

Die Zukunft der Pflanzenproduktion

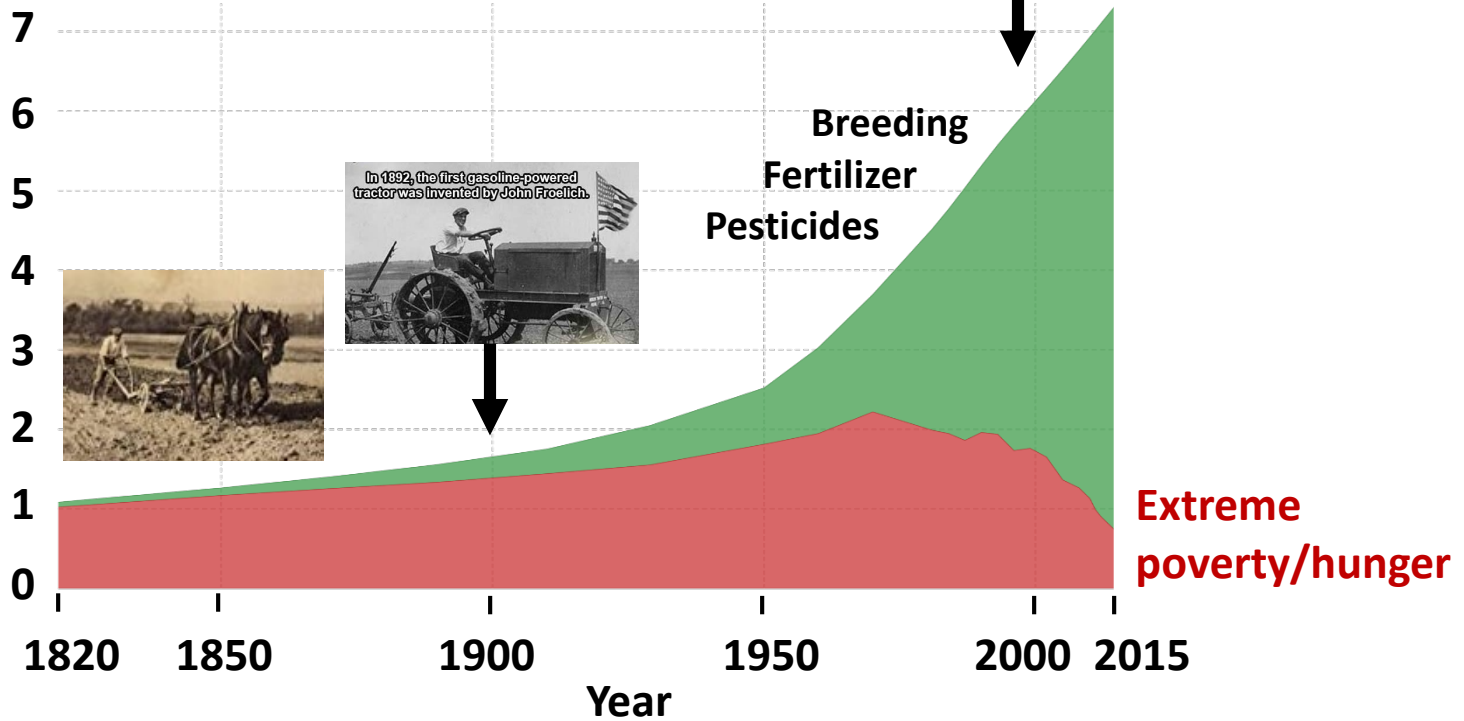
Senthold Asseng

Technical University Munich

- 1. Ag trends**
- 2. Digital ag (Future farming)**
- 3. Crop modeling**
- 4. New food production systems (indoor)**
- 5. Summary**

Agriculture & population growth

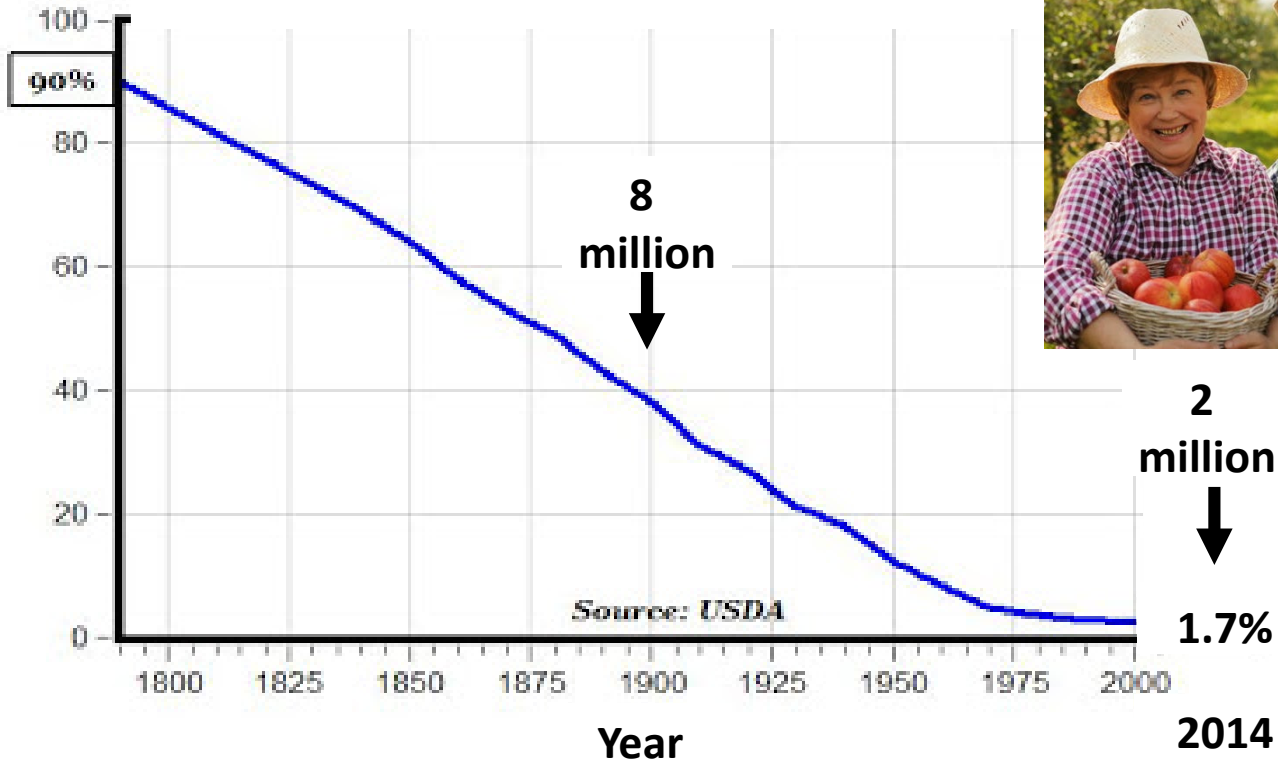
Global population (billion)



World Bank 2016, Bourguignon and Morrisson 2002

Where are the farmers?

