



United States Department of Agriculture

The importance of agricultural total factor productivity growth for global food and environmental security

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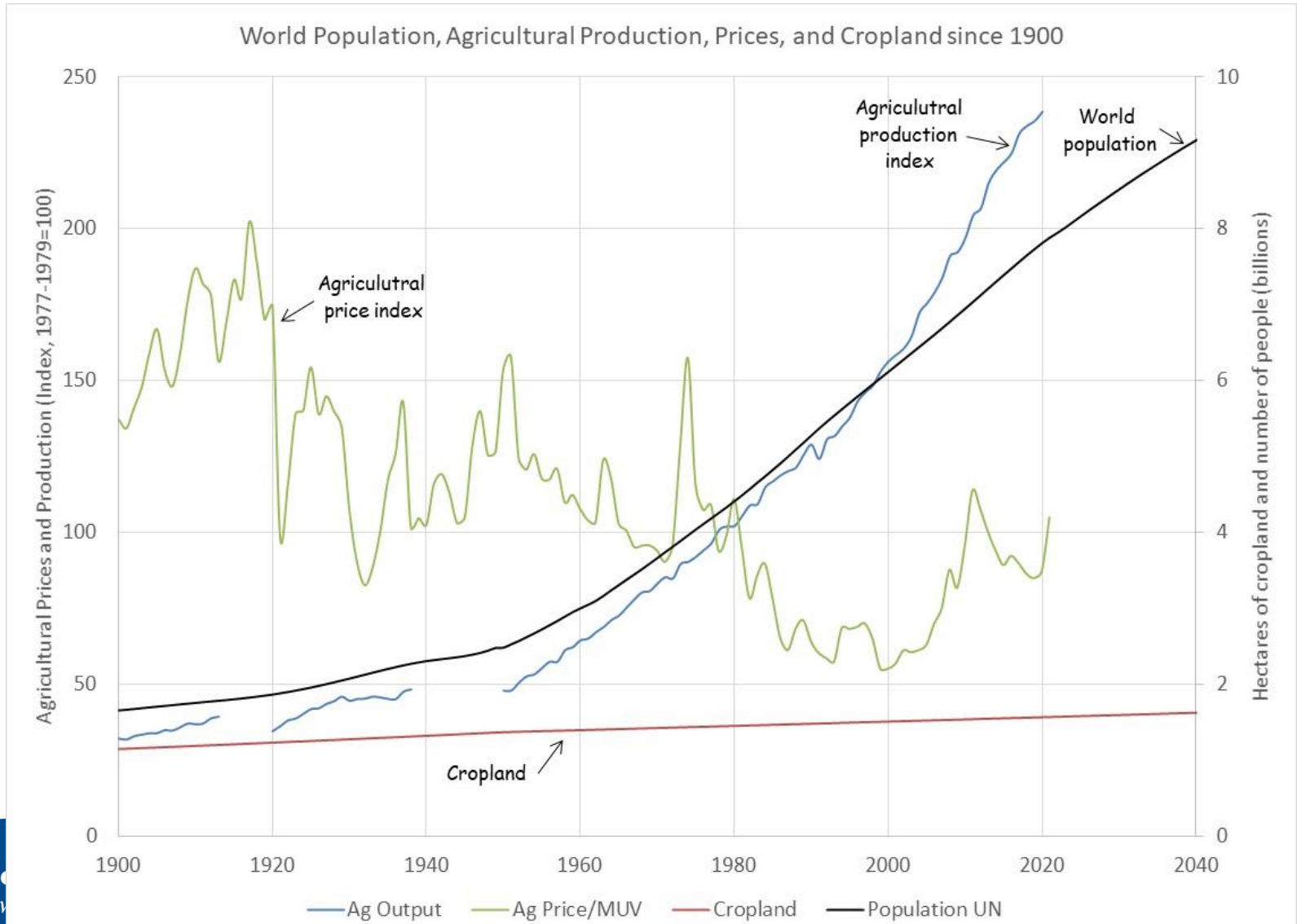
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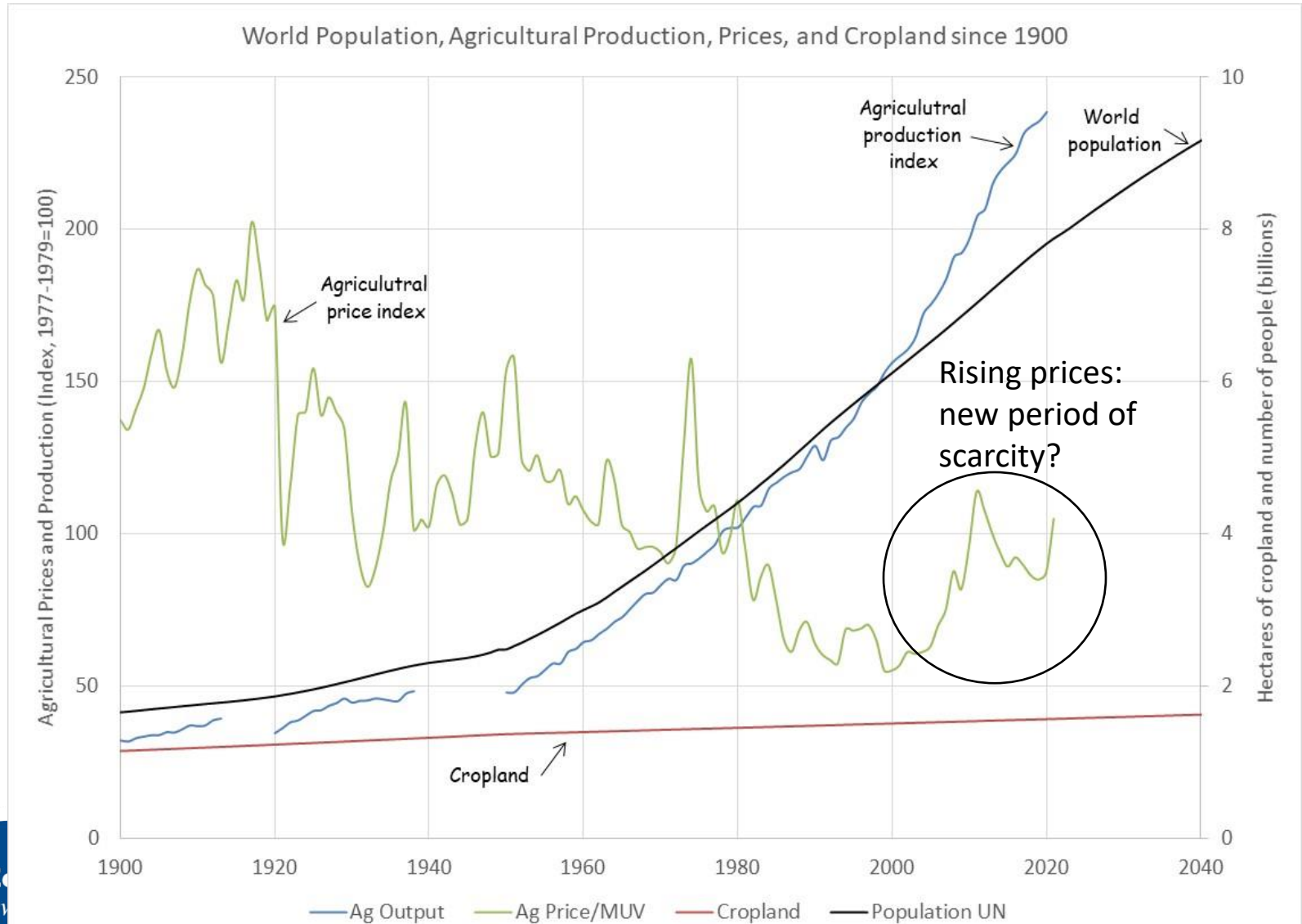
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Over the long-run, increases in agricultural productivity have improved global food security – food has become cheaper even as population has grown



