# FARM FOUNDATION® FORUM

## GLOBAL PRODUCTIVITY, POWER SHIFTS, AND THE FUTURE OF THE GLOBAL FOOD SYSTEM

## MARCH 10, 2026

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# FarmPath Info Session

**Are you ready to launch your farming business, or know someone who is?**

Thursday
March 12, 2026
12:00 PM CT

Virtual via Zoom
Free to attend

**Scan to Register**

# TIM BRENNAN

Vice President, Programs and Strategic Impact

Farm Foundation

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# READY TO BUILD YOUR FUTURE IN FARMING?

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## A 501(c)(3) non-profit at the intersection of agriculture and society.


Farm Foundation
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# OUR MISSION AND VISION GUIDE OUR WORK

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**To build trust and understanding at the intersections of agriculture and society.**

## Vision:

**To build a future for farmers, our communities and our world.**

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## See link in chat function

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# IMPORTANT NOTES

- Submit questions by clicking on the **Q&A Button** at the bottom of your screen.
- Please **include your name and company** so questions may be contextually understood.
- Due to **time limits**, we may not be able to ask all questions submitted.
- This Forum is being recorded and will be posted on our website at **farmfoundation.org** as well as the Farm Foundation **YouTube** channel.
- Please take the **short survey** at the conclusion of the Forum.

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# JESSICA AGNEW

Director of the GAP Initiative , Managing Editor
Global Agricultural Productivity (GAP) Report
Associate Director, CALS Global
Virginia Tech

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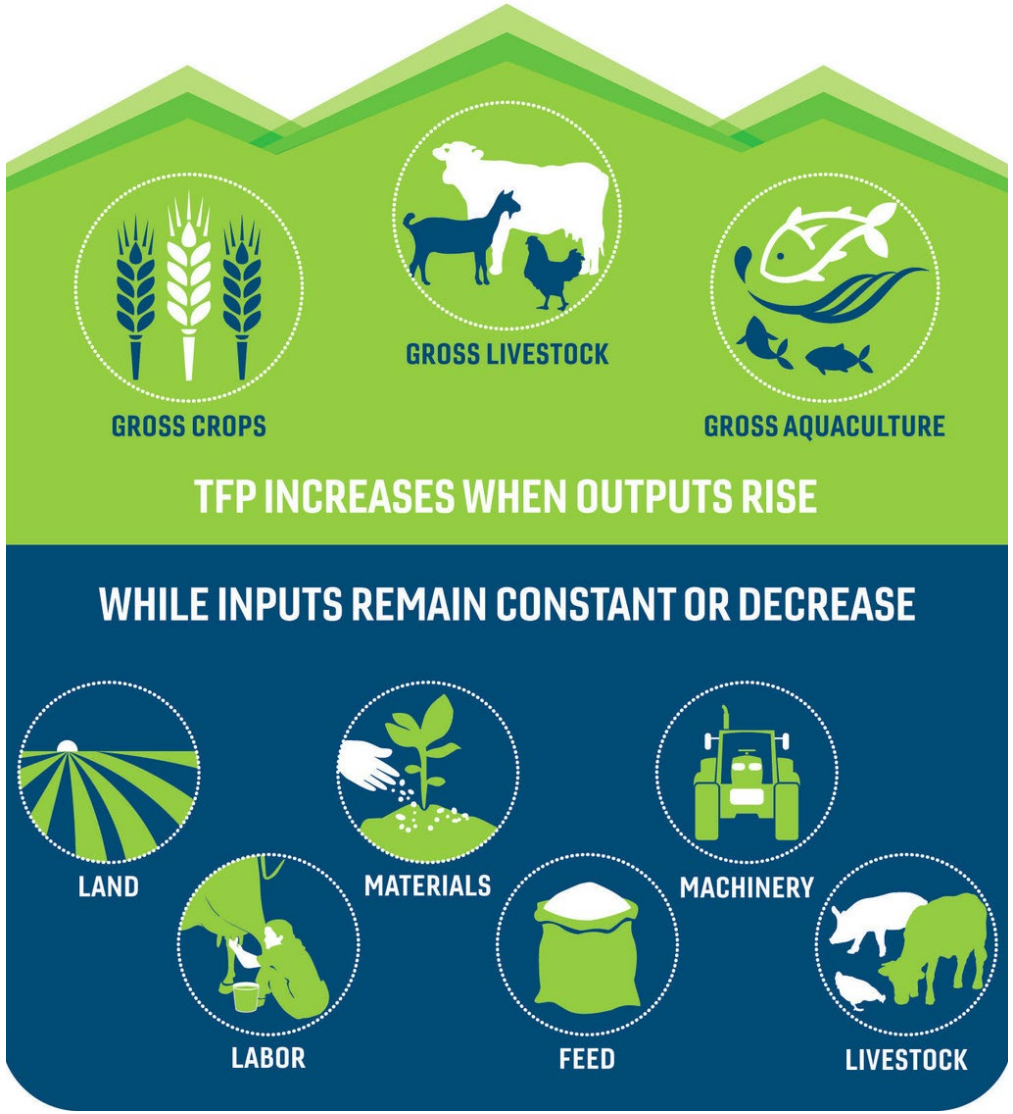
GAP INITIATIVE AT VIRGINIA TECH

# GLOBAL PRODUCTIVITY, POWER SHIFTS, AND THE FUTURE OF THE GLOBAL FOOD SYSTEM

Farm Foundation Forum | March 10, 2026

GAP Initiative | CALS Global | Virginia Tech

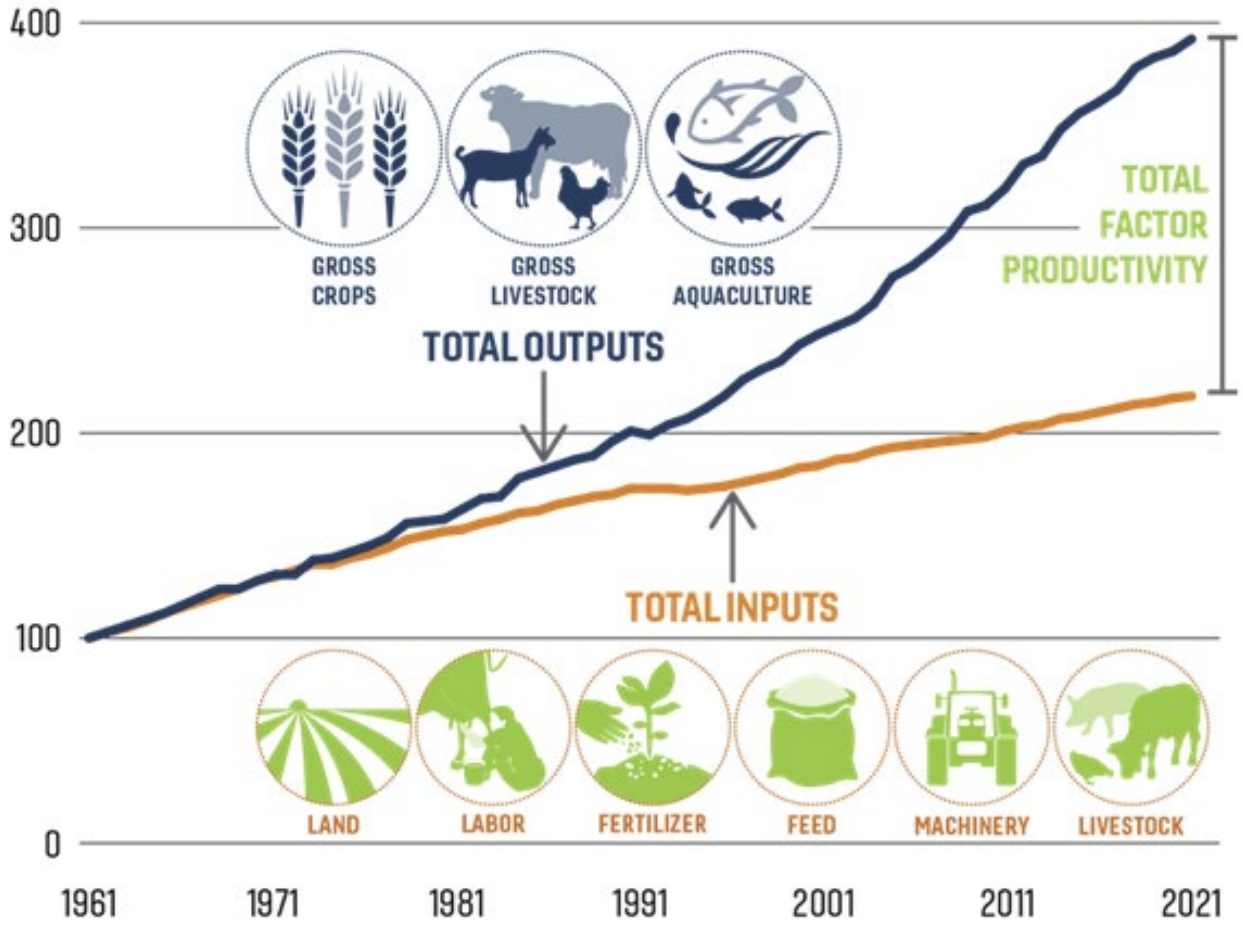
**TOTAL FACTOR PRODUCTIVITY MEASURES THE CHANGES IN HOW EFFICIENTLY AGRICULTURAL INPUTS ARE TRANSFORMED INTO OUTPUTS**



1961-2023

# GLOBAL AGRICULTURAL OUTPUTS, INPUTS, AND TFP

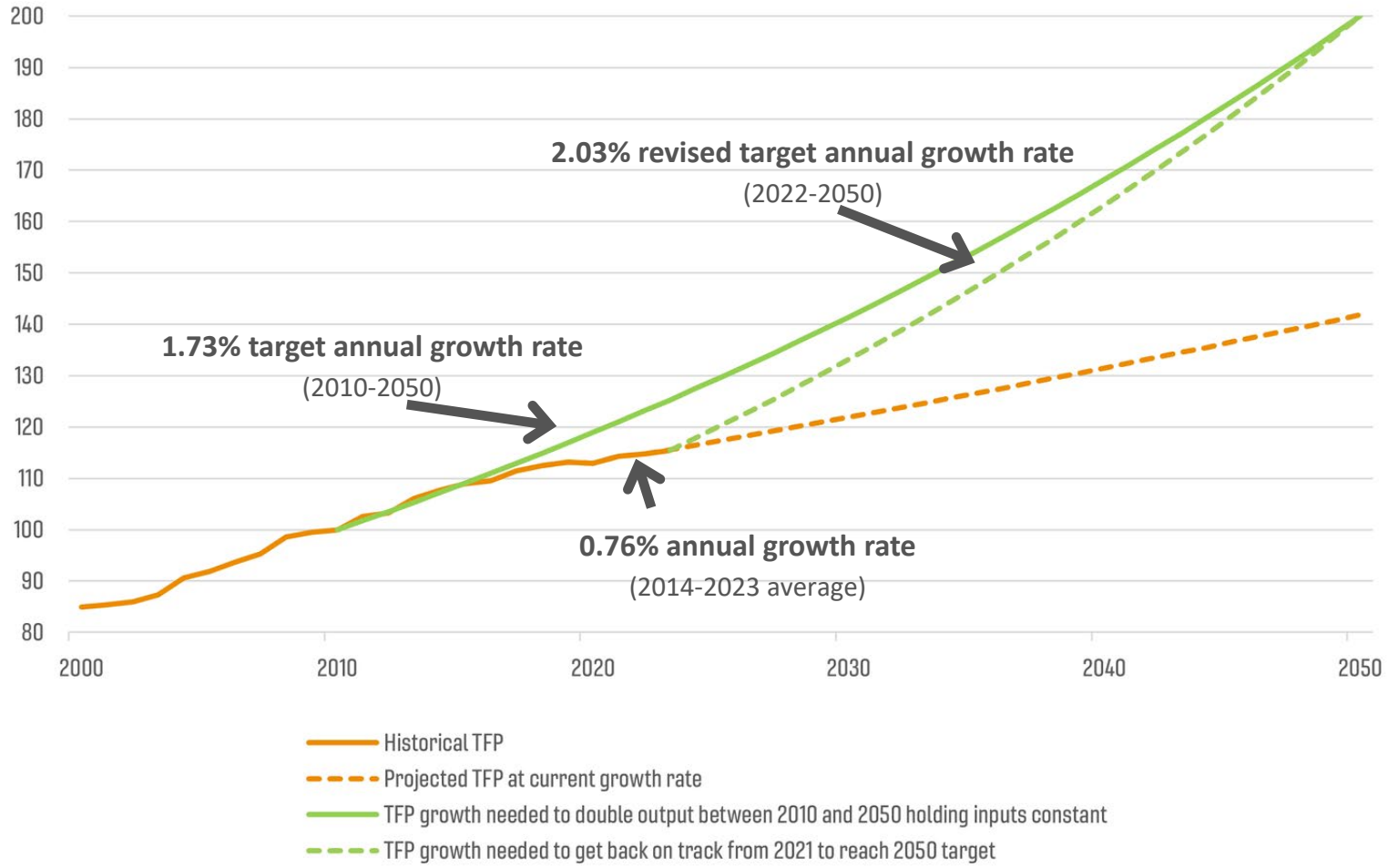
- Agricultural productivity is a measure of how efficiently inputs are converted to outputs.
- Total factor productivity (TFP) considers the overall impact of multiple inputs
- TFP growth rates tell us something about innovation and adoption in the system



