

POLICY AND ECONOMIC CONSIDERATIONS FOR GLOBAL PUBLIC GOODS PROVISION: AGRICULTURAL AND HEALTH R&D FUNDING FROM THE PRIVATE, PUBLIC, AND PHILANTHROPIC SECTORS

**PIERRE E. BISCAYE, C. LEIGH ANDERSON, TRAVIS REYNOLDS,
MATTHEW FOWLE, & TRYGVE MADSEN**
EVANS SCHOOL POLICY ANALYSIS & RESEARCH GROUP (EPAR)
DANIEL J. EVANS SCHOOL OF PUBLIC POLICY AND GOVERNANCE
UNIVERSITY OF WASHINGTON



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Overview

- > Background
- > Methods
- > Funders' Incentives and Capabilities for R&D Public Goods Investment
- > Agricultural and Health R&D Investments by Sector
- > Discussion of Findings



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Agricultural and Health R&D “Publicness”

- > R&D produces knowledge that can be used repeatedly – non-rival
- > Results of R&D may fall under patent or IP protections – some excludability incentivizes private sector R&D investment
- > Knowledge from basic ag and health R&D may have wide potential applications – “global” public goods
 - Results of more applied ag and health R&D, specific to certain crops/diseases, may have more geographically concentrated benefits



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Why Multiple Sectors Funding R&D?

- > New health technologies can improve individual health and educational outcomes, boost incomes, and contribute to herd immunity and other social benefits (Røttingen et al., 2013; Banke-Thomas et al., 2015)



- > New agricultural technologies can improve farmers' yields and promote regional food security, sustainable use of natural resources, and other social benefits (reduce poverty and environmental degradation)

(Naseem et al., 2010; Adato & Meinzen-Dick, 2007; Meinzen-Dick et al., 2003; Hazell & Haddad, 2001; Kerr & Kolavalli, 1999)



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Characteristics of Selected Areas of Agricultural and Health R&D

> *Agricultural R&D*

- **Cash crops/commodity gains:** more frequently traded, cultivated by both low- and high-income populations, higher potential financial returns, high social benefits
- **Orphan crops/subsistence crops:** less frequently traded, more commonly cultivated by low-income populations, lower potential financial returns, but high social benefits

> *Health R&D*

- **Overall global health:** includes diseases and other health conditions affecting both high- and low-income populations, high potential financial returns and social benefits
- **Neglected diseases:** diseases primarily affecting low-income populations, lower potential financial returns, but potentially high social benefits



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Research Questions

From the perspective of a global planner, an efficient allocation of scarce global R&D funding would match private, public, and philanthropic resources to R&D types consistent with each funder's private or social goals

- > How do characteristics of agricultural and health R&D and of private, public, and philanthropic providers of R&D funding affect the relative advantages of alternative sectors from a global planning perspective?
- > How do trends in agricultural and health R&D funding from public, private, and philanthropic sources for different categories of crops and diseases compare to expectations based on those hypothesized advantages?



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Methods

- > Draw on literature to summarize incentives for R&D public good investment by sector (private, public, philanthropic) and public good characteristics of categories of agricultural and health R&D
- > Develop hypotheses for how a global planner would efficiently allocate funding by sector for:
 - Agriculture in general, and comparing R&D for cash crops and commodity grains to R&D for “orphan” crops and subsistence crops; and
 - Global health in general, and for “neglected diseases” in particular
- > Compare funding expectations against trends in private, public, and philanthropic investment in categories of agricultural and health R&D



Data



Data for agricultural R&D funding:

- > CGIAR Agricultural Science and Technology Indicators (ASTI) - multiple years
- > United States Department of Agriculture (USDA) Economic Research Service
- > Reviews and estimates from the literature (e.g., Fuglie et al, 2016; Pardey et al., 2016)

Data for health R&D funding:

- > Jamison et al. (2013), Røttingen et al. (2013), Chakma et al. (2014), and Viergever & Hendricks (2016)
- > G-Finder surveys of neglected disease R&D funding (Moran et al., 2010; Moran et al., 2015; Chapman et al., 2016)

Other data:

- > Global Burden of Disease (2015)
- > Crop production and export value (FAOSTAT)



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Simple Model of R&D Funding Considerations

$$\text{Eqn. 1: } E(NPV) = \left[\text{prob. to market} \left(\frac{R + SOC \ (0 \leq s \leq 1)}{(1+r)^t} + \right) * (0 \leq loc_R \text{ weight} \leq 1) \right] \\ - \sum_i \left[\text{prob.} (phase_i \mid phase_{i-1}) \left(\frac{C_i}{(1+r)^{t_i}} \right) * (0 \leq loc_C \text{ weight} \leq 1) \right]$$

> Financial returns

- Function of excludability, market size, market share, & consumer willingness-to-pay

> Social benefits: e.g., herd immunity from vaccines, food security

> Distribution of benefits: e.g., recovery of benefits by public investor constituents

> Probability of getting products of R&D to market

> Estimated time to market

> Costs of completing stages of R&D



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Hypothesized Funder Weighting

<i>Preferences</i>	Private	Philanthropic	Public
<i>Financial Returns</i>	Necessary	Not necessary	Not necessary
<i>Social Returns</i>	Not accounted for ($s = 0$)	Necessary (s closer to 1)	Valued to some degree ($s > 0$)
<i>Location of Returns</i>	Indifferent (loc_R weight = 1)	Preferences but ranked below social returns (loc_R weight = 1 for areas with high social returns)	Prefer domestic returns (loc_R weight < 1 for non-domestic beneficiaries)
<i>Location of Expenditures</i>	Indifferent (loc_C weight = 1)	Indifferent (loc_C weight = 1)	Prefer domestic expenditures (loc_C weight < 1 for domestic expenditures)



