Agriculture and Food Security Considerations

There is an increasing push towards a new concept for agriculture that extends beyond yields, production, and prices to prioritize nutrition and ecological sustainability

We need agricultural development scenarios and landuse trajectories that meet regionally-varied nutritional needs with “climate smart” management practices

Sonali McDermid, NYU
AGCI-LUMIP
Snowmass, CO
September 16-21, 2019

AgMIP

Agriculture and Food Security Considerations: What, and for whom?

Defining Food Security:

Stability

Physical availability of food

Economic & physical access to food

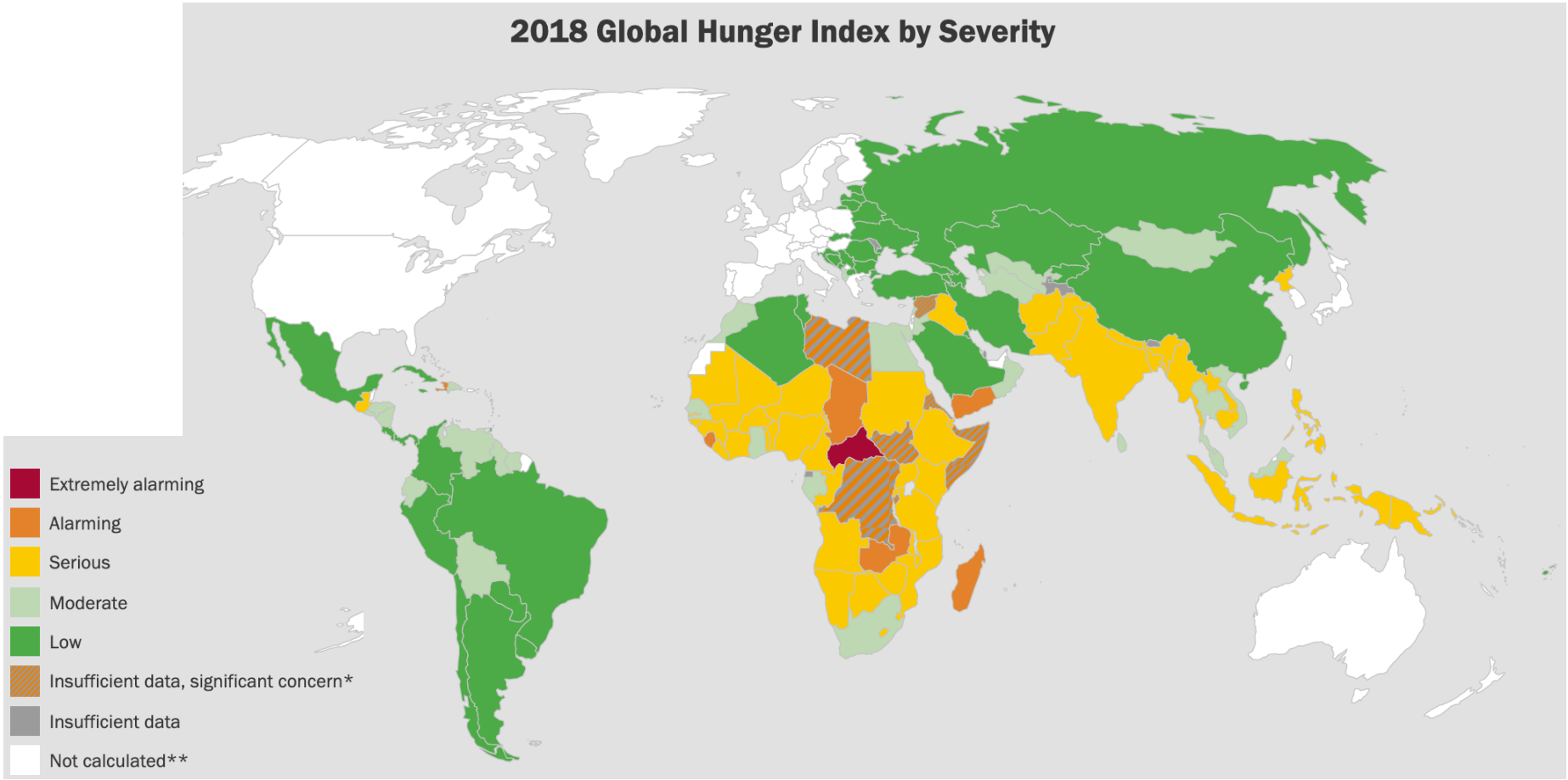
Food utilization

Food security is not just about production and available land

There exist many regional heterogeneities and trade-offs in achieving food security alongside other Sustainable Development Goals

Agriculture and Food Security Considerations: What, and for whom?

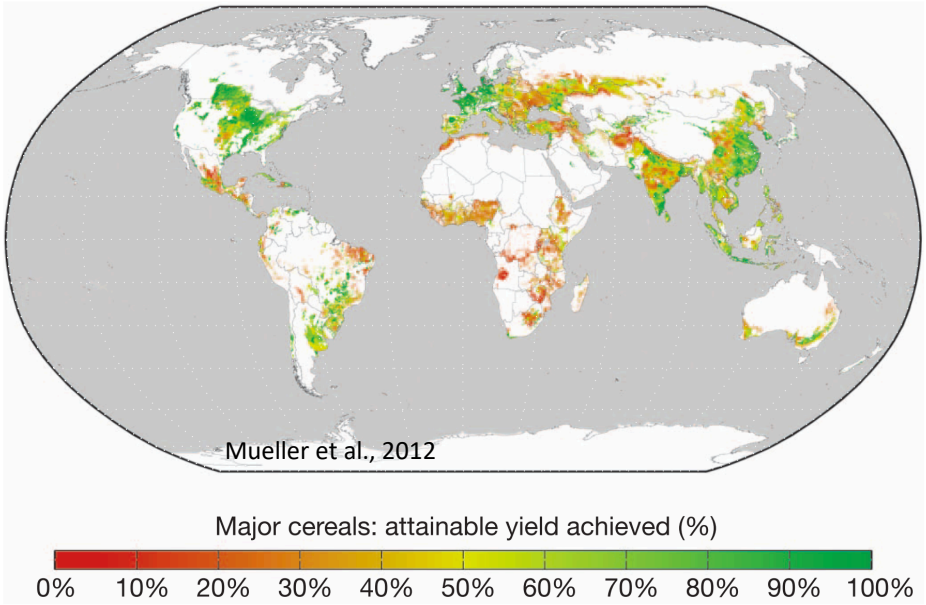
The geography of global food insecurity
What do we need to evaluate food security at a regional level?



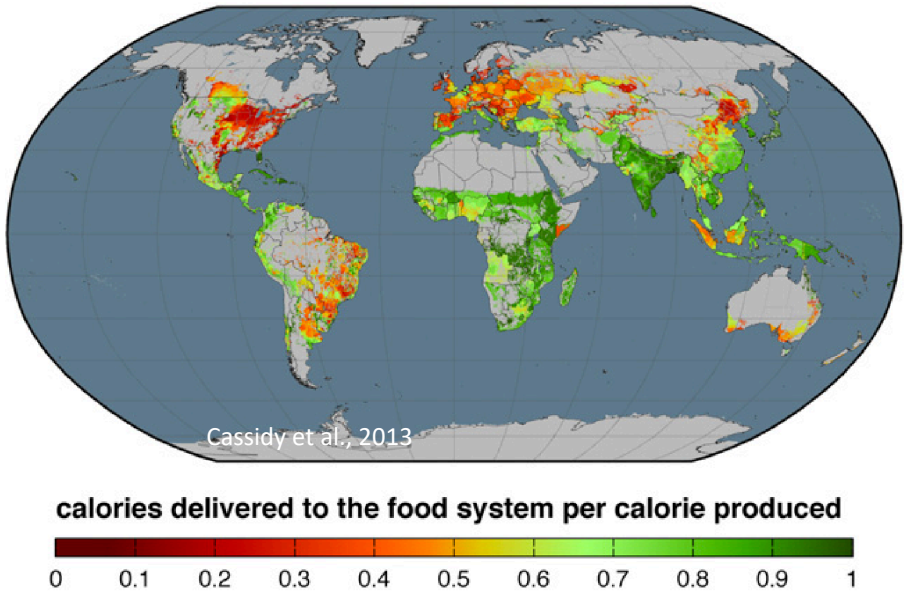
Agriculture and Food Security Considerations: What, and for whom?