GLOBAL TFP GROWTH

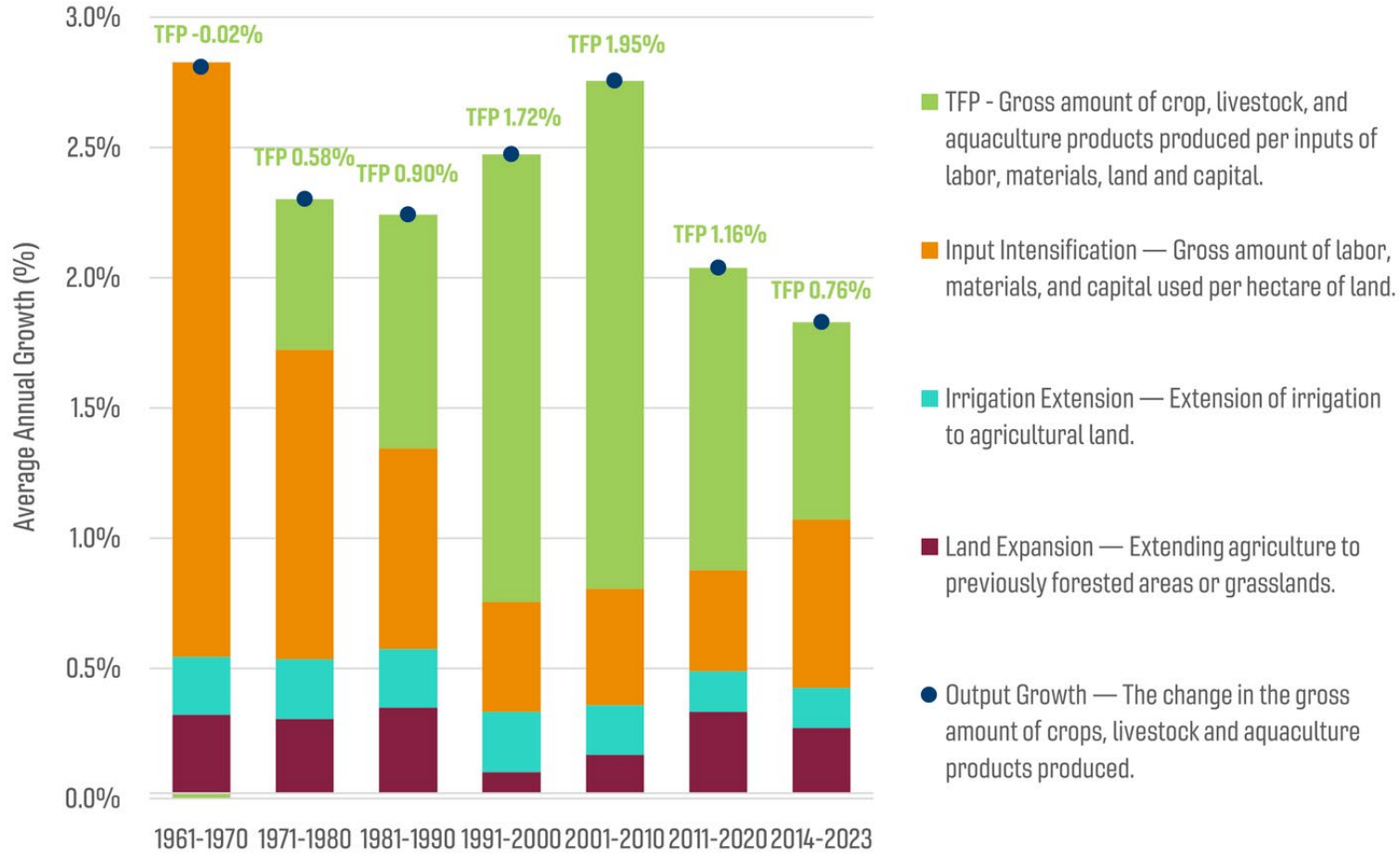
# THE GAP INDEX

- TFP growth is imperative for meeting evolving and growing agricultural demands.
- Due to lagging growth, the TFP average annual growth rate target was increased to 2% in 2023.



1961-2023

# GLOBAL SOURCES OF OUTPUT GROWTH



1961-2023

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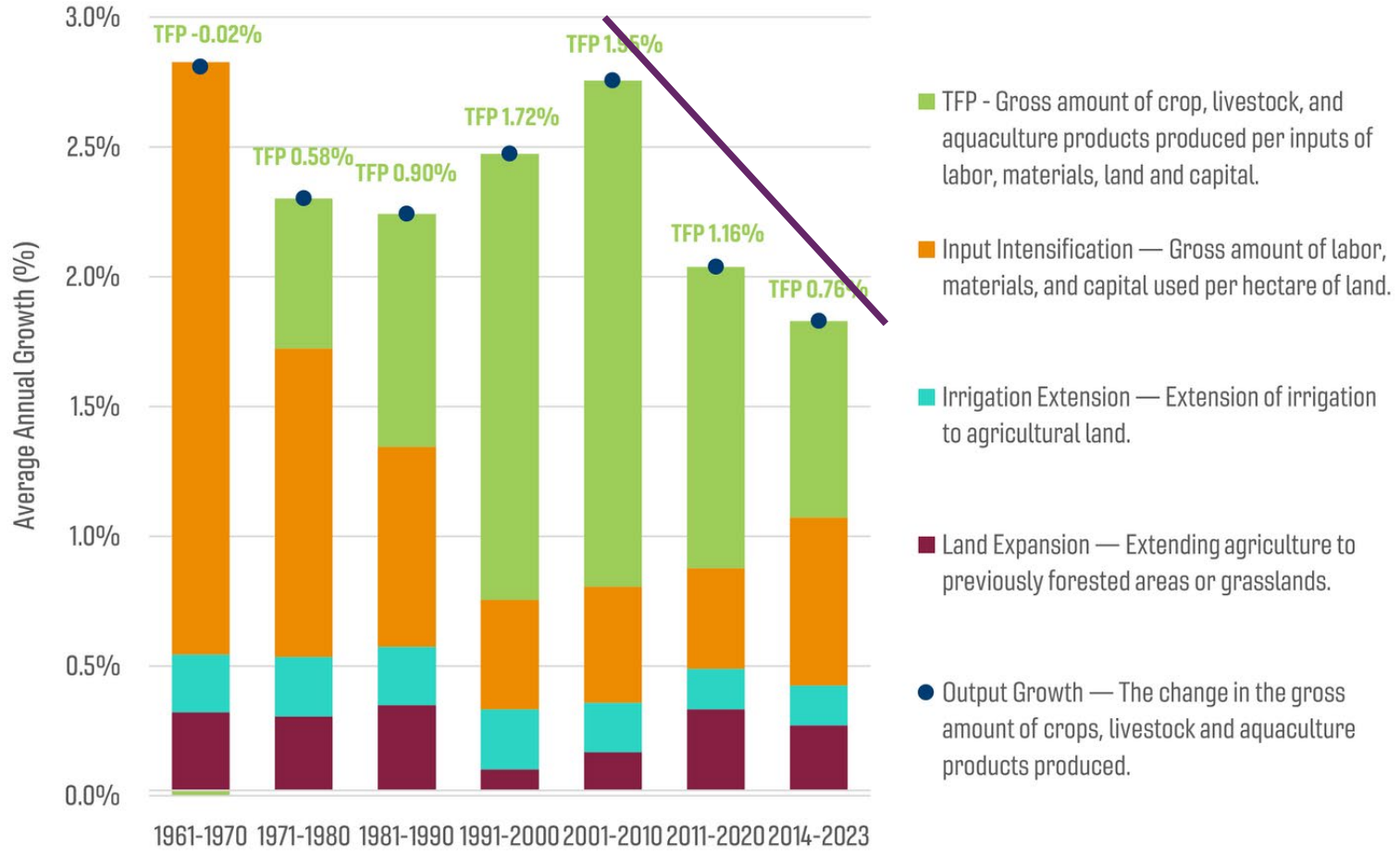
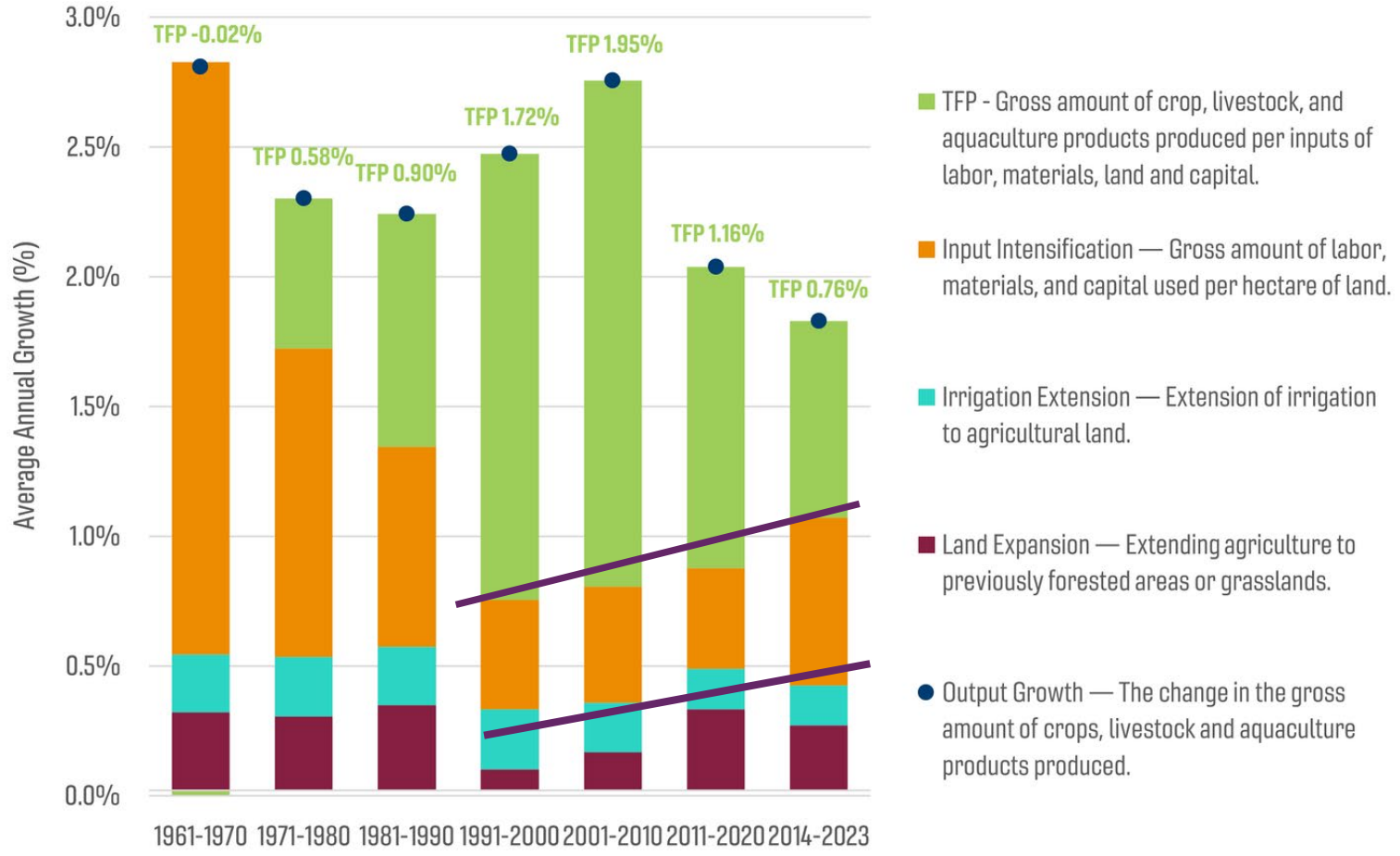