Hypotheses

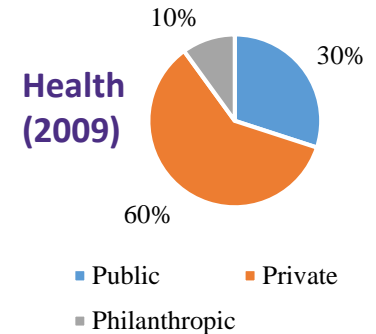
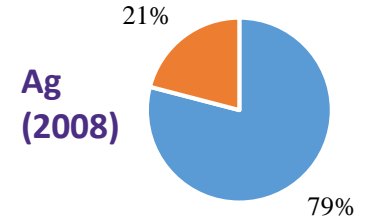
- > Economic theory suggests that:
 1. Compared to the private sector, the *public and philanthropic sectors* direct a greater proportion of their agricultural R&D funding toward subsistence and orphan crops
 2. Compared to the private sector, the *public and philanthropic sectors* direct a greater proportion of their health R&D funding toward neglected diseases



Overall Comparison of Agricultural & Health R&D Funding

- > Total global spending (private and public) on health R&D has increased dramatically since the 1980s
 - Estimated \$30 billion in 1986, estimated \$240 billion in 2010 (Røttingen et al., 2013)
- > Health R&D is largely (over 80%) funded by the private sector in high-income countries (Rottingen et al., 2013; Jamison et al., 2013; Chakma et al., 2014)
- > Health R&D more funded than agricultural R&D
 - \$69.3 billion in food and ag R&D in 2011 (Pardey et al., 2016b)
- > Agricultural R&D largely funded by the public sector

Share of R&D spending by sector



Sources: Beintema et al., 2012;
Røttingen et al., 2013



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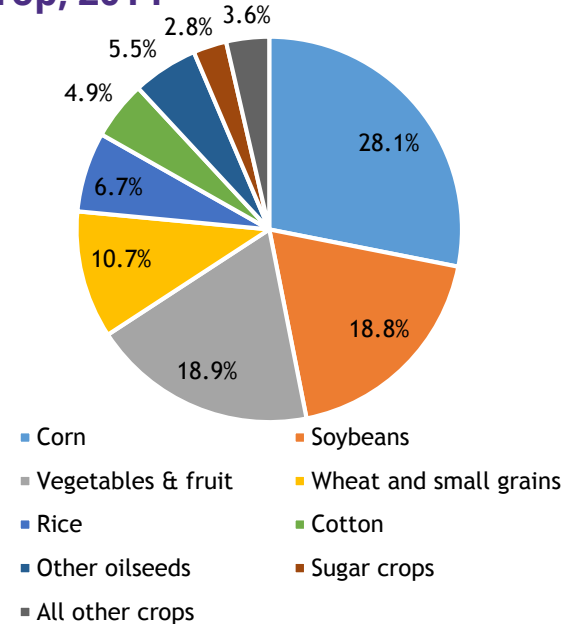
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Private Funding: Agricultural R&D

- > Focus on large-acre market-oriented crops, in particular corn, soybeans, and wheat, in addition to small-acre cash crops like fruit and vegetables (Fuglie et al., 2016)
- > Subsistence crops like cassava, pearl millet, and sorghum are characterized by substantially lower levels of private research intensity (Naseem et al., 2001; CGIAR, 2011)

Private Sector R&D Spending by Crop, 2014



Source: Fuglie et al., 2016



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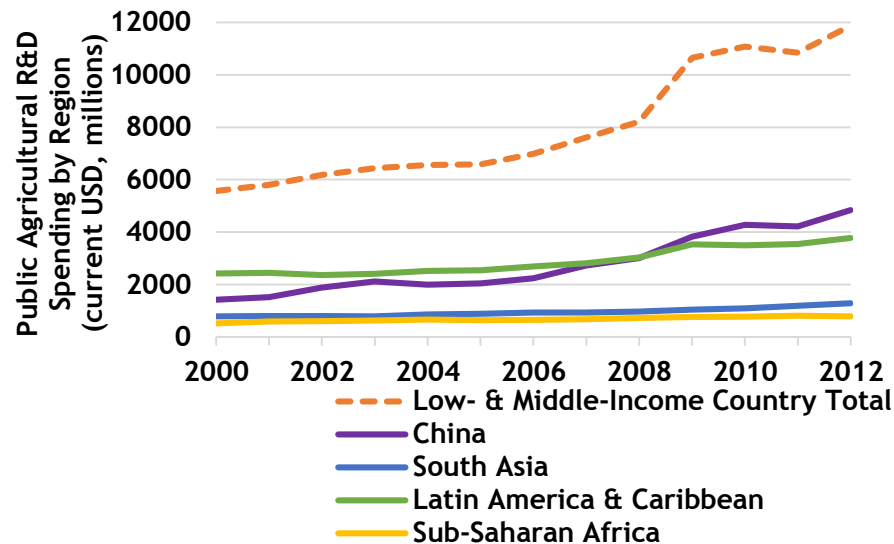
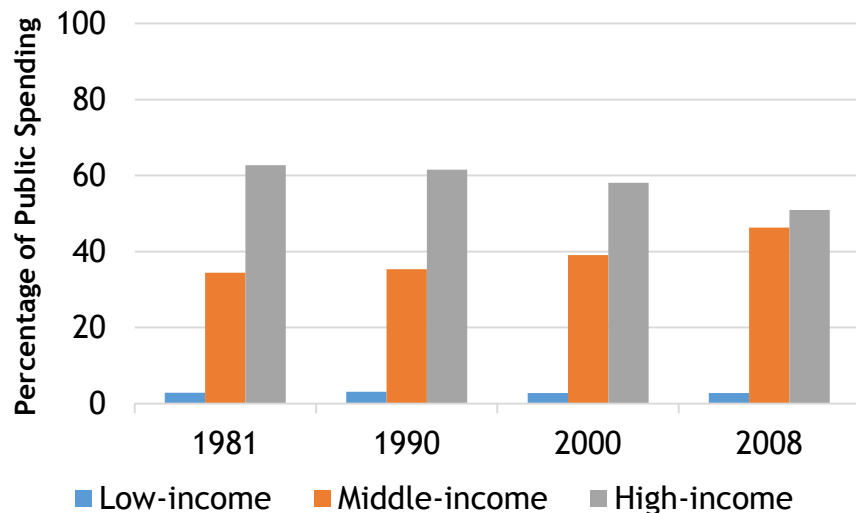
Private Funding: Health R&D

