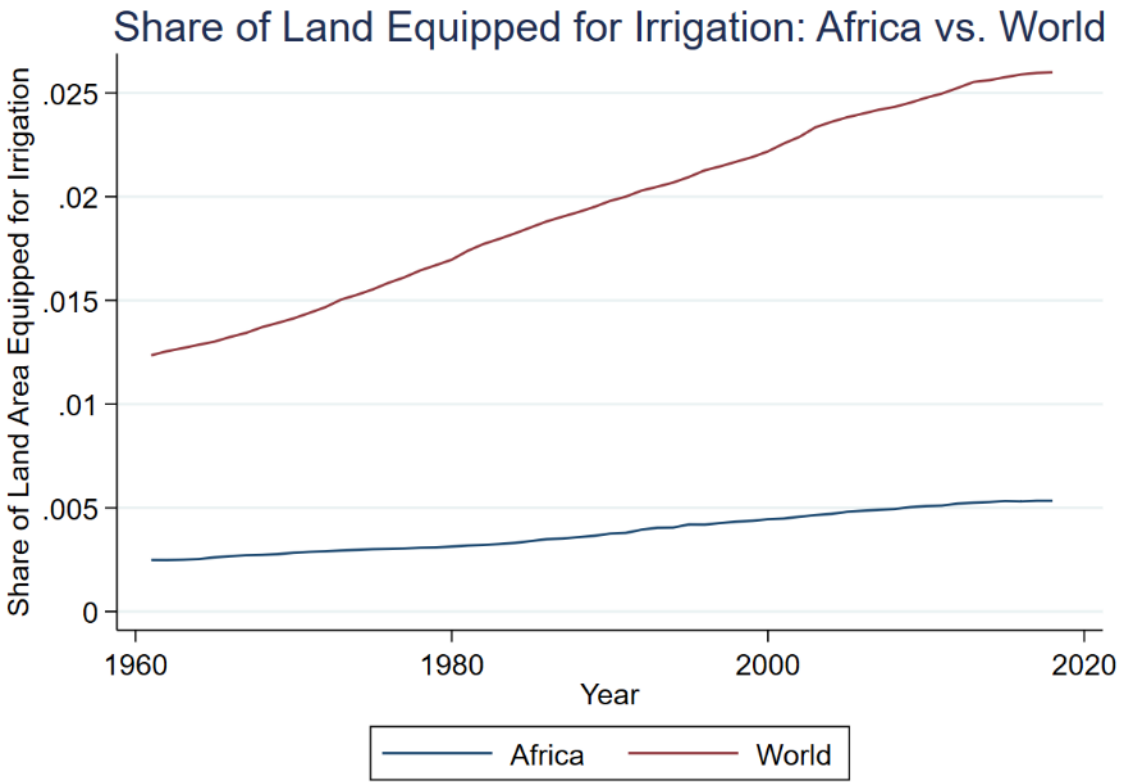
Productivity varies dramatically across the world



SOME TRENDS

Some of the productivity differences is input differences





QUESTIONS

Literature has focused on understanding these trends

The Why

- Why is productivity lower in some parts of the world than others?
- Technology has stagnated in some parts of the world (largely Africa): why?

The Where and When: Heterogeneity

- Where and when is productivity high? Where and when is technology use high?

The How: How Can Policy Help?

- What is the role of policy?

The What Next: Open Questions

The Why

THE WHY

Why the stagnation in productivity and technology use? Constraints

Credit, liquidity and savings constraints

Beaman et al (2021), Nakano & Magezi (2020); Burke et al. (2019); Fink et al. (2020); Duflo et al. (2011); Brune et al. (2016), de Janvry & Sadoulet (2020), Abay et al. (2022) Karlan et al. (2014), Harou et al. (2022), Matsumoto et al. (2013), Dorward and Chirwa (2011), Ricker-Gilbert et al. (2013), Carter et al. (2021) Jayne et al. (2018), Hoffmann & Jones (2021), Gilligan & Karachiwalla (2023), Aggarwal et al. (2018), Omotilewa et al. (2018), Mukherjee et al. (2022), Brune et al. (2021)

Insurance constraints

Karlan et al (2014), Casaburi **&** Willis (2018); Carter et al. (2017); J-PAL (2016), Adong et al. (2020), Afshar et al. (2021), Shin et al. (2022), Serfilippi et al. (2020), Kramer et al. (2023), Elabed & Carter (2018), Ahmed et al. (2020), Castaing and Gazeaud (2022), Karlan et al. (2011), Arouna et al. (2021), Ceballos et al. (2019)

