Microdevelopment research on agriculture in the last 20 years: what have we learned, and where to go

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The starting points

- Many of the world's poor are still in the rural areas
- Agricultural still close to half of all employment
  - Mostly self-employment
- Green Revolution showed the potential of productivity growth through agricultural technology adoption leading to (rural) poverty reduction
  - One particular package/bundle: high yielding varieties + fertilizer (+extension, credit, infrastructure,…)
- Also some more recent examples of potential of agricultural growth and (rural) poverty reduction
  - including in SS Africa – e.g. Ethiopia

The challenge

- Productivity growth in SS Africa has been generally much more limited
- 20 years ago we thought there were a lot of “profitable” ag innovations “sitting on the shelf” but not being adopted
- Lots of research on constraints to technology adoption
  - We’ve learned a lot about the constraints (reviews by Magruder, 2018; Suri and Udry, 2022)
    - on the “supply” and “demand” side (de Janvry and Sadoulet, 2020)
  - But even so, technology adoption or quality upgrading often hasn’t occurred

Outline

- Leaves us with many open questions
  1) Do we need to understand more about technology bundles?
  2) Or maybe the technologies are not the right ones to begin with?
  3) Or is the problem that innovations haven't scaled?
  4) Or is climate change and deteriorating environmental health offsetting gains that otherwise would have happened?

     => Implications of climate change and deteriorating health for addressing knowledge constraints

Do we need to understand more about technology bundles?

One solution to heterogeneity could be offering more than one technology/innovation
Some additional empirical evidence

- New focus on socio-technological innovation bundles among non-economists (Barrett et al 2020)
- Arguably the Green Revolution also resulted from diffusion of a particular bundle
- NGOs and some private sector actors often promote bundles, but also long literature on partial adoption
- Heterogeneity implies that different farmers may adopt different types of innovations (Kosmowski et al, 2020)
- Dairy farmers made aware of variety of feeding practices chose according to their endowments (Behaghel et al, 2024)
- Another example: Bundling weather insurance with drought-resistant maize to offer protection against different shocks: Boucher et al (2024)

Different types of household are reached: summary of correlates

Variable	Total size of parcels	Distance to market (km)	Asphalt as a main access road	Livestock manager is female	Female share of family labor is > 50%	Annual consumption per capita (ETB)	Bottom 40% annual consumption	Productive asset index	Annual off-farm income (ETB)	Age of household head
Animal agriculture										
Large ruminant crossbreed	0.5***	-3.17***	n.s	n.s	-0.03**	n.s	n.s	n.s	1,874**	n.s
Poultry crossbreed	n.s.	-2.78**	0.14***	0.06***	n.s	n.s	n.s	-0.16*	-1,058***	n.s
Crop germplasm improvements										
Barley varieties	n.s	n.s	-0.15***	-	n.s	4,870**	-0.28***	0.39**	n.s	n.s
Chickpea kabuli varieties	1.18***	n.s	-0.14**	-	n.s	n.s	n.s	n.s	n.s	n.s
Maize varieties	n.s	n.s	n.s	-	n.s	n.s	n.s	n.s	n.s	n.s
Drought-tolerant maize varieties	n.s	n.s	n.s	-	n.s	n.s	-0.19**	n.s	n.s	-5.2**
Natural resource management										
River diversion	n.s	-2.58**	n.s	-	n.s	n.s	n.s	n.s	n.s	n.s
SWC practices	0.25***	-7.03***	0.10***	-	n.s	-1,620**	n.s	0.22***	1,041***	n.s
Minimum tillage CA	0.51***	n.s	n.s	-	-0.05***	-2,722***	n.s	0.42***	n.s	n.s
Mango	n.s	-2.18**	n.s	-	n.s	-1,876***	n.s	0.45***	n.s	4.3***
Papaya	n.s	n.s	n.s	-	n.s	n.s	n.s	0.47***	n.s	n.s
Avocado	n.s	n.s	0.04**	-	n.s	-1,873***	0.15***	0.36***	n.s	n.s
Policy influences										
Productive Safety Net Program (PNSP)	-0.29***	n.s	n.s	n.s	n.s	-3,088***	0.20***	-0.27***	-1,124***	n.s
Water users associations	-	n.s	-4.51**	-	-	-	-	-	-	-

*** p < 0.01; ** p < 0.05; n.s = non-significant, Kosmowski et al (2020)

Does the R&D process fail to deliver appropriate & profitable technologies?