- > Global spending on health R&D in 2009 by the private sector amounted to \$148.8 billion, about 60% of total funding (Jamison et al., 2013)
- > Most private investment targets non-communicable chronic diseases, especially cancers (Jamison et al., 2013)
- > In 2015, the private sector invested \$471 million in neglected disease R&D, 15% of the total from all sectors (Chapman et al., 2016)
 - 82% from multinational pharmaceuticals [MNCs], 18% from small pharmaceuticals and biotech firms [SMEs]
 - 72% of MNC investment in neglected disease R&D went towards the “big three” infectious diseases (HIV/AIDS, malaria, and tuberculosis); only 24.9% of SME investments went to the “big three”(Chapman et al., 2016)



Public Funding: Agricultural R&D

Total spending by country income group



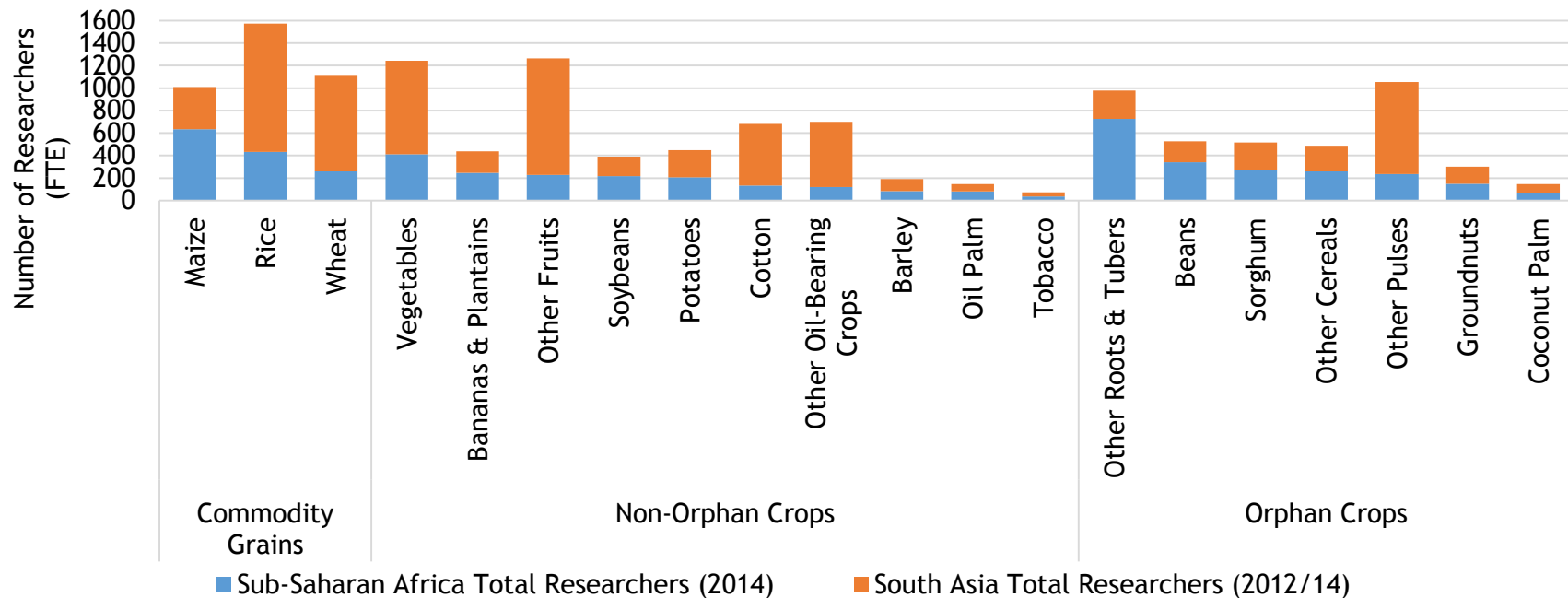
Total spending by country/region

Source: ASTI, 2012



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Public R&D Researchers by Crop Category



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Source: ASTI Database, 2017

Public Funding: Health R&D

- > In 2012, the public sector in the United States, Europe, Canada, and the Asia-Pacific Region spent \$99.6 billion for health R&D (Chakma et al., 2014)
- > Estimated 30% of all health R&D funding in 2009 (Røttingen et al., 2013)
- > The U.S. is the largest public investor in health R&D (\$48.9 billion in 2012) (Røttingen et al., 2013; Chakma et al., 2014)
 - U.S. National Institutes of Health (NIH) - \$26.1 billion in 2013 (Viergever & Hendricks, 2016)



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Public Funding: Health R&D

- > Top NIH-funded disease areas (2014): cancer, infectious diseases, brain disorders, rare diseases, pediatric disorders (Mullin, 2014)
- > The public sector provided \$1.925 billion of funding for neglected disease R&D in 2015 (Chapman et al., 2016)
 - 63% of the total
 - Mostly targeting the “big three” infectious diseases - HIV/AIDS, malaria, and tuberculosis