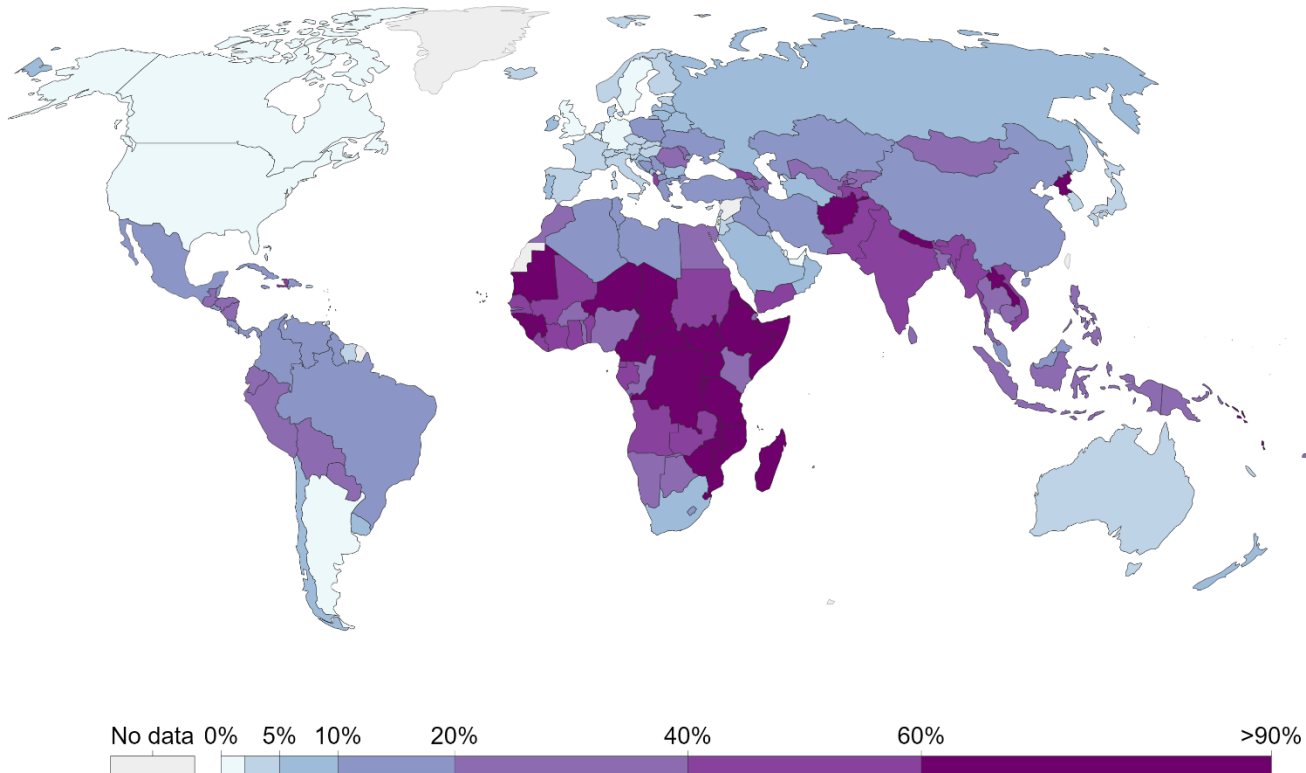
Farm Jobs in % of total US Jobs



- **Germany:**
 - 1900**
 - 38%**
- 2012**
- 1.6% (IMA, 2013)**

Share of the labor force employed in agriculture, 2017

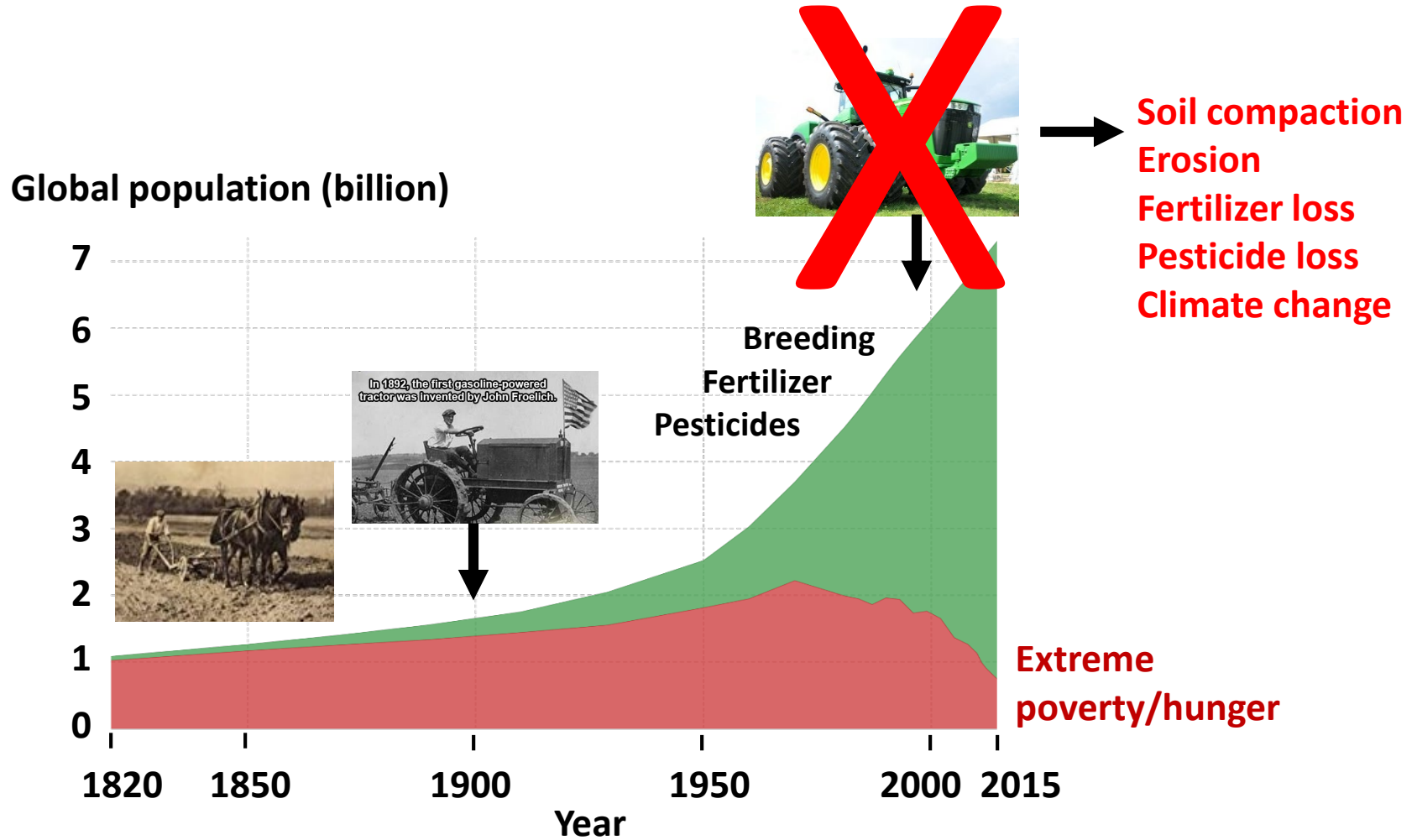
Share of persons of working age who were engaged in any activity to produce goods or provide services for pay or profit in the agriculture sector (agriculture, hunting, forestry and fishing).