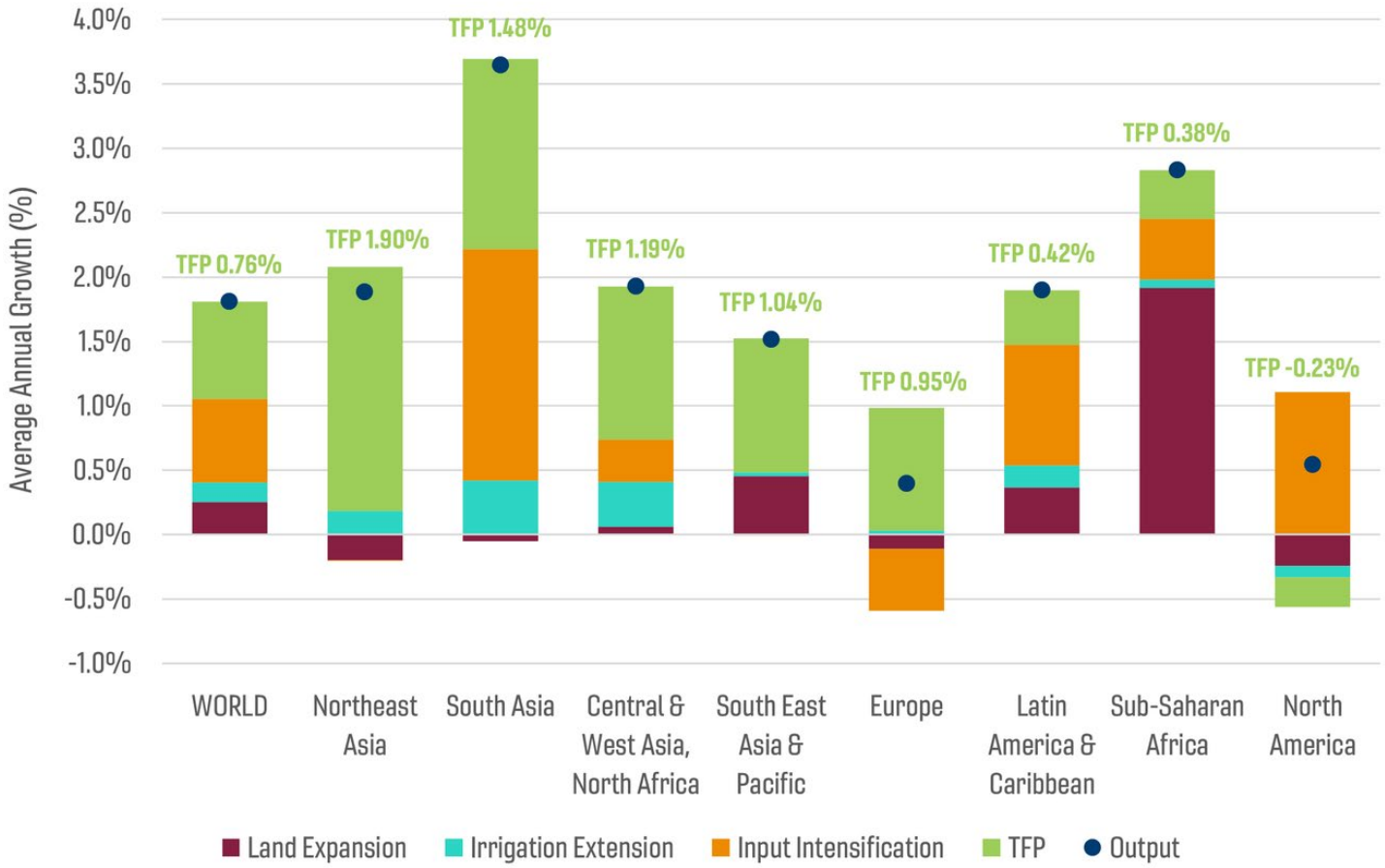
1961-2023

# GLOBAL SOURCES OF OUTPUT GROWTH



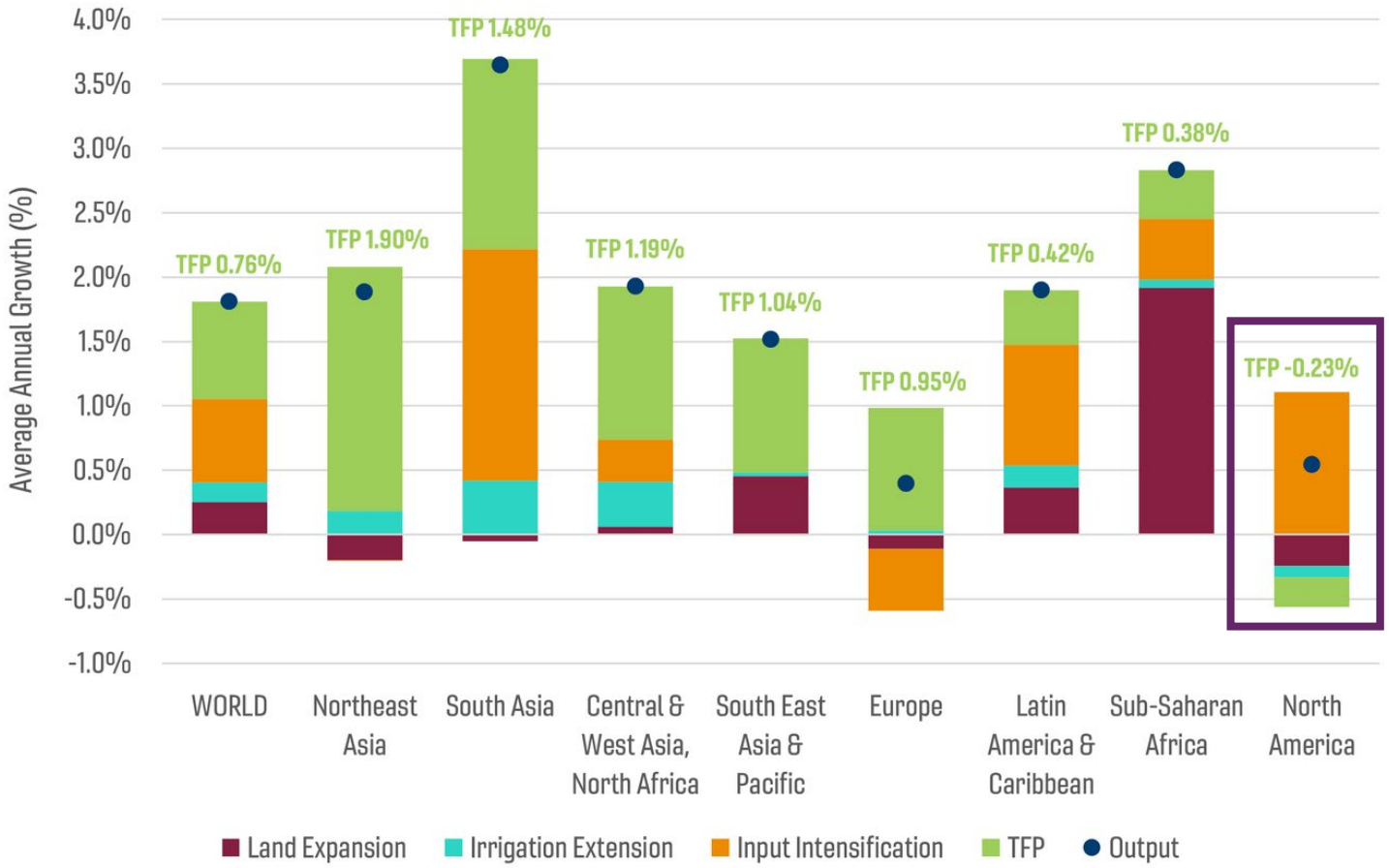
# GROWTH BY REGION, 2014-2023

## SOURCES OF OUTPUT GROWTH



# GROWTH BY REGION, 2014-2023

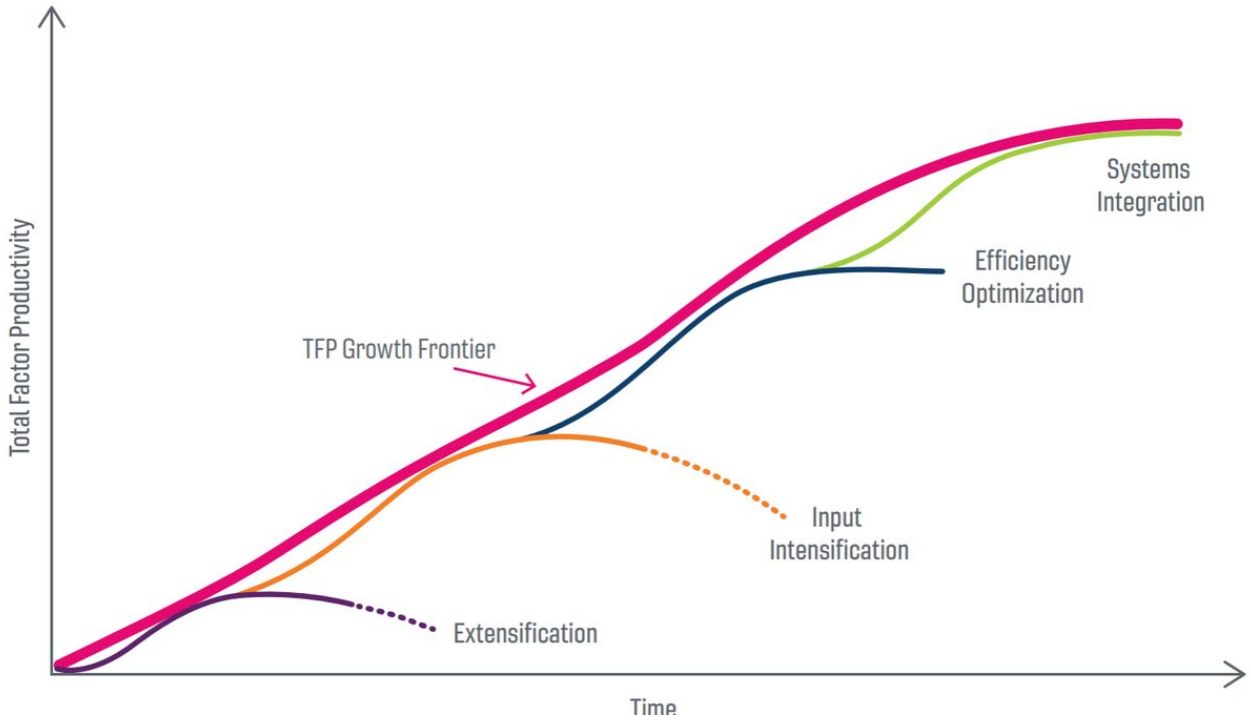
## SOURCES OF OUTPUT GROWTH



# TECHNOLOGICAL DOMAINS
# THE TFP GROWTH FRONTIER

## 4 Technological Domains that Shape TFP Growth

1. Extensification - Expanding or transitioning agricultural land
2. Input Intensification - Driving yield increases on existing land.
3. Efficiency Optimization - Maximizing resource use efficiency and farmer profitability while minimizing environmental impacts.
4. Systems Integration - Managing agriculture within broader socio & ecological systems.

