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Priority-setting in agricultural research for poverty reduction, nutrition improvement and resilience

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Organized Symposium at the Annual Meetings of the AAEA on Agricultural Policies for Reducing Poverty and Improving Nutritional Outcomes

Overview

- Agricultural R&D is still among the highest-return public investments
  - No decline over time or lower returns in specific regions
  - Gains arise from higher productivity of land and labor in target locations
  - Large impacts on poverty, nutrition and resilience
- Impacts revealed by diverse kinds of evidence
  - Individual household data for adoption and response to innovation
  - Aggregate country data for systemic change & structural transformation
  - Modeling food systems to estimate rates of return and private sector growth
- Recent history can help guide research priorities
  - To lower poverty, aim for large targets (species & systems) in poor places
  - To improve nutrition, aim at purchasing power for better diets (income/prices)
  - To improve resilience, aim at level *and* stability of poverty/nutrition outcomes

We start with a systematic literature review

- Topic is longstanding and broadly defined, so we focus on:
  - recent studies (most are since 2010, earliest cited is 1996)
  - peer-reviewed, high-impact work (mostly journals, include gray literature)
  - target regions (mostly Africa and South Asia, some Latin America)
  - relevance for specific objectives (poverty, nutrition and resilience)
- Research uses diverse methods and terminology
  - repeated searches with different search terms
  - personal outreach to individual scholars and practitioners
- Research uses different kinds of data:
  - Qualitative studies (for questions without numerical data)
  - Statistical estimates (both household surveys and aggregate data)
  - Simulation models (built from statistically-estimated components)

Causal mechanisms and types of evidence

Impacts of R&D occur through systemic change

Reduced poverty and hunger among smallholder farmers

Reduced poverty and hunger through non-farm rural employment

Increased household income

Increased farm earnings (gross margins)

Increased farm productivity

Increased demand for locally produced goods and services

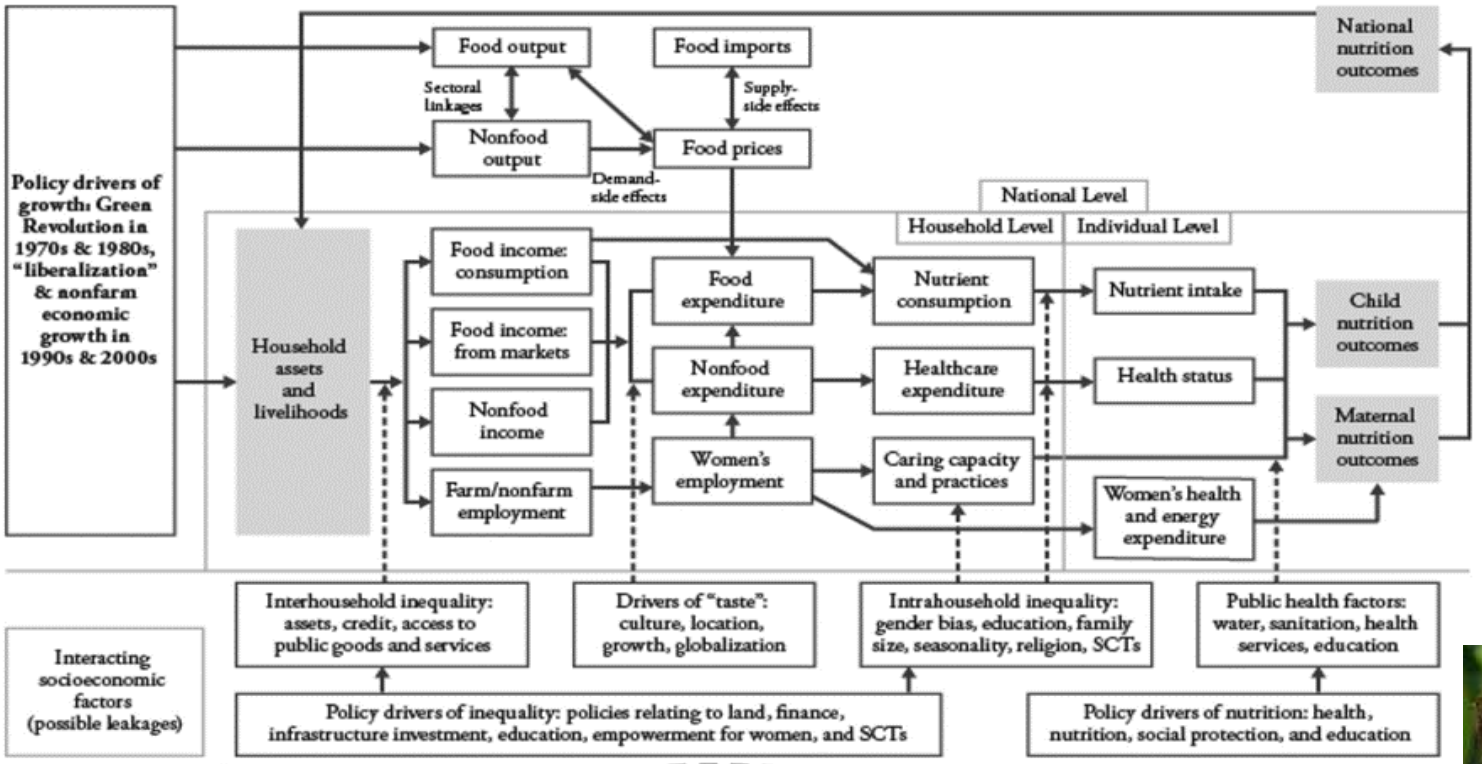
Increased food supply for marketing, processing, transport