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Philanthropic Funding: Agricultural R&D

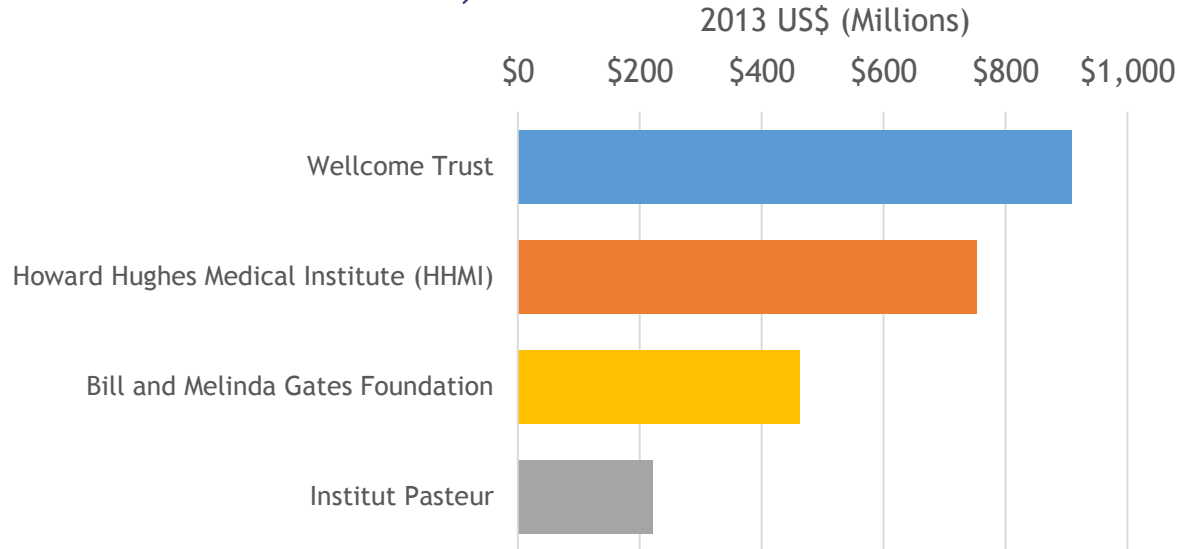
- > Data on philanthropic investments are limited
- > Estimates for total philanthropic funding in 2008 ranged from \$245.6 million (Coppard, 2010) to \$450 million (Morton, 2010)
- > Top five Gates Foundation agricultural R&D grant recipients received \$244.2 million from 2003 to 2010 for breeding and delivery of improved seed varieties (Gates Foundation, 2011)
 - Three of these five grants, totaling \$99.2 million, focus on R&D for maize and wheat
 - One grant totaling \$45 million targets development and delivery of staple crops, including commodity grains and crops that are generally for subsistence only (e.g., sweet potato, beans, millet, and cassava)
 - Largest grant, totaling \$100 million, targets capacity building for both public and private breeding programs in 13 Sub-Saharan African countries.



Philanthropic Funding: Health R&D

About 10% (\$21.4 billion) of health R&D investments in 2009 came from “other” sources, such as private non-profits and philanthropies (Røttingen et al., 2013)

Top philanthropic funders for overall health R&D, 2013



Source: Viergever & Hendricks, 2016



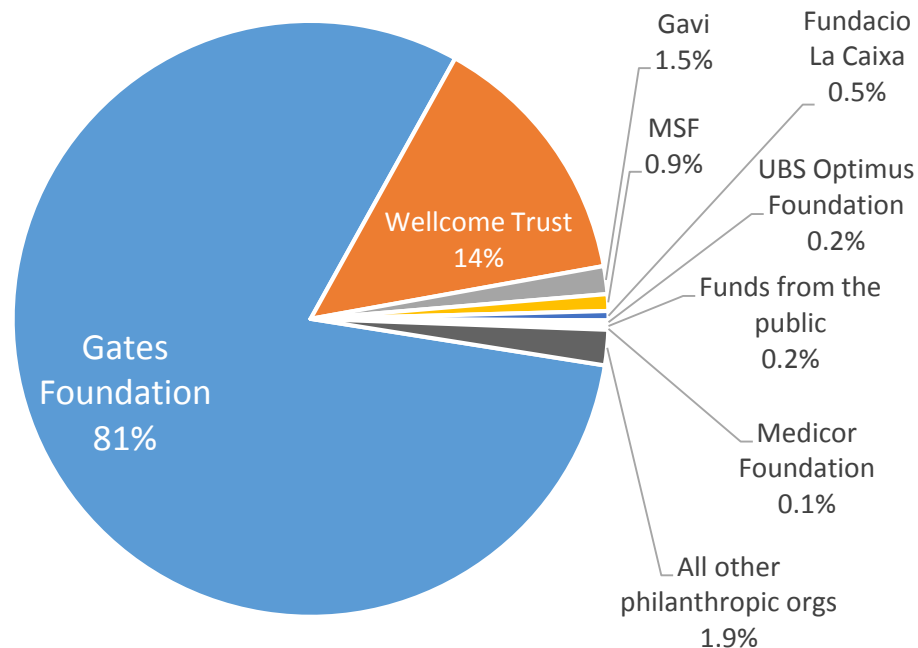
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Philanthropic Funding: Neglected Disease R&D

- > In 2015, private foundations contributed \$645 million to neglected disease R&D, 21% of the total (Chapman et al., 2016)
- > 62% of funding goes to the “big three” infectious diseases - HIV/AIDS, malaria, and tuberculosis (Chapman et al., 2016)



Source: Chapman et al., 2016



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Funding of “Orphan” or Subsistence Crops