Is the world investing sufficiently in R&D to keep productivity growing fast enough to meet demand and save land and resources?

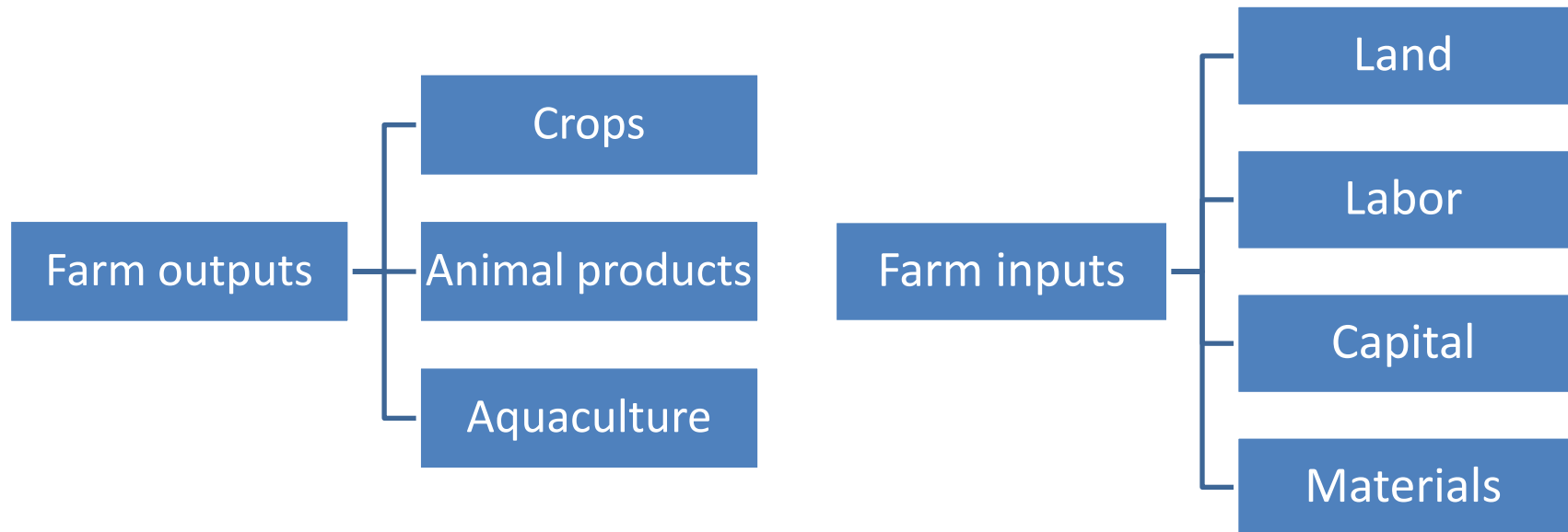


Measuring agricultural productivity

- Productivity: ratio of output to input
- ‘Partial’ productivity
 - Output per unit of one input or ‘factor of production’
 - Crop Yield: output per acre of LAND
 - Labor productivity: value-added per hour of work
[value added = gross output minus intermediate inputs]
- ‘Total’ productivity or Total Factor Productivity (TFP)
 - All economic outputs / All economic inputs



USDA ERS construction of agricultural TFP: index of total farm outputs per unit of total farm inputs; reflects contribution of “technical change” to output



$$\text{Agricultural TFP} = \frac{\text{Total farm outputs (crops, animals, aquaculture)}}{\text{Total farm inputs (land, labor, capital, materials)}}$$