Source: World Bank

OurWorldInData.org/employment-in-agriculture • CC BY

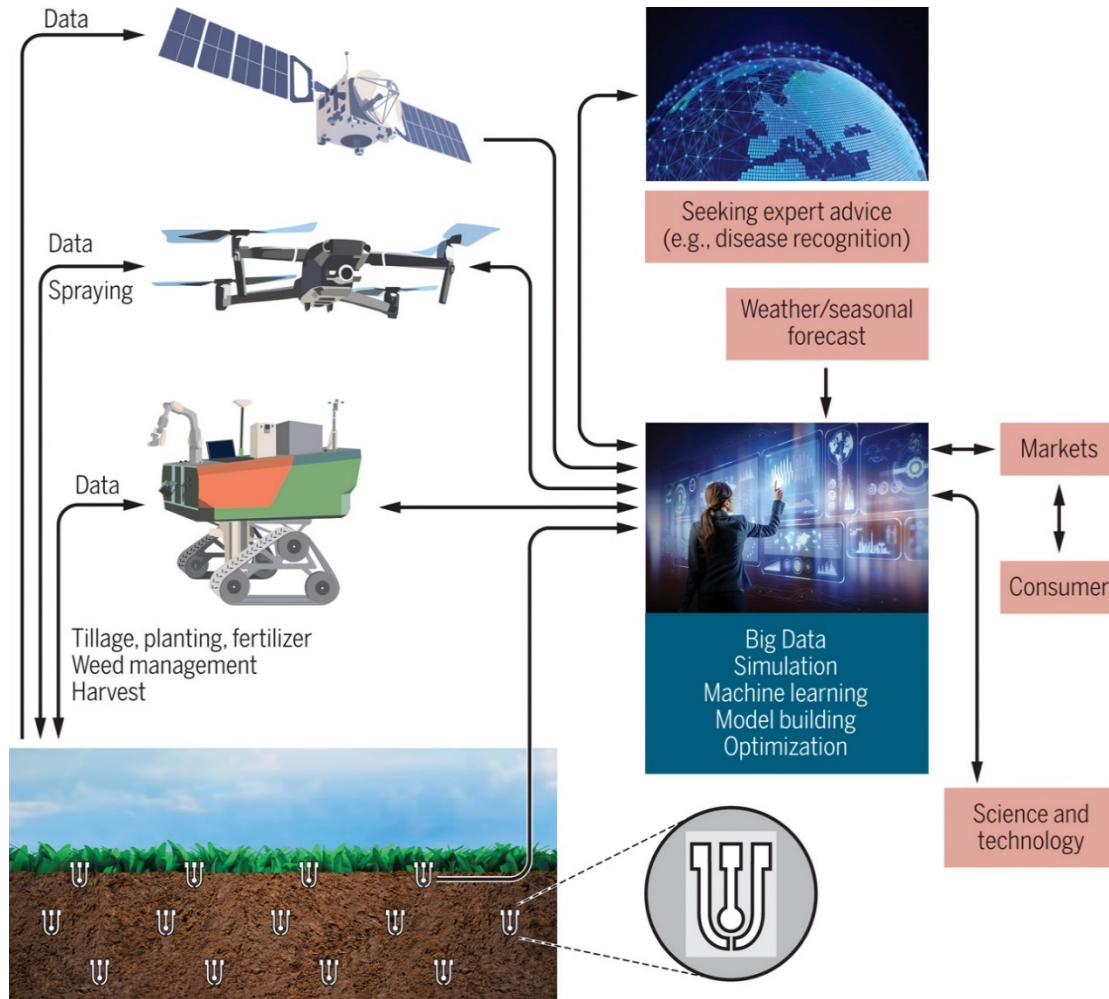
Agriculture & population growth



World Bank 2016, Bourguignon and Morrisson 2002



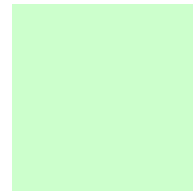
Future farms without farmers ?



Asseng & Asche, Science Robotics 2019

- 1. Increased productivity**
 - a) Economy of scale less important**

Economy of scale less important



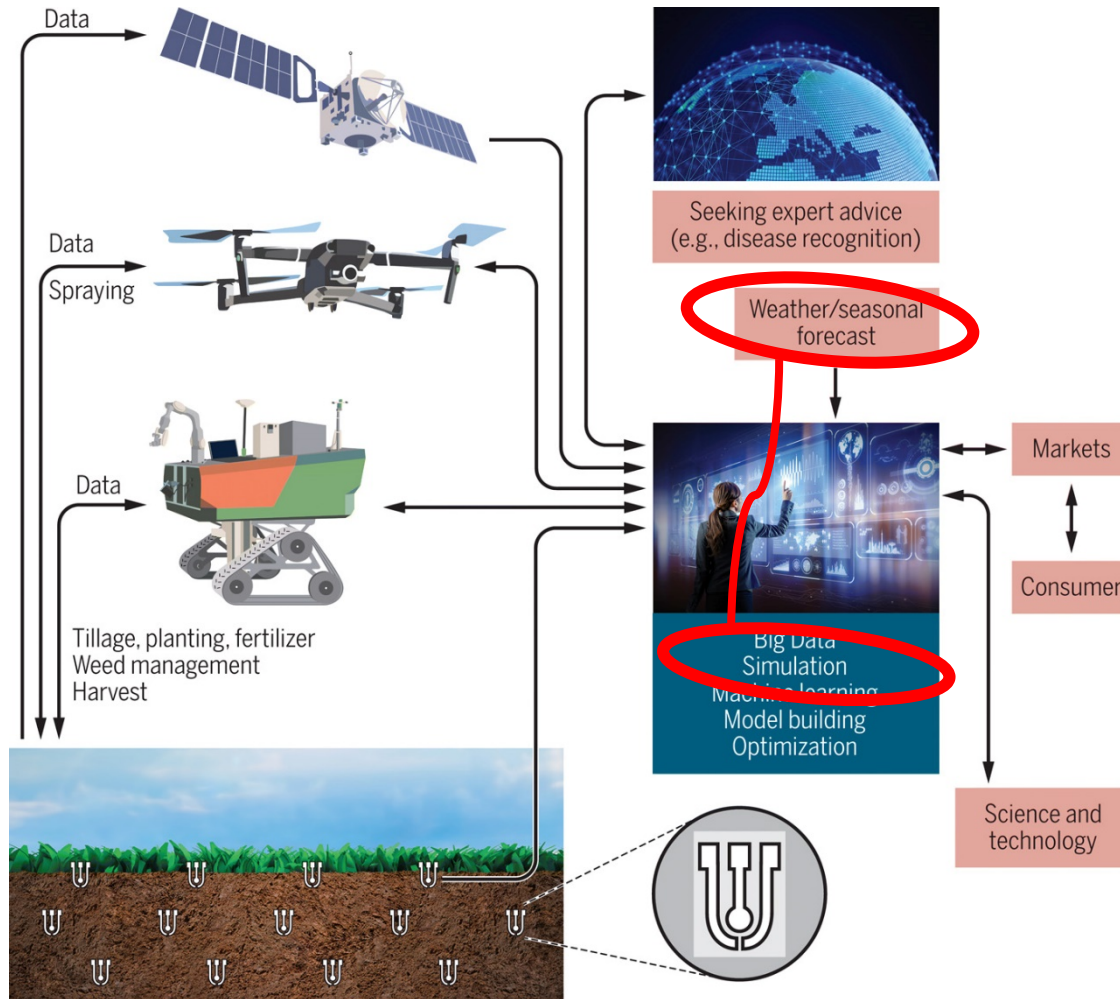
- 1. Increased productivity**
 - a) Economy of scale less important
 - b) Reduced labor
 - c) Reduced inputs & higher yields through optimization

- 2. Reduced environmental impact**
 - a) Reduced soil compaction
 - b) Reduced pesticides
 - c) Reduced fertilizer
 - d) Opportunities for re-arranging fields

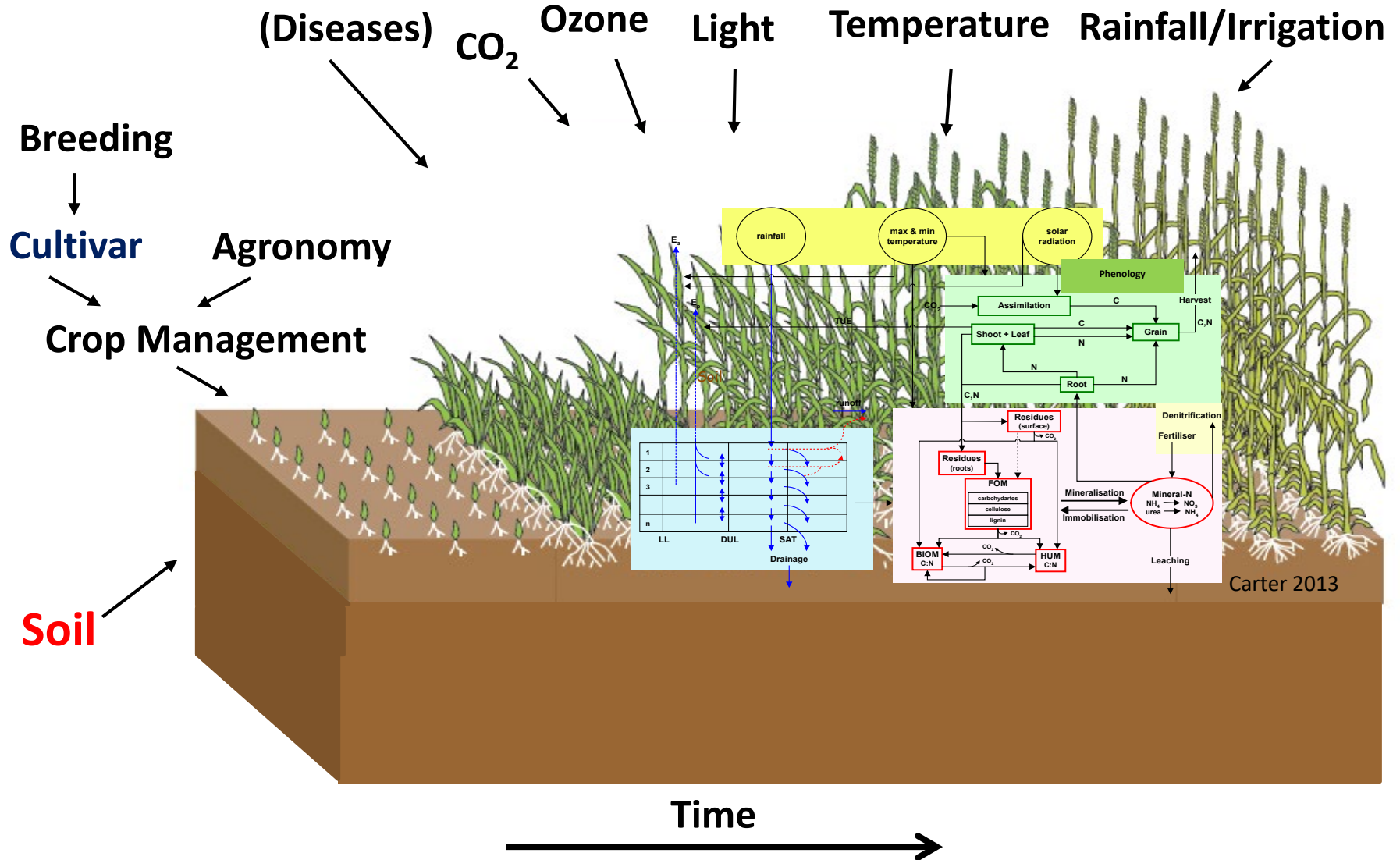
- 3. Traceability of food**
 - a) Early warning systems