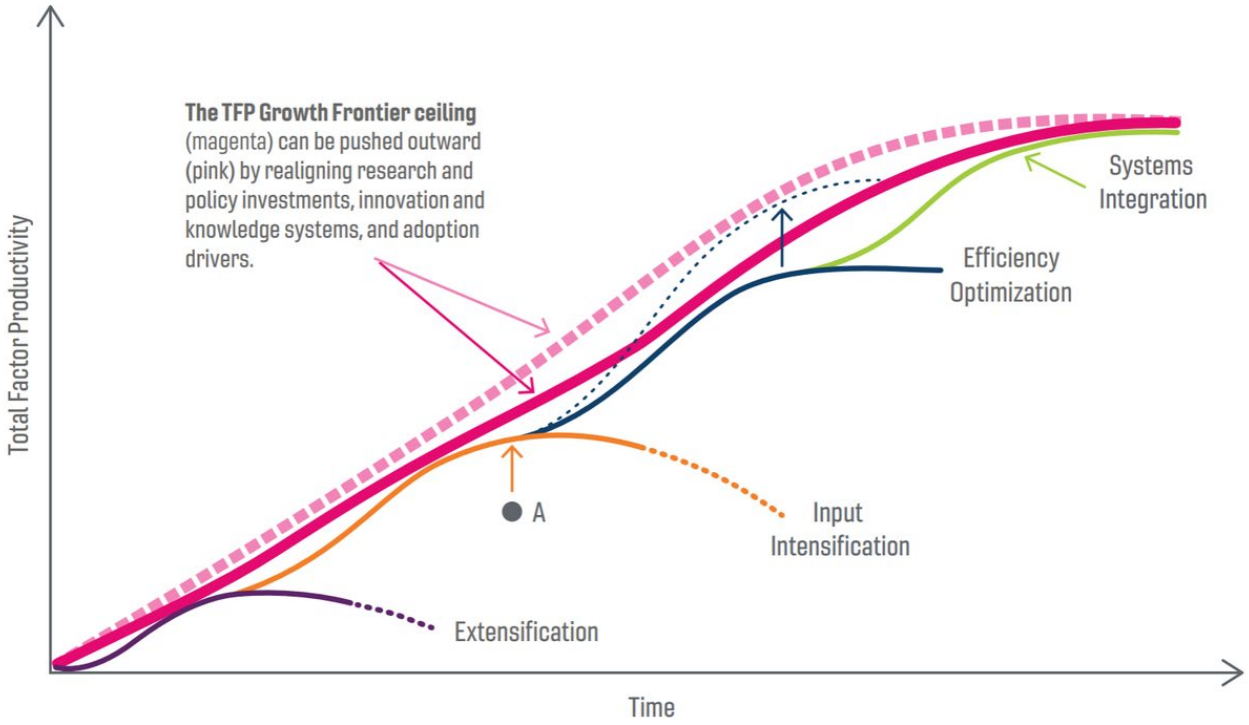


ACCELERATING PROGRESS

# THE TFP GROWTH FRONTIER

## 4 Strategies to Accelerate TFP Growth

1. Scale adoption of proven tools
2. Push domain frontiers outward
3. Transition to the next domain
4. Enable leapfrogging across domains in emerging economies



REGIONAL ANALYSIS

# TFP GROWTH IN THE UNITED STATES

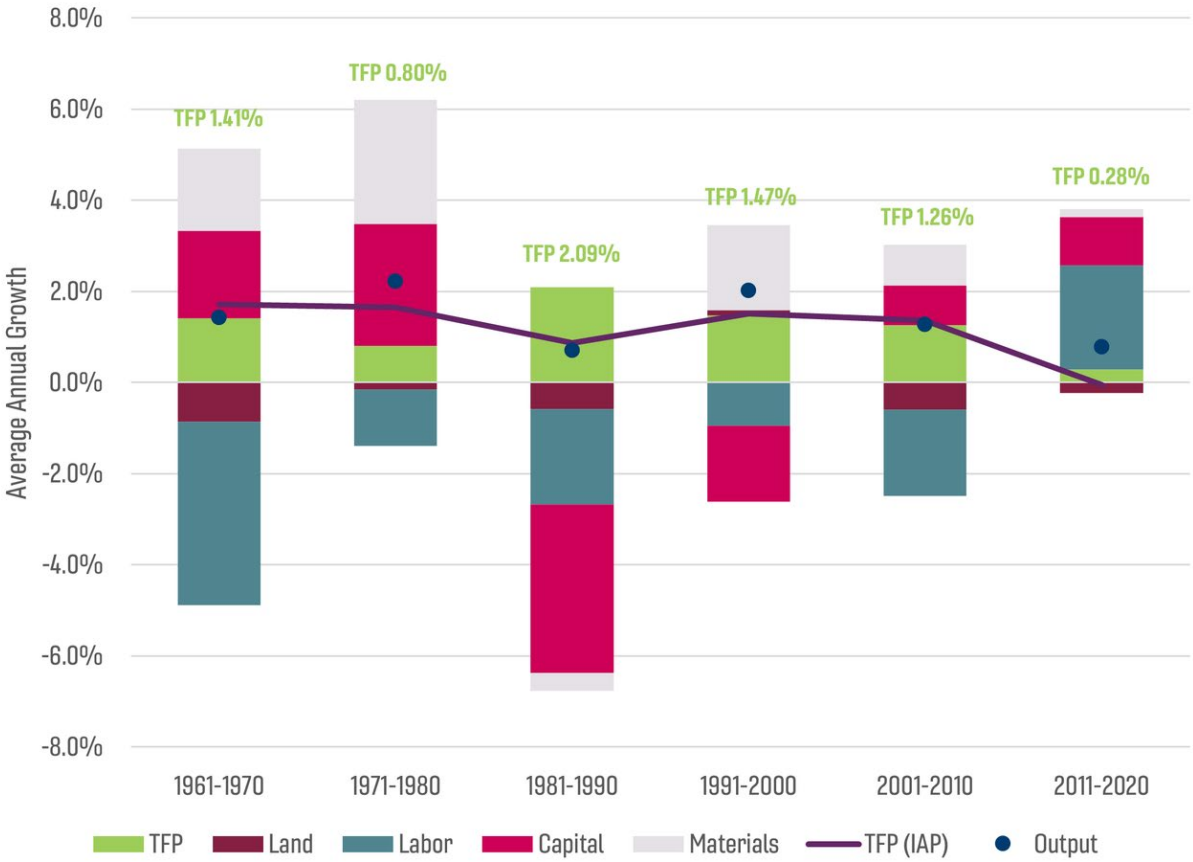
GAP Initiative | CALS Global | Virginia Tech

Photo Credit: The Mosaic Company

# UNITED STATES, 2014-2023

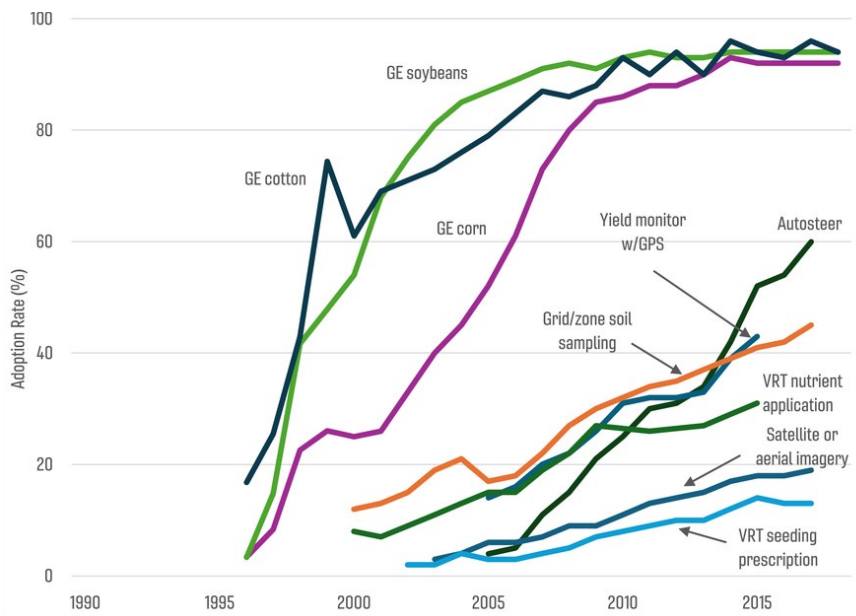
# SOURCES OF OUTPUT GROWTH

- According to National Accounts - TFP Growth peaked in the 1980s (2.1%) but fell to 0.28% during 2011-2020.
    - The International Agricultural Productivity dataset estimates a slightly negative growth rate of -0.05% (2011-2020).
    - Fell further to -0.19% from 2014-2023.
- Both datasets show a clear trend of declining TFP, which is now very low or negative.



