Has agronomy kept up with digital agriculture?

Simon Cook; Rob Bramley; Myrtille Lacoste and Elizabeth Jackson

Murdoch University, Australia

18th Congress of the European Society for Agronomy in Rennes, France

OVERVIEW

- **Retrospective**: "Did agronomy keep up with precision ag.?"
- Globally, plenty for **demand** for change. What role for digital?
- Modality for digital ag is different. Requires a **review of basics**
  - Food system change [not just production]
  - Technology – What's on offer? What does it 'do'?
  - Value: How does digital tech create value? Who gets it?
- Review: Evidence of change towards digital ag
- **Examples** of digital ag (and the role for agronomy)
- Suggestions to move forward

RETROSPECTIVE

2001

Was agronomy left behind by precision agriculture?

https://www.agronomyaustraliaproceedings.org/images/sampledata/2001/plenary/2/cook.pdf

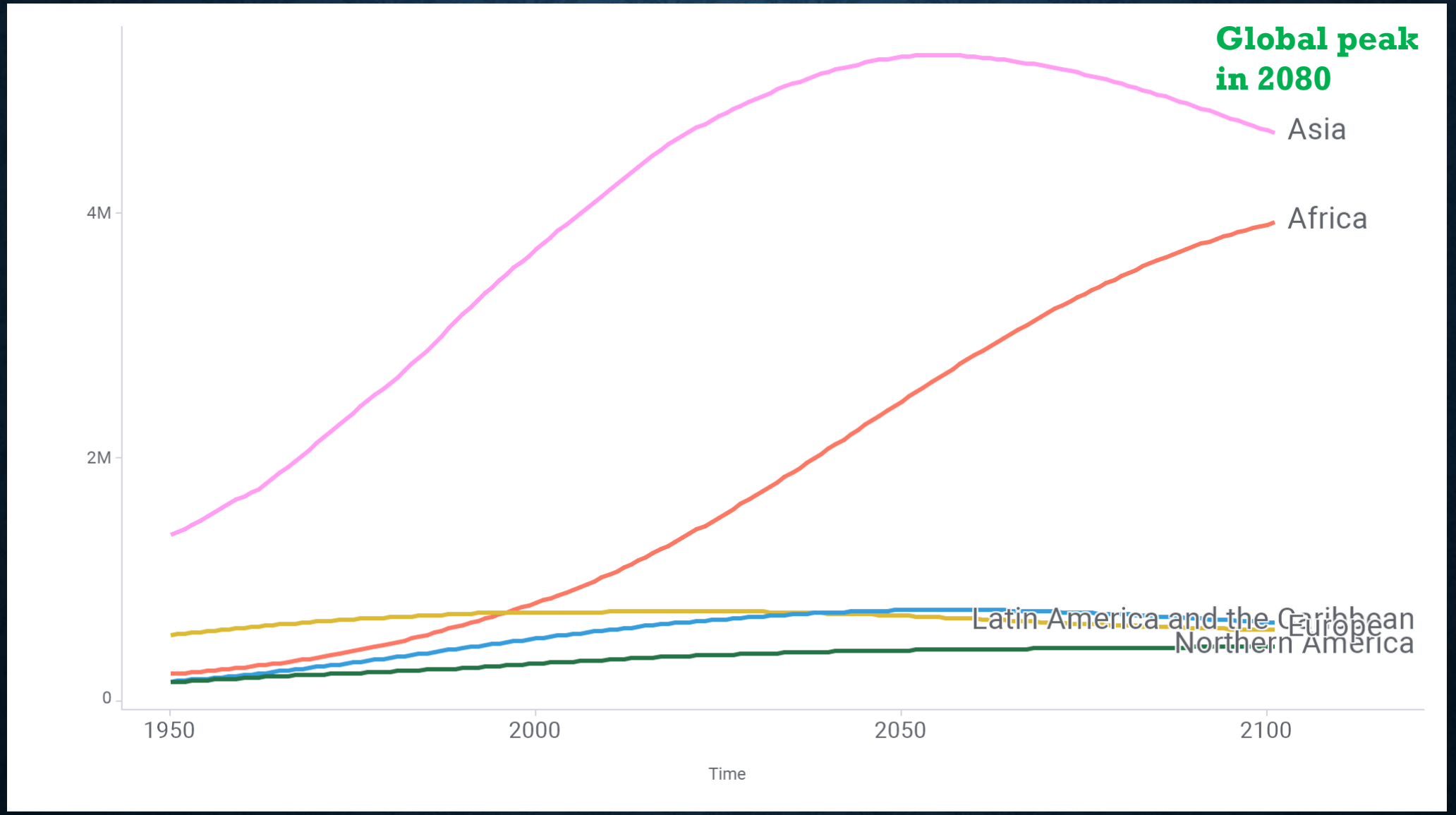
2001 Australian Agronomy Conference

- We noted
  - Consultants and advisors **reluctant to learn data science**
  - **Data**: 'troublesome, noise, unexplained variation'
  - **Improvement slow**, capacity to explain data overwhelmed by a grower's capacity to acquire it
  - "Agronomy appears **generally unwilling** to tackle problems of such complexity and scale"
- We suggested:
  - Use information in systematic explanation of agricultural processes
  - Increase modelling realism- Use more data
  - Move research towards a site-specific participatory mode
    - Explain variation on-farm and at full-scale, in a form that is immediately relevant to growers.