- > The private sector primarily funds market-oriented commodity crops and cash crops
 - Very little invested in “orphan” or subsistence crops
- > Philanthropic investment data are limited, but funding appears to overlap with public and private funding
 - No evidence of targeting of “orphan” or subsistence crops
- > More data available on public sector R&D investment – number of public researchers by crop in Sub-Saharan Africa and South and Southeast Asia

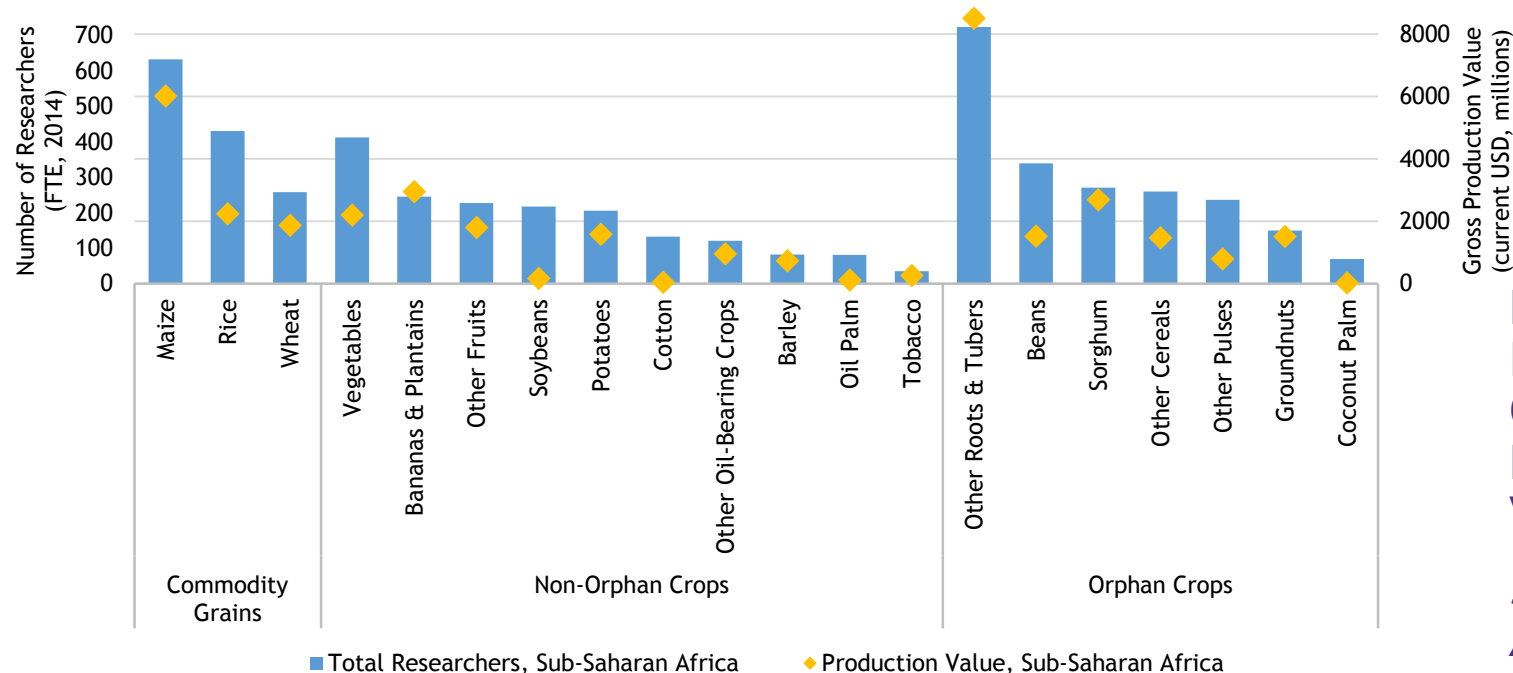


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Drivers of Public Funding for Ag R&D in SSA?



Public R&D
Researchers by
Crop and Gross
Production
Value

*Sub-Saharan
Africa, 2014*



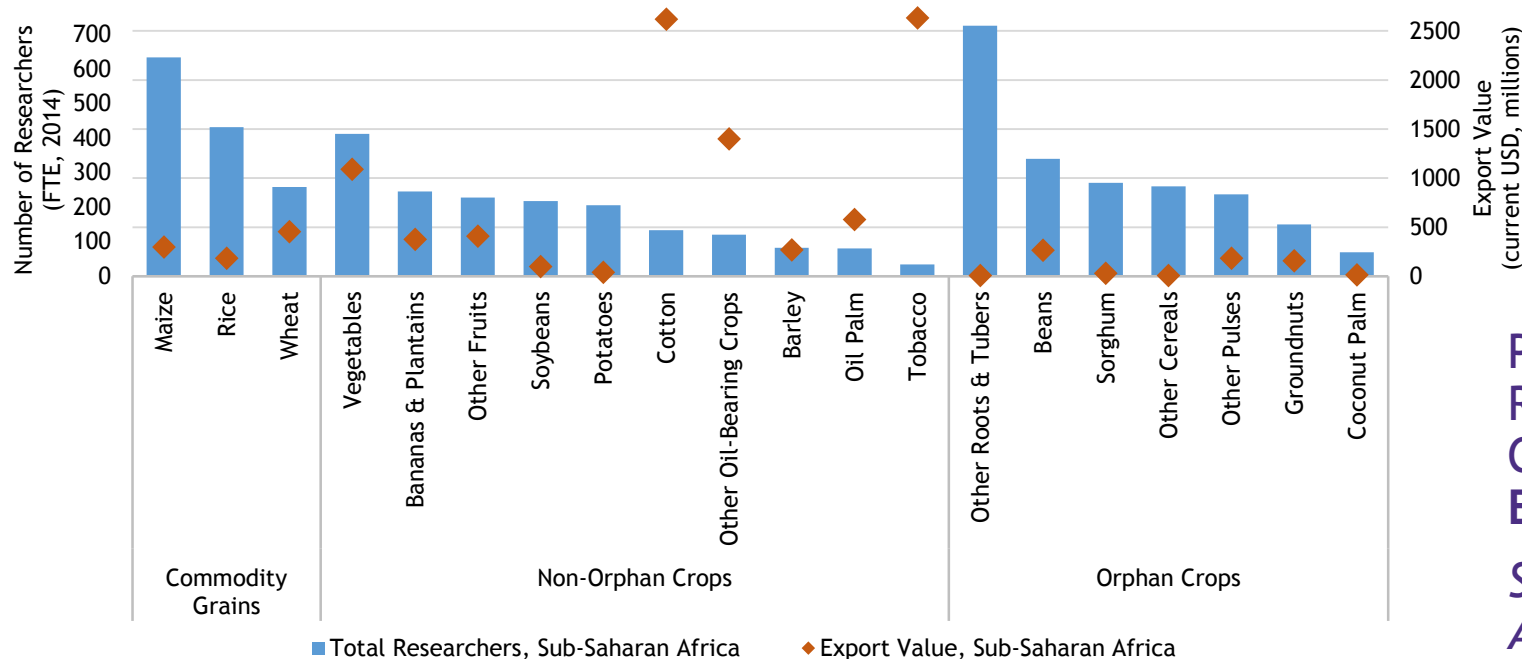
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Source: ASTI Database, 2017