How do we normalize food system metrics in order to meet food security needs?

Global Yield Gaps

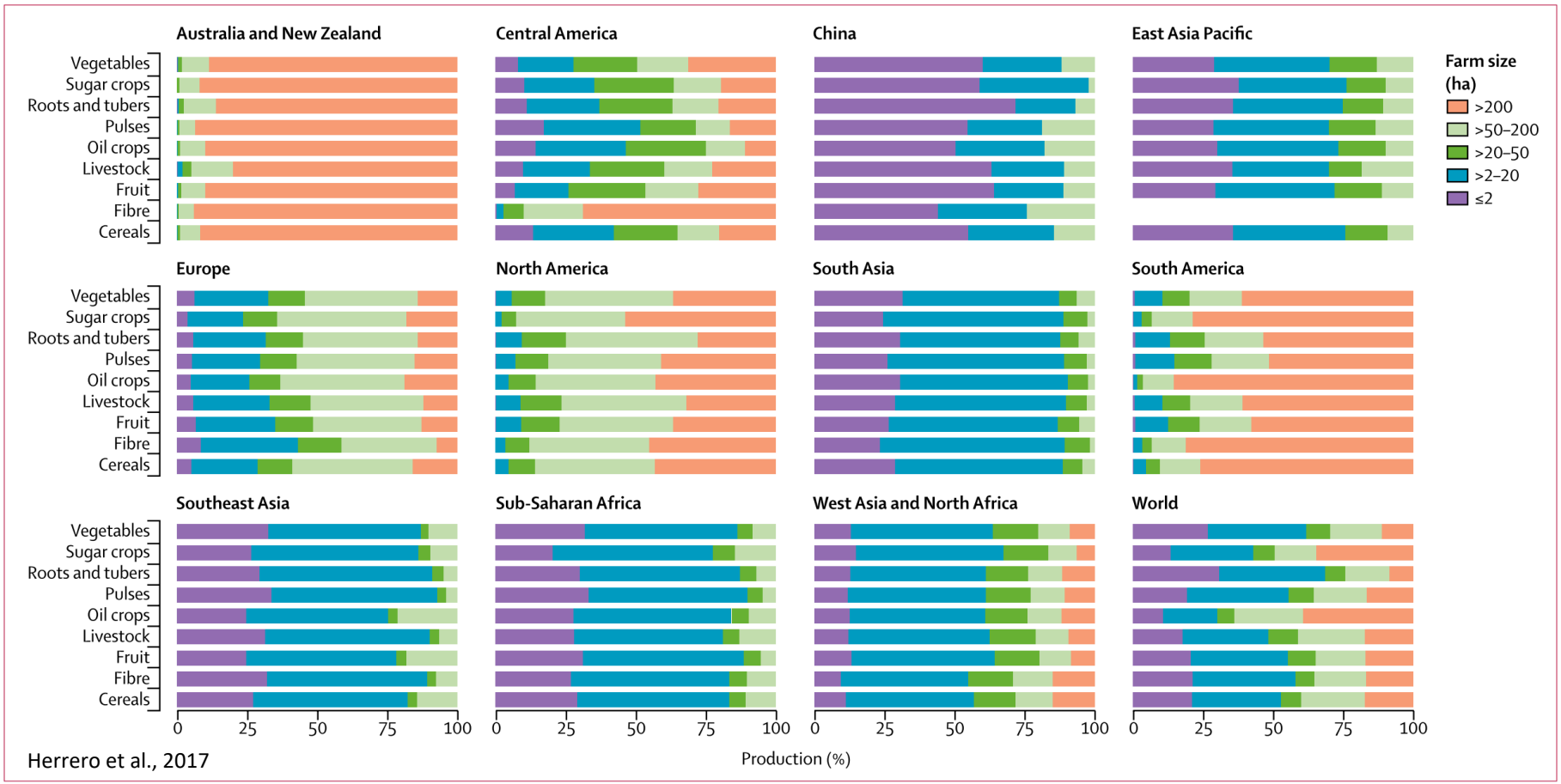


Calorie Delivery Fraction



~ half of crop calories produced feed people directly
~1/3 of crop calories used for animal feed
<10% used for fuel+industry

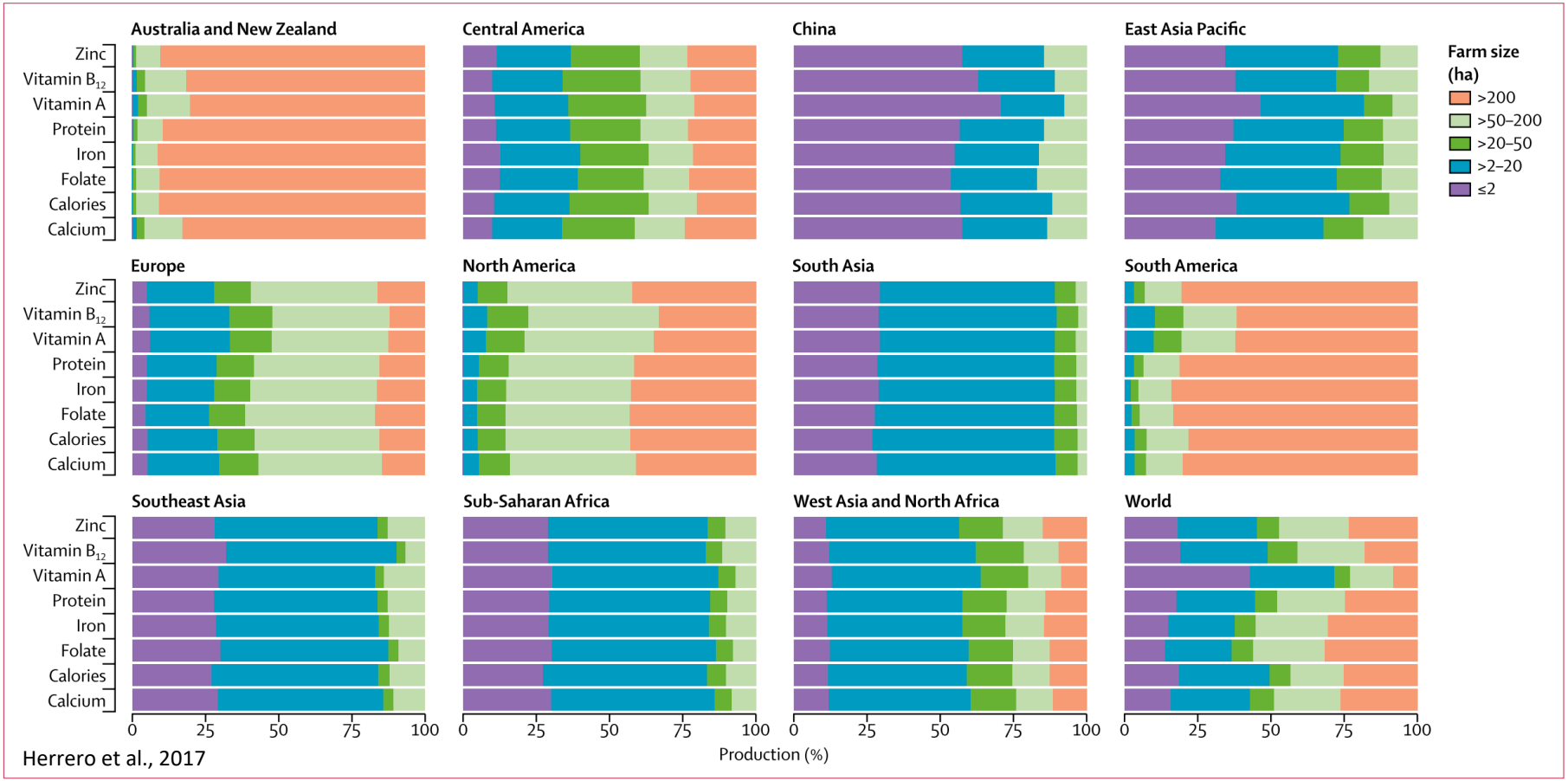
Agriculture and Food Security Considerations: What, and for whom?