GLOBAL CHALLENGES REMAIN FOR DIGITAL AGRONOMY TO TACKLE

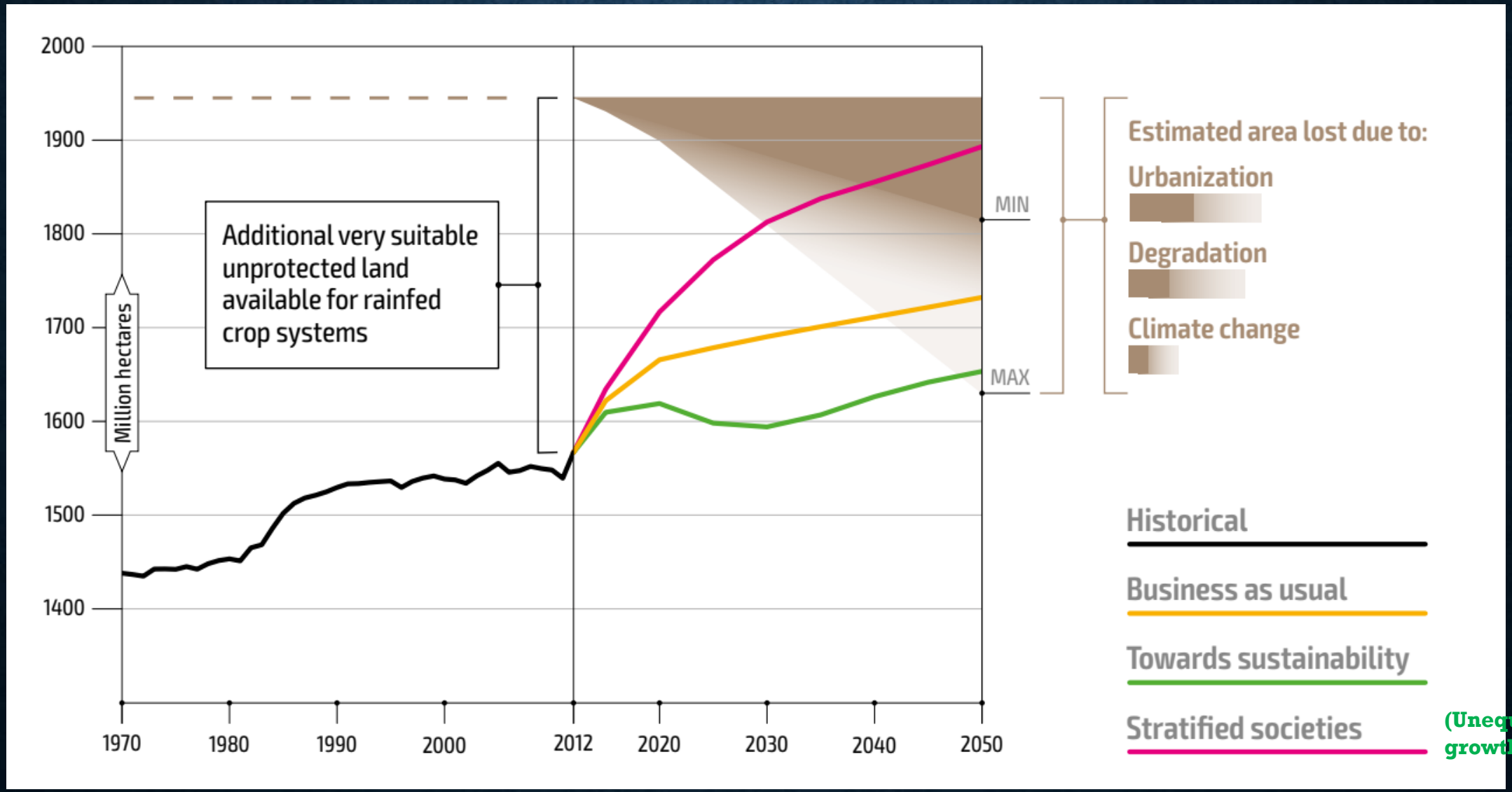
ESA Rennes August 2024

POPULATION GROWTH

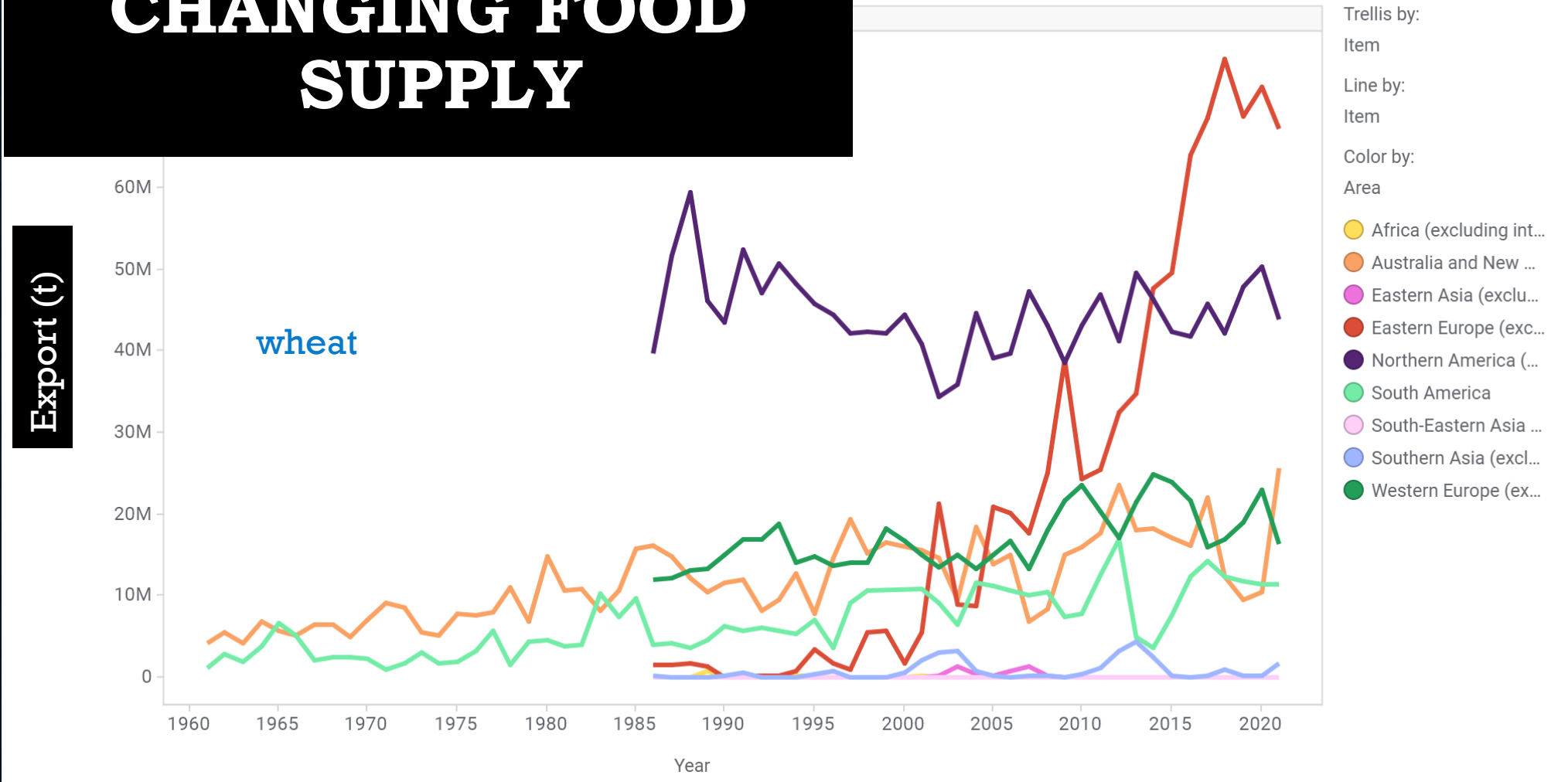


Food demand

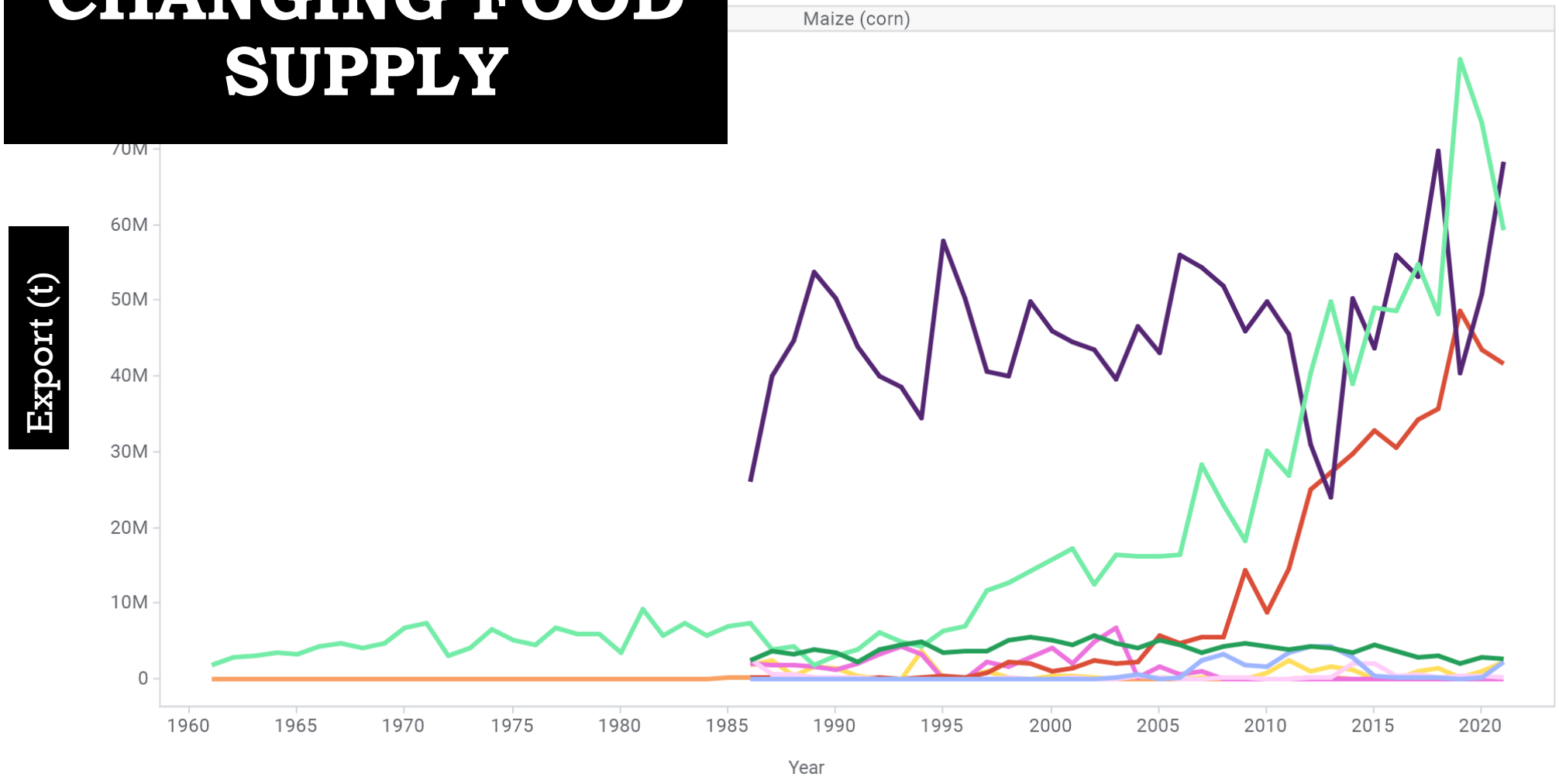
ARABLE LAND REQUIREMENTS (FAO 2022)