- Agriculture as prime example of global public good
  - R&D process may be generating inappropriate technologies ? (Moscona and Sastry, 2022)
  - CGIAR system born out of early successes of Green Revolution at CIMMYT and IRRI
    - 15 international agricultural research centers working in collaboration with national agricultural research system (NARS)
- Possible biases in the R&D process due to site and farmer selection in agronomical trials, under 'controlled' environments (Laajaj et al, 2020)
- But also R&D probably should lead to many innovations failing and some succeeding
  - Expect a skewed distribution, like for any other innovation system

Different types of innovations have scaled, but many innovations have not

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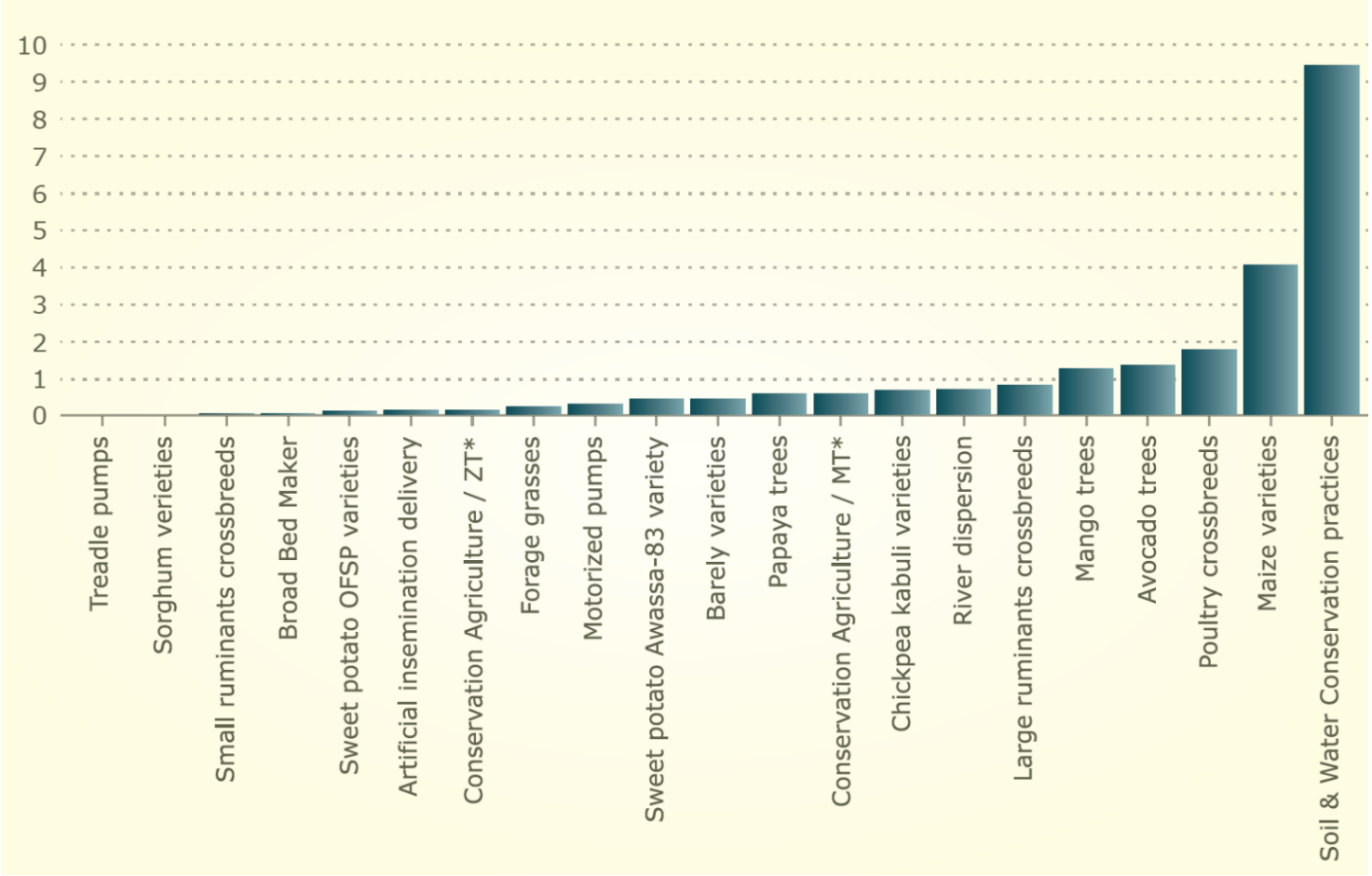
Number of rural HHs adopting each innovation (millions)