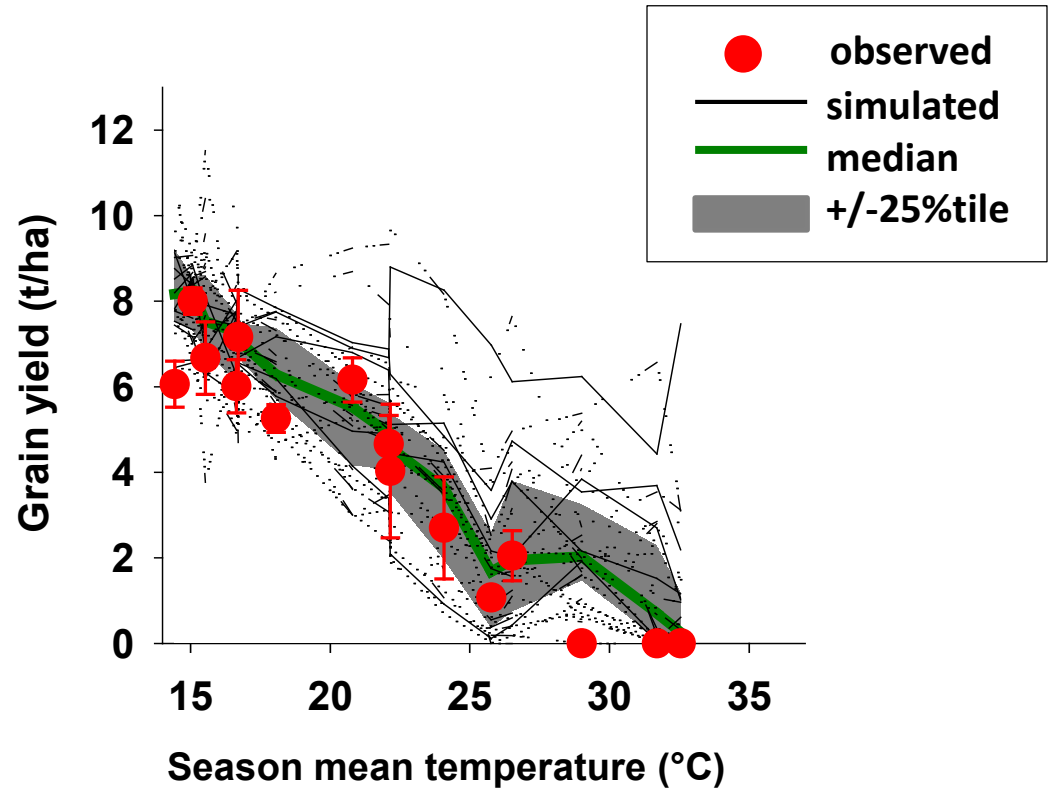
- 4. New opportunities in R & D (new jobs)**