Knowledge constraints

Fabregas et al (2017), Kondylis et al (2017), Bonan et al (2023), Bernard et al (2017), Horner et al (2019), Maertens et al (2021), Aker & Jack (2023), Carter et al (2021), Boucher et al (2024), Michelson et al (2021), Ashour et al (2019), Bold et al (2017), Hoel et al (2024), Conley & Udry (2010), Ambler et al (2023), Beaman et al (2021), Abdulai (2023), Tjernström (2017), Van Campenhout et al (2020), Mawunyo et al (2023), Sheahan & Barrett (2017) Jayne et al (2023) Laajaj & Macours (2021)

Labor market imperfections

Jones et al (2022), Sheahan & Barrett (2017), Daum et al (2021), Dillon & Barrett (2017), Fink et al (2020), Carranza et al (2022)

THE WHY

Why the stagnation in productivity and technology use? Constraints

Limited market access: poor infrastructure and high transport costs

Atkin & Donaldson (2018), Aggarwal et al (2018), Bergquist & Dinerstein (2020, Casaburi et al (2013), Newman et al (2018), Casaburi & Reed (2021), Teravaninthorn & Raballand (2009), Porteous (2019), Aggarwal et al (2022) Dillon & Tommaselli (2022), Aggarwal et al (2023), Omotilewa et al (2018), Burke et al (2019), Channa et al (2022), Le Cotty et al (2019), Delavalladde & Godlonton (2023), Cardell & Michelson (2022), Dillon & Dambro (2017), Nakasone et al (2014), Hildebrant et al (2023), Bergquist et al (2022), Wiseman (2023), Barrett et al (2020), Nyarko & Pellegrina (2022)

Limited markets for quality

Bold et al (2024), Casaburi & Reed (2020), Bernard et al (2017), Magnan et al (2021), Prieto et al. (2021), Hoffmann et al (2023), Kadjo et al. 2016, Hoffmann et al (2022(, Hoffmann et al (2020), Macchiavello & Morjaria (2021), Michelson et al (2023), Bold et al. (2017), Sanabria et al (2013), Sanabria et al (2018), Ashour et al (2019), Hoel et al (2024), Michelson et al (2021), Gharib et al (2021), Maertens et al (2022), Bulte et al (2014), Michelson et al (2024), Miehe et al (2023), Hsu & Wambugu (2023), Gilligan et al (2022)

Land market imperfections

Goldstein & Udry (2008), Agyei-Holmes et al (2020), Ali et al (2014), Wren-Lewis et al (2020), Goldstein et al (2018), Burchardi et al (2019), Deininger et al (2017), Jayne et al (2021), Restuccia & Santaeulàlia-Llopis (2017), Barrett et al (2020), Krah et al (2024), Acampora et al (2022), Deininger et al (2011), Deininger & Goyal (2023)

THE WHY

Bottom line: no single binding constraint

However: no single binding constraint

Different combinations of constraints bind for different farmers: implies packages of interventions may be the most useful approach to close these gaps

Very small literature on this, so lots to be done!

Examples of packages:

- Drumnet (Ashraf et al. 2009)
- One Acre fund (Deutschmann et al. 2019)
- Multi-faceted “economic inclusion” program in Niger (Bossuroy et al. 2022)
- Also Mukerjee et al. (2022), Deutschmann et al. (2021), Macchiavello & Miquel-Florensa (2019), Arouna et al. (2020)

THE WHY

What do we know about multifaceted programs?

But, multifaceted programs are far from a silver bullet:

- Drumnet collapsed after a year when farmers were unable to meet EU requirements
- Failures like the Integrated Rural Development Programs from the 1970s-1980s (Chambers 2014)
- Some community-driven rural development programs had minimal effects (Appiah et al. 2020).
- Often costs exceed the value of additional crop output (Jayne et al. 2018)

Farmers do overcome constraints when the technology is sufficiently productive (i.e. increases yields enough) and hence actually profitable (Suri 2011)

- Examples: cocoa in Ghana & Cote d'Ivoire; flowers in Kenya & Ethiopia; improved cassava in Nigeria; rainwater harvesting techniques in Niger

But the notion of "sufficiently productive and profitable" is limited to a geographic, economic and social extent by immense heterogeneity

The Where and When

THE WHERE AND WHEN

The role of heterogeneity

Agricultural technologies are extremely sensitive to local circumstances: **nutrients, moisture, soil quality, altitude, temperatures, soil structure, topography and solar energy**