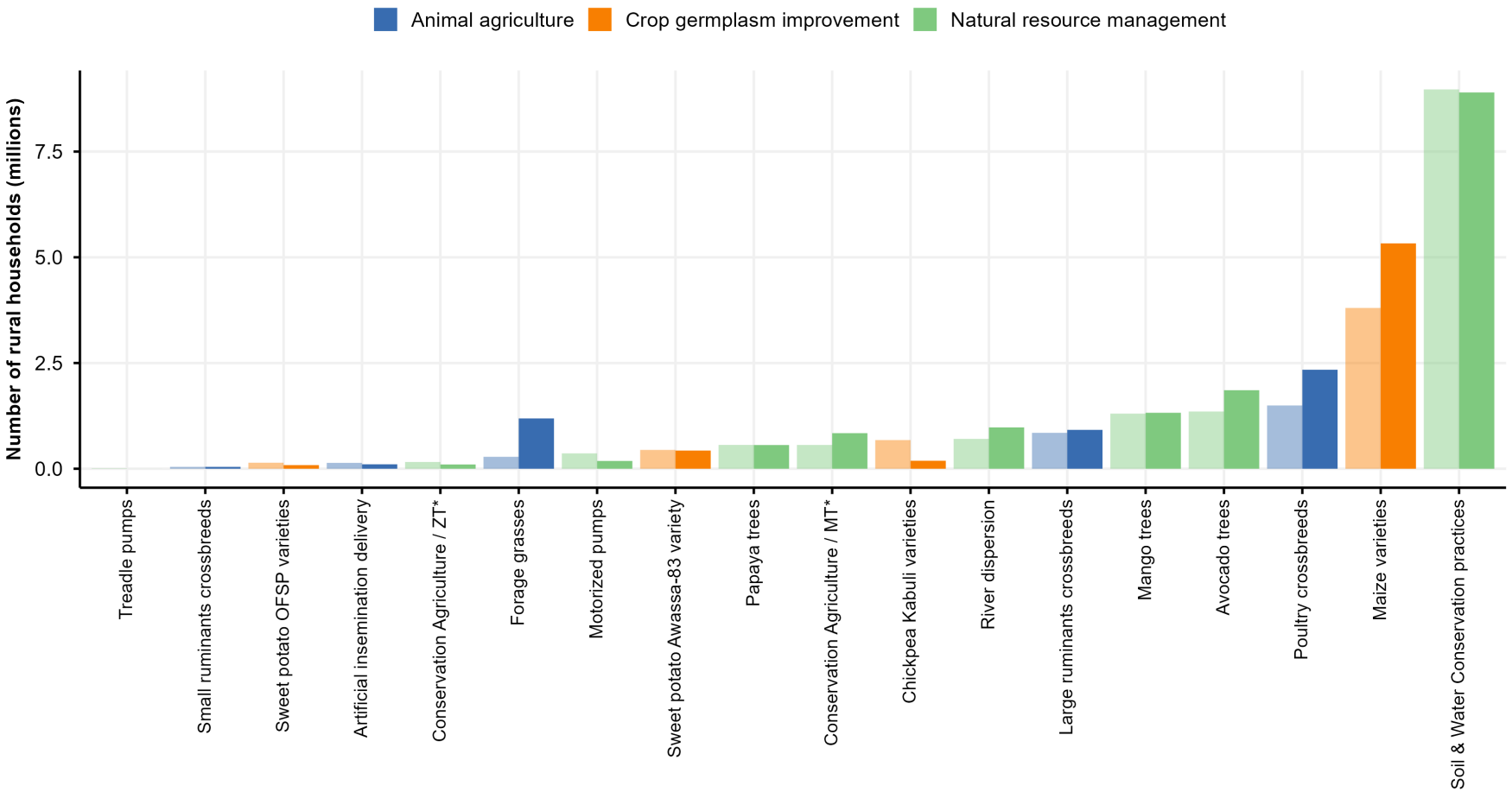


Based on data collected in ESS4 ~ LSMS-ISA: national representative ag survey, Kosmowski et al 2020

What do we know about scaling of agr. innovations in SS Africa?