Future farms without farmers



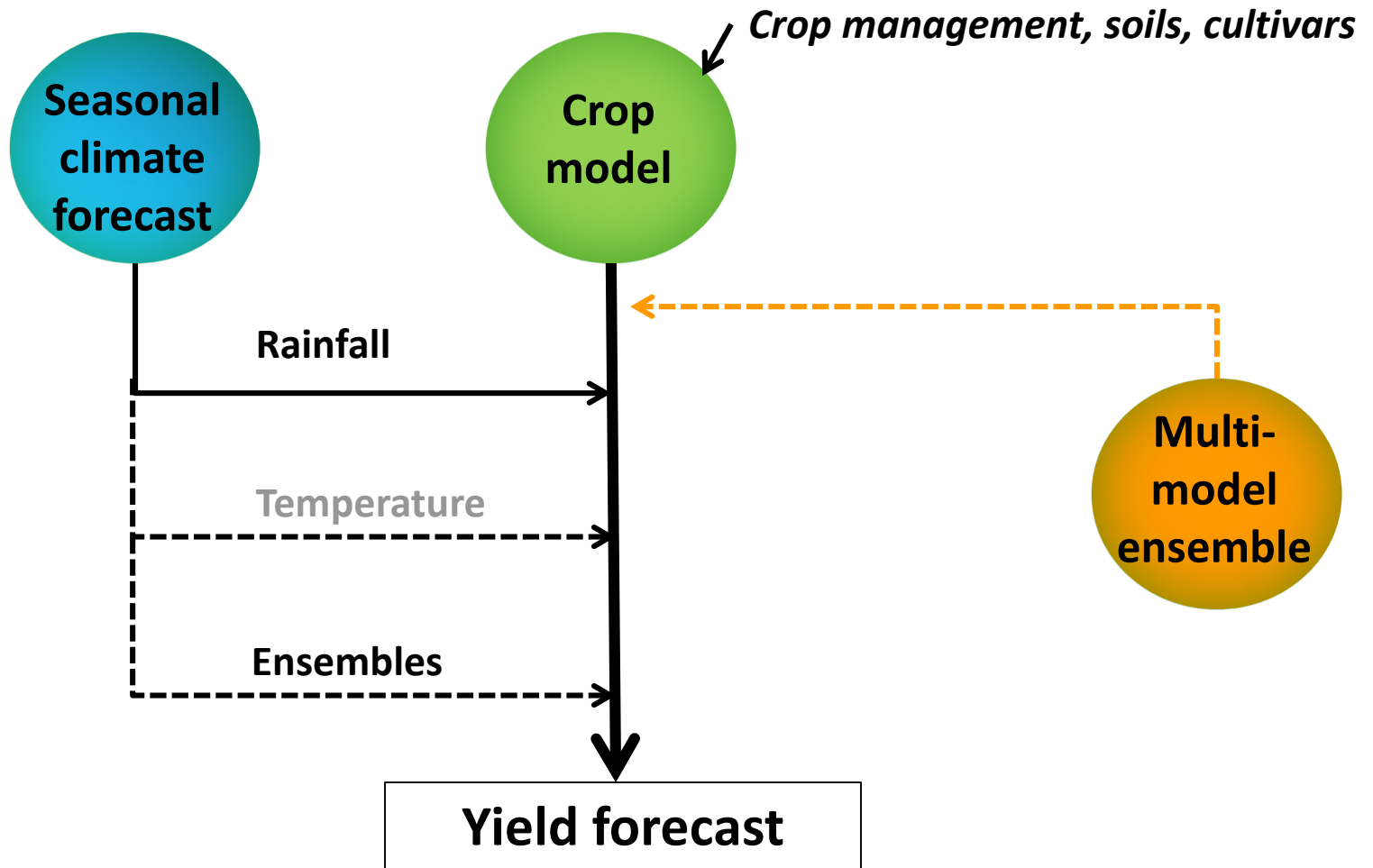
Modeling (Wheat) Cropping Systems

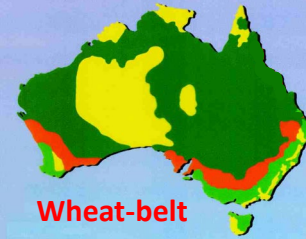




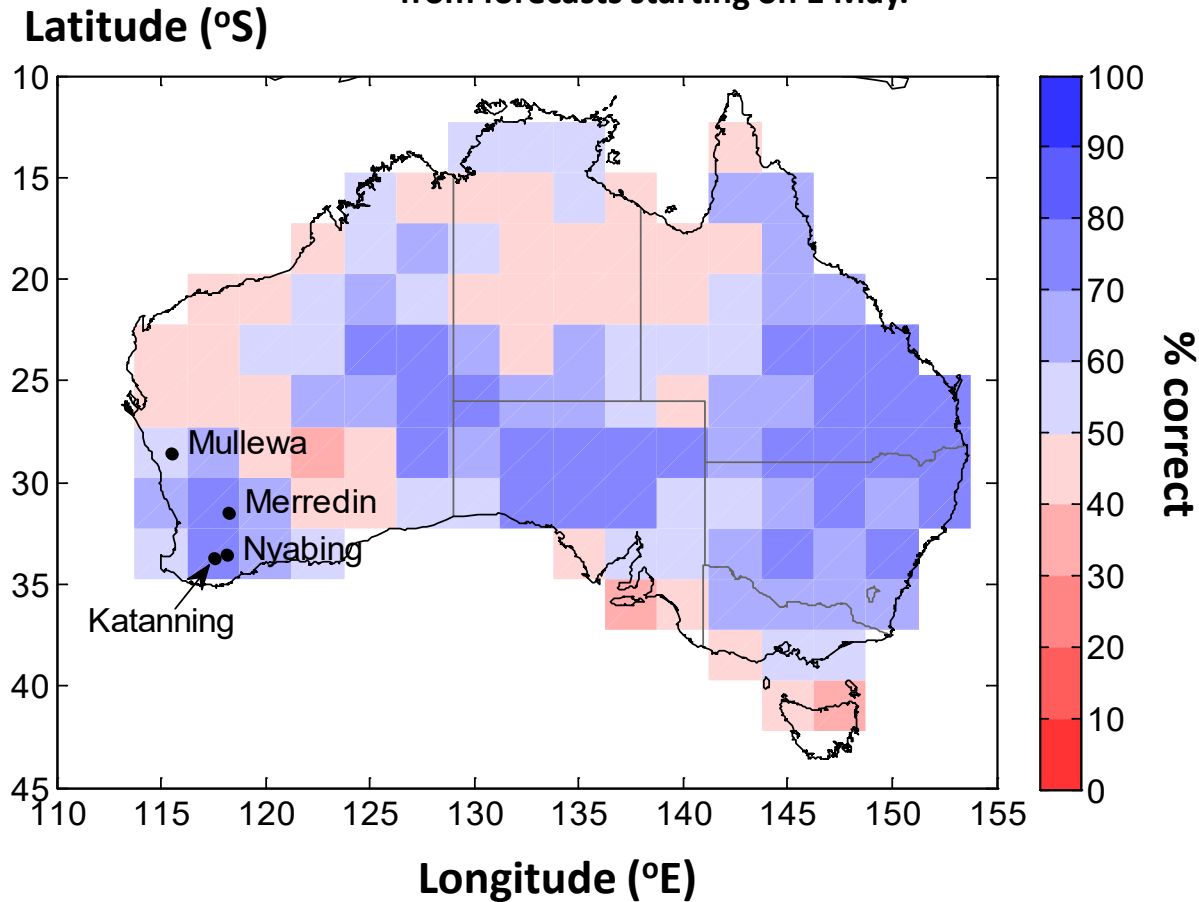
Asseng et al. 2015 Nature CC

➤ Multi-model ensemble median is a better predictor than any single model !





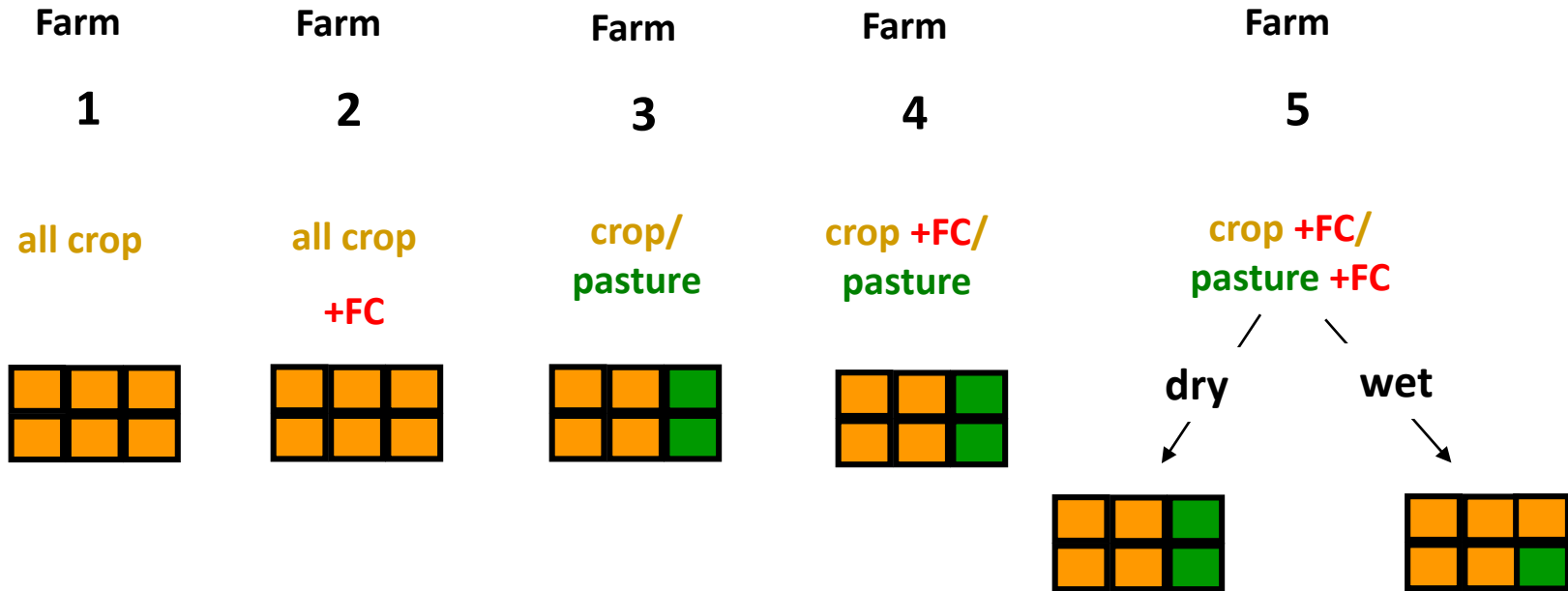
Percent correct in 2 categories for May-Oct rainfall from forecasts starting on 1 May.