Drivers of Public Funding for Ag R&D in SSA?



Public R&D
Researchers by
Crop and
Export Value
*Sub-Saharan
Africa, 2014*



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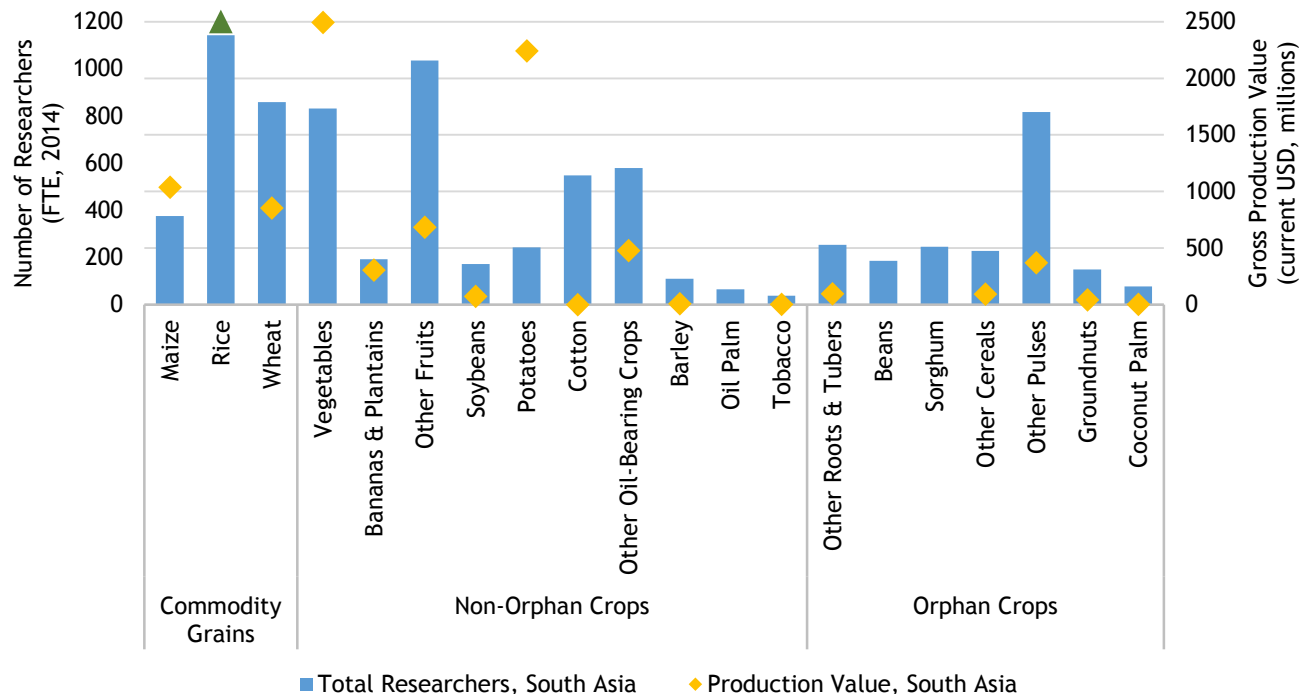
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Source: ASTI Database, 2017

Drivers of Public Funding for Ag R&D in Asia?

