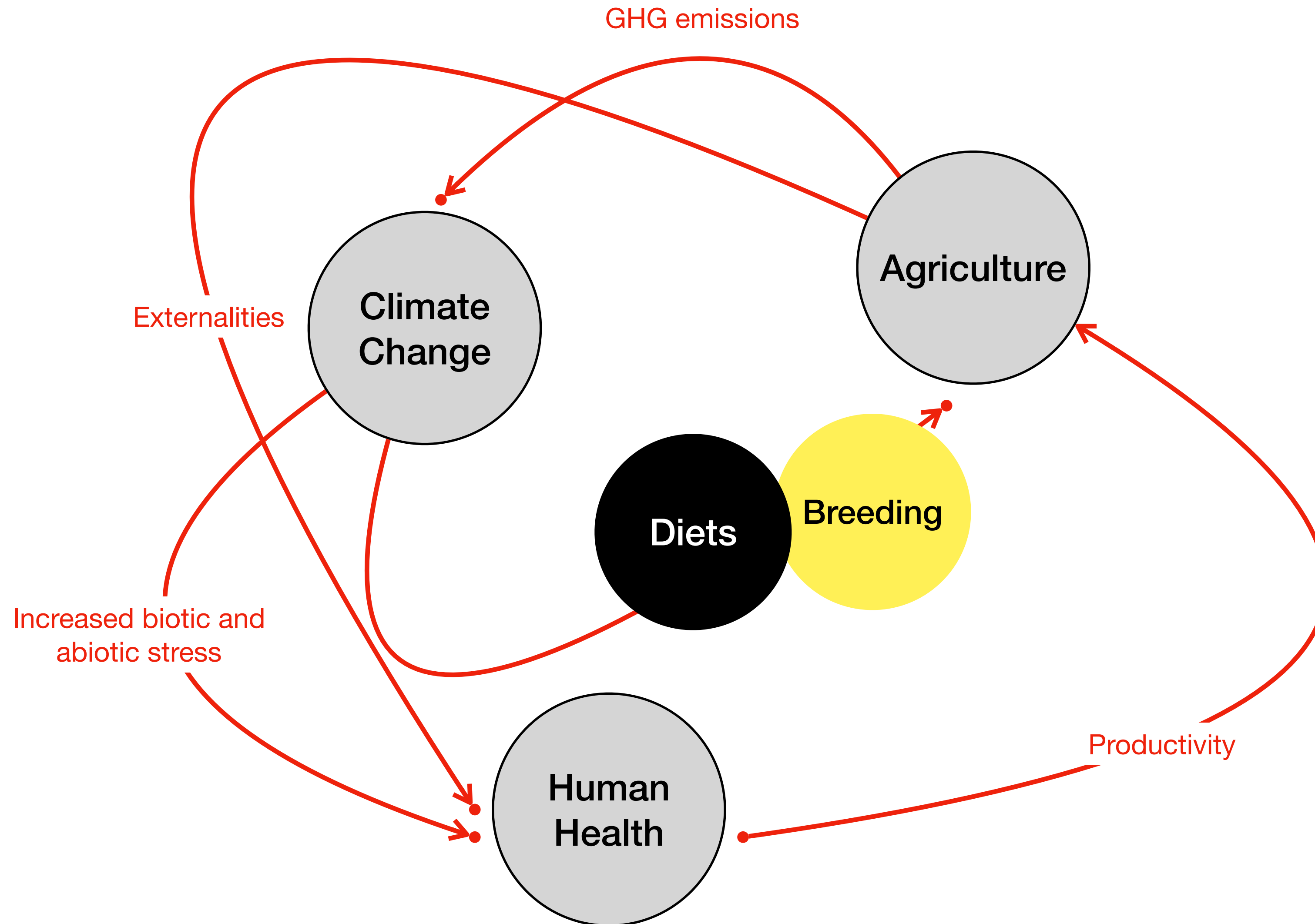


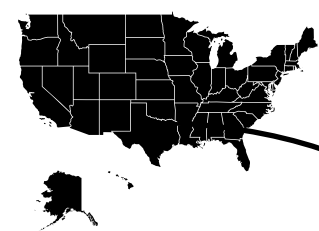
Taking aim at the current Syndemic ^{Part I}