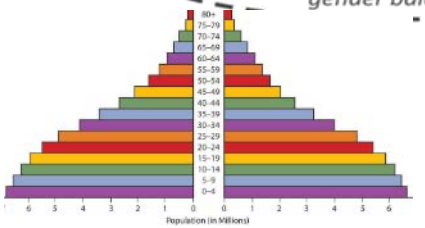
Increased demand for purchased farm inputs

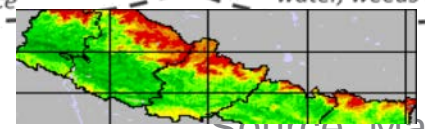
Source: Pathways diagram from Oehmke et al. 2010; photos from W. A. Masters

Causal mechanisms and types of evidence

Adding nutrition and resilience requires even more data







Source: Masters, Webb, Griffiths, & Deckelbaum (2014), modified from Gillespie, Harris and Kadiyala (2012).

Principal results – driving force is productivity

Country-level data on systemic change reveals how public ag R&D is a key lever to raise outputs/inputs (total factor productivity, TFP)

- Fuglie et al. (2012): over 87 countries from 1961 to 2009, agricultural TFP accounted for 40% of the sector's growth, driven by R&D
- Fuglie and Rada (2012): focusing on 37 SSA countries since 1977, public R&D accounts for all the TFP turnaround and growth since 1981
- Country studies find that at some places & times (e.g. Brazil, India) public research has large direct impacts visible in the data; elsewhere (Indonesia, China) the data are dominated by changes in trade policy, infrastructure and institutional changes

Principal results – links to private investment

Public research drives growth by attracting private investment, on and off the farm; privately-financed R&D still very low in Africa