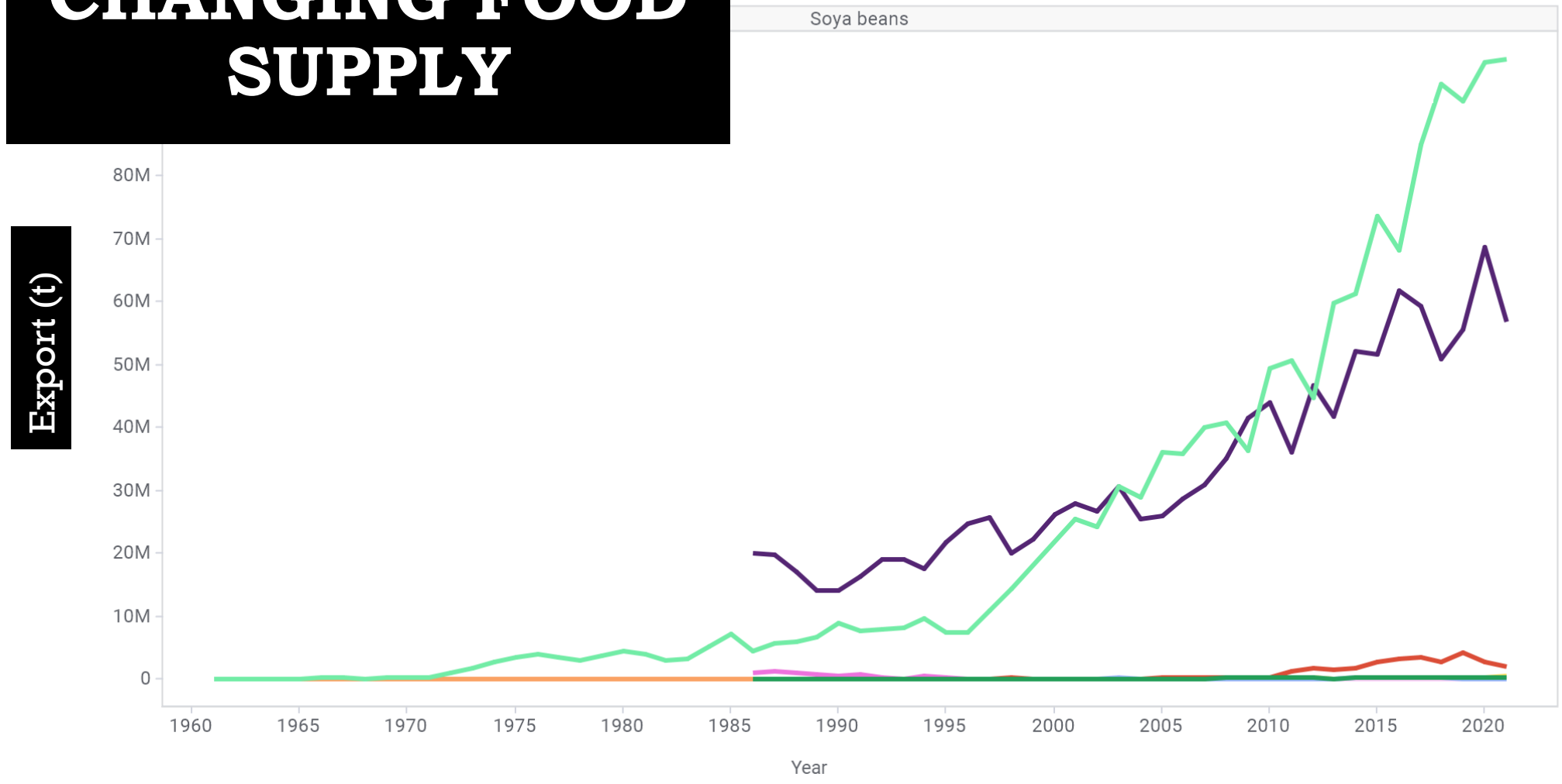
CHANGING FOOD SUPPLY



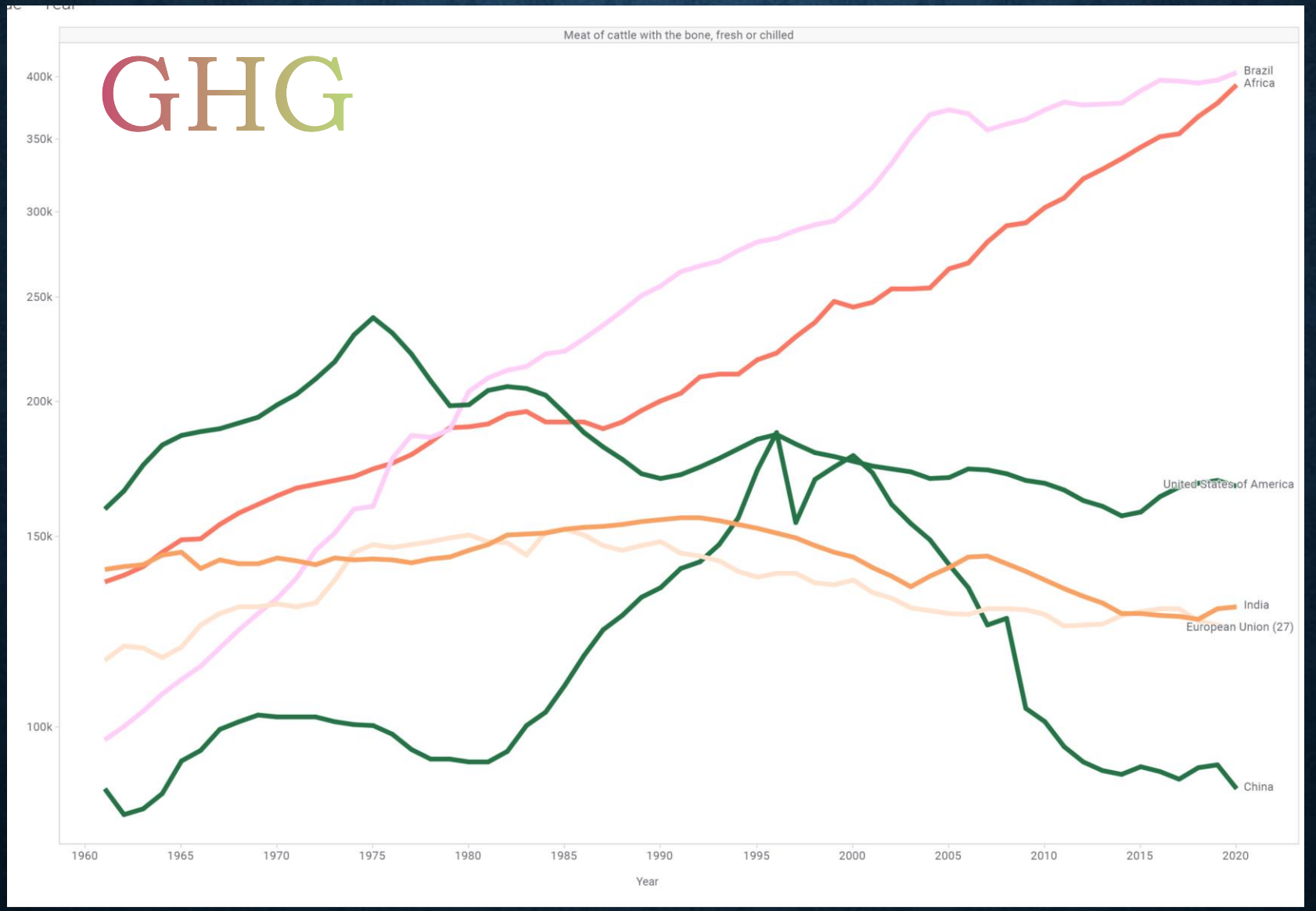
CHANGING FOOD SUPPLY



CHANGING FOOD SUPPLY



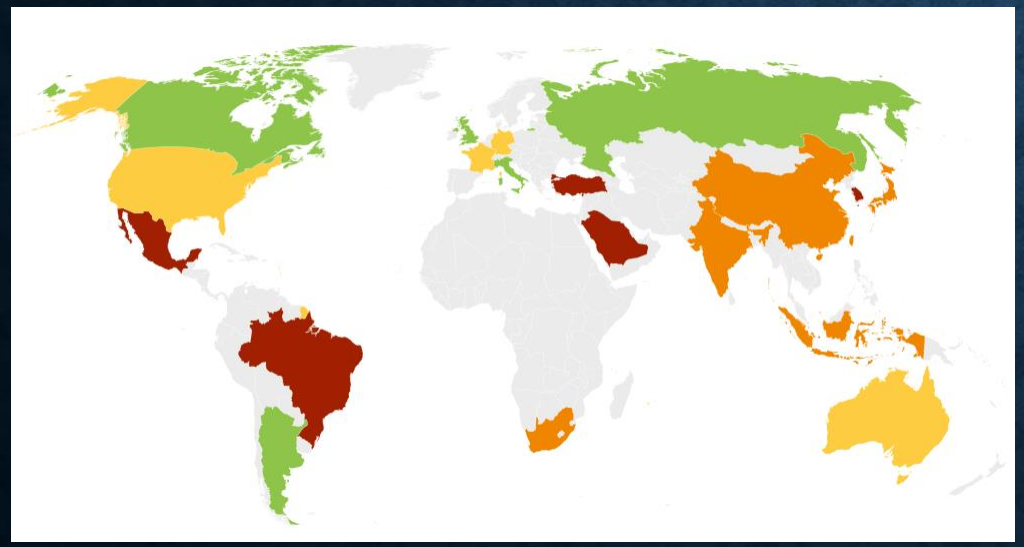
EMISSIONS [$CO_{2\ EQ}$]. MEAT. SELECTED AREAS

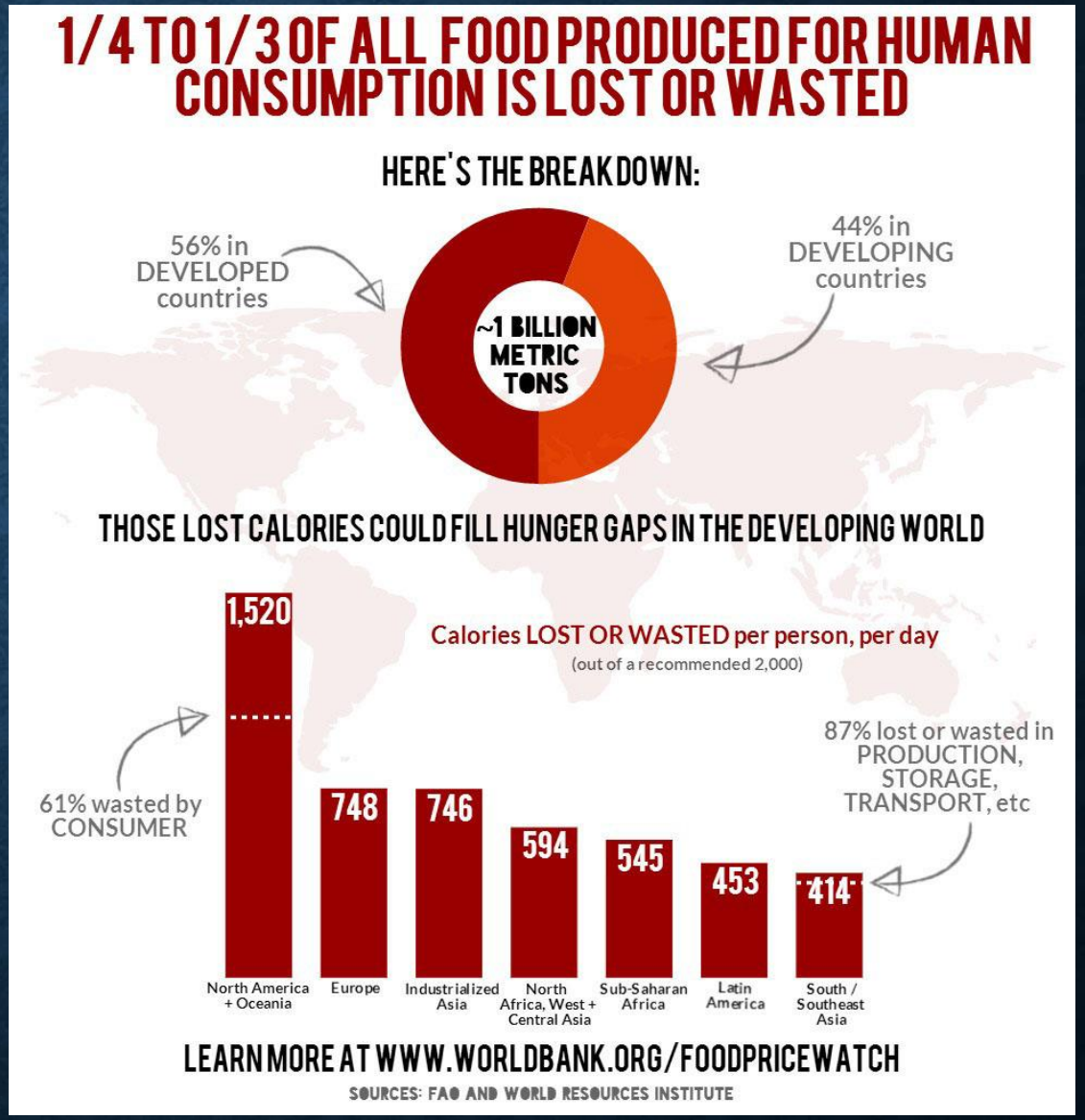


FOOD WASTE

Food loss as a % of total food production in the country

Source, FSI, 2023

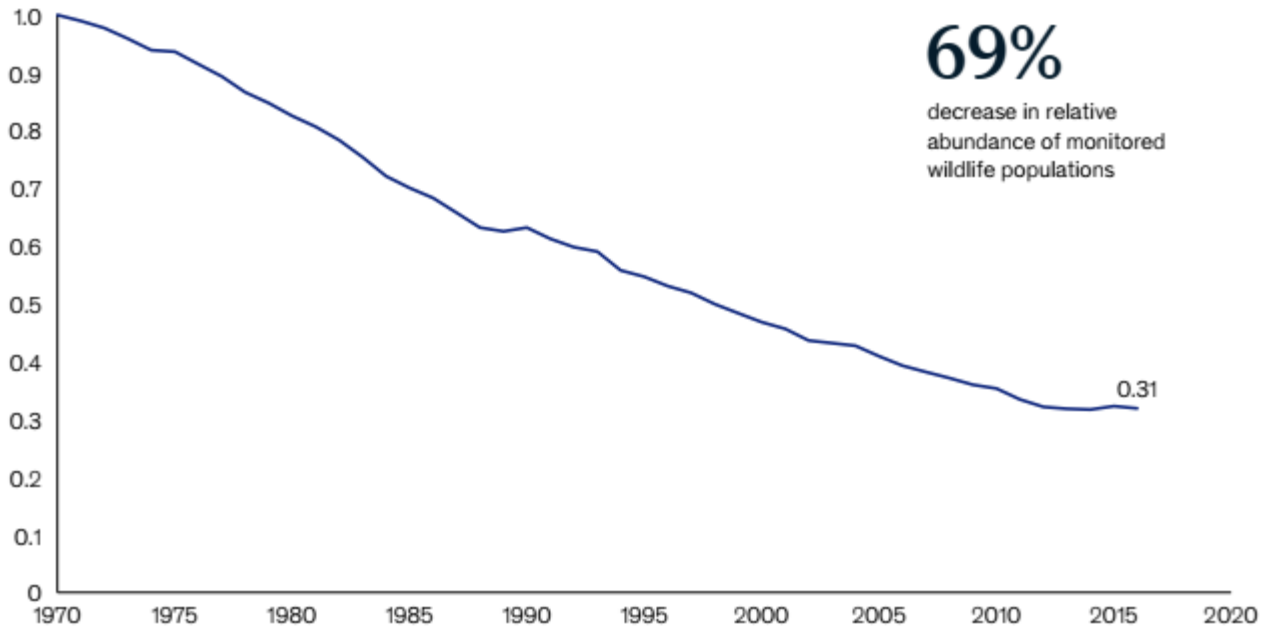




NATURAL CAPITAL LOSS

Nature is in rapid decline across dimensions.