Messina Charlie | Horticultural Sciences | UF/IFAS
NASEM GUIRR 2023

Syndemic

Multiple interconnected disruptions at global scale





+2.1 Trillion



HUMAN HEALTH

1,145



ENVIRONMENT

350



BIODIVERSITY

455



LIVELIHOODS

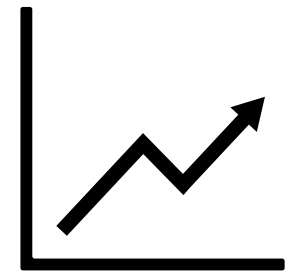
134



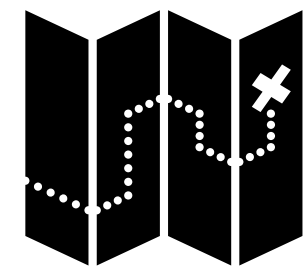
ECONOMY

21

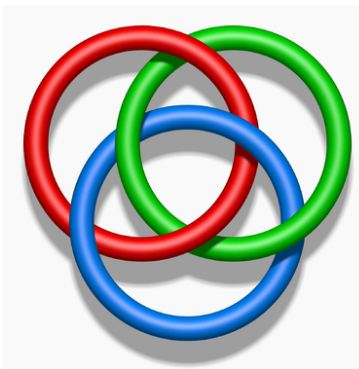
Primitives



Breeding enable us to reimaging **agriculture** as a **solution** to climate change and human health crisis

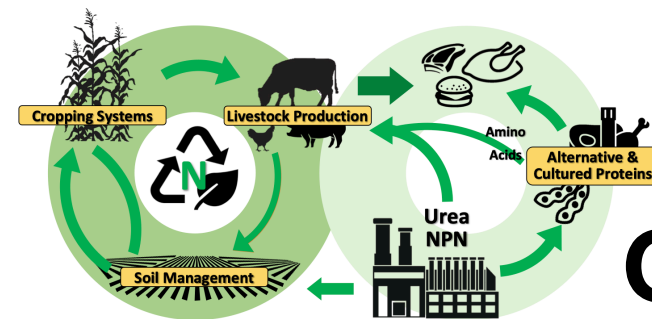


New breeding technologies and breeding efforts will be required to enable the transition of agricultural systems



Need a framework for plant breeding for climate change (and Urban Agriculture) to improve **availability**, **access** and **adoption** of nutrient rich foods

“How to harmonize crop improvement and AI efforts for agricultural systems to regenerate the environment while providing nutrition security, improve human health and adapt to climate change?”



CERCA



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RESEARCH®**



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agriscience

Food as Medicine

Crop improvement opportunity (I)