# UNITED STATES

# WHY IS US TFP GROWTH STAGNATING?




**SOURCE: PARDEY & ALSTON, 2020**

**DIMINISHING MARGINAL RETURNS FROM EARLY STAGE DOMAIN TOOLS**

- Early-stage single-trait varieties
- Reaching biological limits
- Environmental pressures

**LIMITED ADOPTION OF LATER-STAGE DOMAIN TOOLS**

- Early-stage domain tools have reached adoption saturation
- Adoption of later-stage tools varies by sector, farm size, and geography
- Knowledge, capital, and infrastructure barriers

# UNITED STATES

# WHY IS US TFP GROWTH STAGNATING?

| | |
|---|---|
| **FRICTIONS LIMIT THE EXPANSION OF EXISTING DOMAIN FRONTIERS** | • Reduction in public R&D funding<br>  ◦ Fell 30% between 2002 and 2021<br>• Shifting priorities in national funding themes<br>• Private sector R&D is concentrated in a few major crops<br>  ◦ NIFA priorities shifted to economics and social science research |
| **BARRIERS THAT IMPEDE TRANSITION TO THE NEXT DOMAIN** | • Under investment in research and innovation<br>• Digital infrastructure and data interoperability face challenges<br>• Natural resource contraints are tigthening integration margines<br>• Organizational and demographic barriers limit the speed of adoption<br>• Immature market incentives hinder momentum |

UNITED STATES

# GLOBAL IMPLICATIONS

## 1 FOOD SECURITY

- Reduced global agricultural output affects prices
- Import dependent nations suffer
- TFP growth in specialty crops affects accessibility to nutrient-dense foods

## 2 LAND USE CHANGE

- Stagnant US TFP growth is correlated with global land expansion
- Limiting land use change has a direct effect on GHG emissions

## 3 US COMPETITIVENESS

- Brazil and China have invested heavily in agricultural R&D
- US exports are losing price competitiveness in the market

US TFP GROWTH

# WHAT CAN BE DONE

## REIGNITE PUBLIC R&D INVESTMENT

- Expand NIFA and other funding streams
- Priority setting - R&D to push out the frontiers and transition to the next
- Incentivize collaboration

## CLOSE THE ADOPTION CHASM

- Revitalize the agricultural knowledge and innovation system
- Financial tools to facilitate access to advanced tool
- ICT infrastructure
- Interoperability investments
- Expand investment in cooperative extension and human resources

## STRENGTHEN THE REGULATORY ENVIRONMENT

- Streamline multi-agency oversight
- Develop clear, predictable regulatory pathways
- Embed outcome-based risk assessment frameworks

## FOSTER PUBLIC-PRIVATE COLLABORATION

- Leverage the state agriculture experiment station
- Mobilize finance mechanisms to support translational research
- Create exemplars for data-sharing partnerships

GAP INITIATIVE™ AT VIRGINIA TECH
GLOBAL AGRICULTURAL PRODUCTIVITY REPORT™

COLLEGE OF AGRICULTURE AND LIFE SCIENCES
VIRGINIA TECH

# 2025 GAP REPORTTM

## THE TFP GROWTH FRONTIER

## PLATEAUS AND PROGRESS IN AGRICULTURAL PRODUCTIVITY GROWTH

# THANK YOU

Join us in our efforts to accelerate sustainable productivity growth globally!

# CONTACT

**Global Agricultural Productivity Initiative at Virginia Tech**
www.globalagriculturalproductivity.org

Executive Editor
Tom Thompson
tlthomps@vt.edu

Director, GAP Initiative
Jessica Agnew
jlagnew@vt.edu

# KEITH FUGLIE

Senior Fellow National Center for Food and Agricultural Policy (NCFAP) & Chief Economist, Food Security Leadership Council

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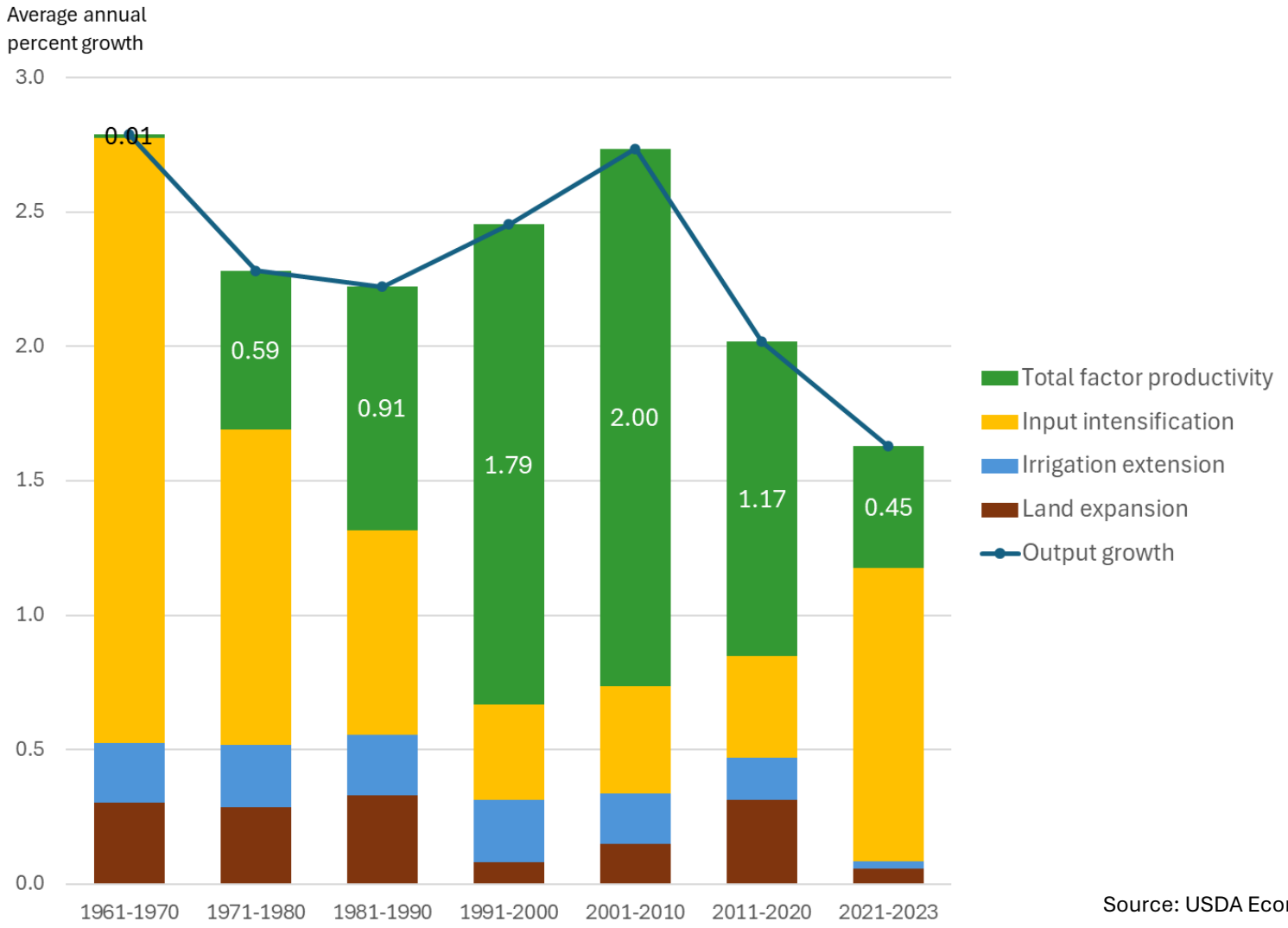
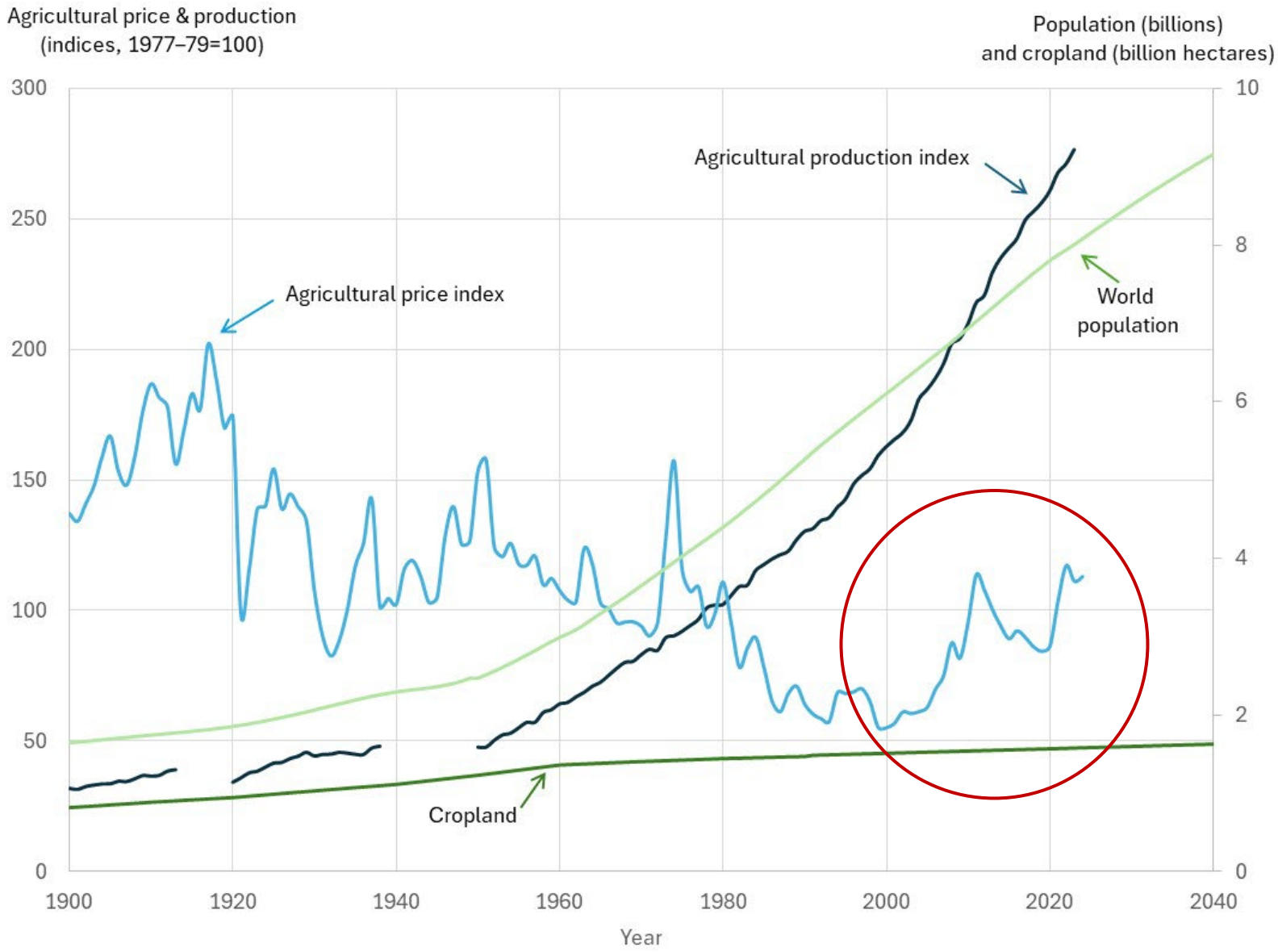
# Agricultural productivity growth has slowed globally




Source: USDA Economic Research Service (2026).