Living Planet Index,[1] 1970–2018



69%
decrease in relative abundance of monitored wildlife populations

Other indicators of nature's decline

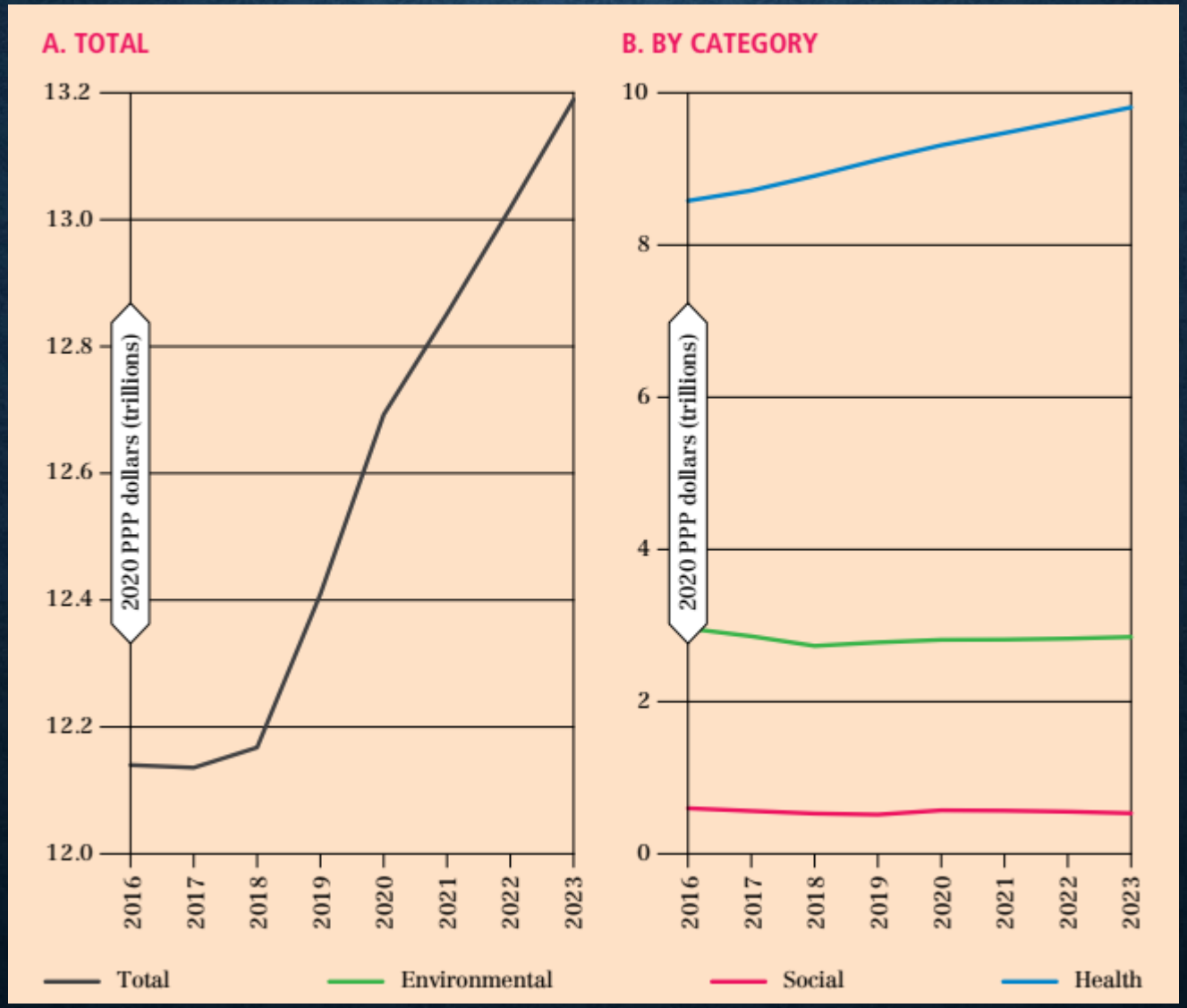
- **20%** decline in forested areas
- **33%** of topsoil degraded
- **85%** of wetlands lost
- **50%** of coral reef system destroyed

McKinsey & Company

Nature in the balance: What companies can do to restore natural capital

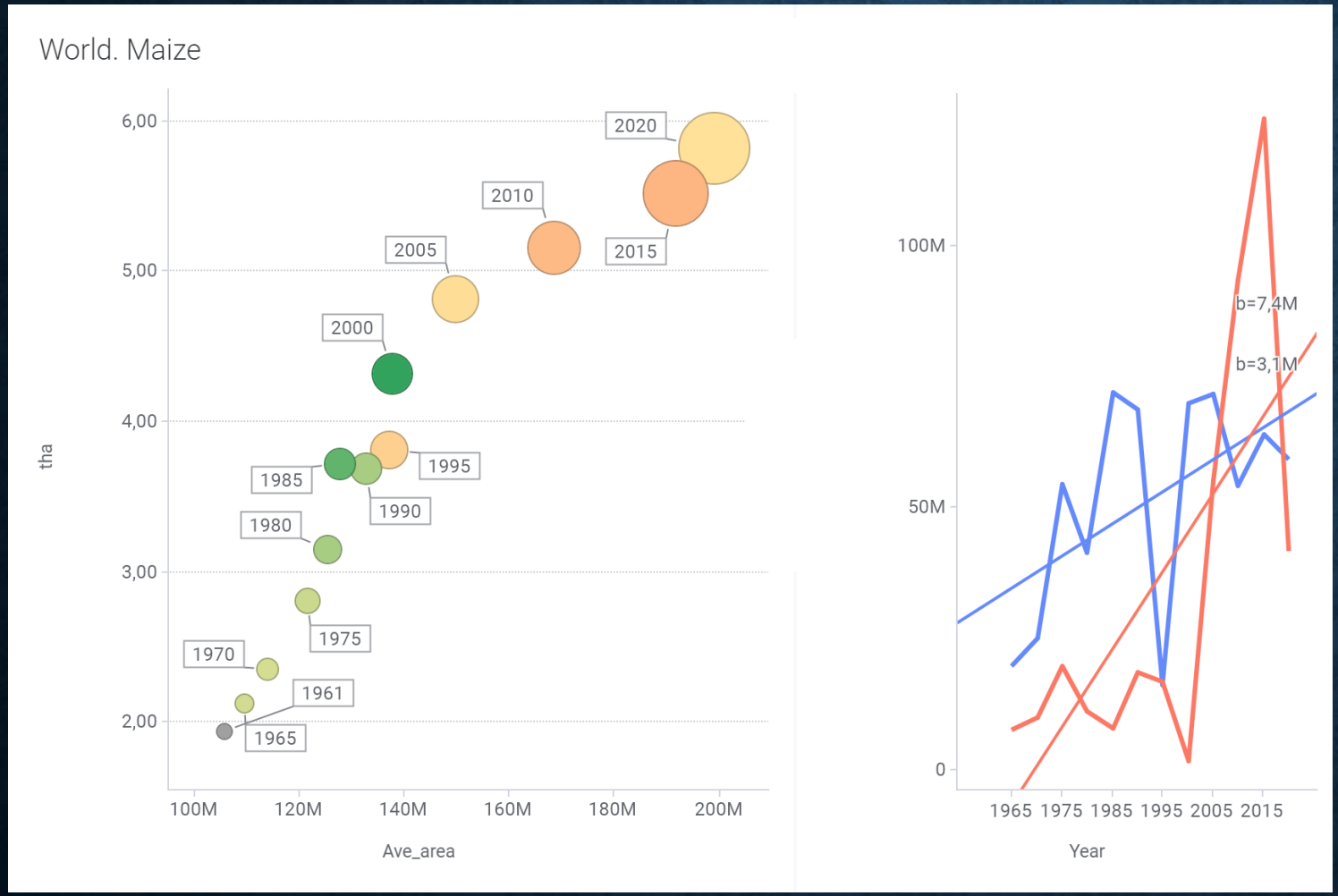
December 2022

HIDDEN COSTS OF AGRIFOOD



Lord, 2023

WHAT ROLES FOR DIGITAL AGRONOMY?