**2X increase consumption
to Fruits and vegetables**

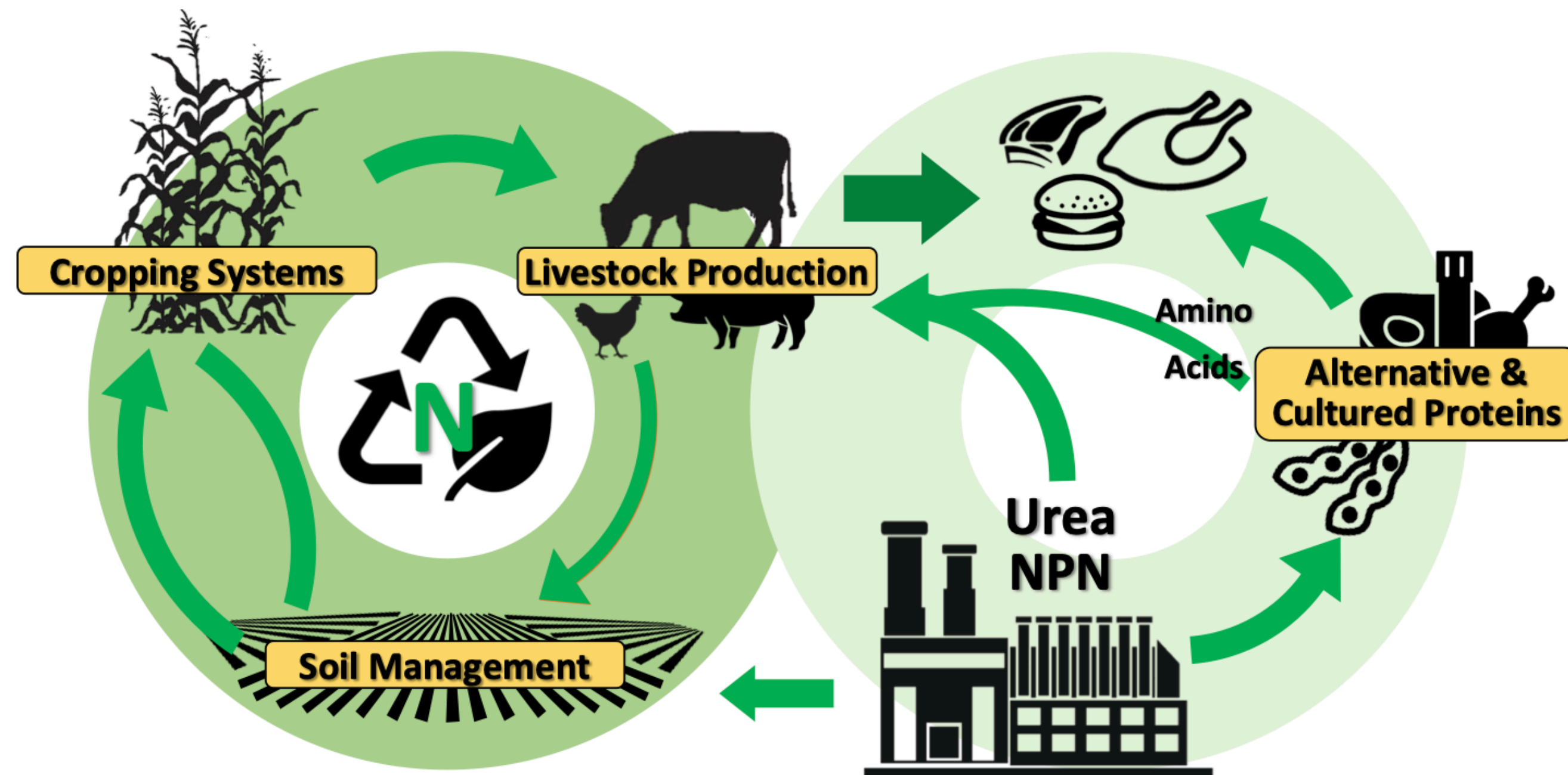
**Expand areas of
production**

New phenomics

**Lack of investment /
focused on row crops**

Circularize nutrient flows (GHG)

Crop improvement opportunity (II)