Small and medium farms (≤50 ha) produce 51–77% of most agricultural commodities and nutrients

Agriculture and Food Security Considerations: What, and for whom?

Nutrient production distributed over Farm Size



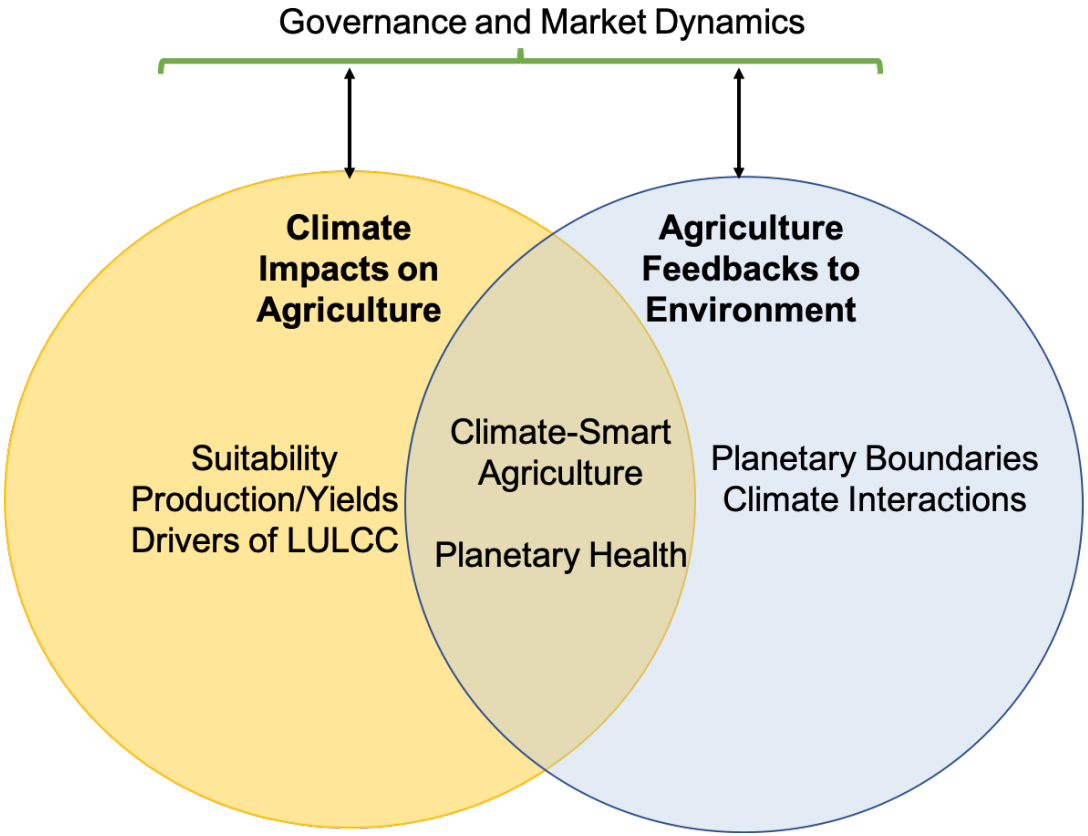
Small and medium farms (≤50 ha) produce 51–77% of most agricultural commodities and nutrients

Agriculture and Food Security Considerations: Modeling Planetary Health

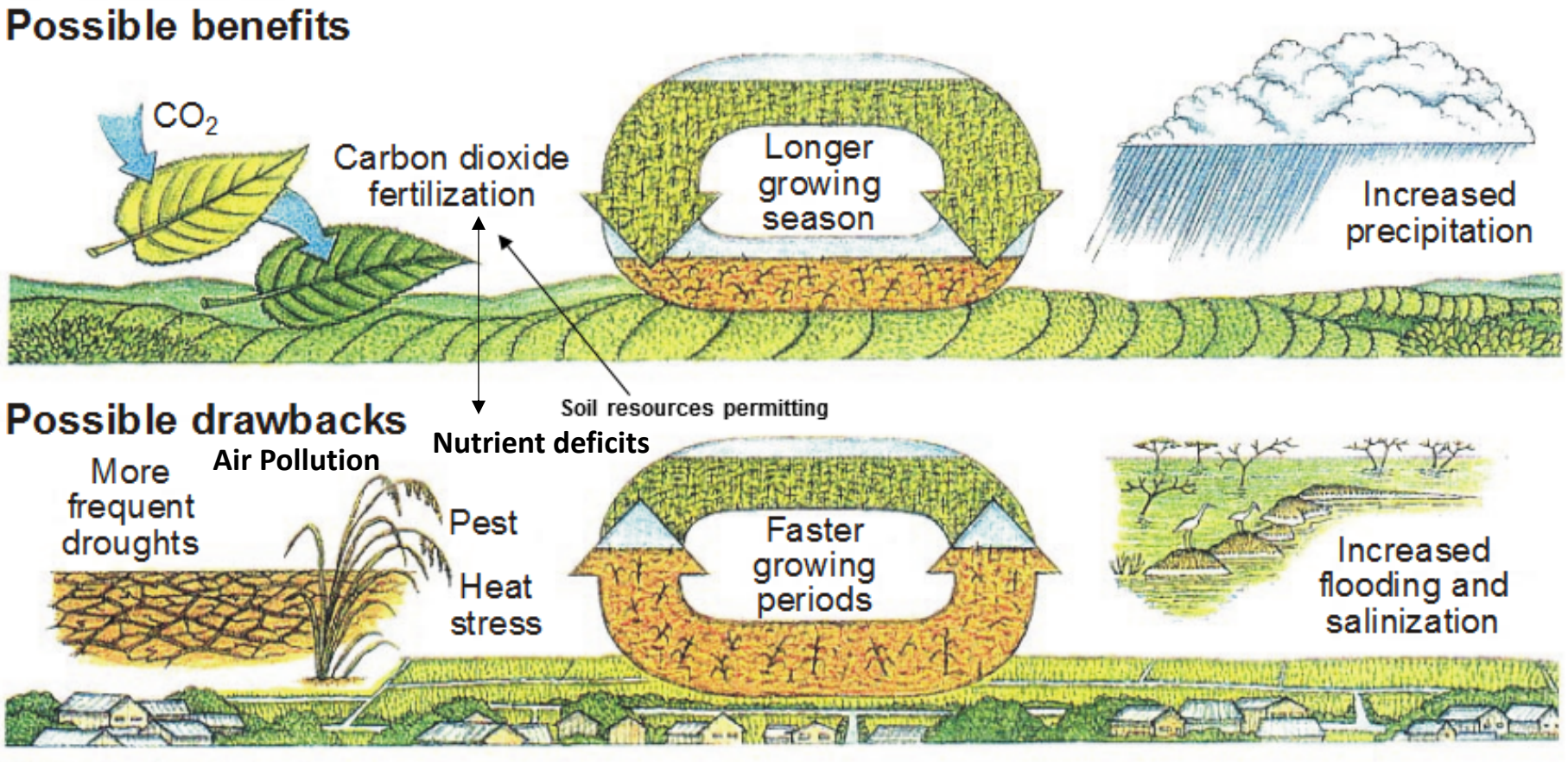
Processes and Frameworks: What agriculture and food security questions do we feel equipped to ask and answer?