SI Efficiency & control

Valorization

AE Value creation & conservation

RA Monitoring, analysis & regulation

N+ Agency

ESA Rennes August 2024

Sustainable intensification; Agroecology; Regen. Ag; Nature positive agriculture

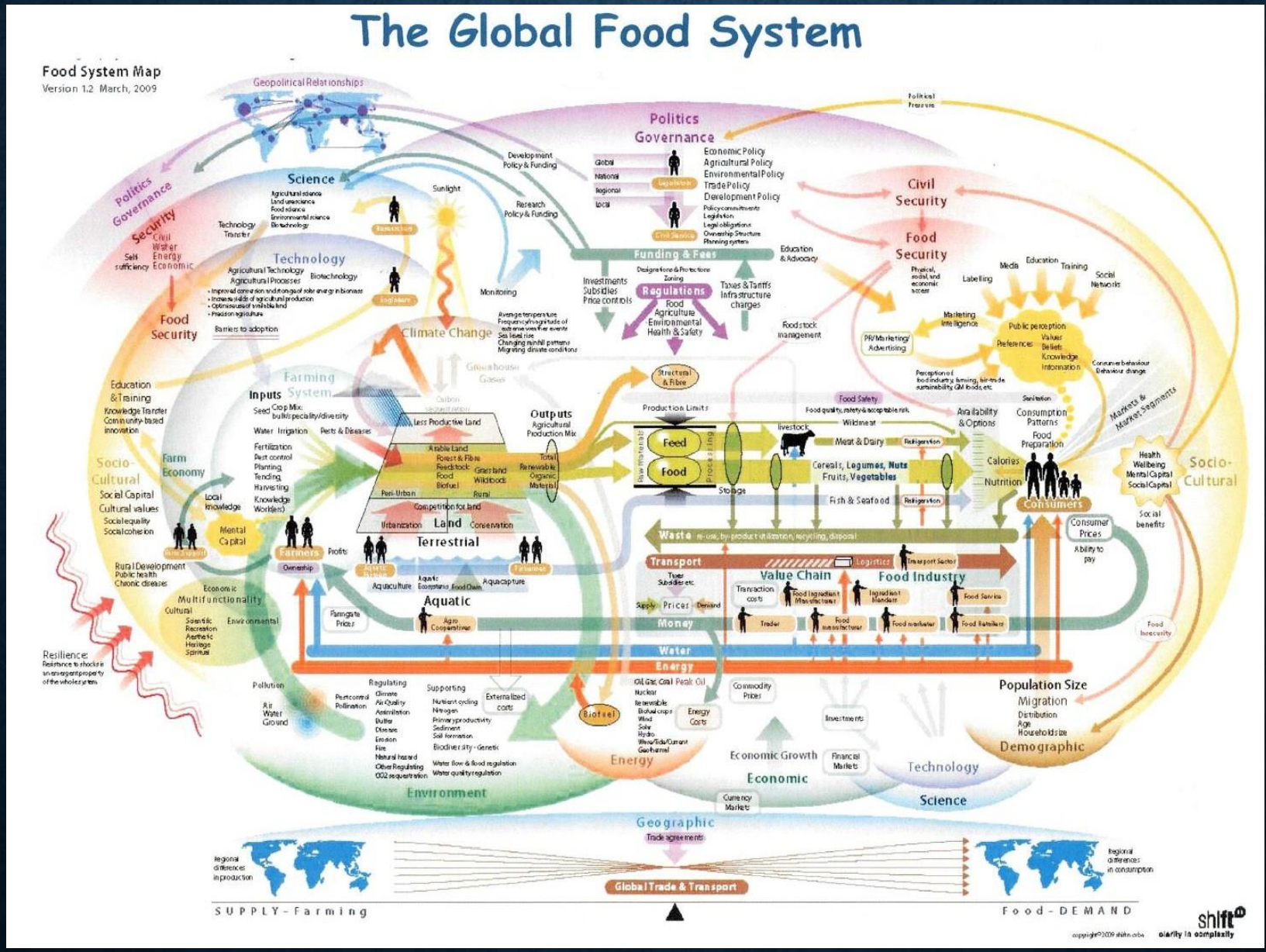
DIGITAL AG BASICS

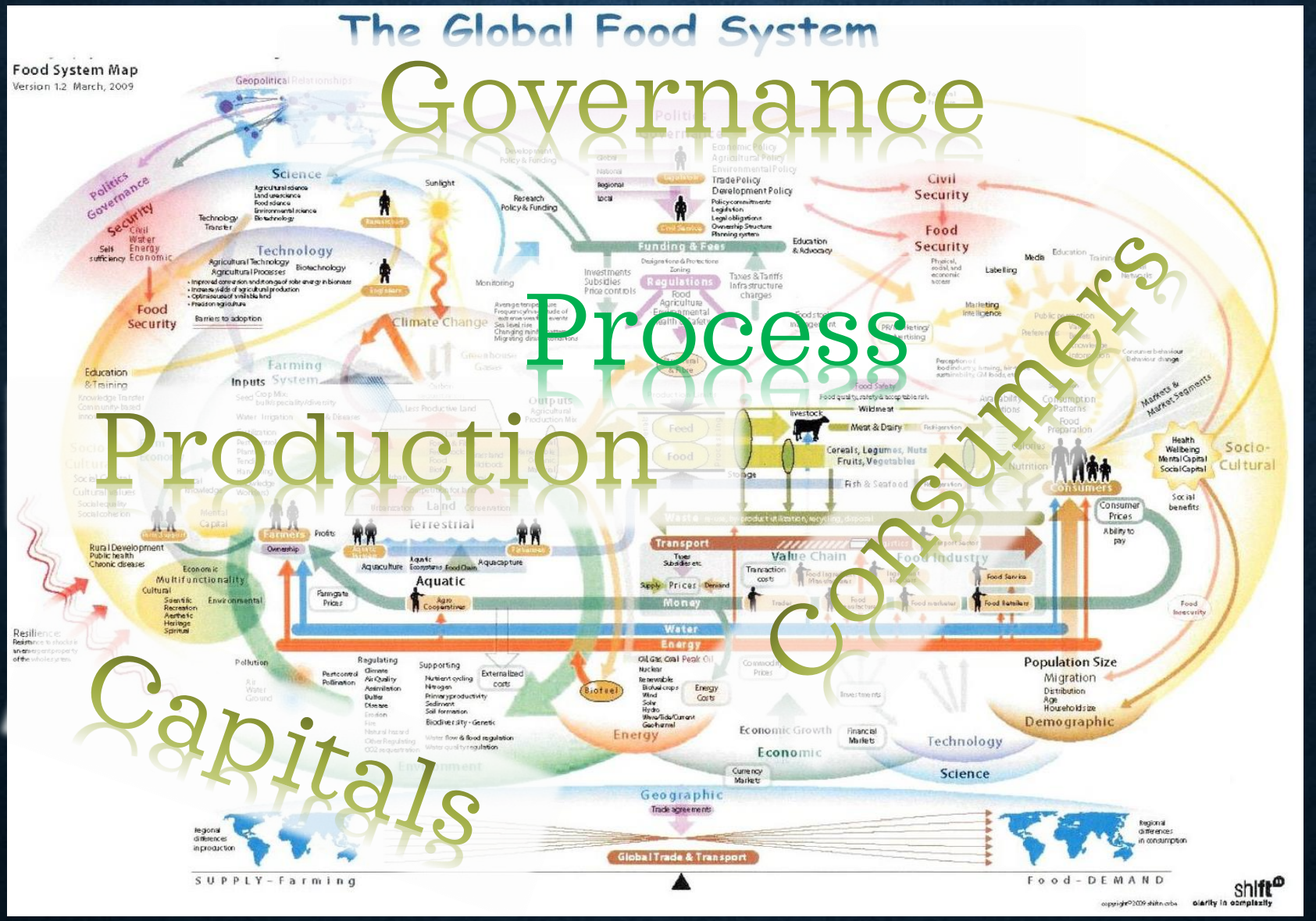
a. Think food systems change, not just production

b. Review the technology – how does it help?

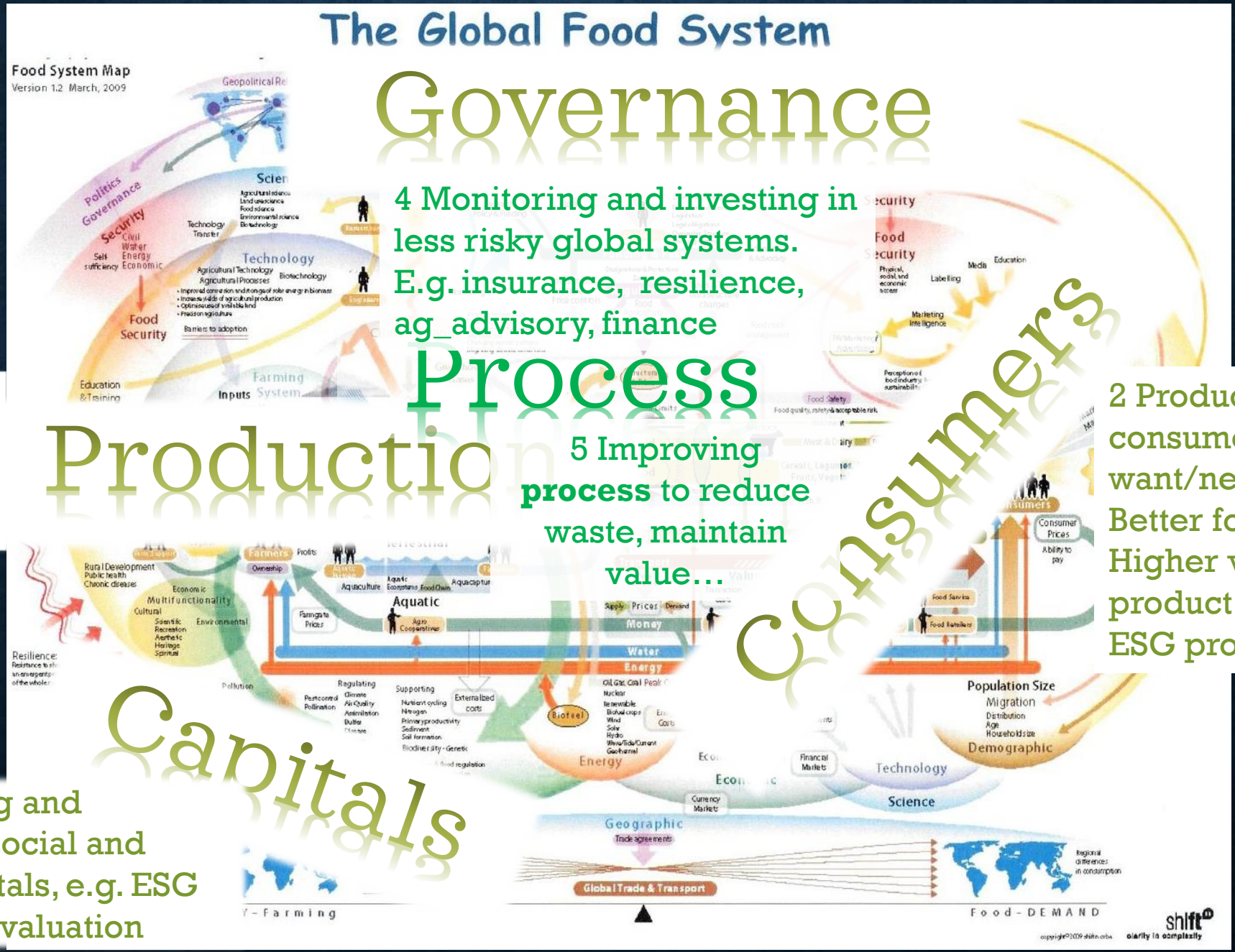
c. Who pays? Who gains? Value models

A. NOT JUST PRODUCTION




The Global Food System
Food System Map
Version 1.2 March, 2009
Governance
Process
Production
Consumers
Capitals
Geopolitical
Politics
Governance
Security
Civil
Water
Energy
Economic
Sufficiency
Food Security
Science
Technology Transfer
Technology
Agricultural Technology
Agricultural Processes
Biotechnology
Barriers to adoption
Sunlight
Climate Change
Research
Policy & Funding
Monitoring
Education
&Training
Farming
Inputs
System
Outputs
Land
Terrestrial
Aquatic
Aquaculture
Aquacapture
Farmers
Profits
Ownership
Rural Development
Public health
Chronic diseases
Economic
Multifunctionality
Cultural
Scientific
Recreation
Aesthetic
Heritage
Spiritual
Environmental
Resilience
Pollution
Regulating
Supporting
Externalized costs
Biodiversity - Genetic
Biofuel
Energy Costs
Energy
Oil, Gas, Coal, Peak Oil
Nuclear
Renewable
Wind
Solar
Hydro
Wave/tide/Current
Geothermal
Funding & Fees
Regulations
Investments
Subsidies
Price controls
Taxes & Tariffs
Infrastructure charges
Trade Policy
Development Policy
Policy commitments
Legislation
Legal obligations
Ownership Structure
Planning system
Education & Advocacy
Civil Security
Food Security
Labelling
Media
Marketing Intelligence
Food Safety
Livestock
Wild meat
Meat & Dairy
Cereals, Legumes, Nuts
Fruits, Vegetables
Fish & Seafood
Storage
Waste
Transport
Value Chain
Food Industry
Transaction costs
Supply
Prices
Demand
Money
Water
Energy
Consumers
Consumer Prices
Ability to pay
Markets & Market Segments
Health
Wellbeing
Mental Capital
Social Capital
Socio-Cultural
Social benefits
Food Insecurity
Population Size
Migration
Distribution
Age
Household size
Demographic
Economic Growth
Economic
Financial Markets
Currency Markets
Technology
Science
Geographic
Trade agreements
Global Trade & Transport
Regional differences in production
Regional differences in consumption
SUPPLY - Farming
Food - DEMAND
shift
clarity in complexity