$$\text{TFP growth} = \text{Total output growth} - \text{Total input growth}$$



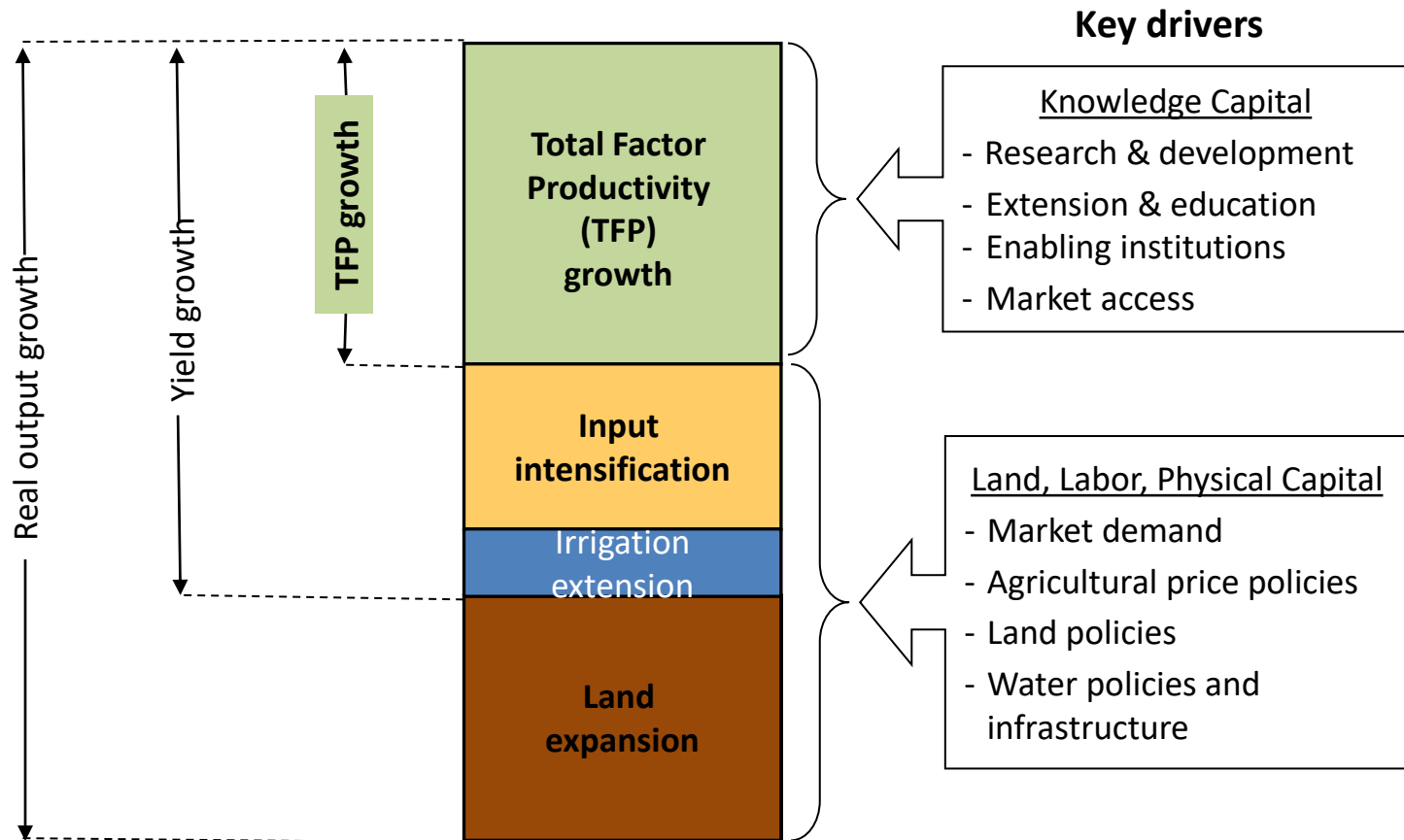
What makes TFP different from other metrics?

- TFP growth rate has economic content:
 - 1% growth in TFP = 1% decline in unit cost of production, holding prices fixed
 - TFP growth measures the shift in the Supply function from technical change
- Other metrics
 - By focusing on just one input, partial productivity measures ignore contribution of other inputs to output growth
 - Other multi-factor measures often use arbitrary weights to combine elements and lack economic interpretation

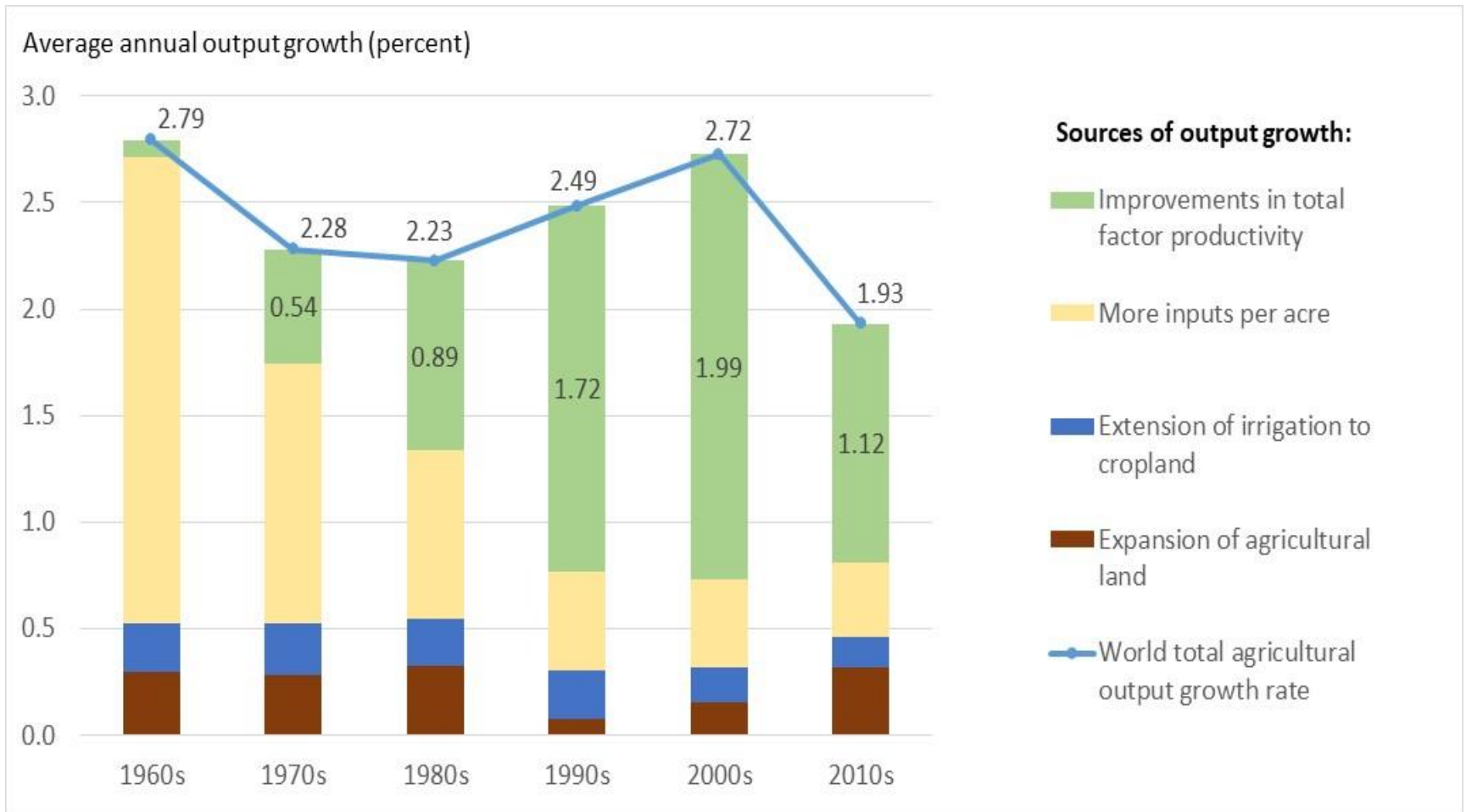
[The Economist Global Food Security Index, Leo-400 National Sustainable Agriculture Standard, Field-to-Market Sustainability Indicators]
- TFP is the broadest available measure of economic efficiency and technical change
- TFP growth rate is widely used as an indicator of long-run economic performance of national economies and sectors