- Do we have both the modeling capacities *and* data?
- At what temporal and spatial scales?

Topics and Questions:



Climate Change Impacts – Agriculture

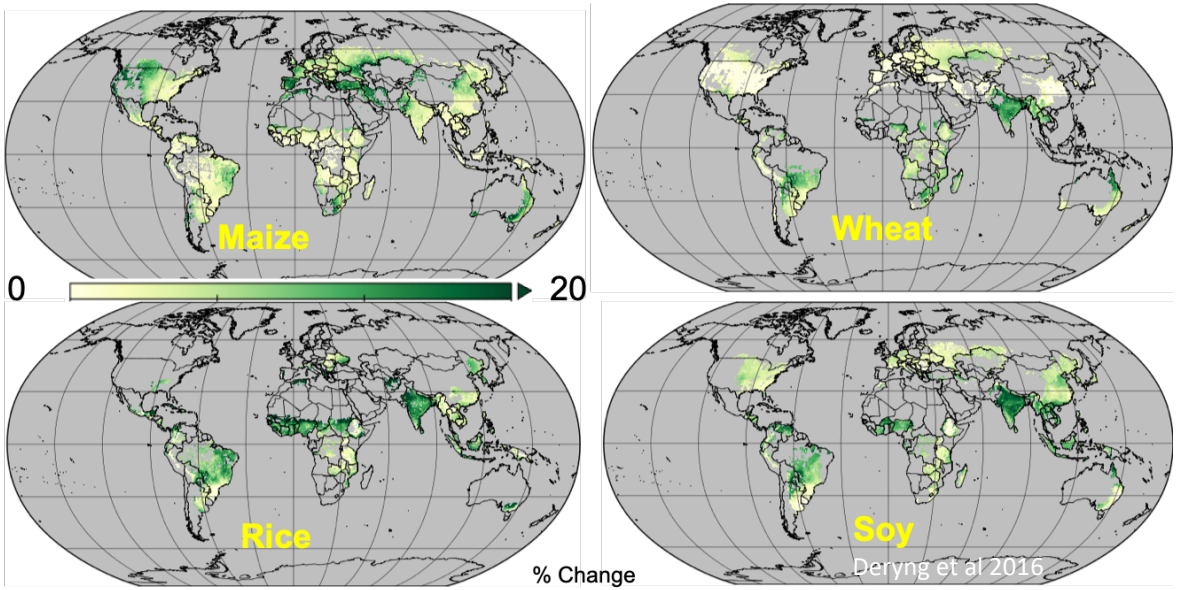


Bongaarts, J., Scientific American, 1992

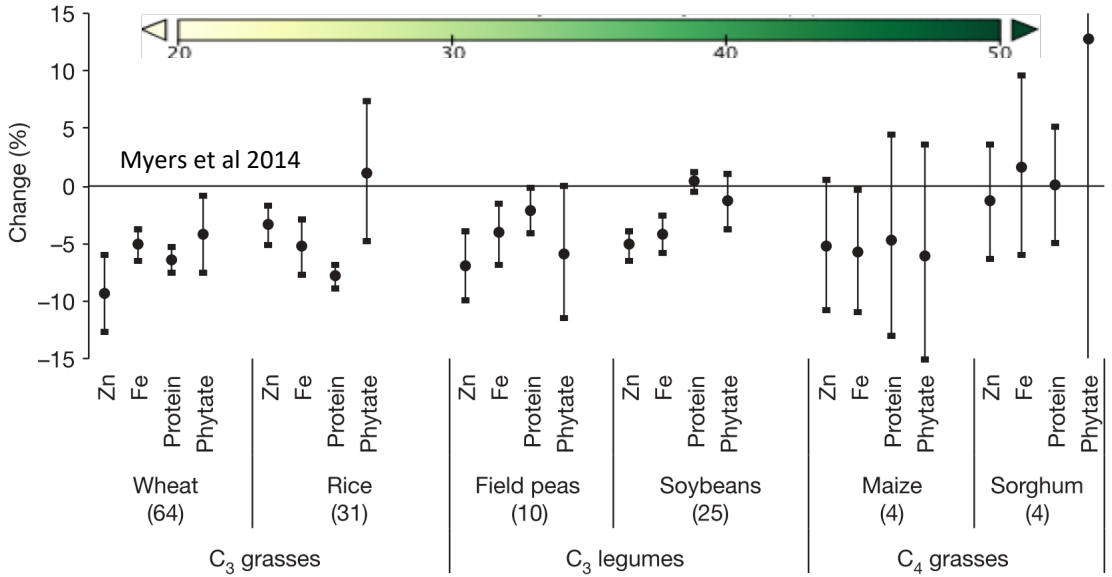
Agriculture and Food Security Considerations: Processes and Frameworks

Carbon Dioxide

Yield % change resulting from inclusion of BAU 2050 [CO_2] fertilization effects



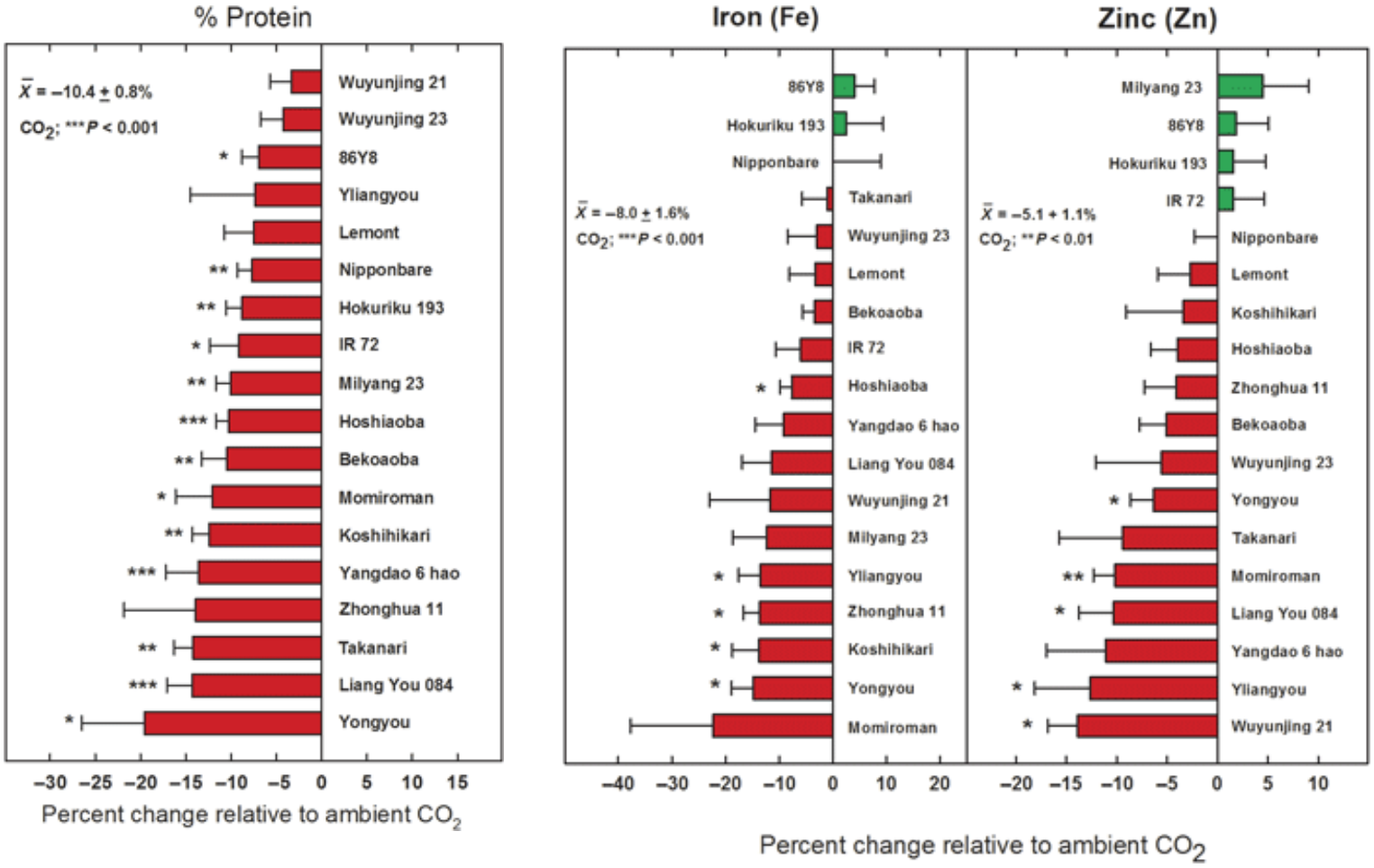
Percentage change in nutrients at elevated [CO2] relative to ambient [CO2]