The Global Food System



4 Monitoring and investing in less risky global systems. E.g. insurance, resilience, ag_advisory, finance

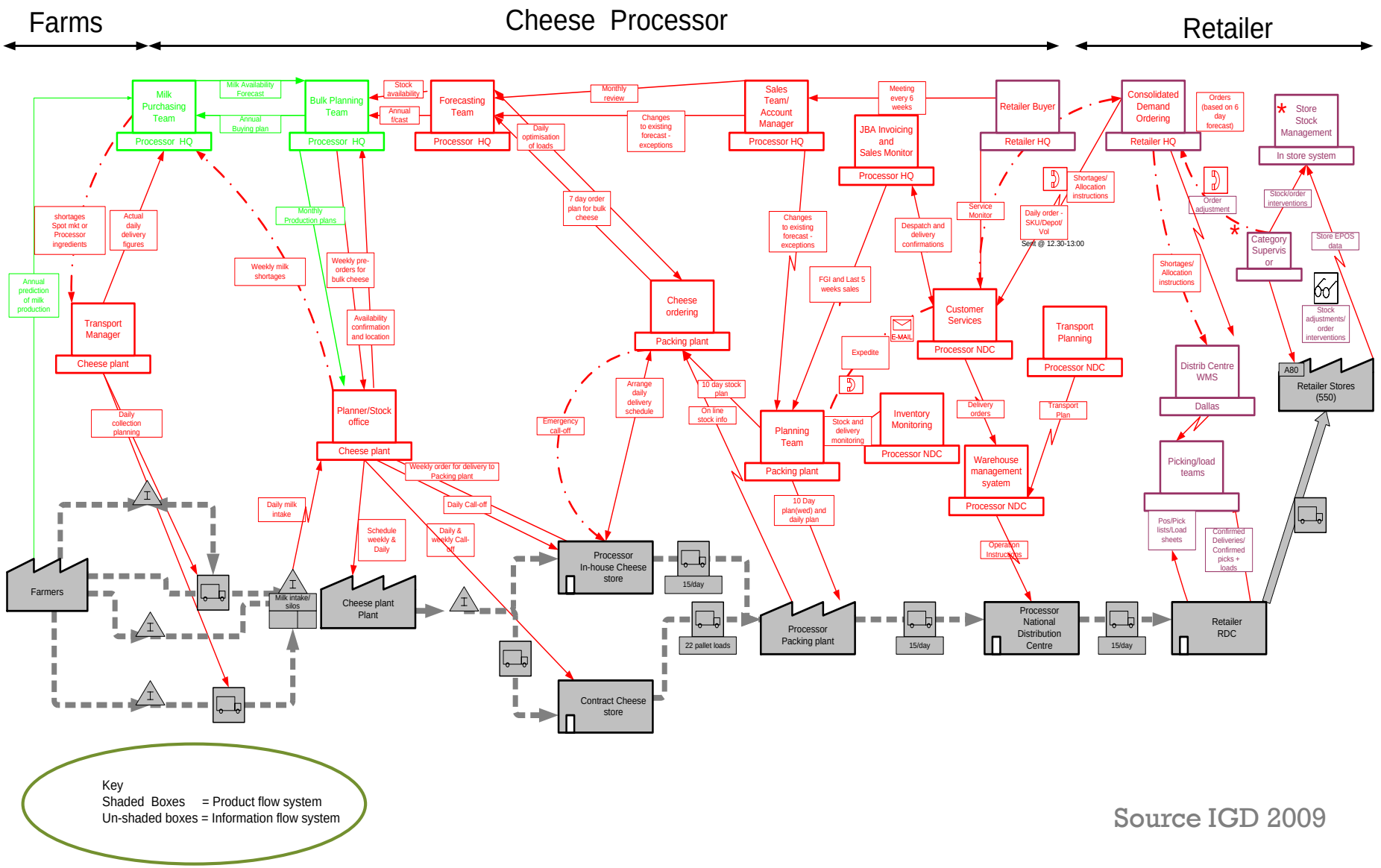
1 Producing 'better' 4R nutrition
Emission reduction
Water accounting

5 Improving **process** to reduce waste, maintain value…

2 Producing what consumers want/need.
Better food quality
Higher value product
ESG product….

3 Monitoring and enhancing social and natural capitals, e.g. ESG accounting, valuation

IN CASE YOU THINK DATA ISN'T IMPORTANT IN FOOD VALUE CHAINS



Source IGD 2009

- What it comprises
- What it *does*
- How that helps (Relevance for agronomists)

B. DIGITAL AGRICULTURE TECHNOLOGY

- Data
  - Sensors in field, in-line, on-board, in-air, above-earth, published data, written word…..
  - Observe crops, environments, climate, animals…..every second….everywhere…
  - Observe, test and build models of complex & dynamic systems
- Control
  - Field robust control, differentiated action
  - Automates, auto-selects, precision action, records
  - Certain control, known variation
- Modelling
  - Multi-variate, high dimensional computation
  - Represents complex systems in detail, full-scale, real time…..
  - Represent and analyze complex systems in near real-time [ML/AI], VR, AR etc ….
- Communication & networking
  - Social networking, machine-to-machine communication
  - Enables innovation & business model development
  - Engages agronomy in innovation systems [forget extension]

C VALUE MODELS
HOW CAN DIGITAL HELP AGRONOMY CREATE VALUE?

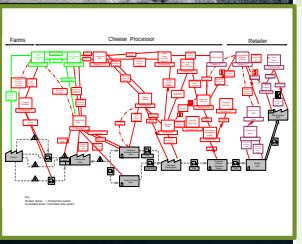
Think beyond production

How to get past the ‘Twilight Zone’? *(Wolfert 2023)*

ESA Rennes August 2024

https://doi.org/10.1016/j.agsy.2022.103558

HOW DIGITAL CREATES VALUE



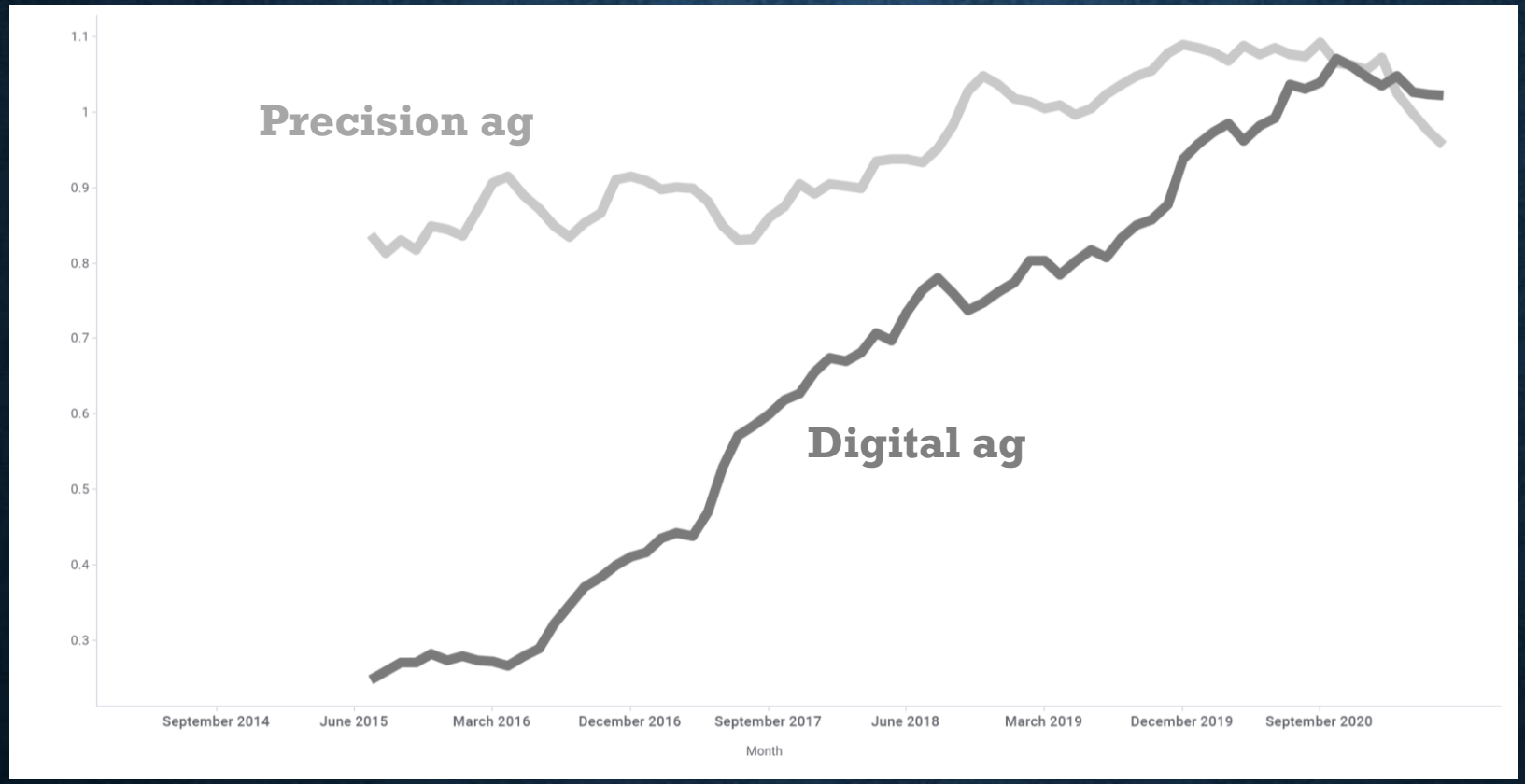
Type of model*	Examples in agronomy	How digital creates value	How they capture IP	Role for agronomy
I Supplier dominated *Farmer-centric*	Farmers – advisors	Cost-cutting Input gains New farming practice	Extension Learning by doing	Develop VP with farmers
II Scale dominated *Unilever-type*	Bulk handlers Processors Supermarkets	Value conservation Smoother processing Quality assurance	Process learning Technical lags	Product value through better agronomy
III Specialist supplier *JD type*	John Deere Syngenta Bayer, BASF	New products & services to sell to farmers	Design know-how Patents	ID value of new product to farmers
IV Community *Ministry of agriculture type*	INRAE Farmer groups	New products or services for the public good	R&D know-how Publishing Patents	Help design digital instruments that serve us

* Pavitt, 1984, Sectoral patterns of technological change

PROGRESS

How is Digital Ag growing?