- LSMS-ISA gives national representative data on adoption of agr. innovations for fertilizer, pesticides and HYV: mixed picture
  - "Agriculture in Africa – Telling Myths from Facts" (Christiaensen, 2017)
- Adoption of improved varieties: self-report by farmers often misleading (Gantier et al, 2023)
- Even with objective measures (DNA fingerprinting) build into LSMS-ISA often find low scale and slow scaling
  - Scaling of Green Revolution package traditionally through incentives of private sector actors
  - But concerns on counterfeiting and input quality (Bold et al, 2017, 2022)
  - And different technologies may need different ToC for scaling
    - Providing information to agrodealers who may have incentive to diffuse, to farmers benefitting most from a given technology (Dar et al, 2023)
    - Possibly not enough for latent traits, or traits that don't have a pay-off every year (resilience to certain climate shocks – parallels to index insurance) - OFSP cautionary tale
  - Who is the right actor to scale?
  - What can we learn from cases where scaling did happen?

Number of rural households adopting each CGIAR-related innovation in Ethiopia, ESS - change between 2018/19 (ESS4) and 2021/22 (ESS5)



Note: Calculation based on logitudinal weights. For Chickpea Kabuli varieties, comparision is between 2015/16 (ESS3) and 2021/22 (ESS5)

Rapid increase in adoption of improved forages

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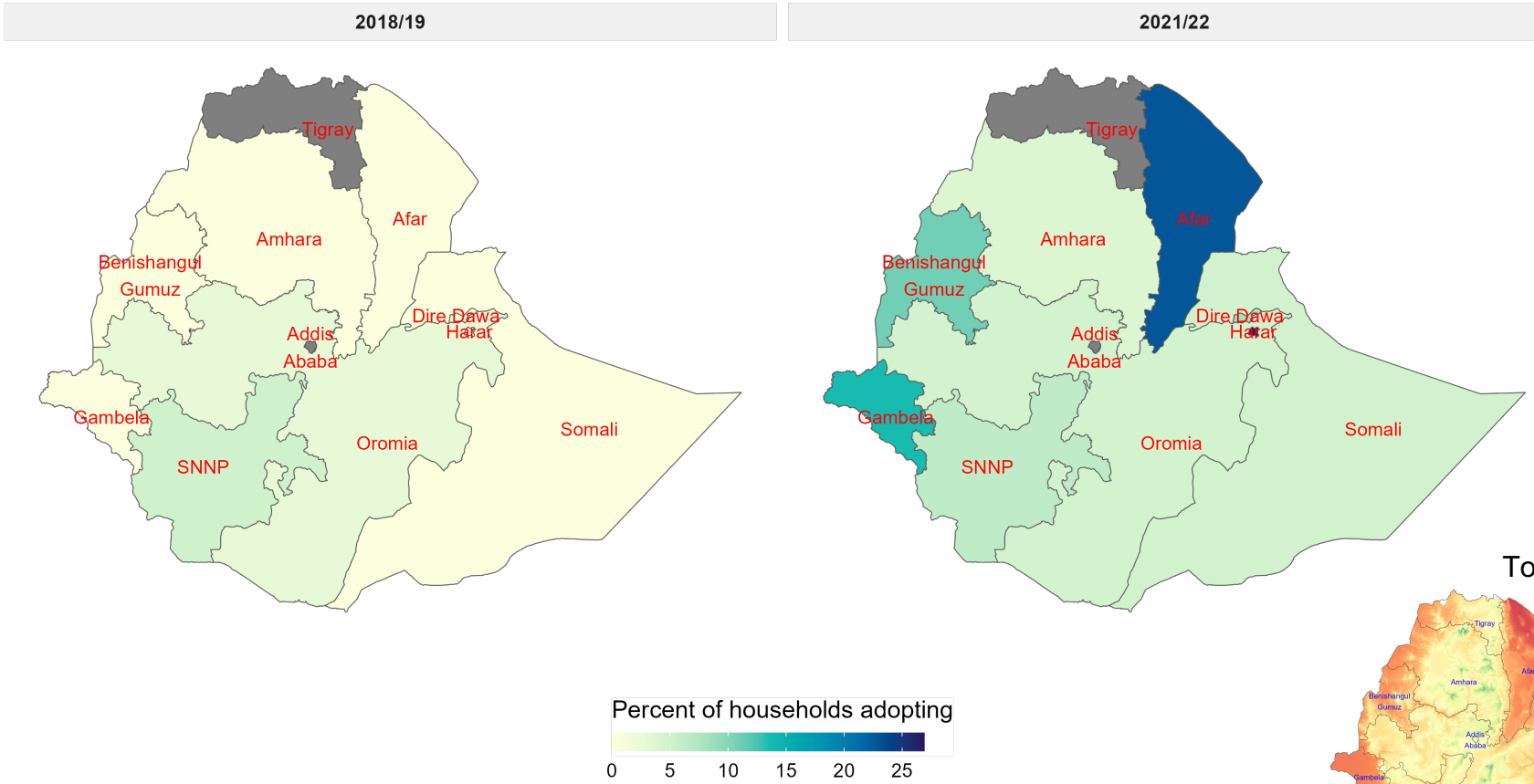
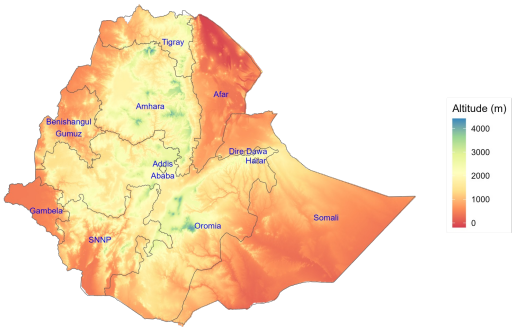
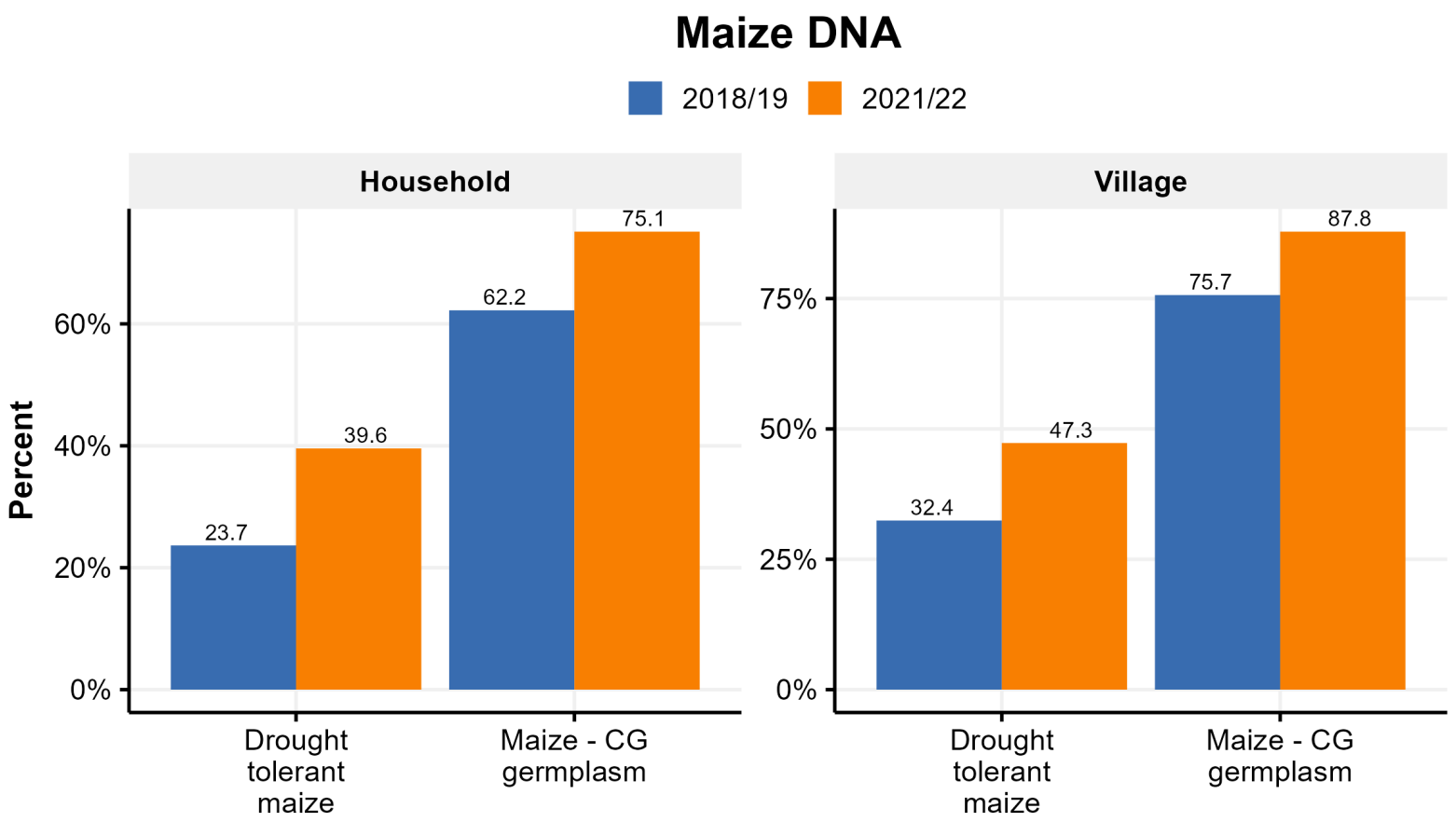