Overlaid on these natural conditions is **heterogeneity in infrastructure and market access, and hence in the prices of inputs and outputs, again both over time and space**

Implications:

- Technologies may simply not be profitable everywhere
- It might be hard to learn from neighbors if they have different conditions to your own
- Limited incentives for R&D of technologies if they have small markets and are only relevant for a small segment of the population

THE WHERE AND WHEN

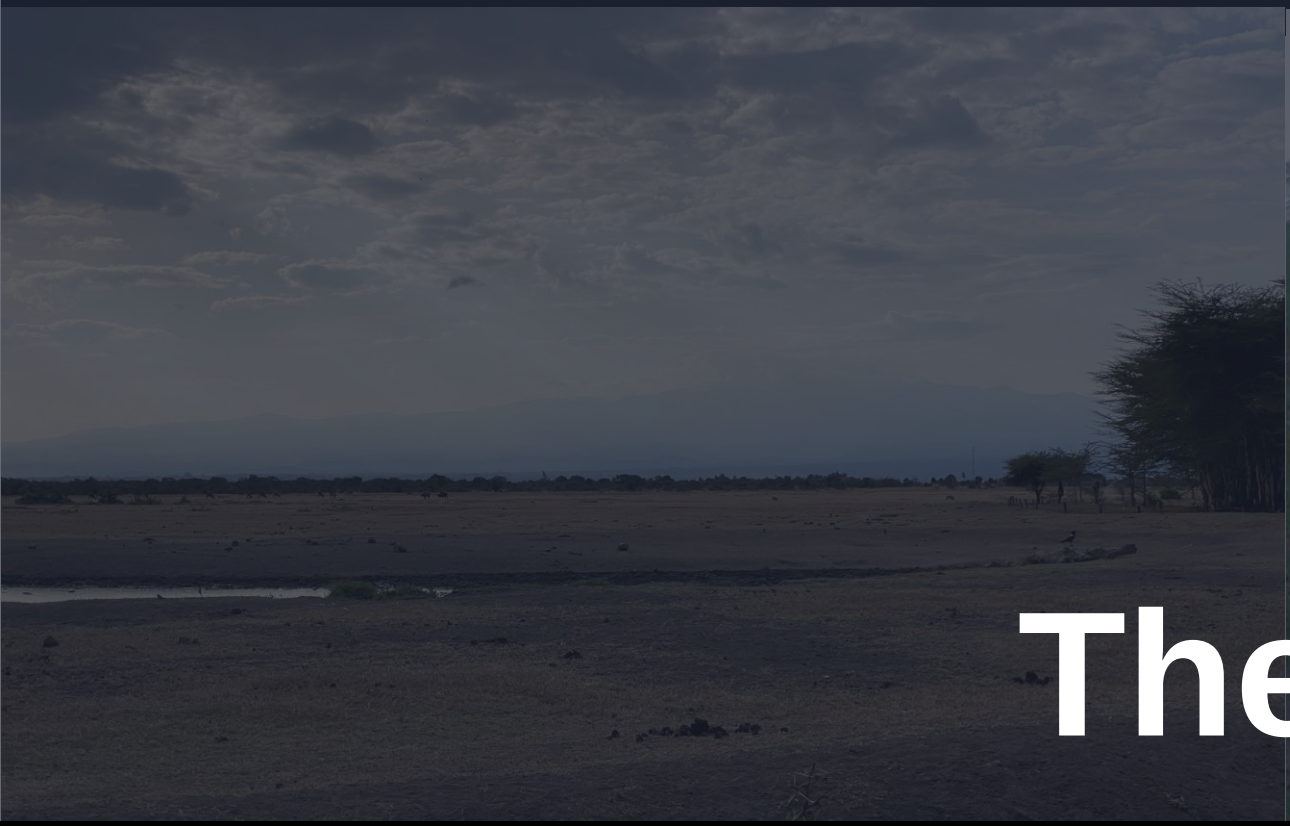
Evidence on heterogeneity

Suri (2011): large heterogeneity in both gross and net returns to hybrid seed and fertilizer

Extent of heterogeneity appears to be far larger in sub-Saharan Africa than in temperate regions: Claassen and Just (2011) vs Gollin and Udry 2021

Where does heterogeneity come from?