20th Century:
Productivity improvements helped lower food prices and relieve pressure on land

21st Century:
Rising food prices suggests rising food scarcity; increasing risk of food insecurity and environmental degradation



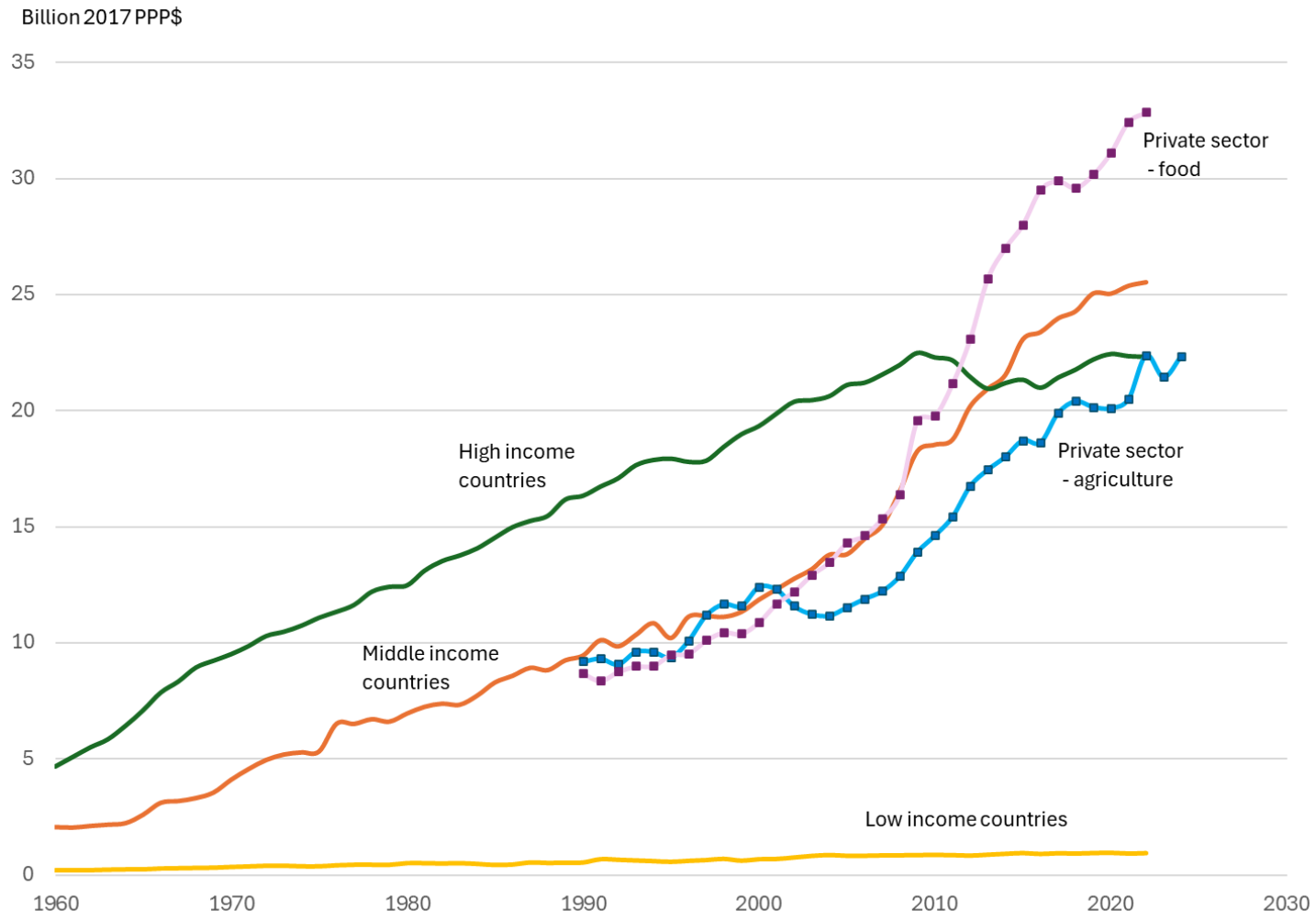

Source: Fuglie, Jelliffe, Morgan (2024, USDA ERS Report)

# Several factors are likely contributing to the agricultural productivity growth slowdown

- Barriers to adoption of new innovations
  - Institutional/regulatory (genetically modified & gene edited crops)
  - Complexity of new technologies (training & extension)
  - Market barriers (high up-front adoption costs; consumer attitudes)
- Environmental degradation
  - Climate change
  - Soil,  water and biodiversity losses
- Underinvestment in agricultural R&D

# R&D is the primary driver of agricultural TFP growth - major global shift underway in where this R&D is done

- Public agricultural R&D spending by **high income countries** has stagnated
- **Middle income countries** now spends more than high income countries on public agricultural R&D
- **Private sector** food and agricultural R&D is growing
- **Low income** countries continue to under-invest in agricultural R&D

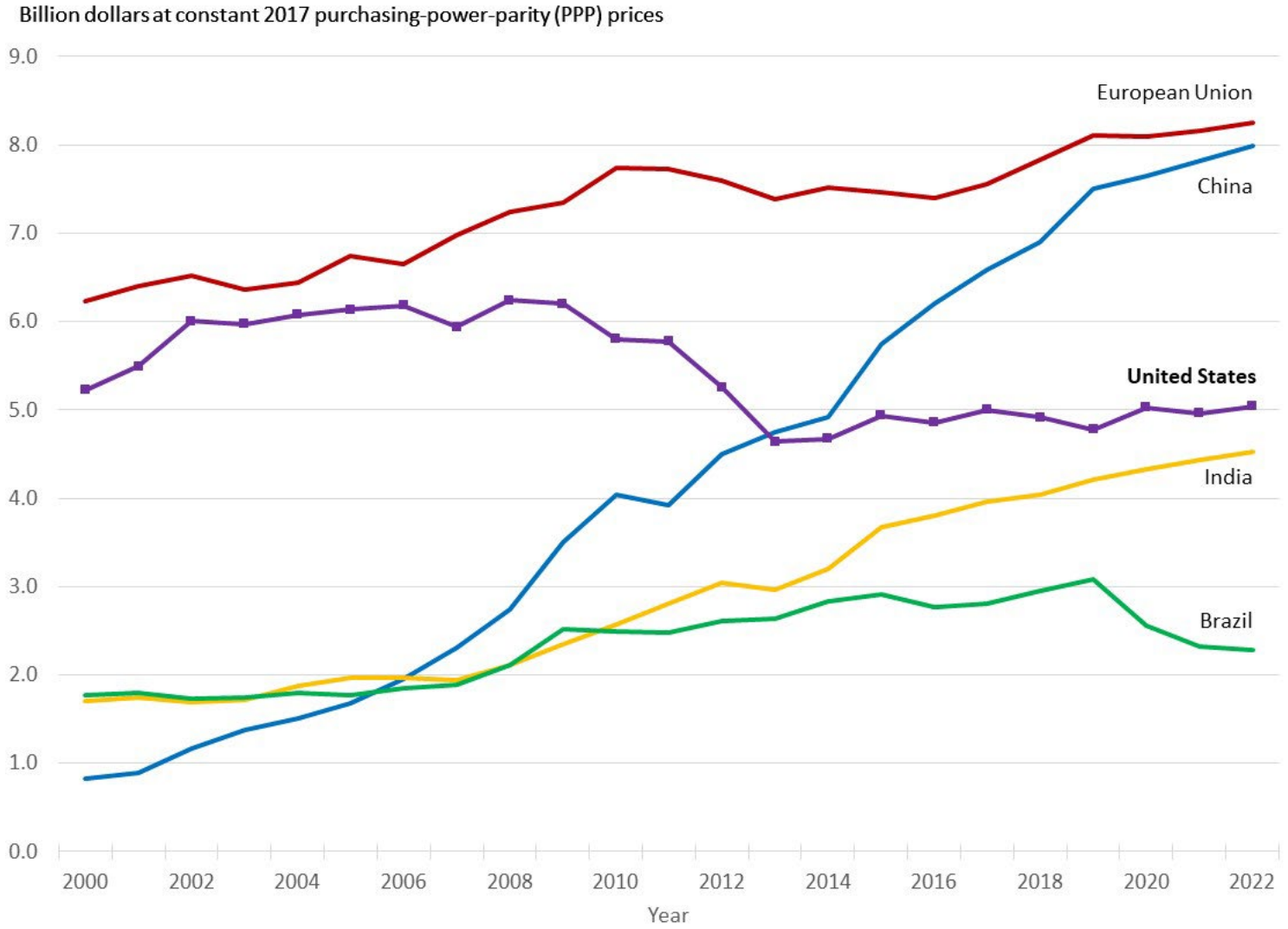



Source: Public Ag R&D from van Dirk, Fuglie, Heisey, Deng (2025, *Science Data*); Private ag R&D from Fuglie (2026,FAO)

# Agricultural R&D investment by major nations

Graph compares public agricultural R&D spending among major agricultural producing countries

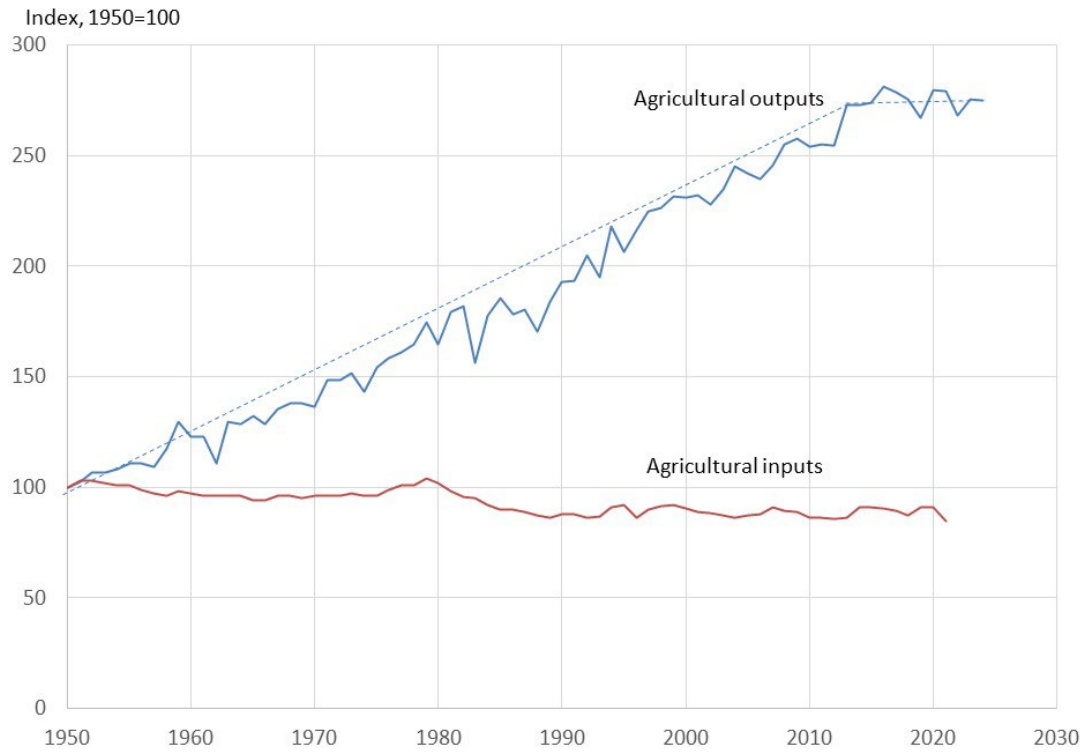
This has major implications for the where and how food will be produced in the future



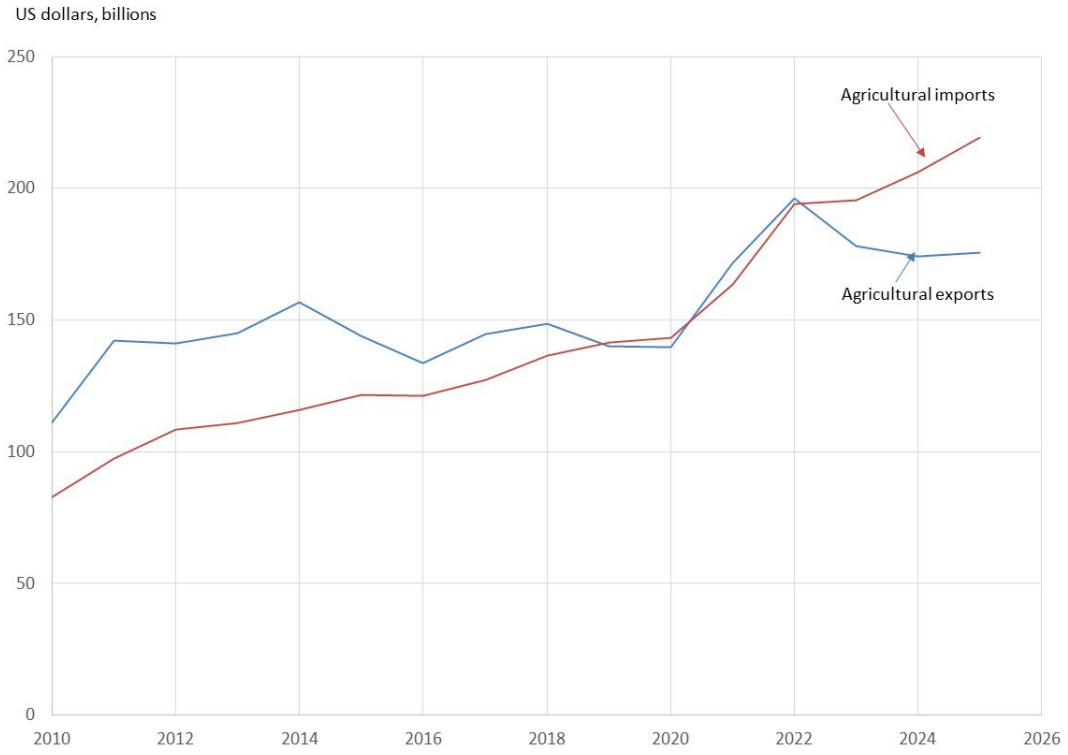

Source: Van Dirk, Fuglie, Heisey, Deng (2025)