Public R&D
Researchers by
Crop and Gross
Production Value

*South/ Southeast
Asia, 2014*



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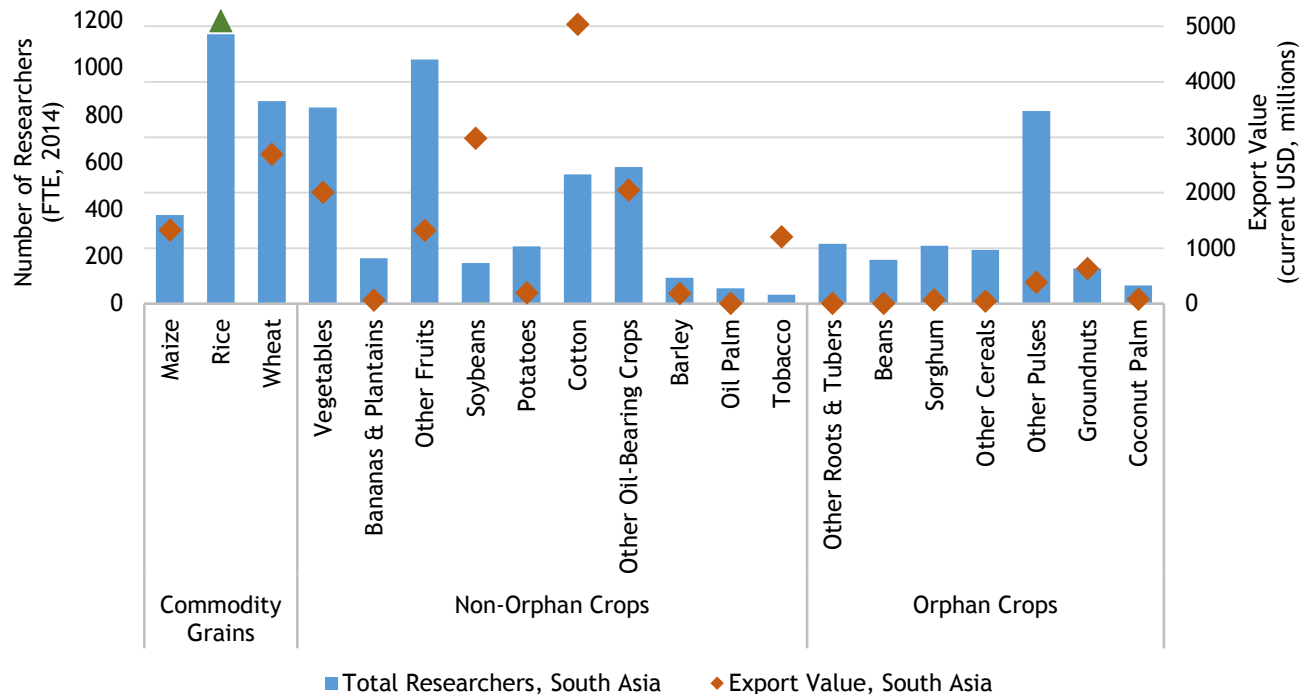
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Source: ASTI Database, 2017

Drivers of Public Funding for Ag R&D in Asia?

Public R&D
Researchers by
Crop and Export
Value

South/ Southeast
Asia, 2014



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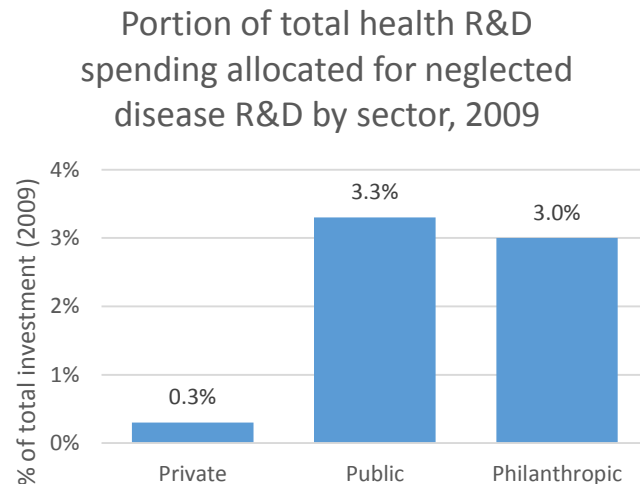
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Source: ASTI Database, 2017

Funding of Neglected Disease R&D

- > Low funding (~1% of total for health R&D) relative to DALYs (~15% of total DALYs from diseases)
- > Public sector provides the majority of funding
- > Philanthropic sector also funds more than the private sector
- > Evidence of more specialization by sector than in agricultural R&D?



Numerator: Moran et al. (2010)
Denominator: Røttingen et al. (2013)



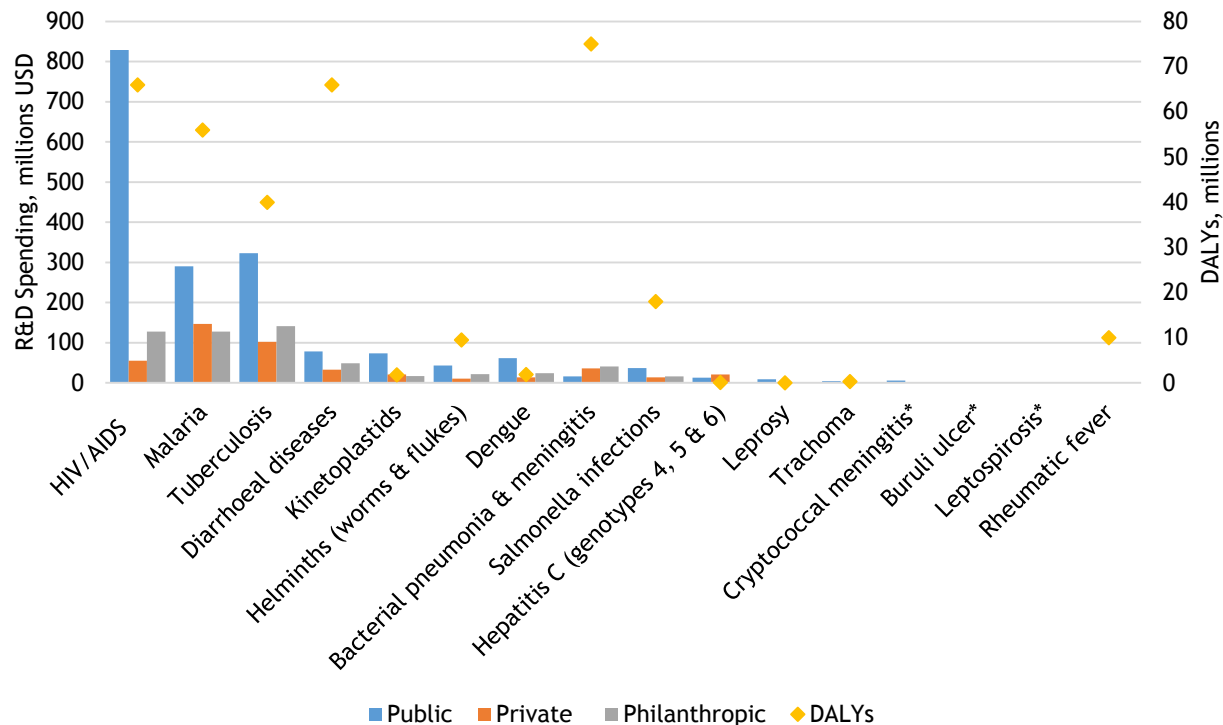
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Drivers of Funding for Neglected Disease R&D?