USDA- ARS Ed Buckler et al

Rethink maize ecophysiology

Breed new traits

Lower N&P in grain

Cold tolerance

Remobilize N to roots

Increase N supply from soil

Sync N supply & demand

Climate change adaptation

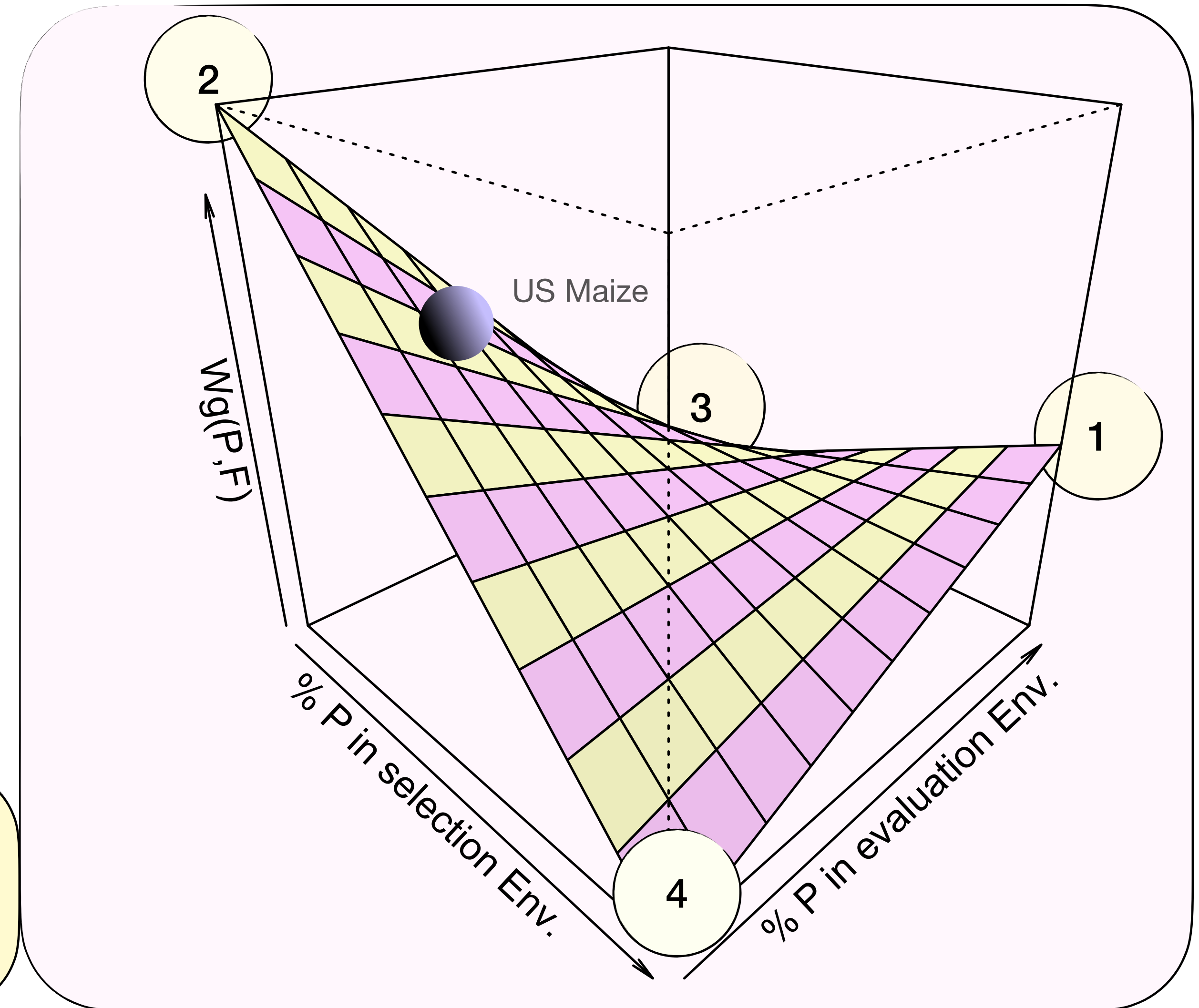
Crop improvement opportunity (III)

Can our breeding systems create the products needed in the future?

No empirical evidence published

Aiming to unknown targets
Unprepared to adapt to climate change

1. Select in P like environments for P like environments | Current breeding
2. Select in F like environments for F like environments | Climate change breeding
3. Select in P like environments for F like environments | No adaptation to the F
4. Select in F like environments for P like environments | No adaptation to P