A closer look at sources of agricultural growth for long-run sustainability



In last decade, global agricultural growth has slowed, largely due to slowing TFP growth

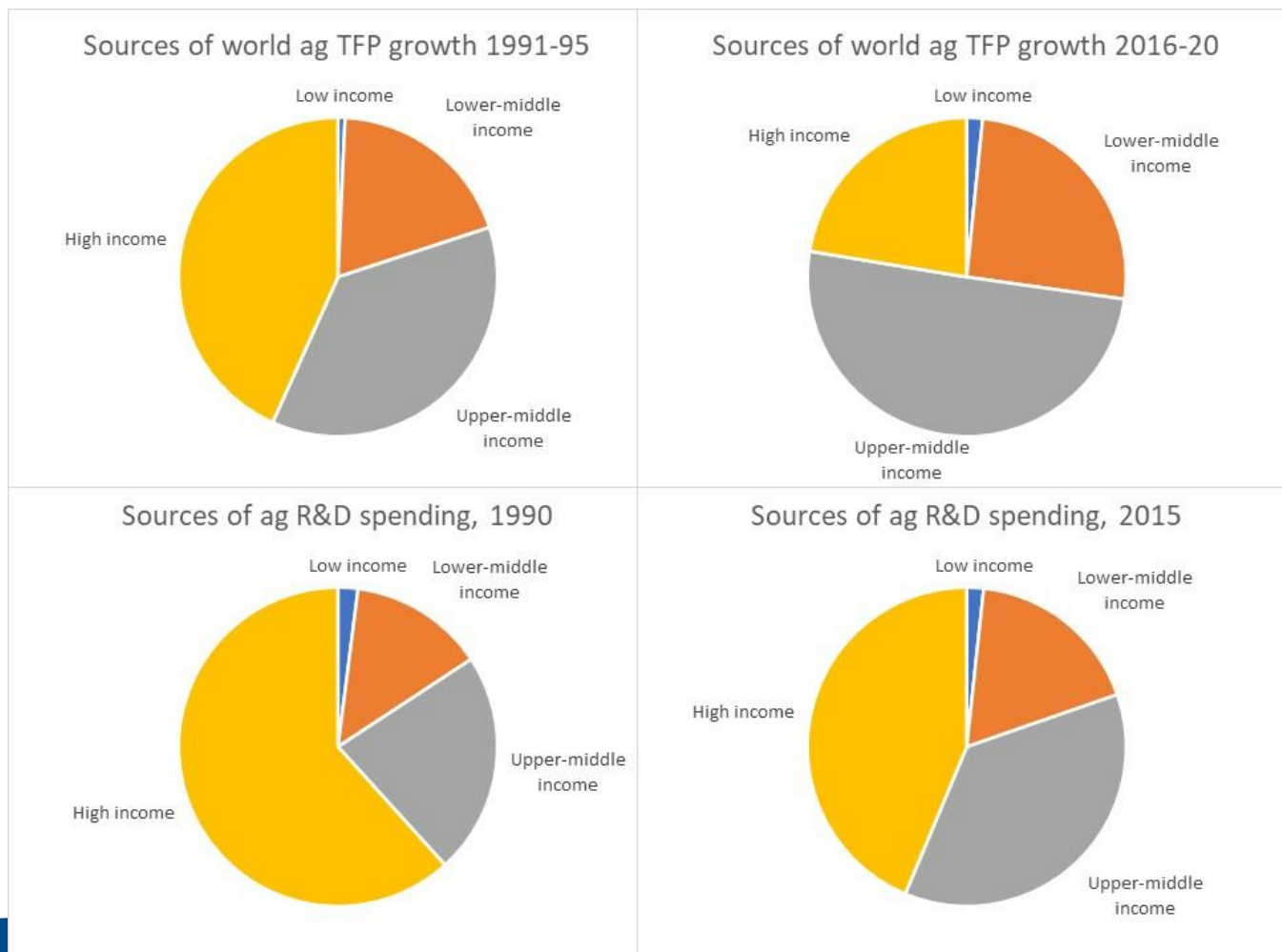


Why is agricultural productivity growth slowing down? Likely suspects:

- Slowing rate of innovation (not enough R&D)
 - Alston & Pardey (2014) *Journal of Economic Perspectives*
- Climate change and weather shocks
 - Ortiz-Bobea et al. (2021) *Nature Climate Change*
- Emergence of new or resistant disease and pests
 - African Swine Fever, herbicide-resistant weeds
- Slow adoption and diffusion of technologies
 - Poor extension, access to credit/insurance, land tenure
 - Public attitudes & regulations towards biotechnology
- Barriers to market access and trade (including trade in technology)
 - Hertel et al. (2020) *European Economic Review*