DIGITAG A RECENT ADDITION

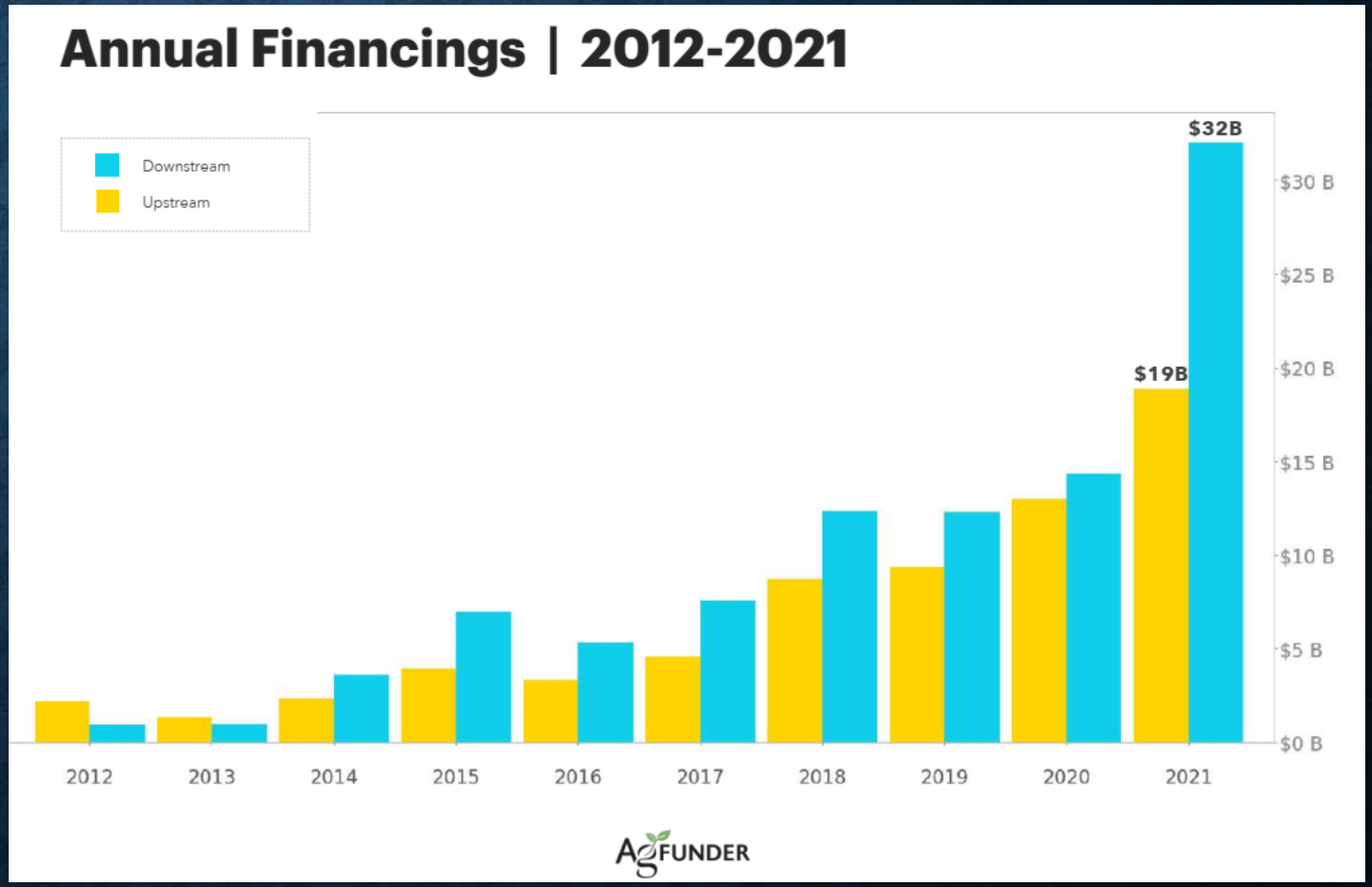


Google trends Normalized to ‘Plant breeding’

AGRICULTURE VIEWED AS AN INVESTMENT OPPORTUNITY

Sector	Overall digitization[1]	Assets: Digital spending	Assets: Digital asset stock	Usage: Transactions	Usage: Interactions	Usage: Business processes	Usage: Market making	Labor: Digital spending on workers	Labor: Digital capital deepening	Labor: Digitization of work	GDP share %	Employment share %	Productivity growth, 2005–14[2] %
ICT											5	3	4.6
Media											2	1	3.6
Professional services											9	6	0.3
Finance and insurance											8	4	1.6
Wholesale trade											5	4	0.2
Advanced manufacturing											3	2	2.6
Oil and gas											2	0.1	2.9
Utilities											2	0.4	1.3
Chemicals and pharmaceuticals											2	1	1.8
Basic goods manufacturing											5	5	1.2
Mining											1	0.4	0.5
Real estate	●										5	1	2.3
Transportation and warehousing	●										3	3	1.4
Education	●										2	2	-0.5
Retail trade	●										5	11	-1.1
Entertainment and recreation											1	1	0.9
Personal and local services											6	11	0.5
Government	●										16	15	0.2
Health care											10	13	-0.1
Hospitality	●										4	8	-0.9
Construction											3	5	-1.4
Agriculture and hunting											1	1	-0.9

McKinsey, 2015



AgFunder 2022

EARLY GAINS PROVED ELUSIVE…

"A few years ago, the agricultural world was full of promises about how the widespread use of data was going to change farming."

"For farmers data has been a disappointment"

"..the promise of agtech hasn't been able to keep up with expectations"

Why Big Data Hasn't Yet Made a Dent on Farms

Startups designed to use information to boost agricultural productivity are struggling. So now tech companies are changing their approach.

Blue River Technology's See & Spray machines scan for weeds and squirt them with pesticides. PHOTO: BLUE RIVER TECHNOLOGY

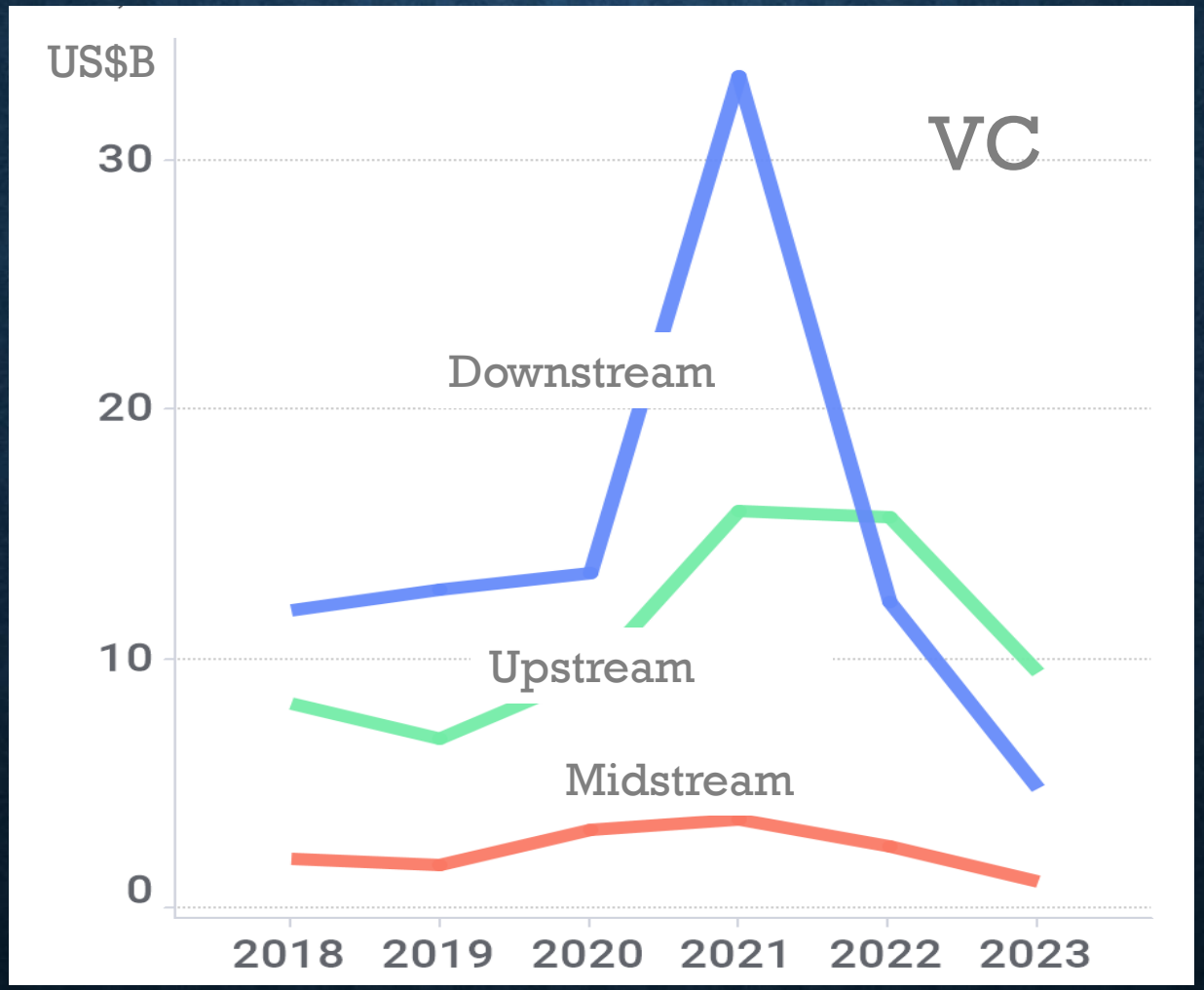
THE WALL STREET JOURNAL.
WSJ

By Eliot Brown

May 15, 2017

"Everybody is still trying to figure out where the value in data is,"

UPSTREAM INVESTMENT STABLE, DOWNSTREAM….?

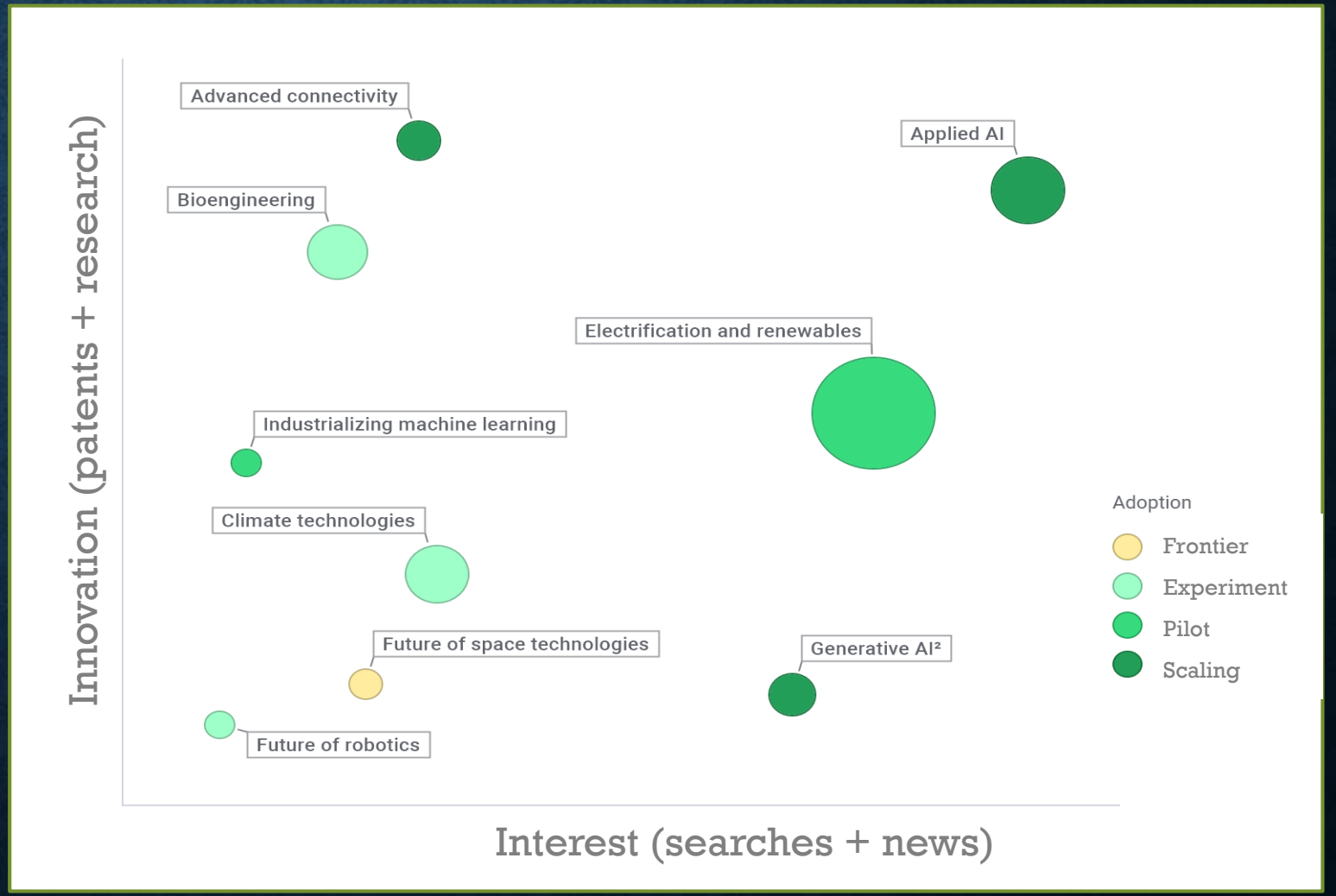


Agfunder, 2024

2024 TECH UPDATE. ADOPTION UP, INVESTMENT REASONABLY STABLE

From McKinsey
Technology Trends Update
2024

- Adoption **advanced**
- 9 of 15 trends include agriculture
- Total equity investment [size of bubble] $B 3-183. (est ~32 $B for Ag)
- Jobs growth slowing



ESA Rennes August 2024

EXAMPLES

What could **digital ag** look like?