Asseng et al. 2012 EJA

5 crop management options

Forecast: Above or below average yield



Asseng et al. 2012 EJA

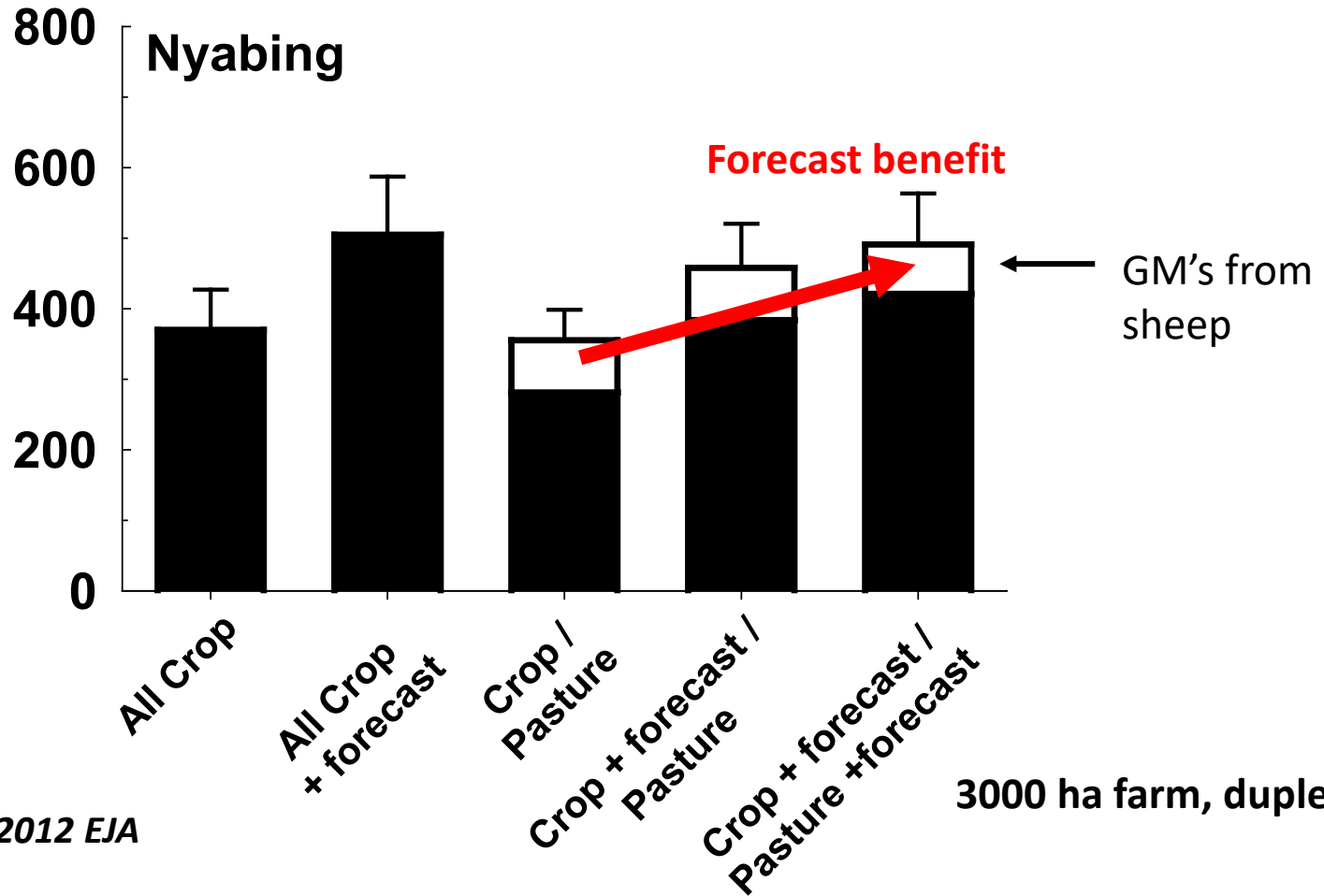
Asseng et al. 2012 AS

Ramirez-Rodrigues et al. 2014 CRM

Ramirez-Rodrigues et al. 2016 AS

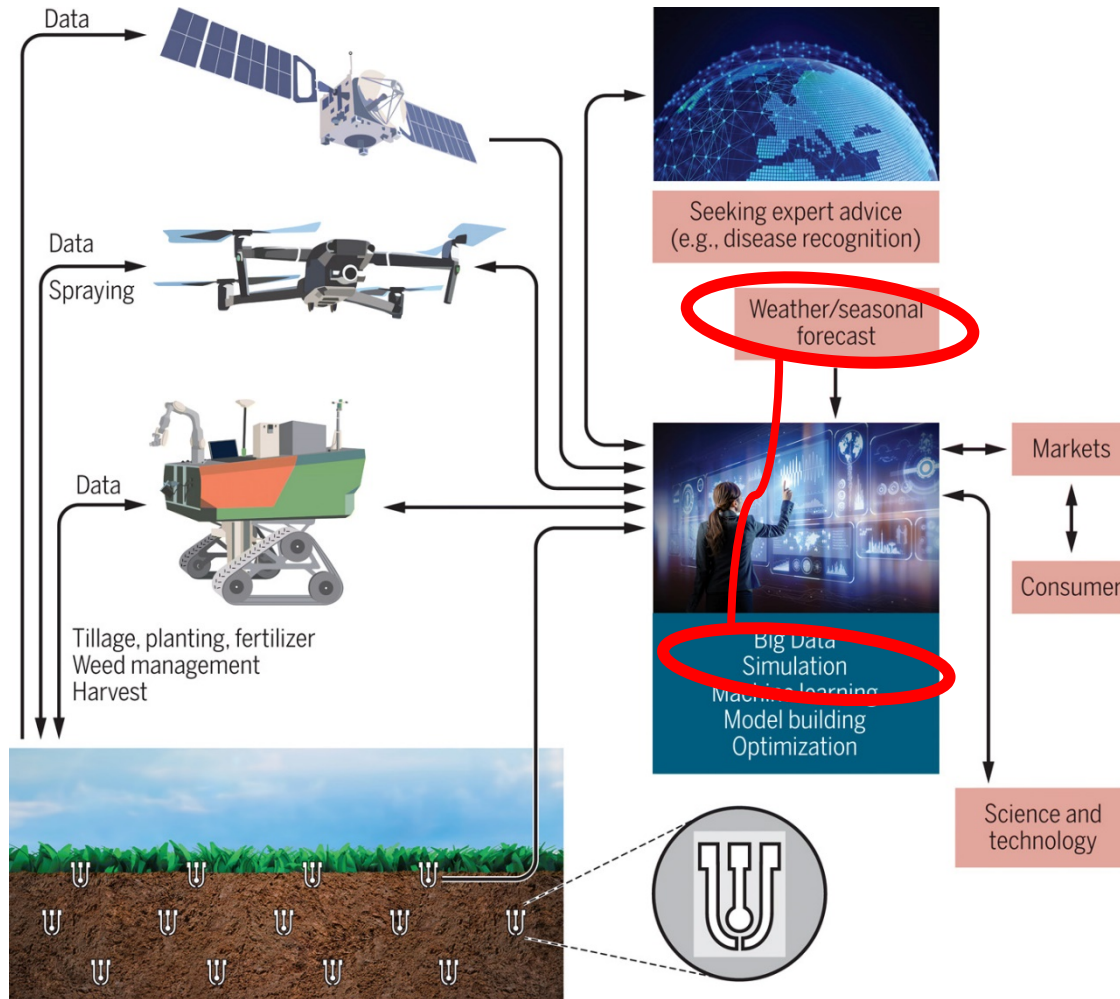
Farms benefits from seasonal POAMA forecasts (based on a 27 years hindcast)

Gross margins (A\$/farm) (,000)