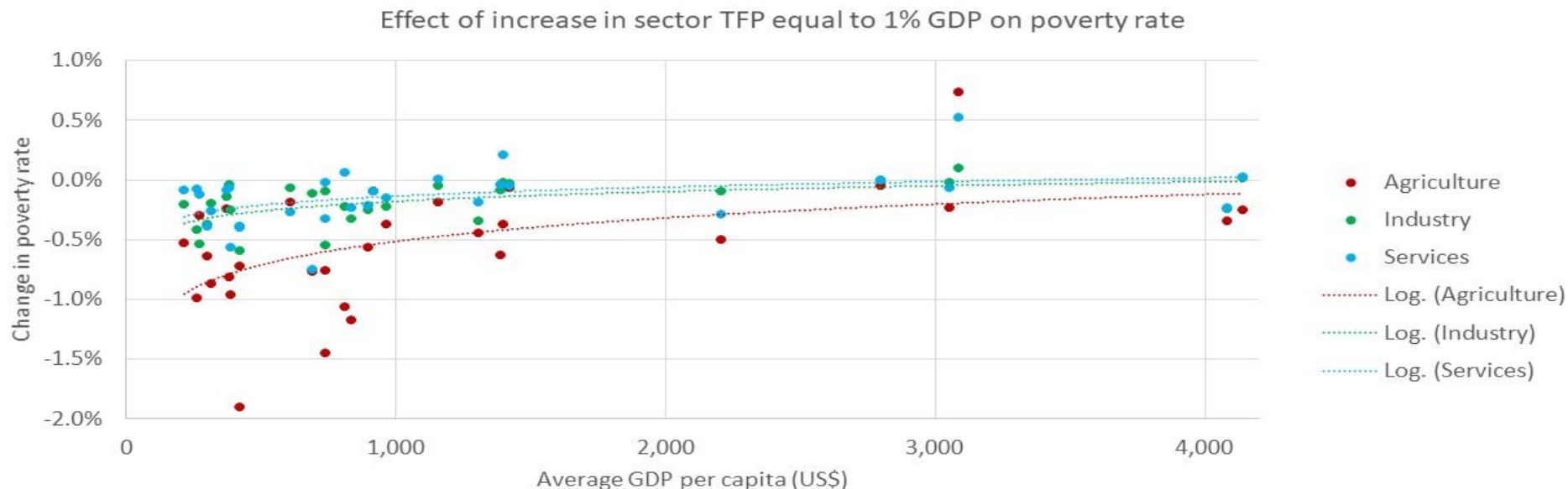


R&D investment is a major driver of TFP growth – and both are shifting to developing countries

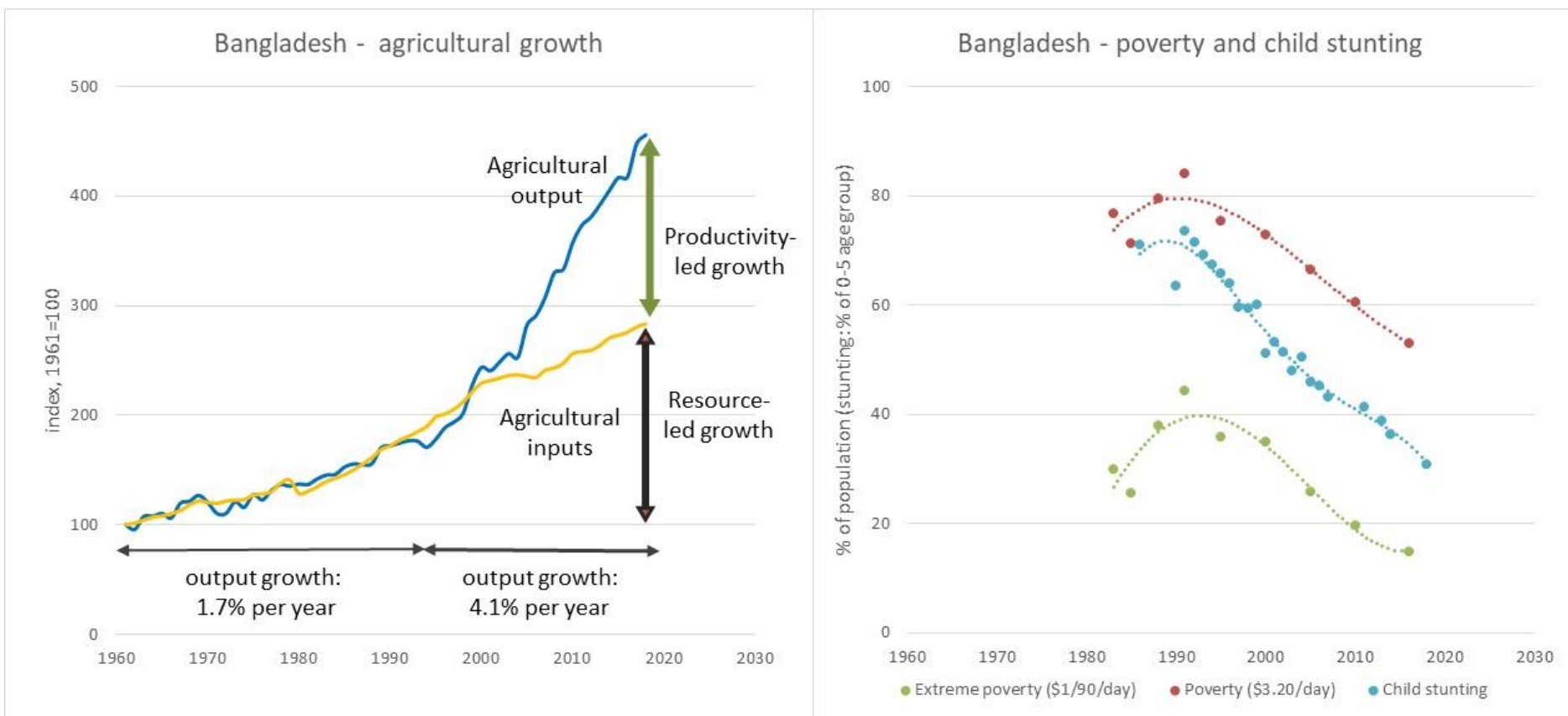


Slower agricultural productivity growth could slow progress on reducing poverty and undernutrition

- Ligon & Sadoulet (2018)
 - Comparison among 62 countries over 1978-2011 (310 observations)
 - Agricultural growth 3-4 times more effective at reducing poverty
- Ivanic & Martin (2018)
 - Modeled results with global CGE model and 315,000 household surveys
 - Agricultural TFP growth up to 4x more effective at reducing poverty in low income countries than growth in manufacturing or services