1. **Soil and land quality: government recommendations often wrong**
   - Sanchez (2019), Burke et al. 2020, Hengl et al. (2021), Tjernström et al. 2015, Harou et al. (2022)
2. **Heterogeneity in weather**
   - Rosenzweig and Udry 2020, McCullough et al. (2018), Emerick et al. 2016 and Boucher et al. 2019
3. **Heterogeneity in access to markets (input and output)**
   - Bergquist and Dinerstein (2020), Casaburi et al. (2013), Porteous (2020)



The How: Policy?

THE HOW

What can policy do?

Change the profitability equation for farmers… for large numbers of farmers!

Benefit side: public and private R&D

Cost side: costs of inputs

THE HOW

The benefit side: the R&D problem

Investments in technology for agriculture: low levels of public and private R&D

- Low spending per farmer on R&D: in Africa two orders of magnitude lower than developed world
- Low number of agricultural research stations, with low staff & high turnover (Lipton 1988)
  - *US: 134 stations/100K farmers; Ghana 0.28; Malawi 0.34; Mali 1.02; Madagascar 0.42; Kenya 0.22; Cameroon 0.79; Senegal 0.94*
- Volatility in already low levels of investments make the problem worse (Rawat 2020)
- Private R&D: only ¼ of overall R&D, all in the developed world (Fuglie 2016, Heisey and Fuglie 2018)

Agricultural R&D builds on itself

- “Green revolution” (Evenson and Gollin 2003)
- In India: 20-40 new varieties of rice released annually, 10-20 new varieties of maize & wheat
- In Kenya: five or fewer new varieties introduced annually with low yield improvements

THE HOW

The benefit side: broad vs customizable technology

Options:

1. Irrigation + permanent cultivation + terrain engineering can reduce heterogeneity
2. Seek technologies that are customizable or profitable across a wide range of circumstances
   - *Extensive customization in the developed world* *(Griliches 1957, Hurley et al. 2004, Stoorvogel et al. 2015, Schimmelpfennig 2016)*
   - *Not in Africa* *(van Asselt et al. 2018); fertilizer recommendations uniform over large areas (Michelson et al. 2021)*

Need:

- Greatly expand use of farmer participatory trials
- Rapid expansion of information network availability across Africa to carry out on-farm trials of new technologies at a much larger scale than has been possible in the past (Newman et al. 2012)

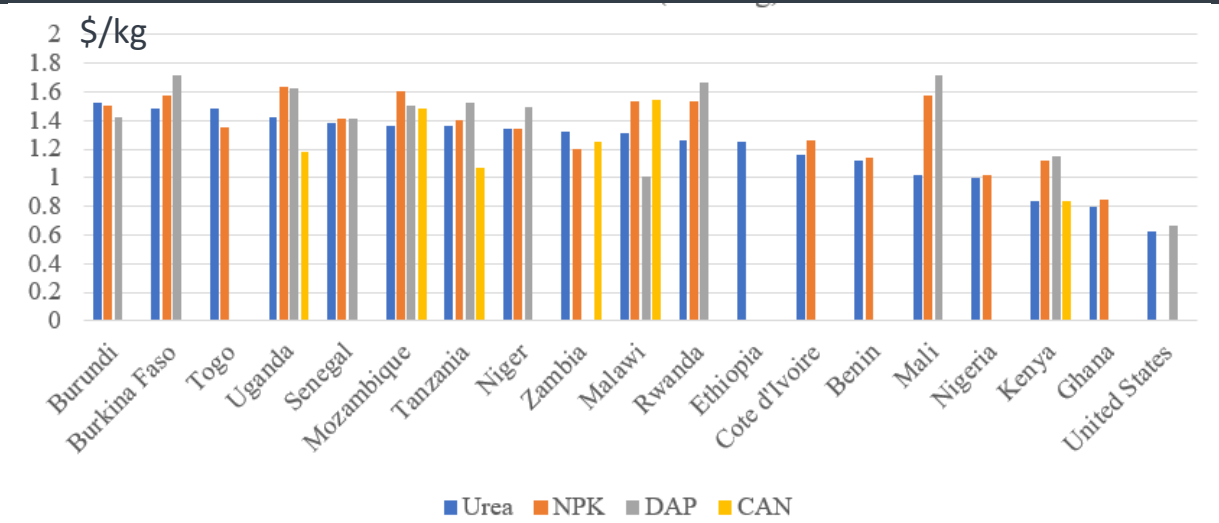
Perhaps large-scale participatory trials are the solution? An era of "citizen science"