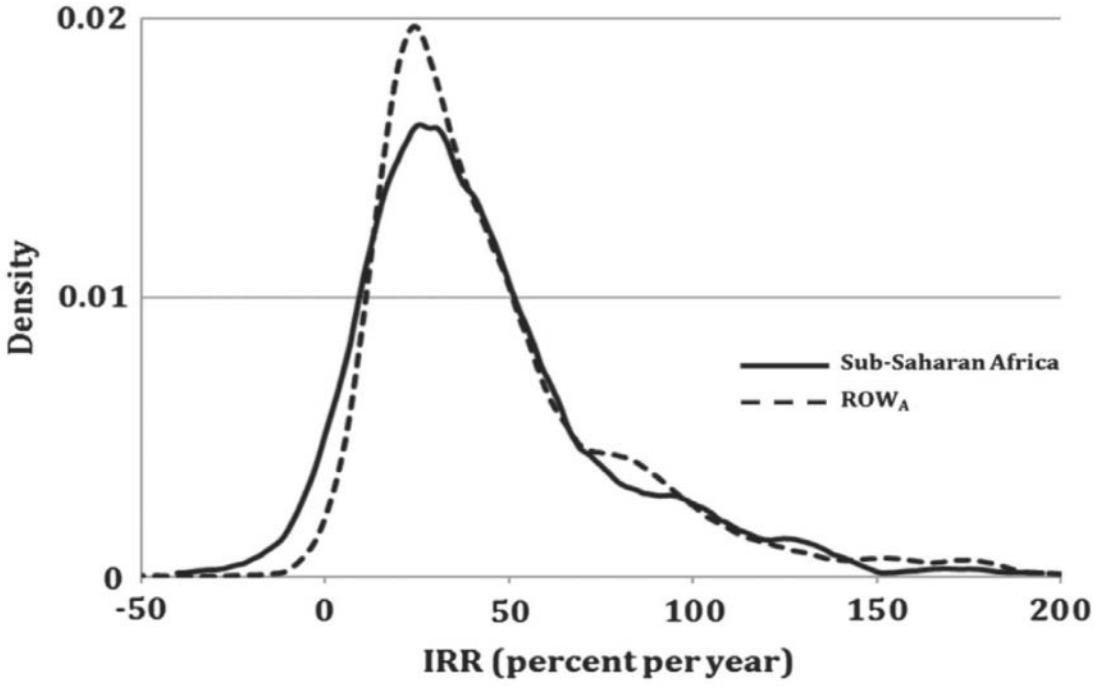
- Private R&D and TFP in US (Huffman & Evenson 2006) and India (Evenson, Rosegrant & Pray 1998)
- Private R&D adds proprietary components to public domain knowledge, skills and market opportunities, e.g. for
    - Poultry (Narrod & Pray 2001)
    - Hybrid maize, millet and sorghum (Pray & Fuglie 2014)
    - GMO cotton, maize and soybeans (Pray & Fuglie 2014)

Principal results – rates of return

Impacts are summarized by return on investment

- Hurley et al. (2016): Over 2,600 estimates from 492 studies in 85 countries reveal high returns in all time periods, sub-sectors and geographic regions

Estimated rates of return to food and agriculture R&D investment in Africa (SSA, n=376) and the rest of the world (ROW, n=2,251)



Source: Pardey, P.G., Andrade, R.S., Hurley, T.M., Rao, X. and Liebenberg, F.G., 2016. Returns to food and agricultural R&D investments in Sub-Saharan Africa, 1975–2014. *Food Policy*, *65*, pp.1-8.

Principal results – examples of high returns

Impacts are summarized by return on investment

- Raitzer & Maredia (2006) use data from 23 studies to aggregate the total costs and benefits of CGIAR–NARS partnership investments in SSA for the period 1966–2004. US$17 billion investments generated benefits of $26-28 billion
- Jutzi and Rich (2016) focusing on livestock find high ROI from rinderpest eradication, goat parasites, dairy policy change, new forages, and natural resource management, but not control of avian influenza

Principal results – poverty reduction

- Thirtle, Lin and Piesse (2003) across 48 developing countries: 10% increase in ag research reduces poverty by 1%
- Thirtle and Piesse (2007), more detail:
  - research increases yield/ha,
  - yield/ha increases income, reduces inequality (except in Latin America)
  - increasing income and reducing inequality reduces poverty
- Alene and Coulibaly (2009) 28 countries of SSA,1980 to 2003
  - R&D expenditures by CGIAR centers in Africa and by African governments increased agricultural value added/hectare,
  - value added/hectare increases average income,
  - increased average income reduces the poverty rate
  - doubling research investment would reduce poverty by 8%