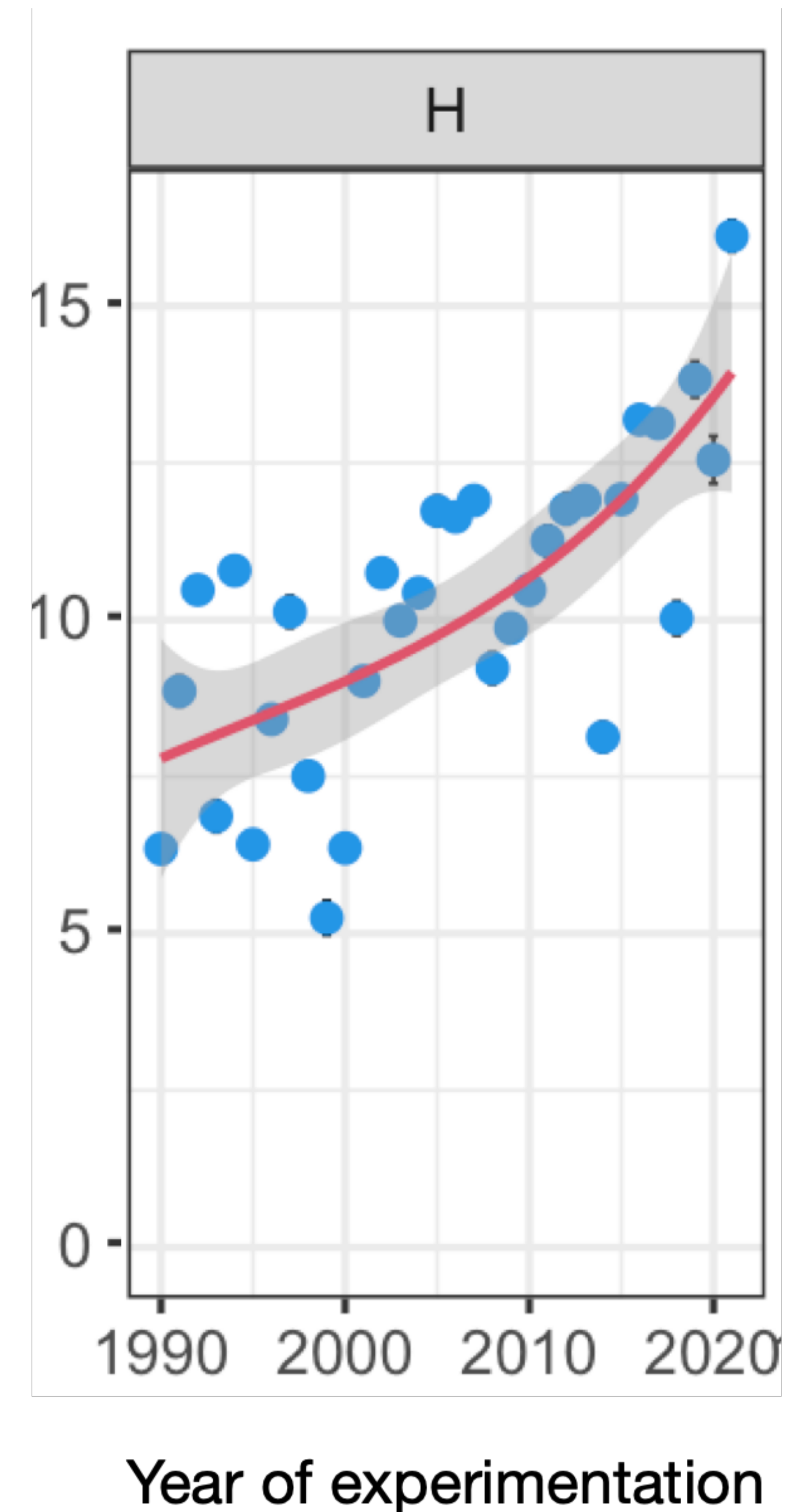
Climate change adaptation

Glimpse from a 100 year long experiment

Messina, Borrás, Tang, Cooper (2023)
<https://www.biorxiv.org/content/10.1101/2023.09.19.558447v1>

Where do we stand with other crops?

Rate of genetic gain ($\text{g m}^{-2} \text{y}^{-1}$)