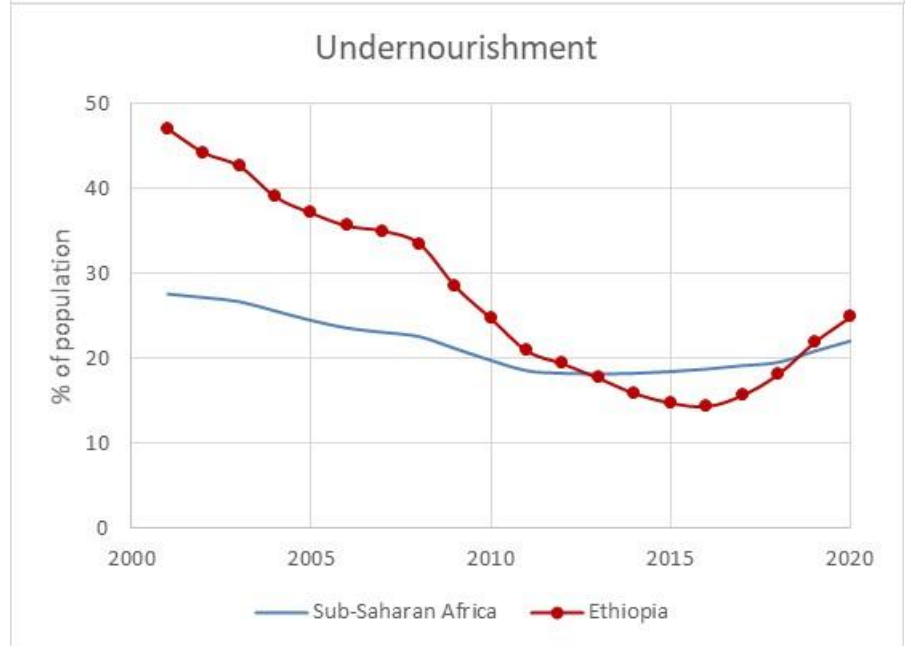
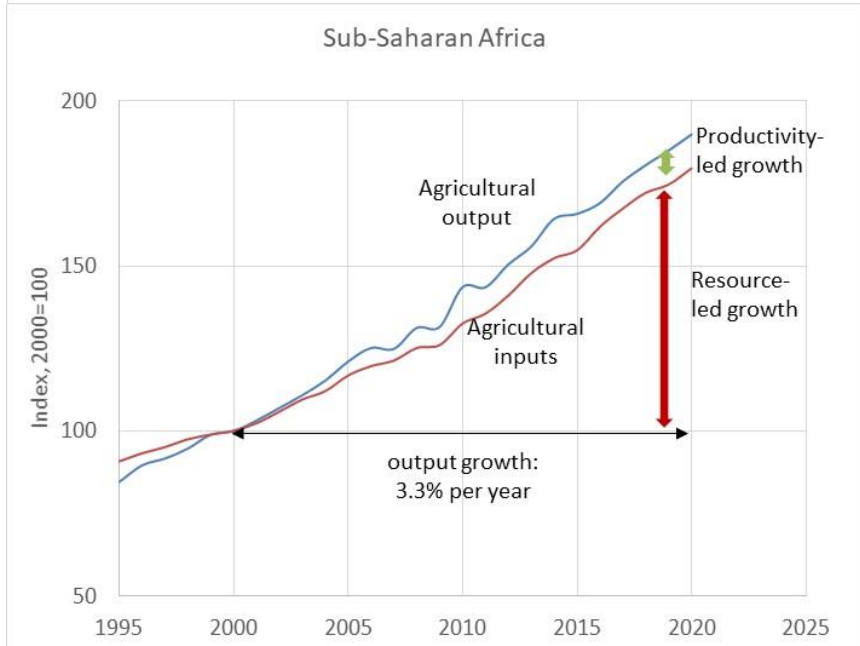
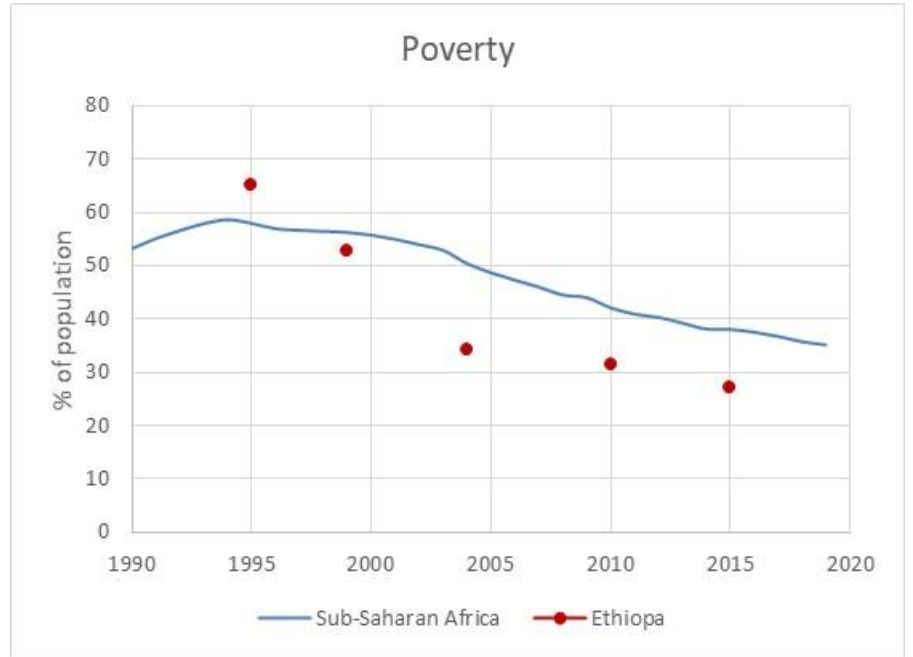
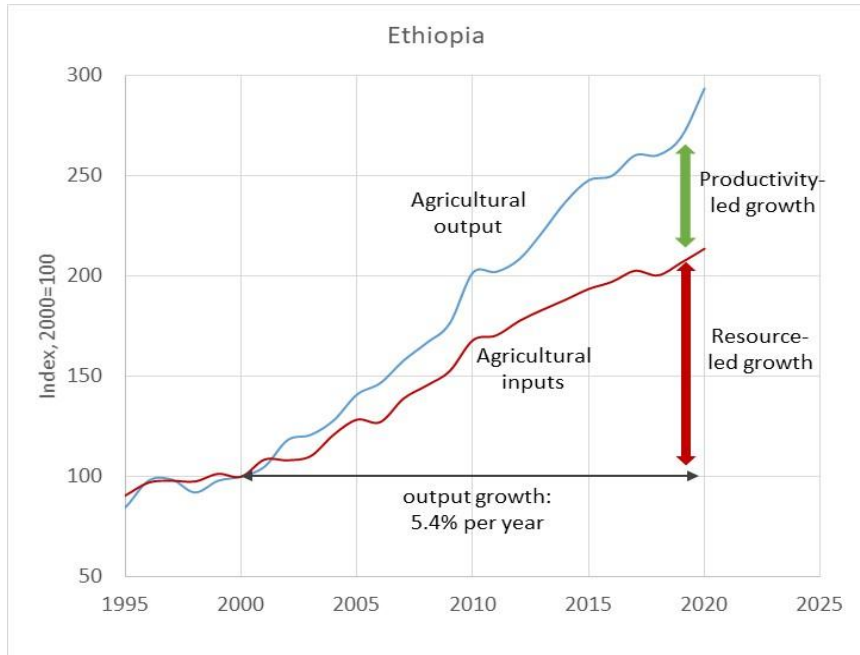
Bangladesh: Poverty and child stunting rates fell sharply during two decades of rapid agricultural TFP growth