# For the U.S., agricultural TFP stagnation is contributing to a loss of international trade competitiveness

## Agricultural output & TFP stagnant since 2013




## Trade balance shrinking since 2014, turned negative in 2022




Source: USDA Economic Research Service

# Public agricultural R&D investment declined by about 1/3 from peak in 2002 through 2021

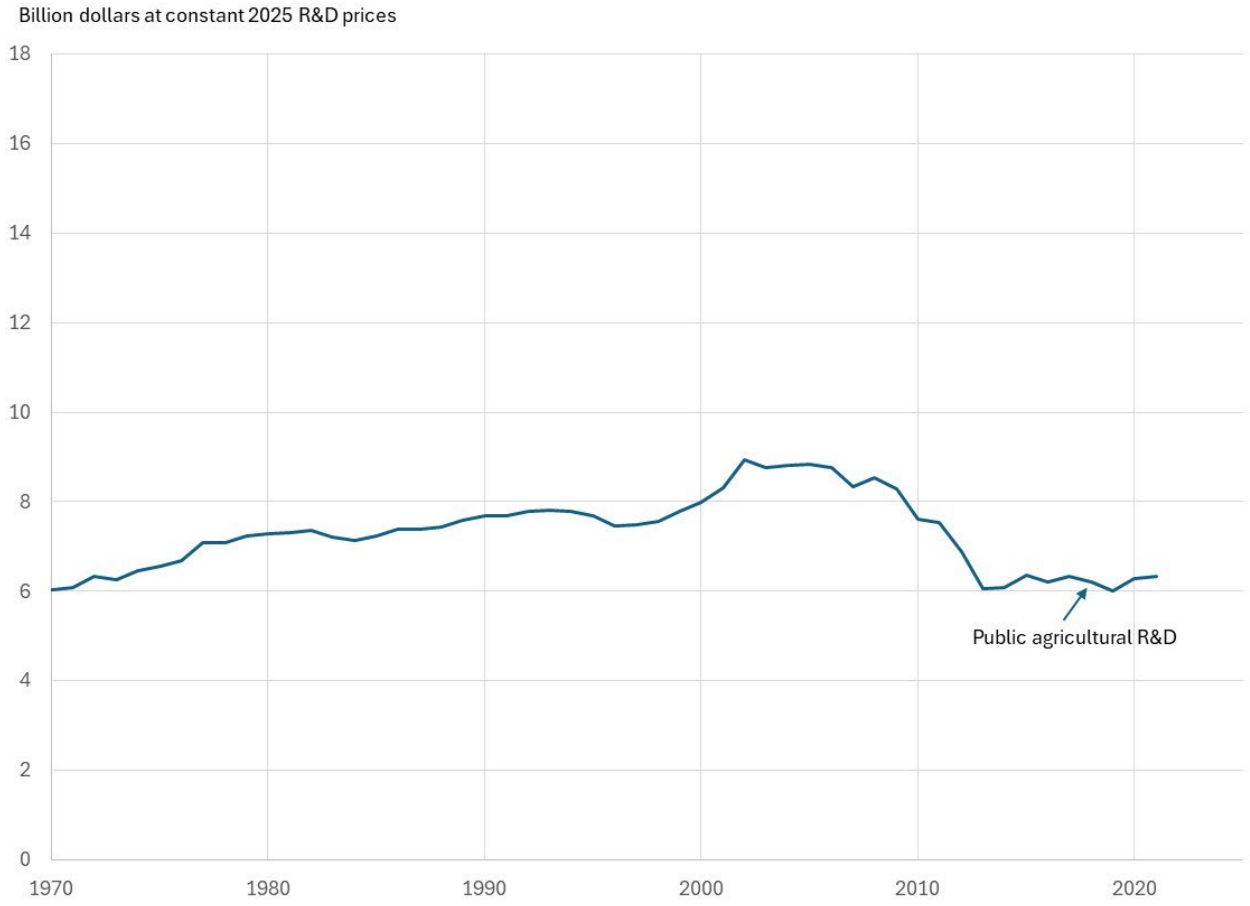
The Federal government funds about 70% of public agricultural R&D; states and non-government sources fund the rest

Universities perform about 70% and USDA research agencies 30% of public agricultural research

Public agricultural R&D spending fell by about one-third between 2002 and 2021

In 2025, the number of staff at USDA research agencies fell by 24%

Spending on agricultural R&D in the United States



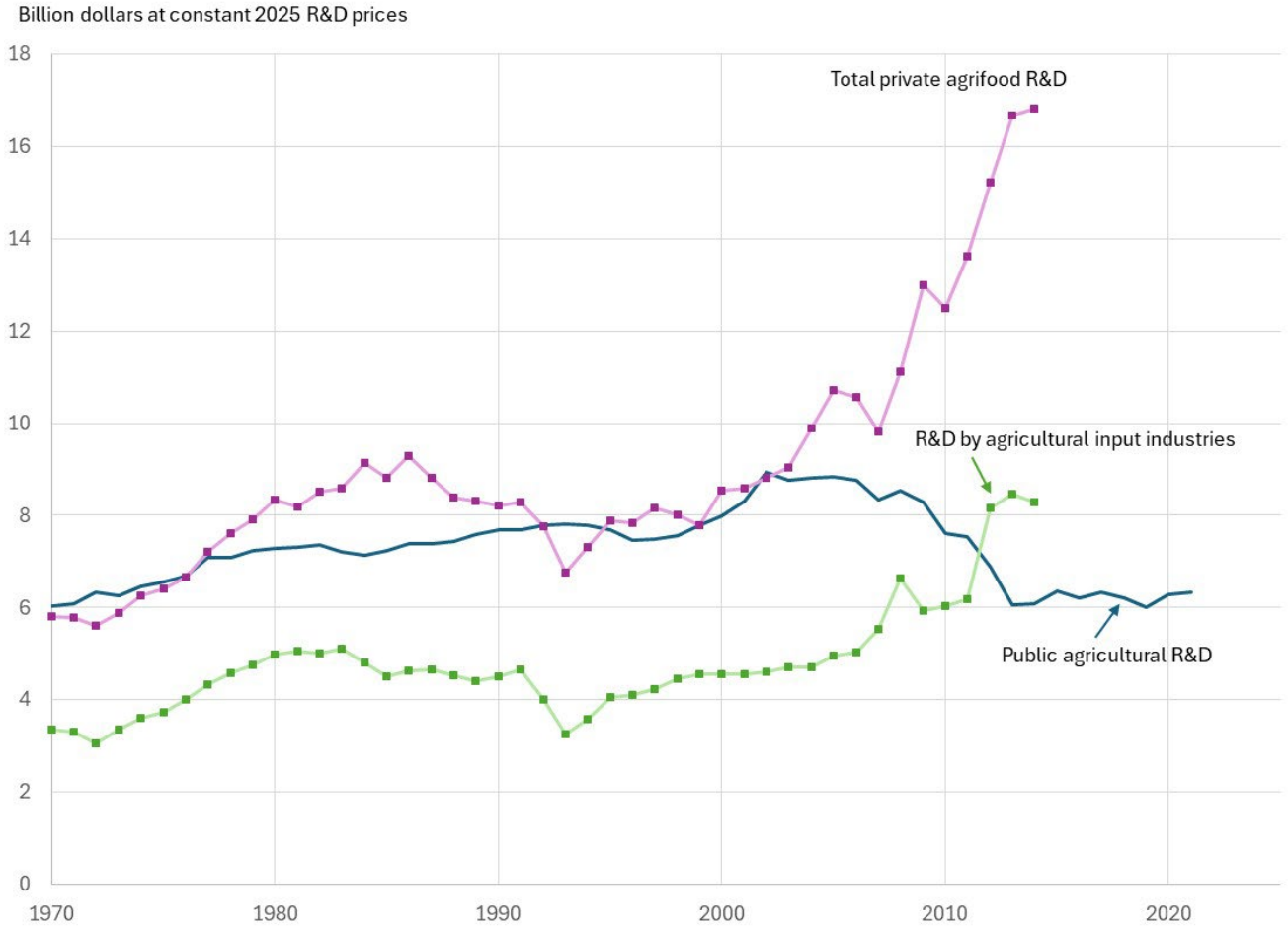

Source: USDA Economic Research Service (2025) (private R&D 2015-2023 are unpublished estimates by author)

# R&D investment in agrifood in the United States has shifted to private sector

Private agrifood R&D is split about evenly between food and agricultural sectors

Private agricultural R&D has increased but is focused on different things

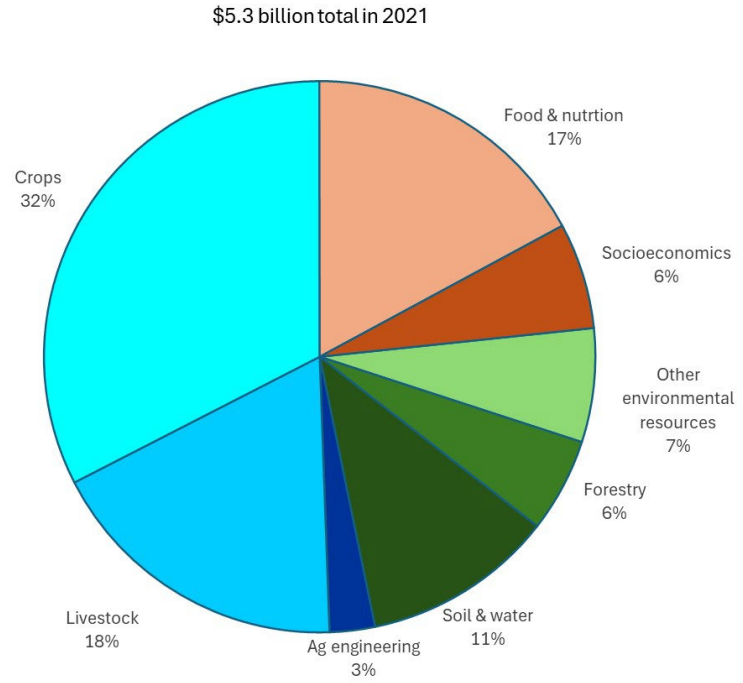
Spending on agricultural R&D in the United States




Source: USDA Economic Research Service (2025) (private R&D 2015-2023 are unpublished estimates by author)