THE HOW

The cost side: reducing costs of inputs

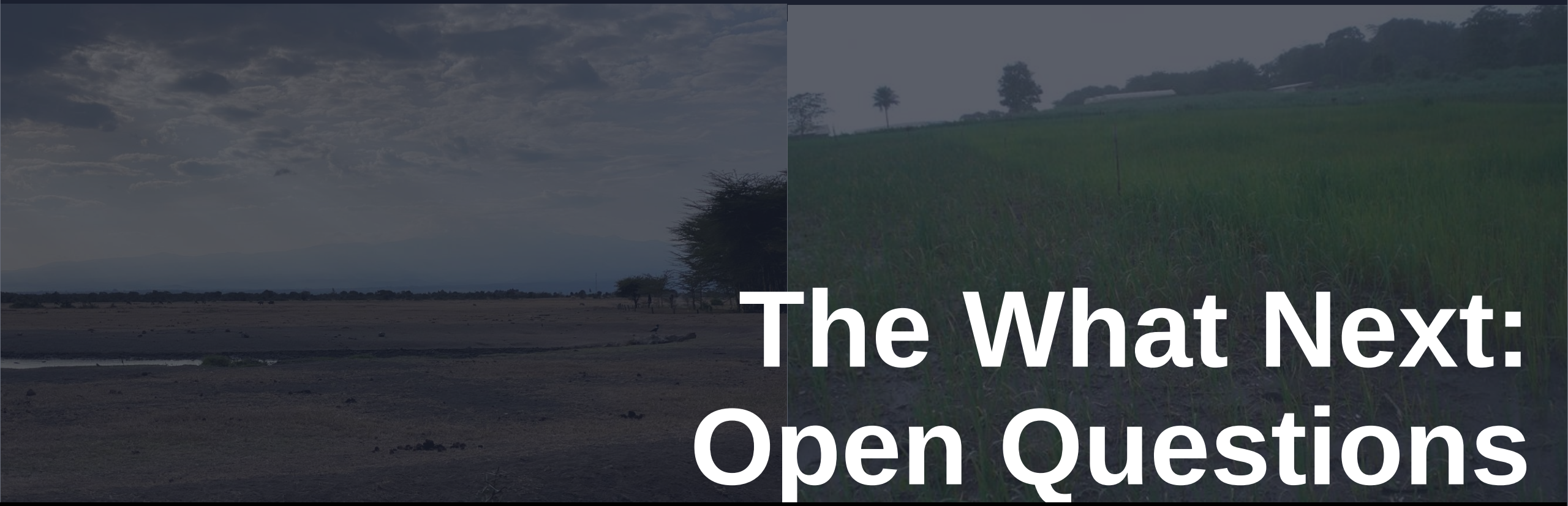
Extremely high fertilizer prices

60% of fertilizer in Africa imported



Policy options:

- Invest in infrastructure
- Encourage more local production of fertilizer or more geographically local trade in fertilizer
  - 135 fertilizer plants across SSA (excl South Africa): 17 are manufacturing plants; 101 are processing (IFDC 2021)
  - Market dominated by a small number of importers: short-term assistance to entrants? Pro-competitive policy?
- Subsidize fertilizer, but has costs and could create overuse (Kishore et al. 2021 for Bangladesh, India, Nepal and Sri Lanka)
- Supporting other inputs like weather insurance



The What Next: Open Questions

THE WHAT NEXT

Open questions

1. How should we provide incentives to either the public or the private sector for the development of new technologies that are locally customized? How should we provide incentives for experimentation with these technologies?

2. Are improvements in agricultural technology & productivity the most useful way to reduce poverty, or should the focus be on investments in the non-agricultural sector?

3. Can the integration of rural and urban markets in Africa provide better incentives to farmers?

4. Is there a way to scale down large-scale infrastructure investments to get more irrigation across Africa? (think coffee mills in East Africa)

THE WHAT NEXT

Open questions

5. What is the role of the state in agriculture. Crony capitalism in agriculture? The political economy around how policy priorities or large infrastructure investments are decided, specifically in agriculture?

6. More to learn about some of the constraints: especially labor, land markets

7. Lots and lots and lots and lots to learn on climate change!
   - How is climate change likely to affect agricultural output in Africa?
   - How will farmers and entire agricultural systems in Africa adapt to these changes?
   - Are there technologies that can really move the needle? If so, how do we trial/test and adapt them to local contexts?

8. What will the process of agricultural or structural transformation look like in Africa?

Thank You!