Agriculture and Food Security Considerations: Processes and Frameworks

Atmospheric Conditions: Carbon Dioxide

Nutrient % change across different rice varieties as a result of high [CO_2]

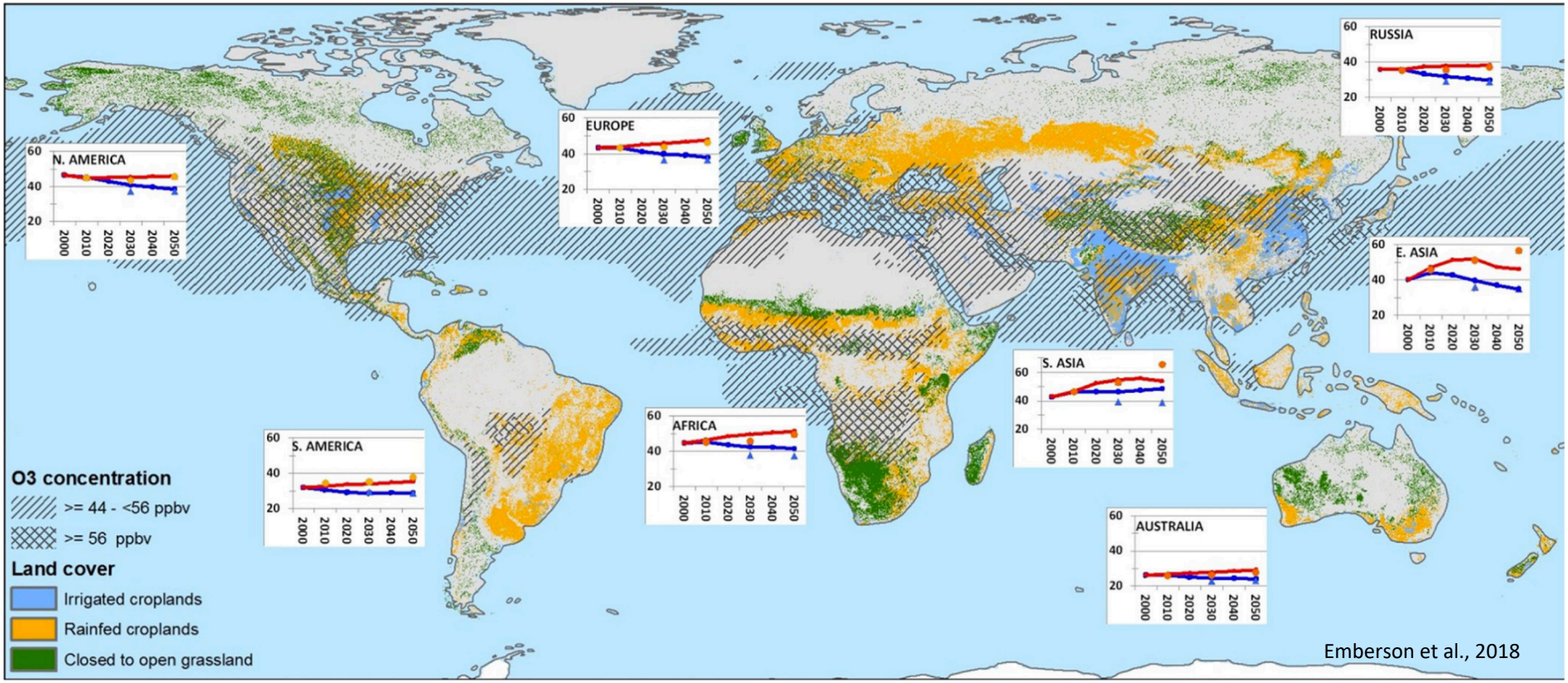


Zhu et al 2018

Agriculture and Food Security Considerations: Processes and Frameworks

Atmospheric Conditions: Air Pollution

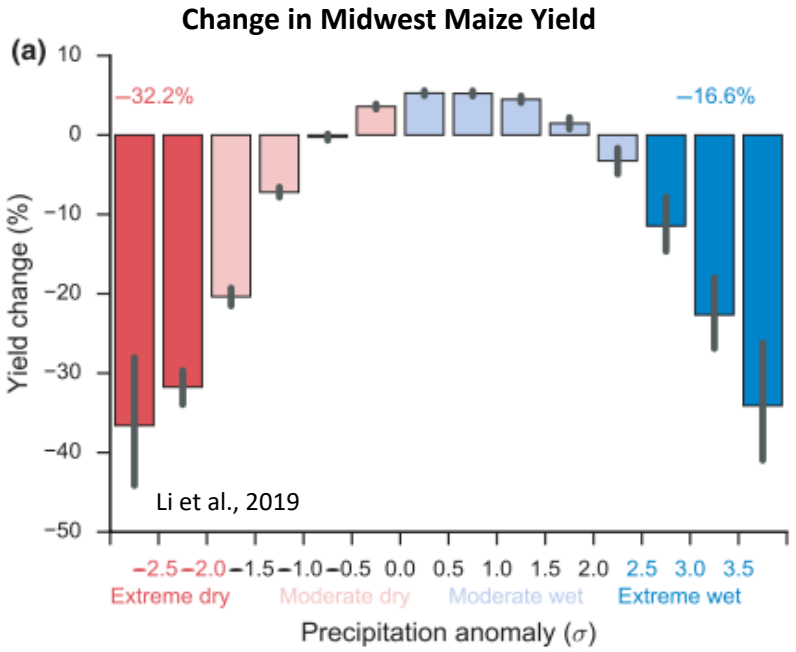
Global distribution of current day ozone 'hotspot' regions



Emberson et al., 2018

Agriculture and Food Security Considerations: Processes and Frameworks

Extreme Events and Episodes



Consider the "known unknowns":

- Most process-based crop models cannot reproduce crop responses to excessive rainfall
- Compounding effects, such as antecedent wet winter/early springs can amplify growing season losses, (also by way of infrastructure)
- Policy changes can interact with climate extremes: e.g. trade wars exacerbate seasonal extremes and drive food system "fragility" (unkown unknowns. . . .)

Agriculture and Food Security Considerations: Processes and Frameworks

Lessons from the global gridded crop modeling community
(in conversation with Christoph Müller and Jonas Jägermeyr)

- GGCMs show mixed skill in reproducing temporal and spatial crop yield variability, and rice is particularly weak (Muller et al 2017)
- Higher N rates increase climate variability in yields, while irrigation diminishes variability (but does not fully ameliorate crop loss from warming) (Muller et al 2017)
- GGCM simulations are quite sensitive to growing season representations, soils, and management (e.g. fertilizer types and applications, rotations, varieties, actual irrigation amounts) – major role for adaptation (Muller, Jaegermeyer, personal communication)
- Scale-dependency in critical parameters determining yield sensitivity highlight importance of using appropriate parameter values (Iizumi et al 2014)
- One of the biggest values of crop model intercomparisons is the ability to learn from each other as models often show complimentary skill (Muller et al 2017)

Agriculture and Food Security Considerations: Topics and Questions

Modeling for Planetary Health:

Better Production?