Topography



Maize DNA: Panel Insights

- CGIAR Maize germplasm increased to 75%
- Large increase in reach drought-tolerant maize varieties to 40%
- Even so average age of maize varieties on farmers' fields is 20 years



Only panel sample used. Percent at the household level are weighted sample means using panel weights.

Farmers' decision-making given increase in challenges due to climate change and deterioration of environmental health

- Long-standing agr. practices and rules-of-thumb (planting seasons, crop choices) increasingly irrelevant
    - Weather patterns (wind, rainfall, temperature) are more variable and extreme
    - Pest and disease environment changes constantly
- Points to importance of distinguishing research on innovations with different traits
    - Risk-related innovations : index insurance, weather forecasts- we have some
    - Soil management and other agricultural practices – we have some
    - Pest and disease management - we have less
    - Nutrition-enhanced crops (as complement to diversified diets)?

New realities and new types of innovations may require revisiting what we have learned about addressing knowledge constraints ?

- Adaptation may involve adopting complex bundles of complementary inputs and practices
- Hard given heterogeneity but also many uncertainties about both the inputs and practices
  - E.g. farmers often don't know the varieties they are growing
    - Gantier et al (2022): review of 16 crop-country combinations (cereals, legumes, roots)
      - 33% doesn't know whether the variety they grow is improved
      - 40% (50% in SS Africa) doesn't know which variety are growing
      - Maybe that doesn't matter given that farmers can observe how the varieties are doing, but harder when it needs complementary investments, which farmer may not make (Bohr et al 2024; Mallia 2023)
  - Equally or even harder inference problems around reasons for yields in a given year being low (pests, diseases, weather shocks. …)
  - Learning costs can be high - Nourani (2019)

Learning from others versus learning from experts

- Learning from others (Bandiera and Rasul, 2006; Conley and Udry 2010) and diffusion through networks (BenYishay and Mobarak, 2018; Beaman et al, 2018)
    - Diffusion through networks is often
        - unequal (Beaman and Dillon 2018; Bandiera et al., 2023),
        - slow (Chandrasekhar et al 2022)
        - or even absent (Duflo et al 2023)
- Some promising evidence on learning from experts about complex technologies
    - Demilunes in Niger (Aker and Jack, 2023), teaching feeding principles not practices (Behaghel et al, 2023), Sustainable intensification in Mexico (Ferguson and Govaerts, 2022)
    - Decision support tools (Chandrasekhar et al 2022; Islam and Beg, 2021)
    - Precision agriculture and customized advice (Fabregas et al. 2019; Corral et al 2020)

Or (multi-season) learning through participatory trials

- Participatory trials
  - Farmer field days: Emerick and Dar (2021): demonstration plots, farmers observe and learn (flood-tolerant rice variety), but not in Kelley et al (2023) (early maturing rice variety)
  - Learning through experimentation through multiple periods
    - CGIAR and national partners did a lot of this in 80s and 90s
    - Largely abandoned because of context specificity, but recent successes (Zhang et al, 2016, *Nature*, 6-year consecutive trials; Van Etten et al, 2019, *PNAS*, 3-5 seasons on-farm participatory variety evaluation using crowdsourced citizen science
    - Laajaj and Macours (2024) show complexity of learning about complementarities over 6 seasons, with initial negative profits and continued experimentation

Challenges of climate change and deterioration of environmental health for agriculture points to non-ag policies

- Solution clearly not necessarily within agriculture
  - Migration and social protection, feedback loops and income diversification (literature on the Ultra-Poor programs; Handa et al, 2018; Gertler et al, 2012; Macours et al, 2022)
  - But also recent evidence on value of work (Hussam et al. 2022; Macchi and Stalder 2023)
  - Given many of the poor continue to work in agriculture, addressing constraints in agriculture probably remains relevant

- Complexity of decision-making points to returns to human capital in agriculture?
  - E.g. educational systems that teach children how to learn using scientific reasoning (as in Ashraf et al, 2022)