Improve crop productivity and nutrient content

Improve Environment

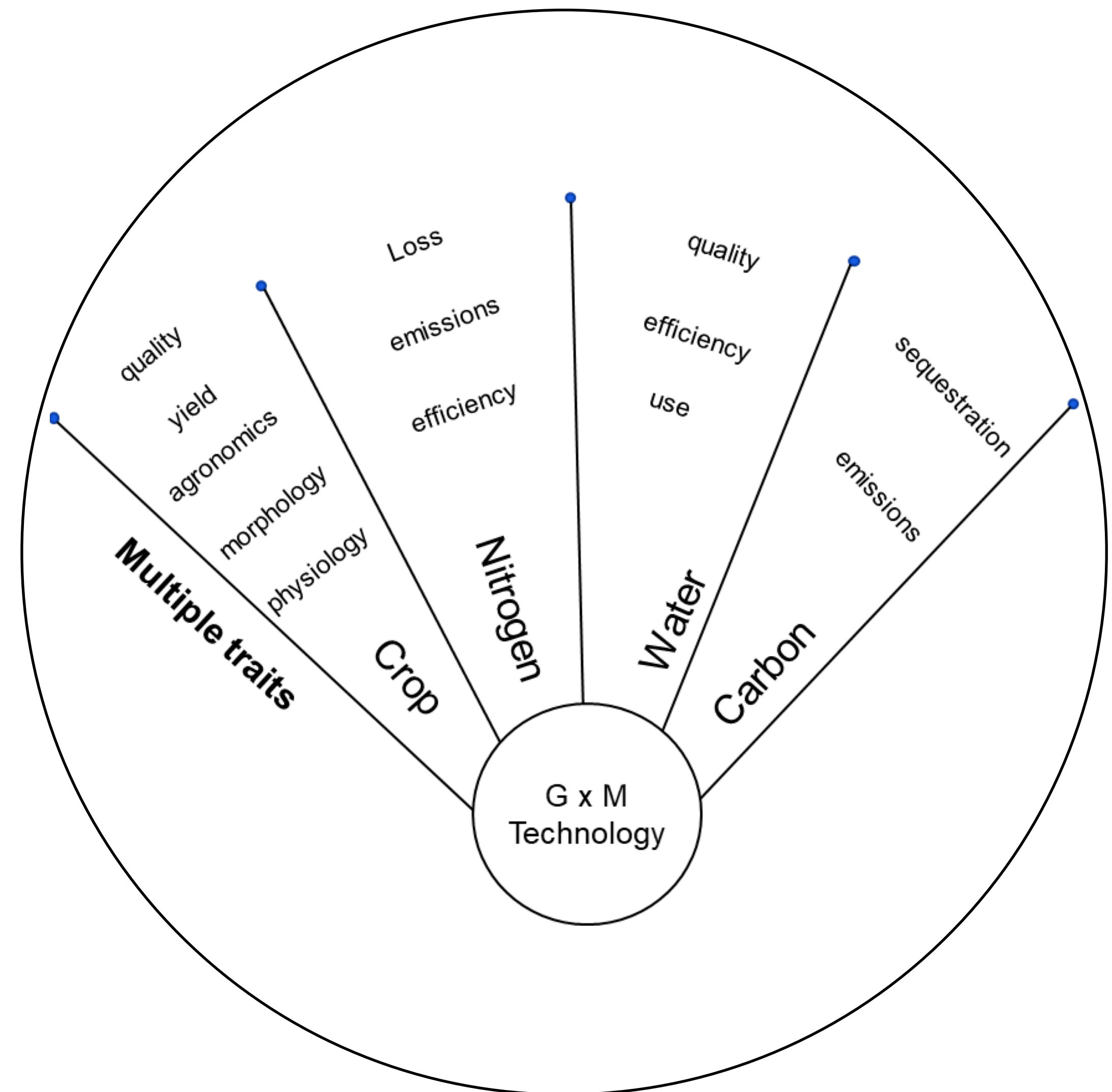
Mitigate impacts

Multidimensional Framework

Symbolic AI + sub-symbolic AI

Scientific
Understanding

Statistical
Learning

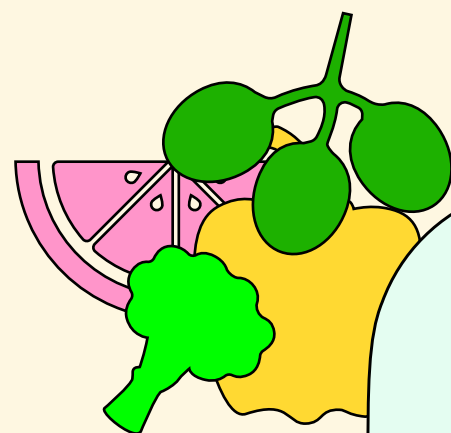


New frameworks for prediction

OMICS integration
Abductive reasoning
Simulation of cropping systems

Phenomics (IoT)

Measure the state of the system at relevant points in time to allow estimation of parameters (physiological and genetic)



Artificial Intelligence

Deductive, Inductive and Abductive reasoning to solve the system of equations
Messina et al. 2018

$$P(\Theta/D) \propto P(D/\Theta)$$

Crop growth model-genomic selection

$$\frac{dW}{dt} = P_m(1 - e^{-Q \cdot PAR \cdot (1 - e^{-k_1 \cdot W \cdot \kappa})}) \cdot f(\theta) - k_2 \cdot W$$

$$\frac{d\theta}{dt} = k_3 \cdot R + kl \cdot (\theta - \theta_0) - \frac{f(W) \cdot (e_s - e)}{\Omega}$$

$$\begin{pmatrix} \hat{\mu} \\ \hat{\mathbf{g}} \end{pmatrix} = \begin{pmatrix} \mathbf{1}_n' \mathbf{1}_n & \mathbf{1}_n' \mathbf{X} \\ \mathbf{X}' \mathbf{1}_n & \mathbf{X}' \mathbf{X} + \mathbf{I} \lambda \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{1}_n' \hat{\boldsymbol{\Omega}} \\ \mathbf{X}' \hat{\boldsymbol{\Omega}} \end{pmatrix}$$

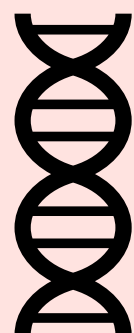


Monitor the environment to quantify the realized value of the random variables that are inputs to the system of equations (e.g. R)