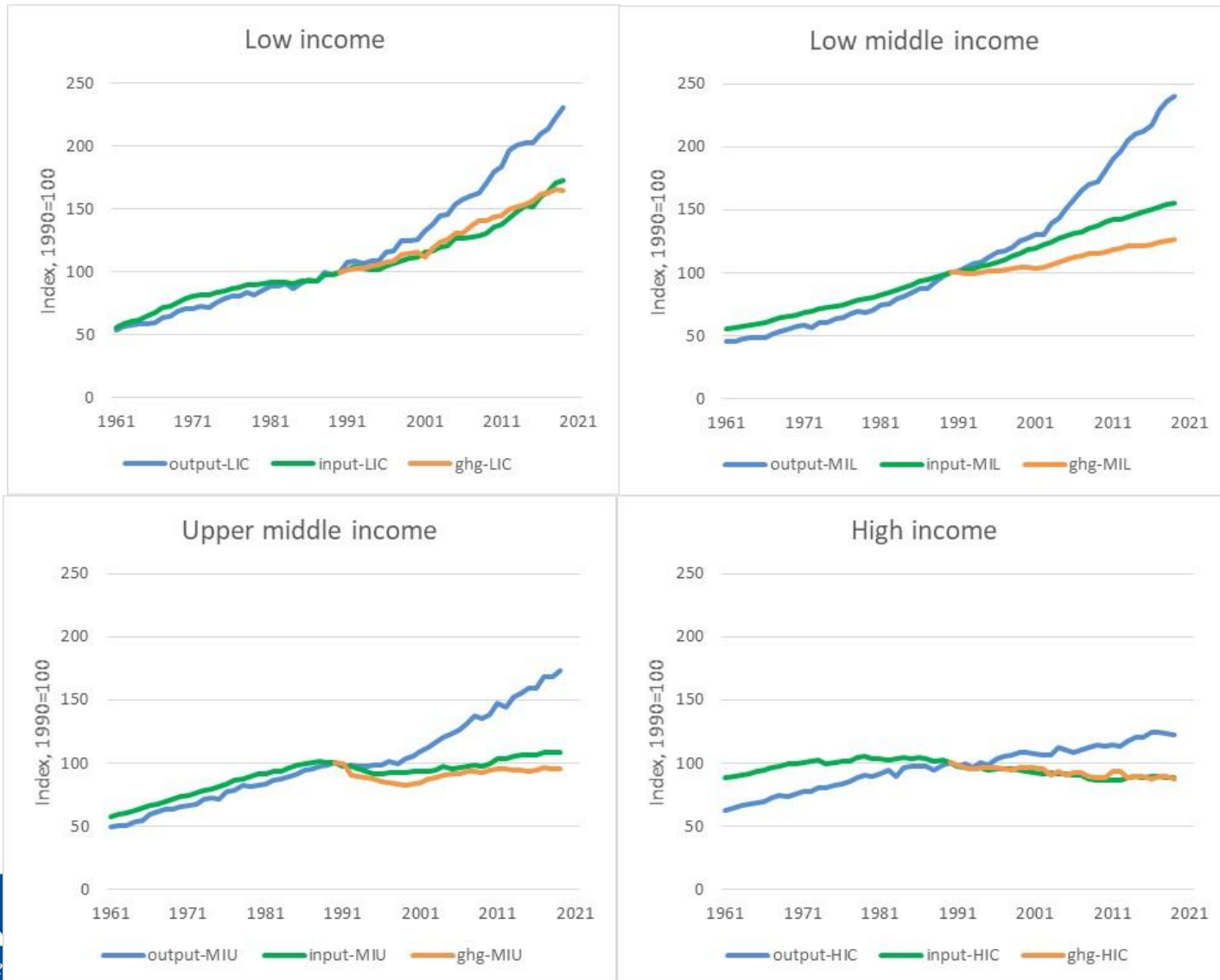
Bangladesh saw poverty and malnutrition fall sharply when agricultural TFP growth accelerated