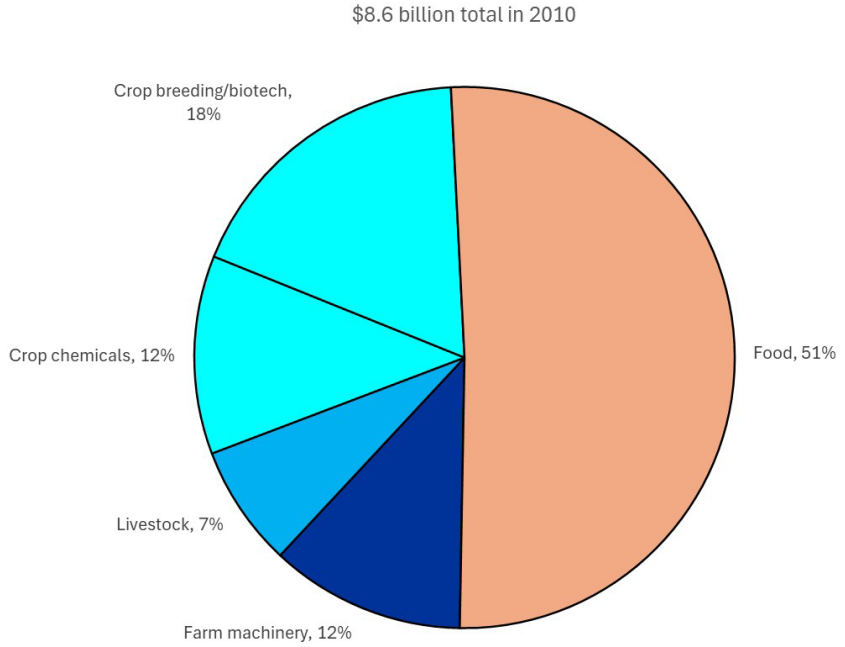
# Components of U.S. public and private agricultural R&D

## Public agricultural R&D portfolio




Public research is more oriented to fundamental sciences and natural resource management

## Private agrifood R&D portfolio




Private research is more applied and narrowly focused, e.g., biotech crops (corn, soybean)

# Public R&D sustains agricultural growth over the long-run

- Public and private R&D are largely complementary (not substitutes)
- Advances in fundamental sciences by public R&D open up new opportunities for technology development by private sector
- Active public-private collaboration speeds up technology transfer
  - Patent licensing, Cooperative R&D Development Agreements (CRADA), Small Business Innovation Grants (SBIR), Material Transfer Research Agreements, Research Consortia
  - Foundation for Food and Agricultural Research (FFAR) – jointly financed public-private R&D
- Economic returns to public agricultural R&D have been high
  - $20 in benefits to U.S. economy for every $1 in R&D spending
  - These are economy wide benefits resulting from higher agricultural productivity, benefiting producers (through lower production costs) and consumers (through lower food prices)
  - Private returns to agricultural R&D are lower because companies only capture a portion of the gains from productivity (through higher prices for agricultural input sales)
- Decline in public R&D investment ➡ stagnation in agricultural TFP ➡ declining competitiveness [these forces play out over decades]

# Summary comments

- Agricultural productivity growth has slowed globally and in the United States
- This can raise food prices and increase pressure to expand land and resources in agriculture
- Agricultural R&D gives a high return on investment and can sustain growth in agricultural productivity, lower food prices and save resources
- Globally, agricultural R&D is shifting from high income countries to emerging middle income countries (China, India, Brazil)
- In the U.S., agricultural R&D by the public sector has fallen while R&D by the private sector has grown, but these are complements not substitutes; this puts at risk productivity and competitiveness of U.S. agriculture

# References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# MIKAYLA MOONEY

Venture Partner
Ag Startup Engine

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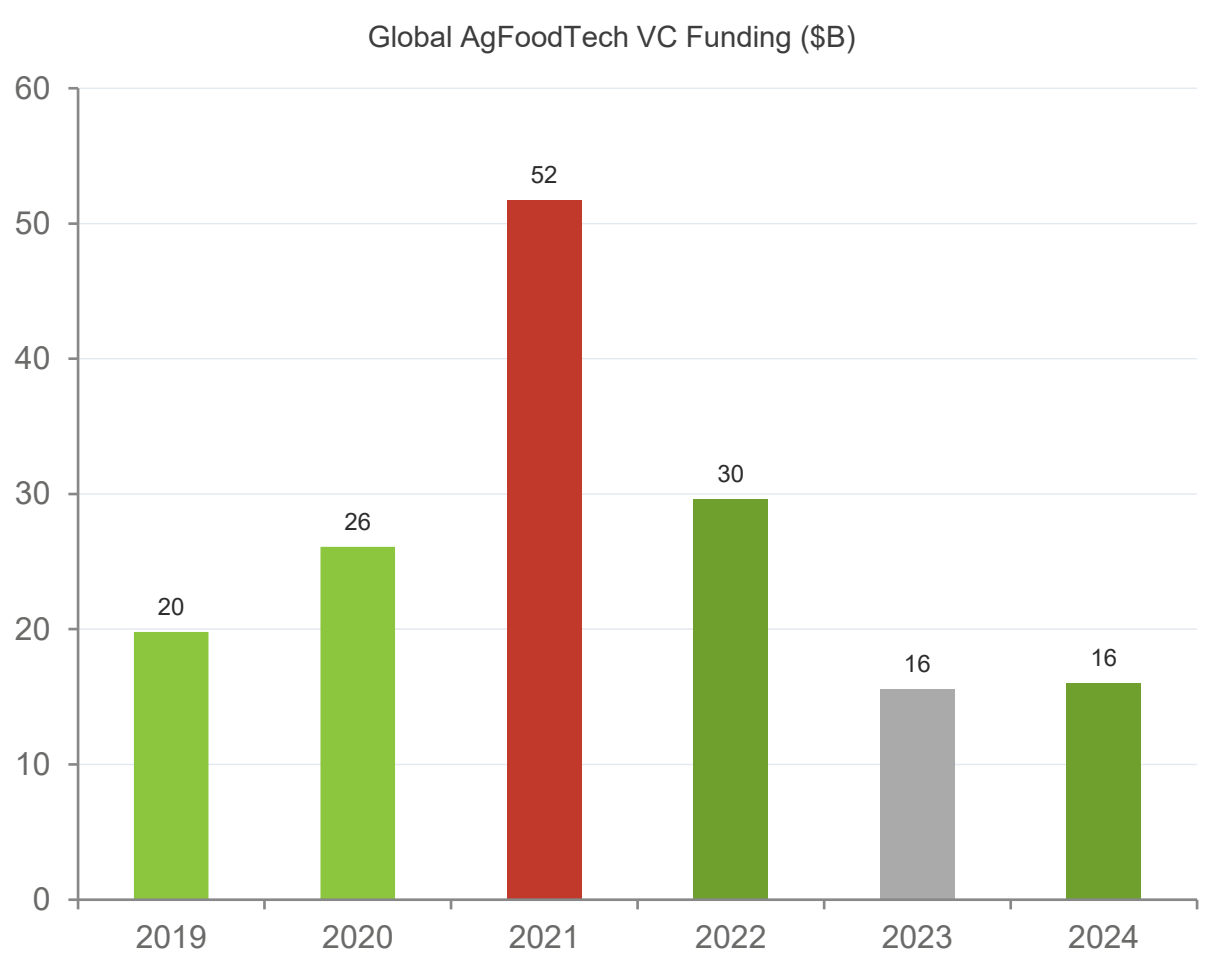
# Private Capital & U.S. Agricultural Productivity

Where Capital Is and Isn't Filling the Gap

Ag Startup Engine

# Setting the Stage: AgFoodTech Capital Today




## CAPITAL MARKET SIGNALS

**49 → 17** new agrifood VC funds launched (23→24)

**<1%** of all global VC reaches agrifoodtech

**$11M↑** average deal size rising

# Why Agriculture Breaks the Standard VC Model

| Standard VC | Agriculture Requirements |
| --- | --- |
| 7–10 year exit horizon | 10–15 years to adoption |
| Hockey-stick growth curves | Validation across years |
| Proven expandable model | Region-specific |
| Low COGS, high margins | Capital-intensive, hardware-heavy |
| Move fast and break things | Proven ROI |

# The Structural Mismatch: Why This Is Hard to Fix

**THE ASSUMPTION** *If public R&D declines, private capital will step in.*

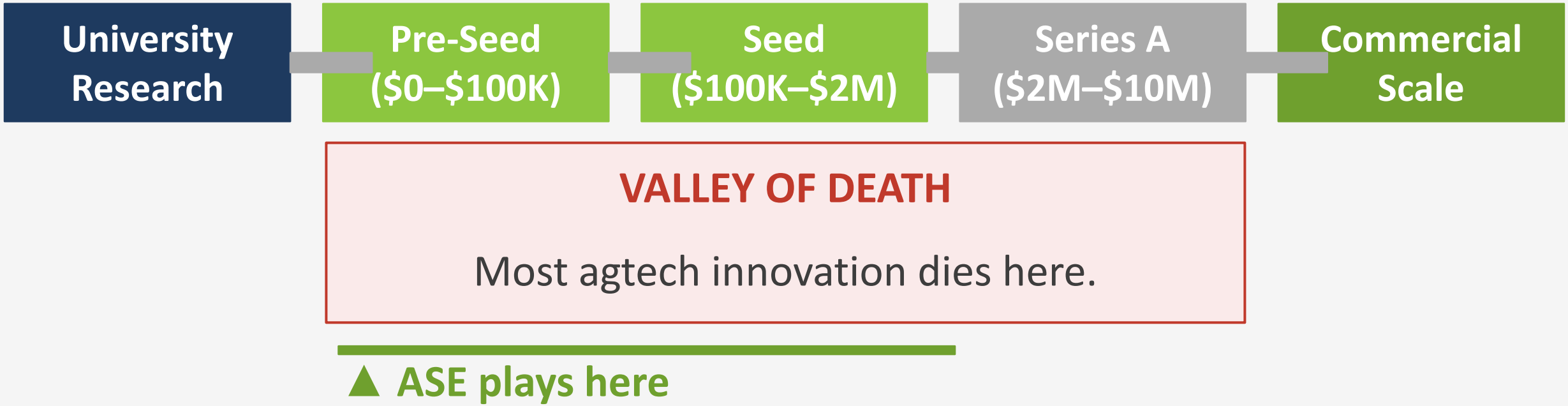
**Public R&D Decline**

+

**VC Pullback**

**= PRODUCTIVITY GAP**

# The Valley of Death: Where Agtech Companies Fail



# What Ag Startup Engine Does: A Different Model

*More than just capital, We're creating community.*

**Farmers at the Table**

**Tied to the University Ecosystem**

**Patient & Creative Capital**

# What We've Learned: Lessons from 48 Agtech Companies

01 Full-time founders move 10× faster

02 Customers must validate the market

03 The network is as valuable as the capital

04 Government relations is a startup function

05 Creative funding models are needed

# What's Driven Productivity?

| 1990s–2000s | 2000s–2010s | 2010s–2020s | NOW |
| --- | --- | --- | --- |
| GPS Guidance & Precision Ag | Variable Rate Technology | Drones & Satellite Imagery | AI & Autonomous Systems |

# Where Productivity Gains Are Likely to Come From

**Foundational Science**

**Systems-Level Efficiency**

**Practice Change & Adoption**

***Institutional innovation matters as much as technological innovation.***

# The AI Gap Is Real — and Founders Are Already Exploiting It

**1 in 4** Executives report using no AI at all

## THE AI ACCELERATION EFFECT

| | |
|---|---|
| **2×** | Faster software development |
| **55%** | Faster task completion |
| **$3-10** | Return on every dollar invested in AI |

# The Path Forward

Ag Startup Engine

01 Appropriate funding for early-stage agtech

02 Clear, stable regulatory pathways

03 Replicate models that work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