Environmics (IoT)

Methods to characterize the genotype of each individual in the training and prediction sets to allow estimation and prediction of performance $\int f(x)dx$

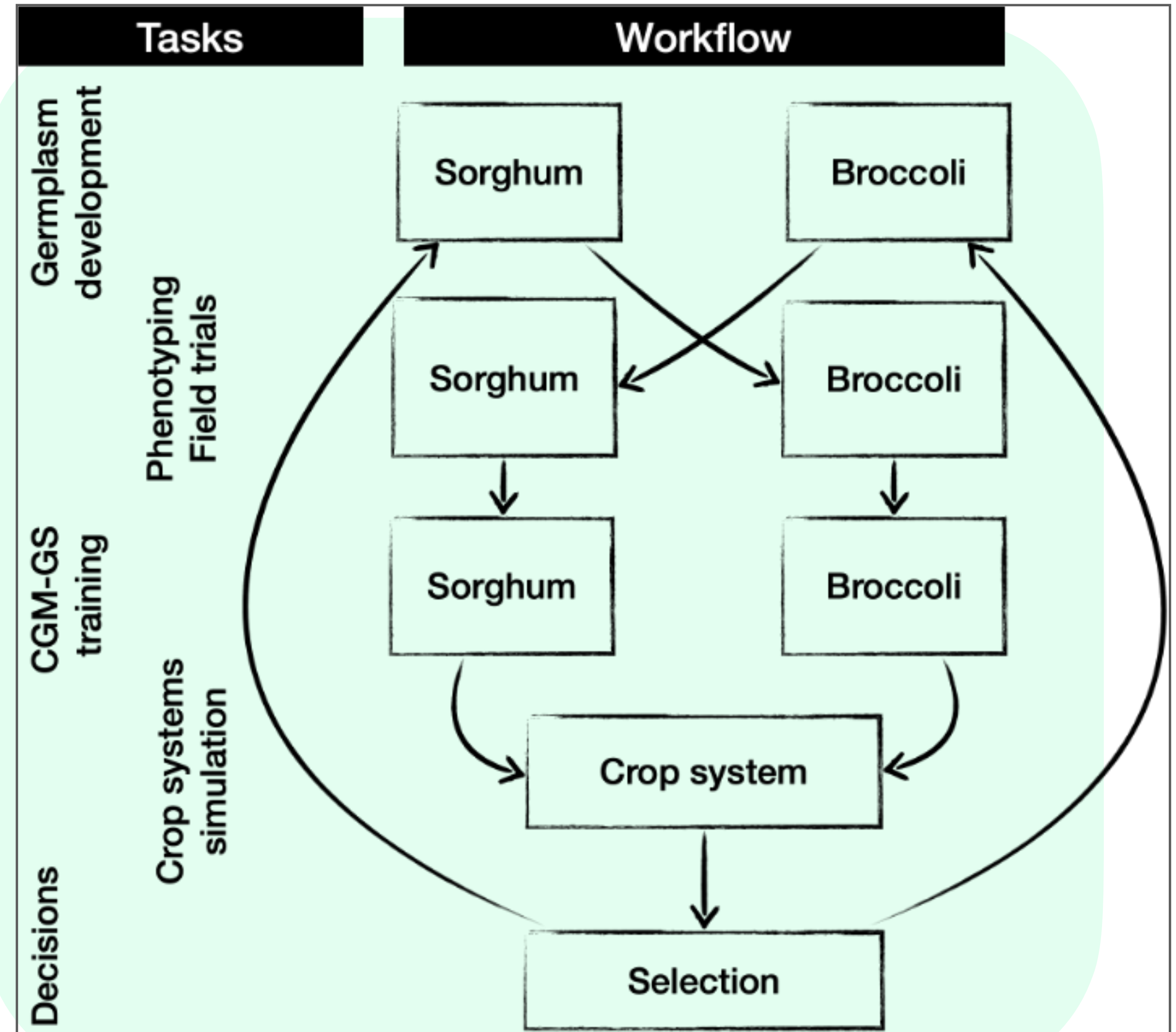
Genomics



Challenge the paradigm

If we can use crop growth models and genomic selection to improve prediction skill and enable agronomic optimization in **one** crop

then, we can use the same approach for **multiple** crops...and systems



Thanks



Agriculture as a solution

Improve human and environmental health

New frameworks needed

New investment for today and future crops