- What crops/products do we need more of to meet nutrition and climate goals?
- How do we grow more of these crops? Intensification, genetic improvement, alternative management, land area . . .

Better Consumption?

- How do changes in diet rectify regional nutrition disparities?
- How do changes in diet impact climate/environment in light of 1.5˚C and planetary boundaries?

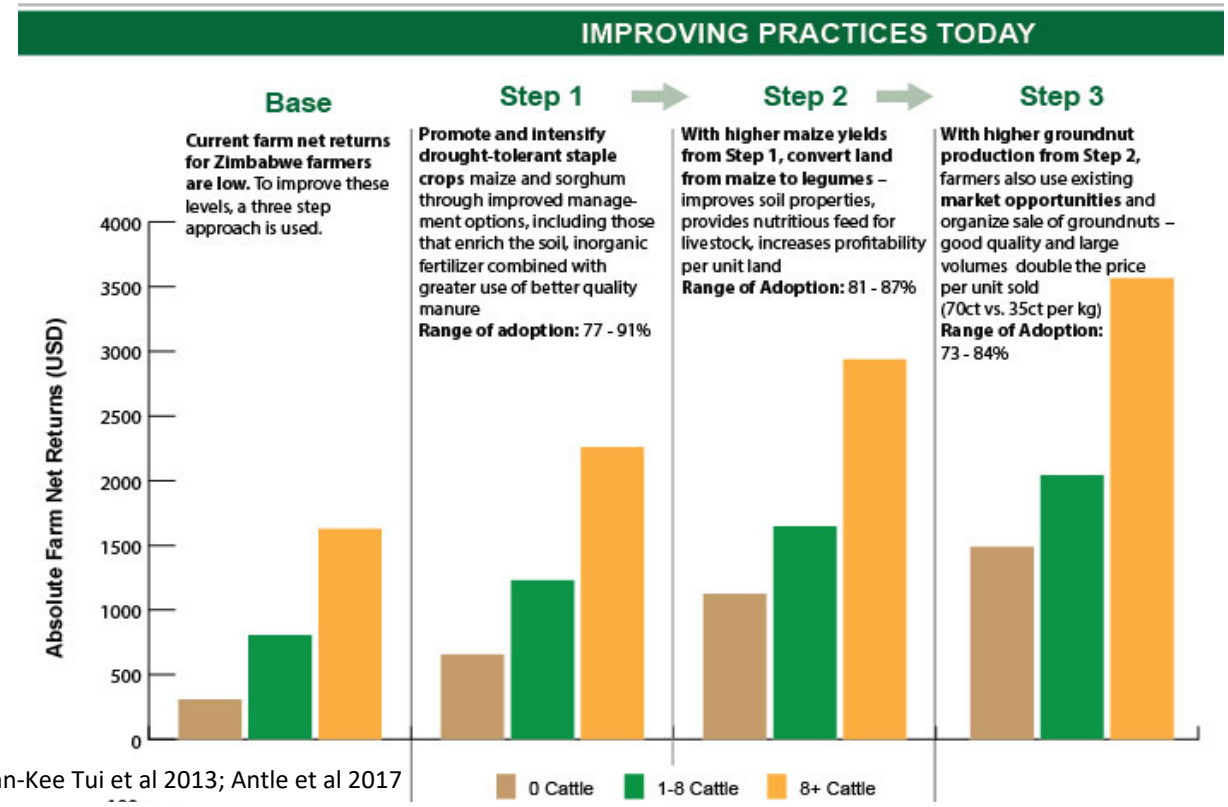
Better Governance?

- How can (Should?) we govern consumption and to what ends? Nutrition, resilience, mitigation. . .
- How can (Should?) we regulate production and to what ends? Nutrition, resilience, mitigation. . .
- What are the implications for landuse distributions?

Agriculture and Food Security Considerations: Production Transformations

An AgMIP Example : Nkayi, Zimbabwe

Exploit gains in legume production to enhance soil fertility; adapt to climate change; and boost household incomes



Homann-Kee Tui et al 2013; Antle et al 2017

Cropping system transitions, initially with local resources, may be a sizeable component of regional climate adaptation

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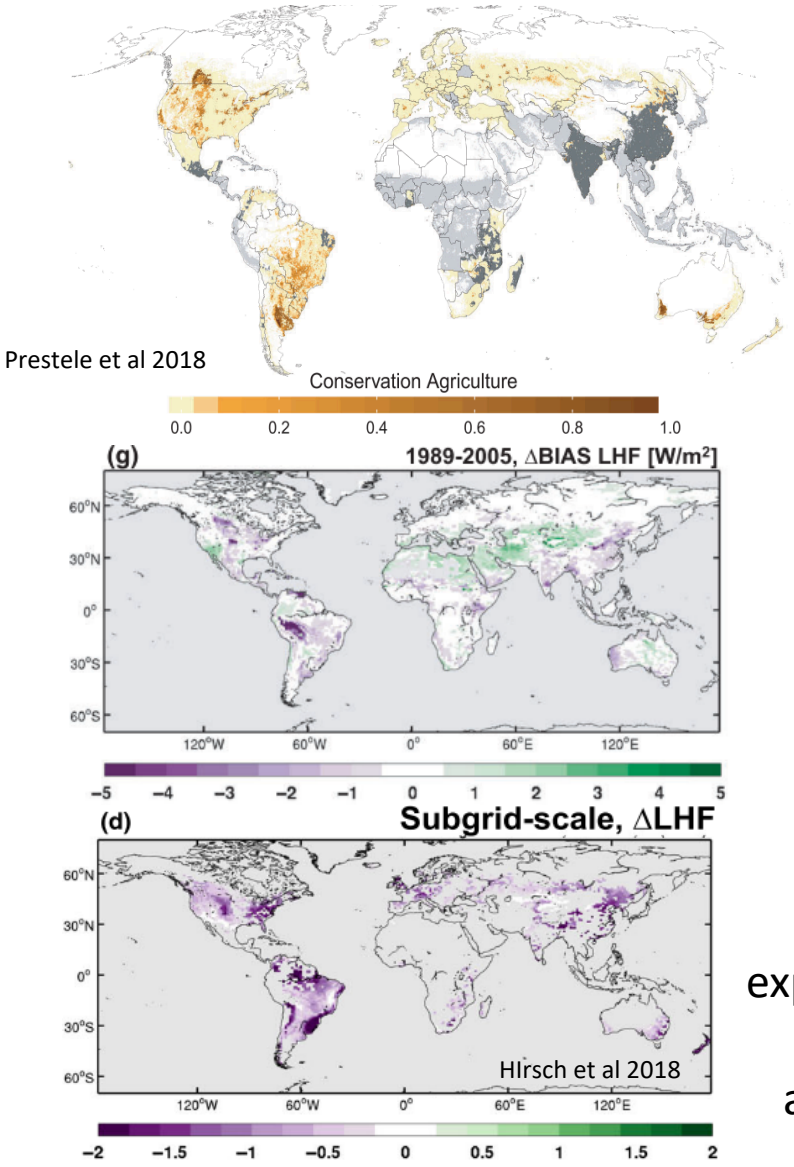
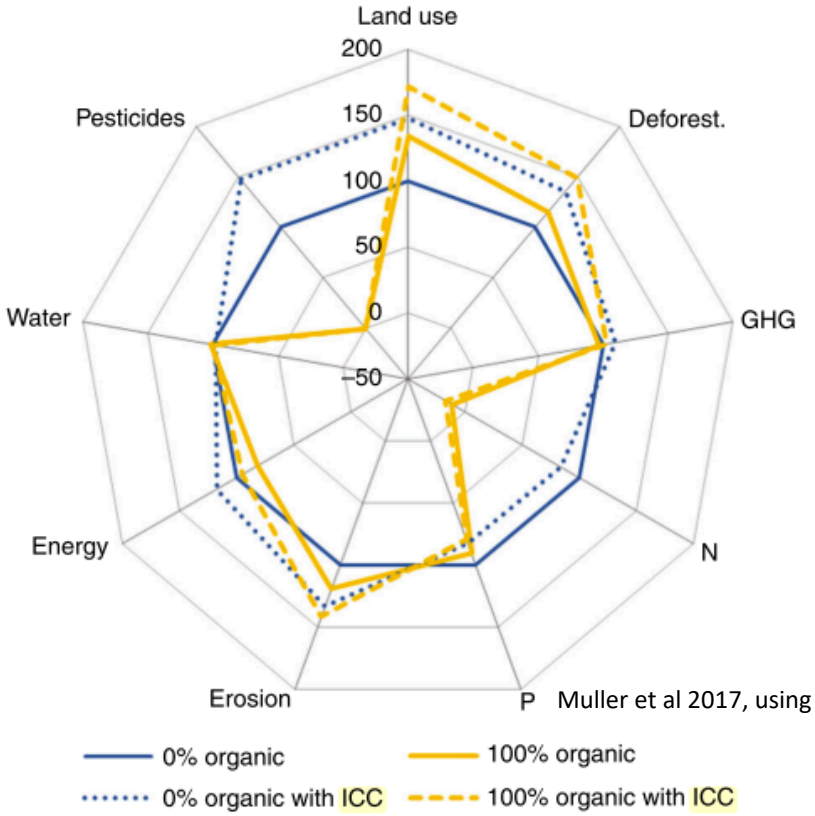
Agriculture and Food Security Considerations: Production Transformations