Principal results – examples of poverty impacts

Authors	*Location*	*Subsector*	*Method*	*Outcome*
Research on production agriculture				
Asfaw, Kassie, Simtowe & Lipper, 2011.	Tanzania	Pigeon pea public	Ex post adoption and poverty reduction	Adoption of improved pigeon pea varieties significantly decreased inequality & severity of poverty, by 4.4–8.1 percentage points
Chagunda et al., 2016	SSA	Improved dairy technology		In Sub-Saharan Africa (SSA), smallholder dairy improved with 3 approaches: ecological, genetic, and socio-economic intensification
Larochelle, 2015	Uganda/ Rwanda: Common beans	Common beans CIAT	Ex post adoption and poverty reduction	Impacts on poverty were 0.4% in Rwanda and 0.1% in Uganda, proportional to small area & small part of diet
Moyo, Norton, Alwang, Rhinehart, & Deom, 2007	Eastern Uganda	Peanuts. Public sector in Uganda, by ICRISAT in Malawi,	Ex ante impact analysis of adopting Rosette-resistant seed varieties by all peanut producers	Full adoption would give 10.5% decline in severity of poverty.
Oehmke et al., 2011	Kenya	USAID supported productivity programs for maize, livestock and vegetables	Ex post analysis using Tegemeo panel of HHs	Between 2004 and 2008, net poverty in the direct treatment group decreased by 4.9%. Among indirect beneficiaries of the programs, a net poverty rate reduction of 9.9%. In 2006- 2008, poverty among female-headed households potentially benefitting from the USAID programs declined from 76% to 67%.
Zeng et al., 2015	Ethiopia	Maize varieties from CGIAR	Ex post based on survey data	0.8-1.3% decline in poverty due to adoption but the poor benefitted least because of their small land holdings

Principal results – postharvest food systems

The main driver of R&D impacts is higher primary productivity (more of all outputs per unit of land, labor and other inputs) but post-harvest food systems are also important targets:

- Postharvest R&D can:
  - reduce product losses, save labor and lower food costs:
    - Hermetic storage of grain improved food security for the poor in Kenya (Gitonga et al. 2013)
    - Mechanization of cassava processing reduced poverty rates in Zambia (Abass et al. 2017)
  - improve *quality* of output:
    - Insect resistant maize reduces mycotoxin exposure for the poor in South Africa (Pray et al 2013)
    - Development of small-scale milk vendor systems improved diet quality for the poor and generated a 55% ROR in Kenya (Kaitibie et al. 2010)

Principal results – R&D impacts on nutrition

The main impacts of R&D are through increased supply and lower average cost of food relative to poor peoples' incomes

	Comparisons to base case (percent changes)	
	With no MVs in developing countries (NGR)	With no IARC programs (NIARC)
Crop yields		
Developed countries	2.4 to 4.8	1.4 to 2.5
Developing countries	−19.5 to −23.5	−8.1 to −8.9
Cropped area		
Developed countries	2.8 to 4.9	1.6 to 1.9
Developing countries	2.8 to 4.9	1.6 to 1.9
Crop production		
Developed countries	4.4 to 6.9	1.0 to 1.7
Developing countries	−15.9 to −18.6	−6.5 to −7.3
Crop prices, all countries	35 to 66	18 to 21
Increase in imports by developing countries	27 to 30	6 to 9
Percent of children malnourished, developing countries	6.1 to 7.9	2.0 to 2.2
Calorie consumption per capita, developing countries	−13.3 to −14.4	−4.5 to −5.0

Source: Evenson and Gollin, 2003.