Public, private, & philanthropic neglected disease R&D spending shows limited associations with disease-specific DALYs



Source: Chapman et al., 2016

* Information on 2015 DALYs not available



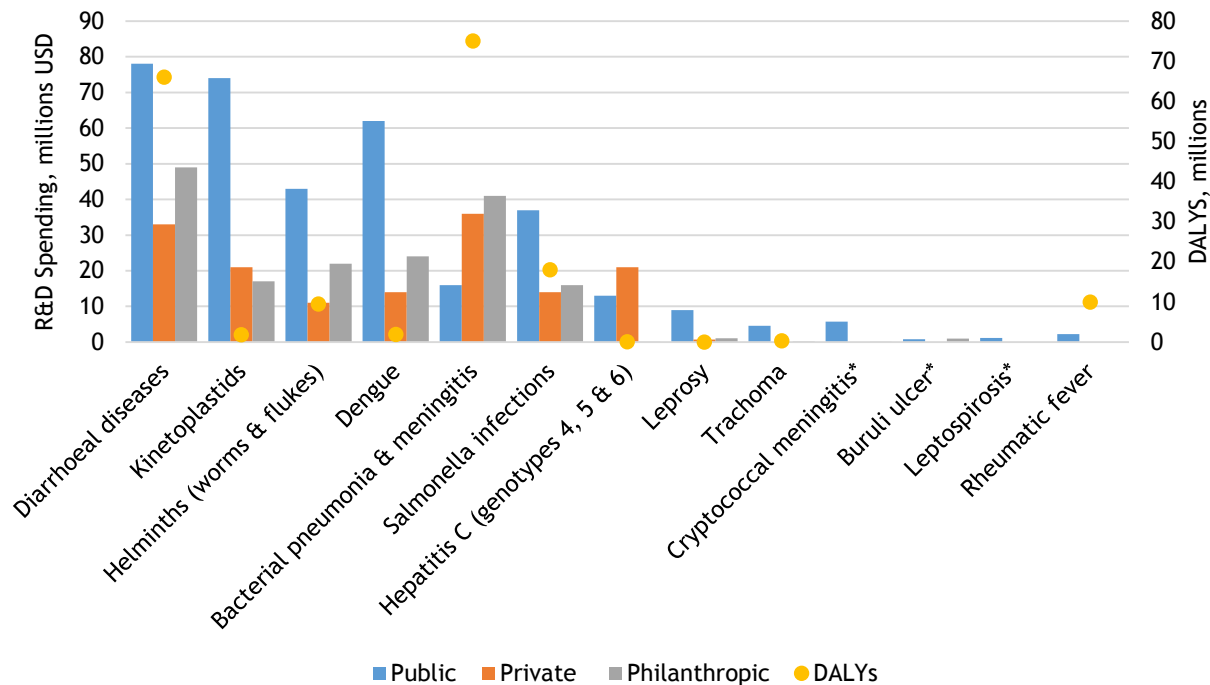
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Drivers of Funding for Neglected Disease R&D?

> Greater role for private sector for certain neglected diseases



Source: Chapman et al., 2016

* Information on 2015 DALYs not available



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Discussion of Findings

- > Evidence supports the expectation that public R&D funding sources focus relatively more than private sources on subsistence and “orphan” crops and “neglected diseases” with smaller potential financial returns
 - **BUT** most public agricultural R&D still targets commodity grains and cash crops, similar to the private sector
- > In health R&D specialization is more apparent - public and philanthropic funders play a much greater role in “neglected disease” R&D funding relative to the private sector than in overall health R&D
 - **BUT** it is not clear that public and philanthropic funding is driven by the burden of disease as measured by DALYs, and most public and philanthropic funding goes to other diseases



Discussion of Findings

- > Limitations in availability of R&D spending data
- > High social returns to R&D for commodity crops and for general health means we might expect some degree of overlap in the spending of public, private, and philanthropic sources
- > Decisions likely vary by funder within each sector, and by crop/disease with agricultural/health R&D
- > Partnerships may influence funding decisions
 - Public-private partnerships are becoming more common in R&D (Spielman, Hartwich, & Gerbmer, 2010; Ferroni & Castle, 2011; Woodson, 2016)
 - Public/philanthropic sources may prioritize spending to promote or facilitate private sector involvement
 - Push/Pull mechanisms to increase private spending



Thank you.





Evans School Policy Analysis & Research Group (EPAR)

Professor C. Leigh Anderson, Principal Investigator

Professor Travis Reynolds, co-Principal Investigator

C. Leigh Anderson, Travis Reynolds, Pierre Biscaye,

Matthew Fowle, and Trygve Madsen

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Please direct comments or questions about this research to Principal Investigators C. Leigh Anderson and Travis Reynolds at epar.evans.uw@gmail.com.