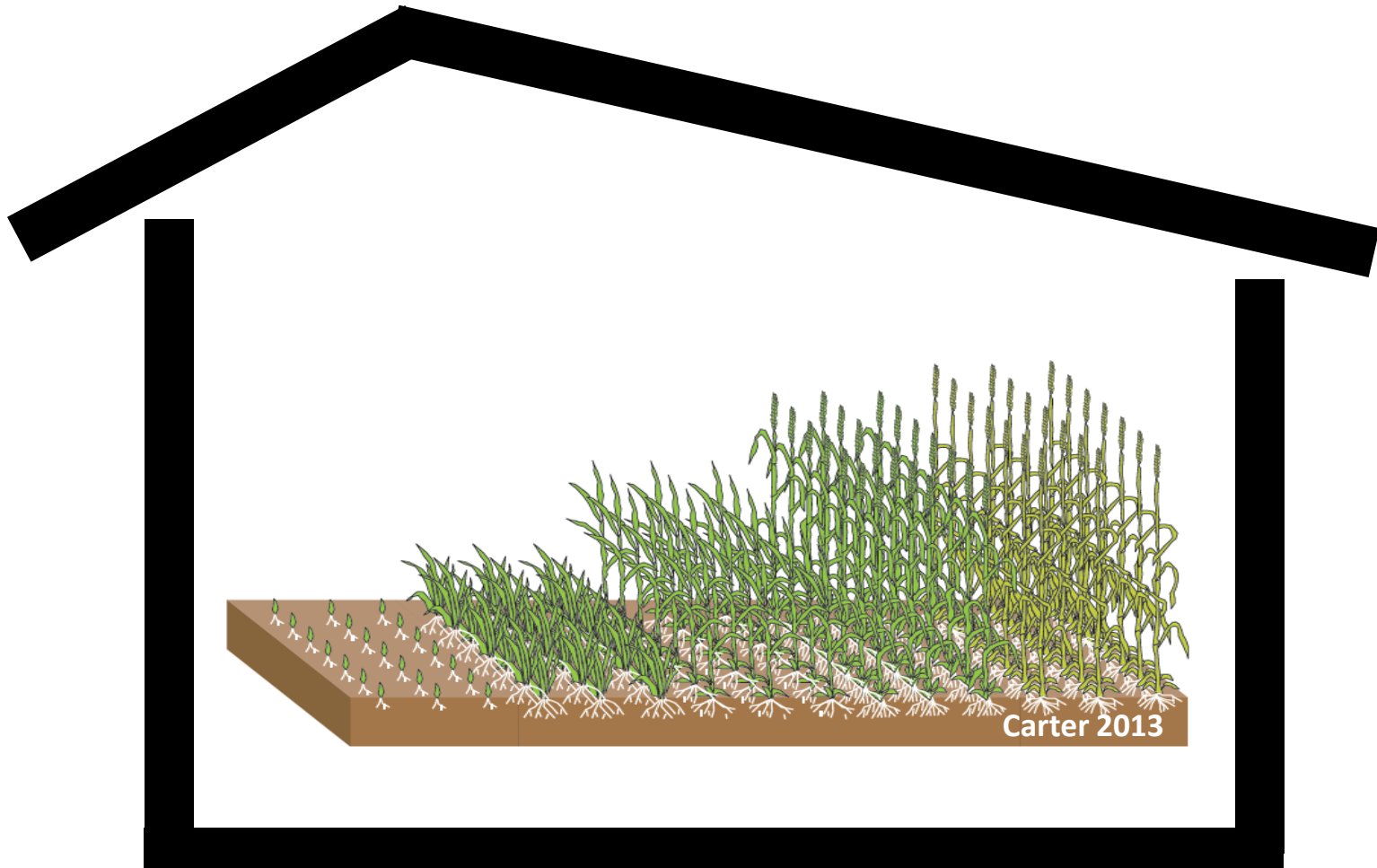
Asseng et al. 2012 EJA

Future farms without farmers

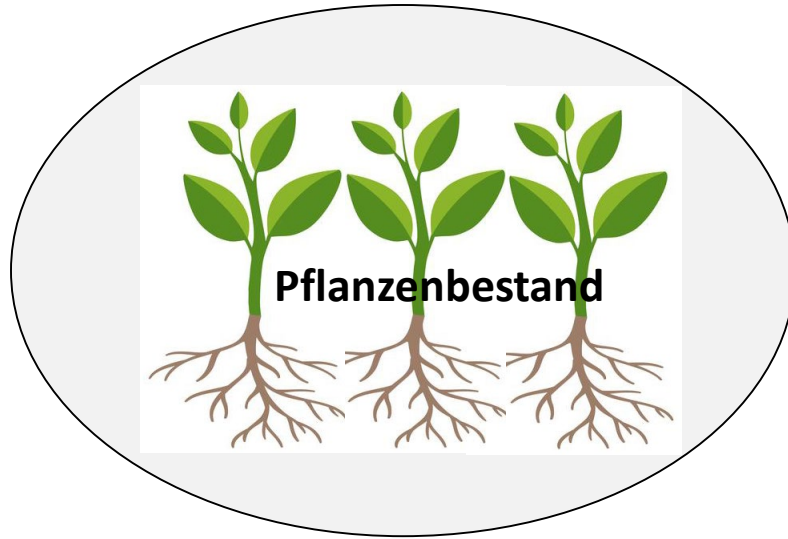


Asseng & Asche, Science Robotics 2019

Growing crops indoor ?



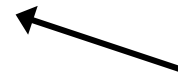
Vom Feld zur Vertical Farm



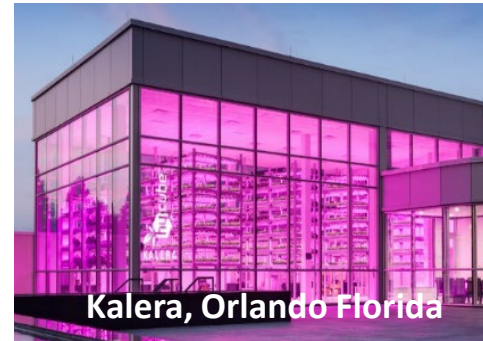
Gesteuerte Wachstumsbedingungen
Viele „Felder“ übereinander

Sonne
Wetter
Boden

Wetter gesteuert
(Zusätzlich Licht)
Boden ja/nein



Vertical Farm: von groß bis klein







- **1960s: light-emitting diodes (LEDs)**
- **Breakthrough in last 10 years, LEDs affordable & so efficient - redefine economics of indoor/vertical farming**

Example

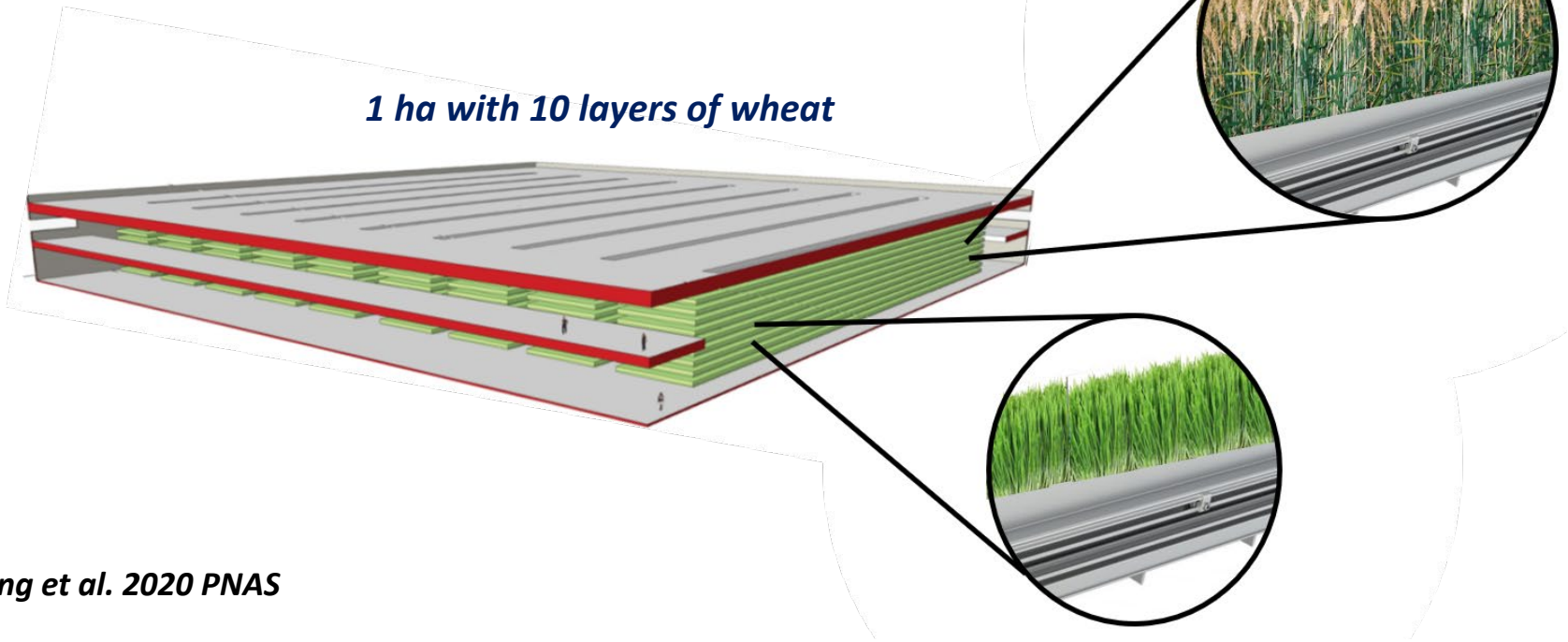
- **AeroFarms® builds world's largest R&D Indoor Vertical Farm in Abu Dhabi, United Arab Emirates (\$100 million)**