Principal results – R&D impacts on nutrition

Beyond food prices relative to incomes, other data reveals systemic impacts on nutrition and health:

- Barnwell et al. 2017 find that modern variety (MV) introduction led to a large declines in infant mortality, using DHS data on 600,000 births in 37 developing countries
- Masters et al. 2014 find that agricultural productivity drives establishment of towns and cities, which in turn improves nutrition of children who remain in rural areas (Darrouzet-Nardi and Masters 2015)

Principal results – R&D impacts on resilience

Pathways by which agricultural research have increased resilience of farm households include:

- Development of farm inputs that stabilize production itself, by reducing vulnerability to biotic stress (insects, diseases), abiotic stress (moisture, temperature, soils) and increasing diversity (Smale 2006, Lipper et al. 2010, Michler et al. 2016)
- Development of food markets and other services that allow “nutrition smoothing” against seasonal and annual shocks (Darrouzet-Nardi and Masters 2017, Mulmi et al. 2016).
- Development of agrifood policies and programs to reduce vulnerability such as safety nets and insurance systems (Janzen and Carter 2013, Jensen and Barrett 2016)

Principal results – synergies with other public investments

Effects of R&D investment scenarios (MED-REGION) show trade-offs, complementarities with irrigation (IX), water saving (ISW) & infrastructure (RMM)

Scenario	Avg. Annual Cost	2030						2050					
		SLO1	SLO2		SLO3			SLO1	SLO2		SLO3		
		GDP	Ag Supply	Hunger	Water Use	GHG	Forest	GDP	Ag Supply	Hunger	Water Use	GHG	Forest
MED	1.4	0.7	1.4	-6.5	0.0	-5.5	0.03	1.9	2.7	-9.3	-0.2	-15.4	0.13
HIGH	2.0	1.3	2.8	-12.4	-0.1	-7.5	0.04	3.4	5.7	-16.6	-0.4	-24.3	0.20
HIGH+NARS	3.0	1.6	3.7	-15.8	-0.1	-8.9	0.04	4.3	7.7	-20.2	-0.4	-26.5	0.22
HIGH+RE	2.0	2.6	6.4	-24.4	-0.2	-12.7	0.06	4.2	7.5	-20.0	-0.4	-26.9	0.22
REGION	2.5	1.1	2.4	-10.9	-0.1	-6.5	0.03	3.1	5.1	-15.4	-0.3	-22.6	0.18
IX	3.6	0.1	0.1	-1.3	2.6	-1.8	0.01	0.2	0.2	-1.1	2.9	0.7	-0.01
IX+WUE	8.3	0.4	0.9	-4.5	-7.2	-1.9	0.01	0.5	0.9	-2.7	-7.5	-0.2	-0.01
ISW	5.0	0.2	0.5	-2.1	-1.5	-0.5	0.00	0.5	0.9	-3.0	-2.9	-1.1	0.01
RMM	11.9	1.0	1.6	-5.8	0.1	6.4	-0.02	0.8	1.5	-4.2	0.0	8.9	-0.08
COMP	26.4	4.1	9.8	-30.6	-9.0	-11.5	0.07	5.7	11.5	-24.4	-11.0	-25.4	0.22

Less Advantageous — Neutral — More Advantageous

Note: costs are in billion USD, while other values are percentage differences in each indicator relative to the REF_HGEM scenario

Source: Rosegrant et al. 2016

Notes: Strategic objectives are SLO1: Reduced poverty, SLO2: Improved food and nutrition security and health, SLO3: Improved natural resource systems and ecosystem services. Policy scenarios are as defined in Table 4.

Conclusion -- implications for priority setting

Agricultural research remains the highest-return driver to reduce poverty, improve nutrition and build resilience.

To reach specific objectives more quickly, use a sequence of investment criteria such as the following:

1. **Poverty**: Is the investment likely to raise real incomes for those at risk?

   ➔ aim for large targets (species & systems) in poor places

2. **Nutrition**: Is the investment likely to lower the real cost of nutritious food, and improve non-food influences on nutrition outcomes?

   ➔ aim for lower real cost of better diets (food prices relative to incomes), and also limit disease exposure, empower household caregivers

3. **Resilience**: Is the investment likely to stabilize real income, food costs and other influences on poverty and nutrition?

   ➔ aim to address large and growing stressors (both biotic and abiotic)

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Thank you!

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