What **role for agronomy**?

EXAMPLES OF DIGITAG APPS

Whats the **VP**?

Who gets the value?

Model type

Type of **digital tech**

Role for **agronomy**

DIGITAL ON-FARM EXPERIMENTATION

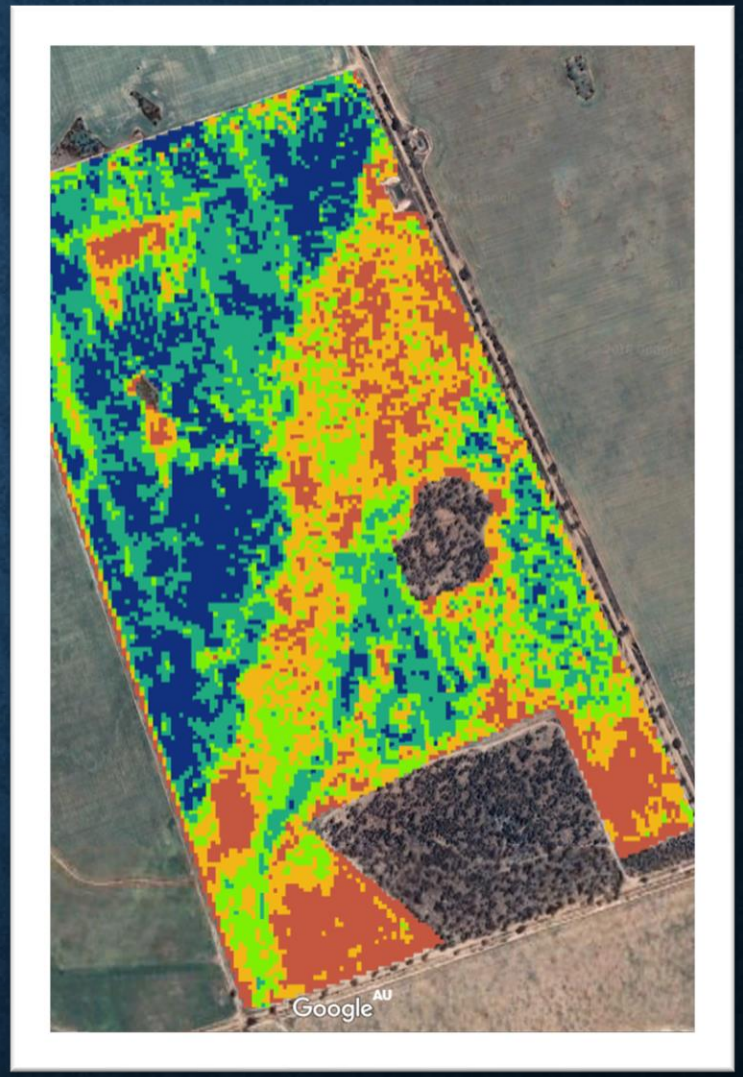
Accelerated learning/business development, Field-scale analysis

Farmers, consultants/advisors, suppliers

Model I (farmer-centric)

Precision ag [yield monitors, RS], AR

Consistent updating of field-based learning models



ADAPTIVE REGULATION OF N USE

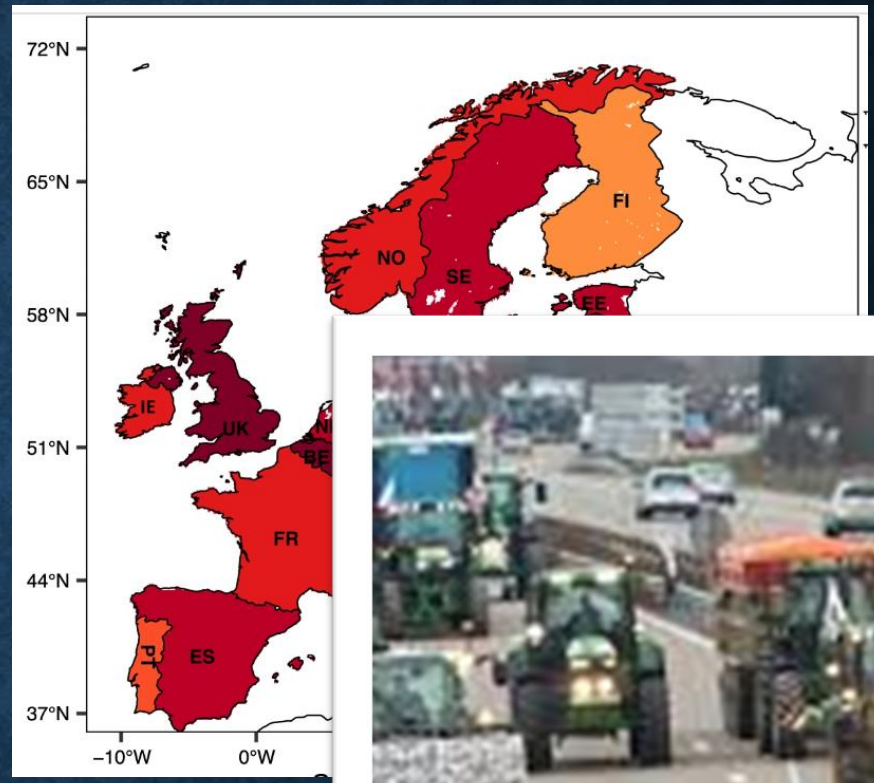
Improve N use through local, data-driven adaptation of regulations and shared agency

Farmers, regulators, community

Model IV & I (community/farmer-centric)

Networked OFEs, field sensors

Model development, field interpretation, standards



Batool et al, 2022

Al Jazeera

‘OMICS FOR NUTRITIOUS FOOD

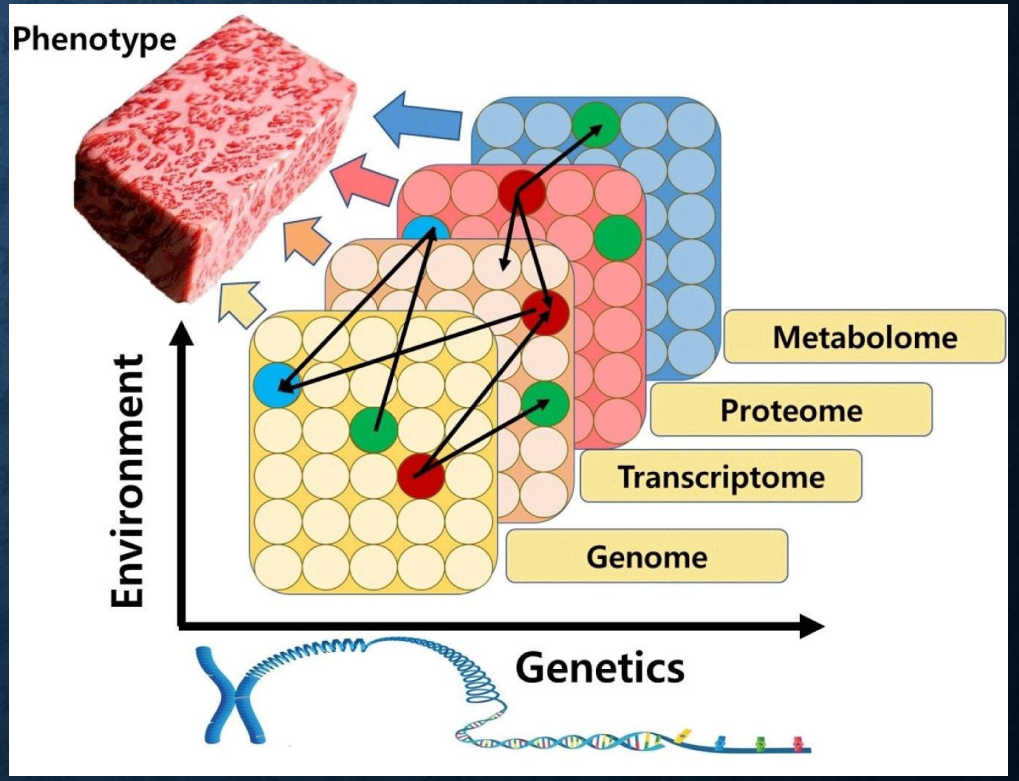
Trusted food of known nutritious quality

Farmers, suppliers, consumers

Model II (Supply chain)

Metabolomics, genomics, agronomics*

G*E*M Model development, field certification process, valuation



https://iptc.org/

ESA Rennes August 2024

*Sylvester-Bradley ei al., 2017
DOI: 10.1017/S2040470017001029

DIGITAL CLIMATE ADVISORY

Site-specific climate risk management

Farmers, insurers, suppliers

Model II or III [depends who provides service]

Climate data, crop data, risk models

Site specific agronomic risk models

MEAT PRODUCTION AND PROCESSING

Maximize value per animal carcass and per hectare

Farmers, processors

Model II

DEXA, robotics, OFE

Linking meat quality to pasture management

NZ Farmers Weekly 2017

MINIMIZING LANDSCAPE ENTROPY

Optimize production, C balance, Water productivity, Landscape entropy,

Farmers, community

Model I, IV (Community centric)

Precision ag tech, 4R (include green NH_3), Remote sensing (SOC)

Landscape agronomy

ESA Rennes August 2024

Beata Zaczek

SUMMARY

- **Has agronomy kept up?**
  Partially. Embracing complexity but not creating the potential value
  - **Model I** (Farmer-centric). Underdeveloped
    - Social engagement (DEPHYS, SYPPRE) who pays?
    - How many farmers use their own data?
    - How many agronomists help them?
  - **Model II** (Supply chain). V little
    - How often is production connected to value chains?
  - **Model III** ("Syngenta"). Most active type. Who does it serve?
    - Link with agronomy less clear
    - Can service providers share IP to improve?
  - **Model IV** (public/community). More possible
    - WB, FAO, EU seem unsure what to do

- **How to accelerate change:**
  Deploy agronomy to create value using the tech.
  - **Model I:** On-farm experimentation
    - Yield monitors / RS / other data
    - Accelerated farmer learning
    - Co-create value
  - **Models II**
    - Link agronomy to value chains.
    - How does better field management improve product value/acceptance?
  - **Model III:**
    - Who holds the knowledge?
    - Increase farmer agency.
  - **Model IV:**
    - Evidence based policy, finance, regulation.

ESA Rennes August 2024

* https://doi.org/10.46830/writn.23.00073

SUGGESTIONS FOR THE FUTURE

- **Be wary** of digital hype…but expect change
- **Engage** with data…
- Consider how to create value from tech…
  …and how agronomy can improve them
- **Engage** with **users** to develop & scale them

THANK YOU

simon.cook@murdoch.edu.au