Indoor wheat farming

100m x 100m = 1 hectare

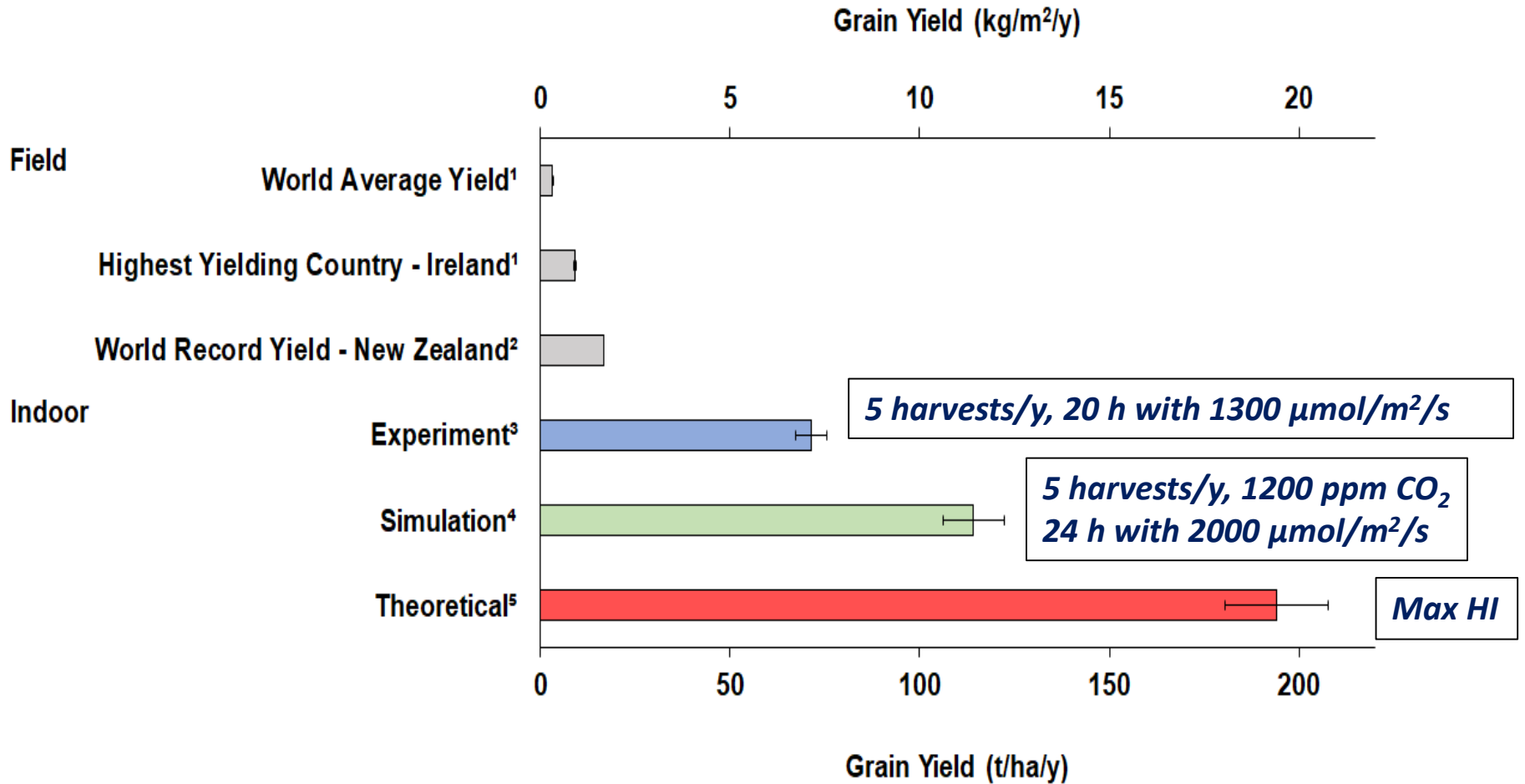
- Independent of climate, season and region
- less land area
- reuse of most water
- pesticides & herbicides free
- no nutrient losses

1 ha with 10 layers of wheat



Asseng et al. 2020 PNAS

Indoor wheat farming (1 layer)



Asseng et al. 2020 PNAS

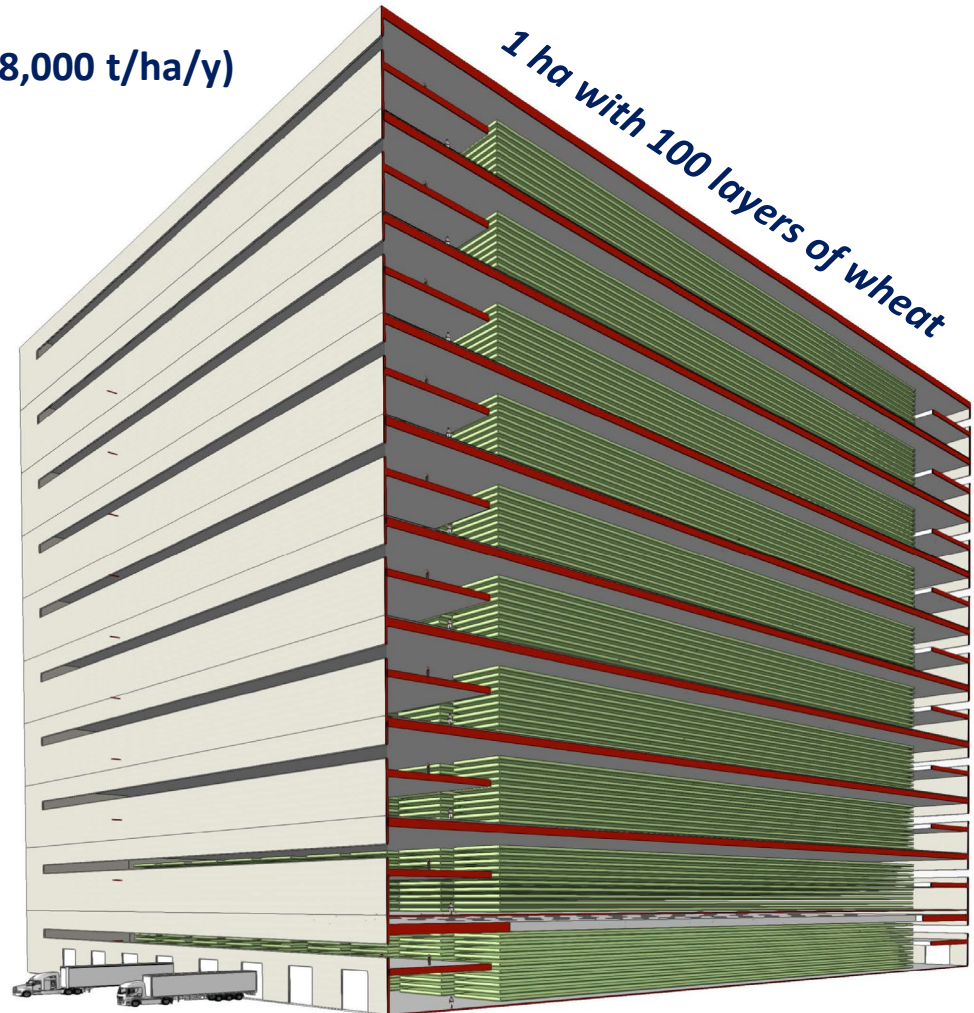
Indoor wheat farming (100 layers)

100m x 100m = 1 hectare

- 6000 x global average yield/ha/y (18,000 t/ha/y)
- Quality ?
- **>50% electricity costs**
- Commercially not viable (wheat)

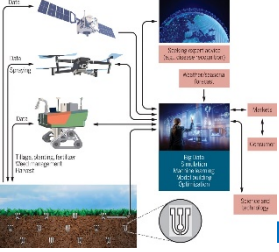
BUT

- **\$528,000,000,000 per year globally in agricultural subsidies**
(OECD Report 2019)
- **'Food as a weapon'**
- **Food security/National security**

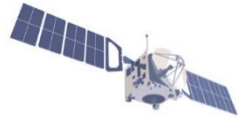


Asseng et al. 2020 PNAS

Needed expertise

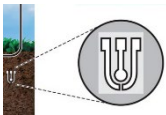


Remote sensing



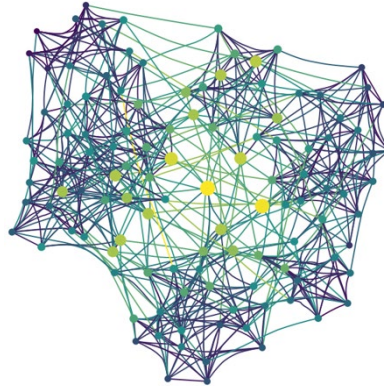
Picture recognition
Autonomous acting

Sensor technique



Crop physiology
Crop nutrition
Plant disease epidemiology
Agronomy/farmer
Soil science

Computer networks



Data management
Data storage
Big data processing
Machine learning
Crop simulation
Optimization

Weather/season forecasting
Web interface
Market/economics
Law
Social science/policy

Weather/seasonal forecast



Seeking expert advice
(e.g., disease recognition)



Markets

Consumer

- 1. Technology revolution in agriculture**
- 2. Less traditional farmer**
- 3. New challenges/opportunities in digital ag (incl crop modeling)**
 - a. Monitoring – new data for model building & testing**
 - b. Crop optimization (optimize yield + minimize inputs & externalities)**
 - c. Indoor farming**
- 4. Crop modeling as an important component.**

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