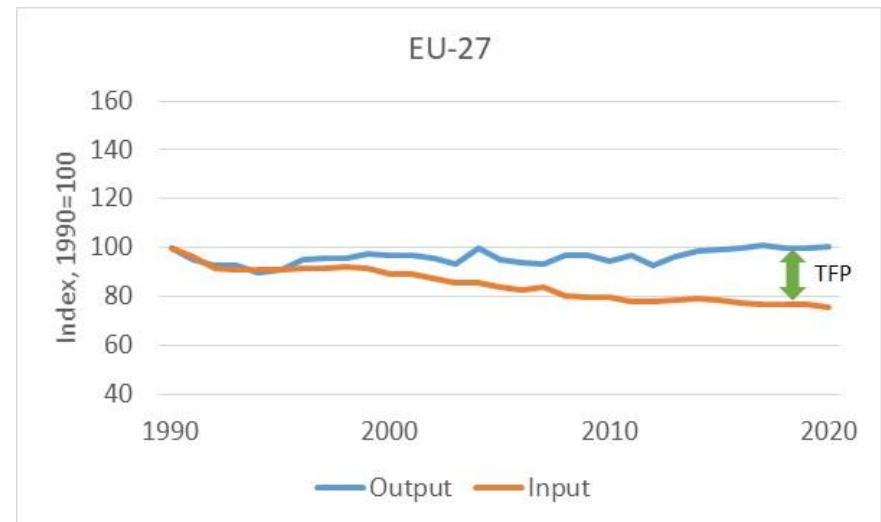
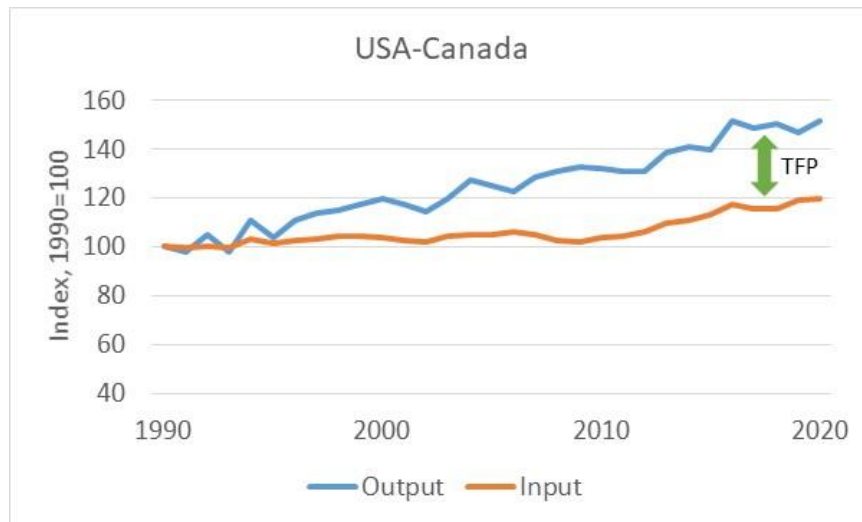
Ethiopia vs. Sub-Saharan Africa



Slowing TFP growth puts more pressure on environmental resources: globally, TFP growth has reduce agricultural land conversion and GHG emissions



USA-Canada versus Europe: Does TFP growth increase outputs or reduce inputs?

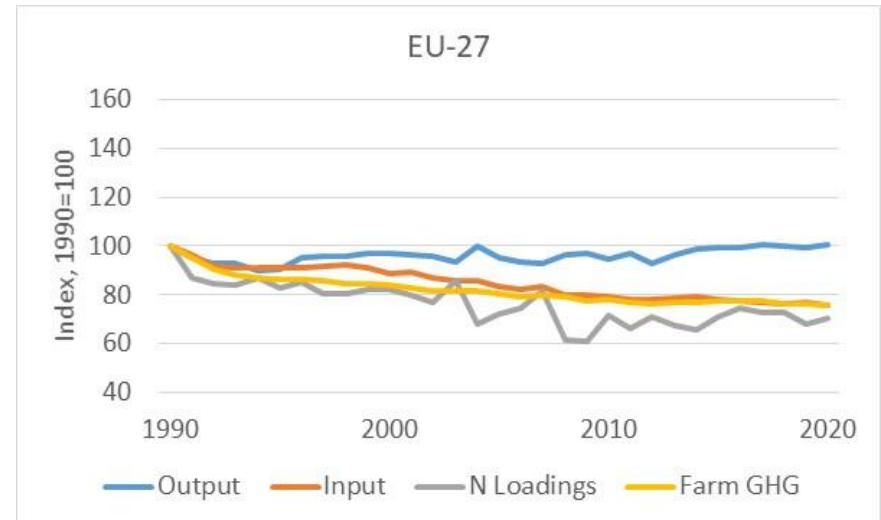
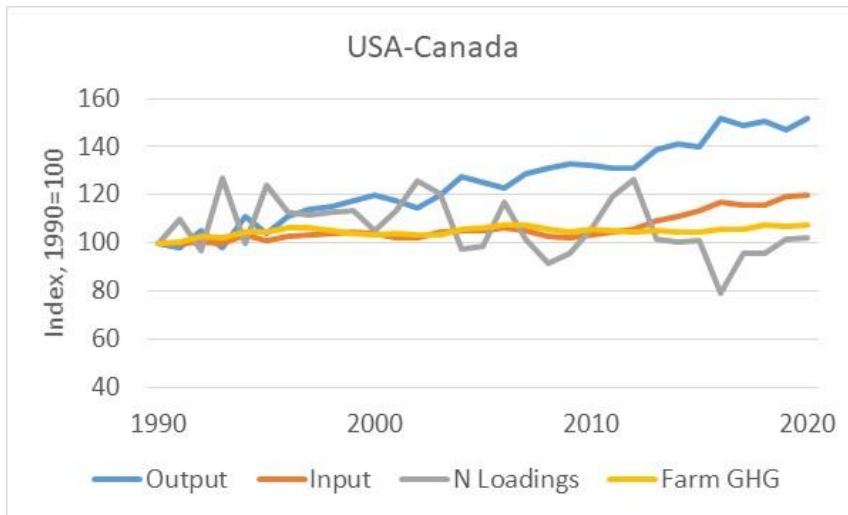


North America: TFP growth raised output and curbed growth in inputs

EU: TFP growth lowered inputs while holding output steady



USA-Canada versus Europe: Does TFP growth save environmental resources?



Depends on whether *composition* of inputs and outputs change
-- some are more closely tied to environmental resources than others



Some conclusions

- TFP indexes provide the broadest available measure of agricultural productivity
- Productivity-led agricultural growth is essential for global food security and environmental resource conservation
- R&D investment is the main policy instrument for raising (and maintaining) agricultural TFP
- Food and environmental policies can provide strong complements to productivity policy