Prestele et al 2018

Hirsch et al 2018

Organic vs Conventional Production



Muller et al 2017, using SOL-26

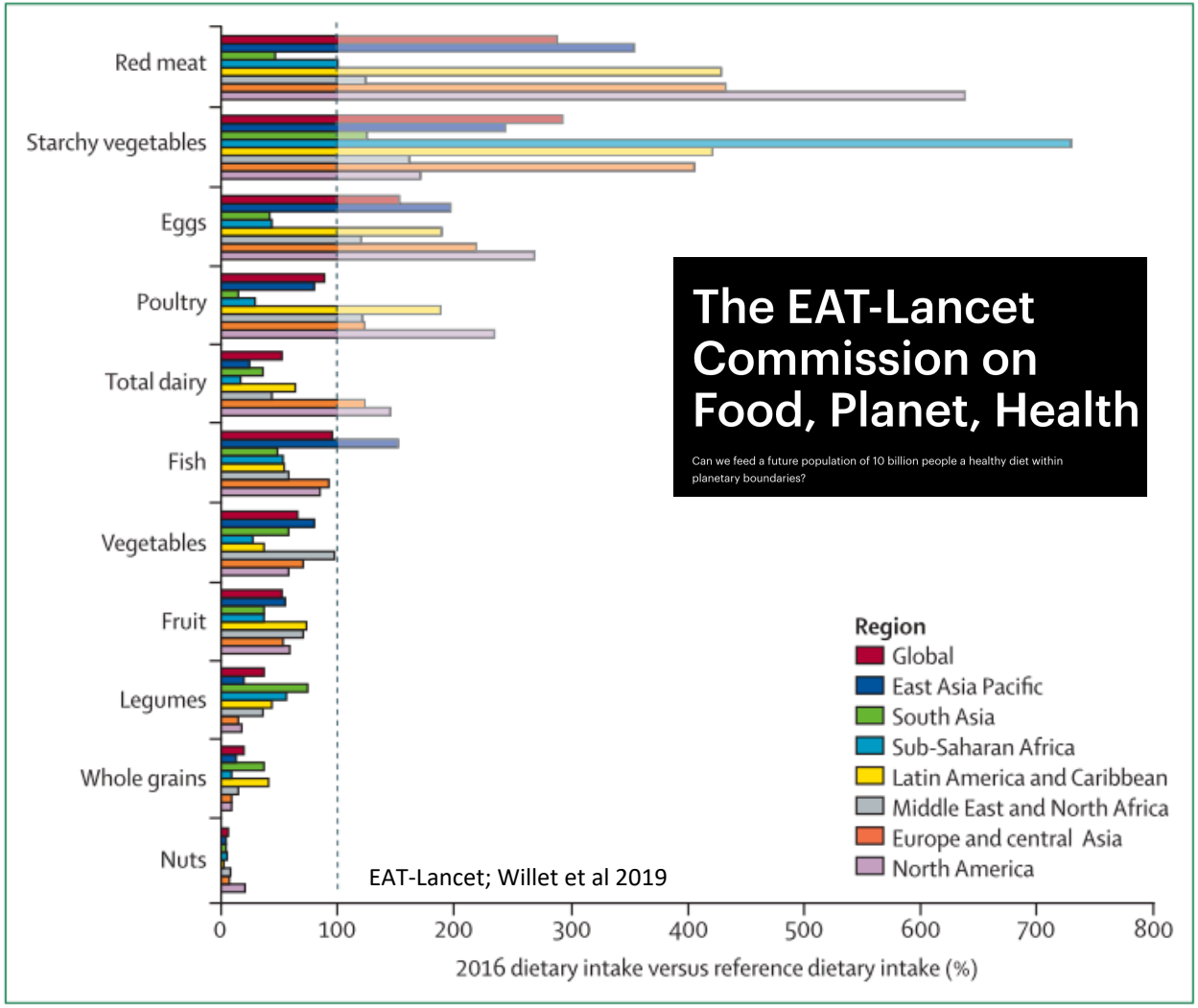
Need to move beyond simple efficiency gains to explore how alternative production systems (crops and management) contribute to planetary health – alternatives "sustainably intensified" monocultures

Agriculture and Food Security Considerations: Dietary Transformations

"Healthy diets" by 2050 will require:
>50% reduction in global consumption of red meat and sugar;
>100% increase in consumption of nuts, fruits, vegetables, and legumes

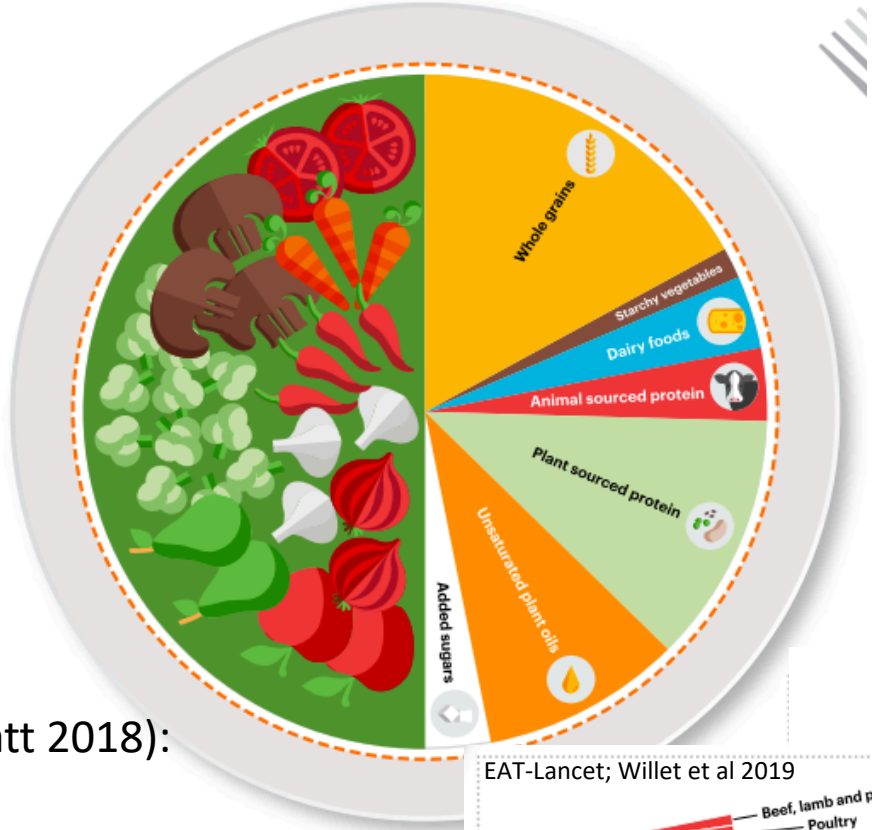
Sustainable food production for ~10 billion should:

- use no additional land,
- safeguard biodiversity,
- reduce water use,
- reduce nutrient pollution, produce net-zero C emissions, and no further increase in CH4 and N2O

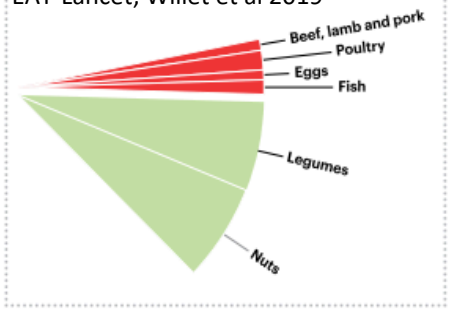


Agriculture and Food Security Considerations: Dietary Transformations

- Livestock sector accounts for ~14% of global GHG emissions
- Global demand is increasing, but regional nutrition disparities persist
- How viable/feasible are substitutions *and* redistributions within the nutrition space?



EAT-Lancet; Willet et al 2019



Sample Policy Framework for transition (Harwatt 2018):

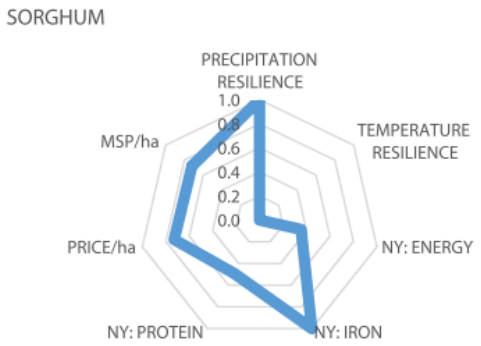
1) "Peak" livestock
2) Target worst offending foods
3) Substitute with "best available"

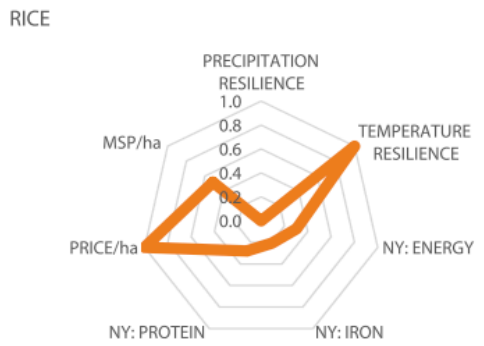
Enabled through tax revenue, climate finance (contributions to NDCs), subsidy restructuring

Agriculture and Food Security Considerations: Dietary Transformations

In addition to re-evaluating the role of meat in a global context, we must also consider the benefits and trade-offs of working towards more diverse diets

How might this impact growers' incentives, cropping systems' design, and ultimately, land and resource use?





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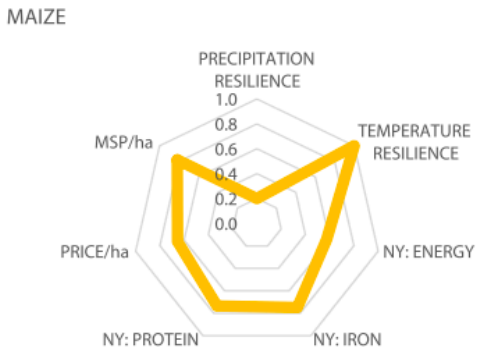

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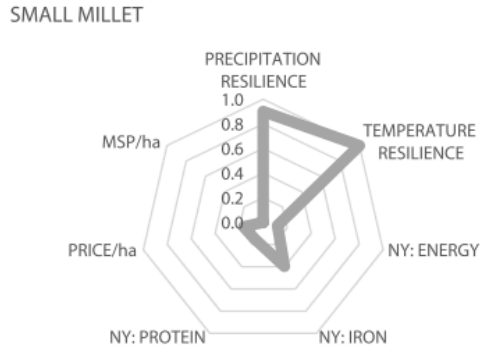
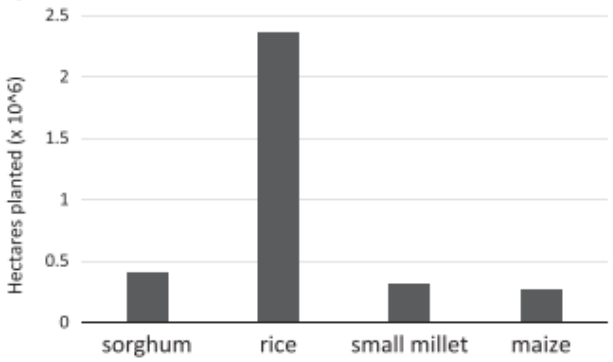
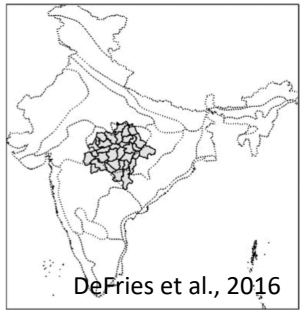
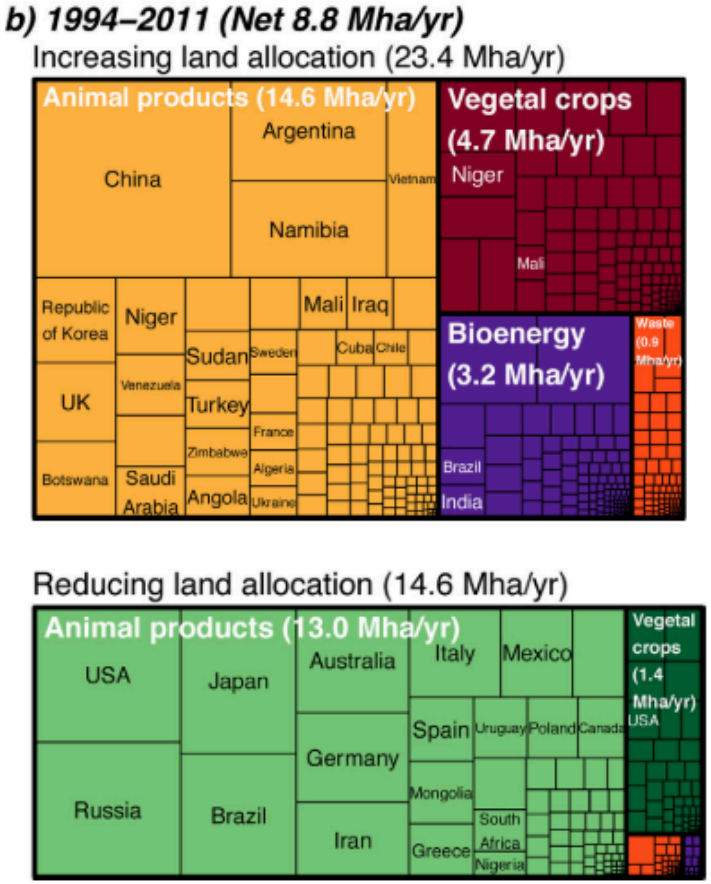


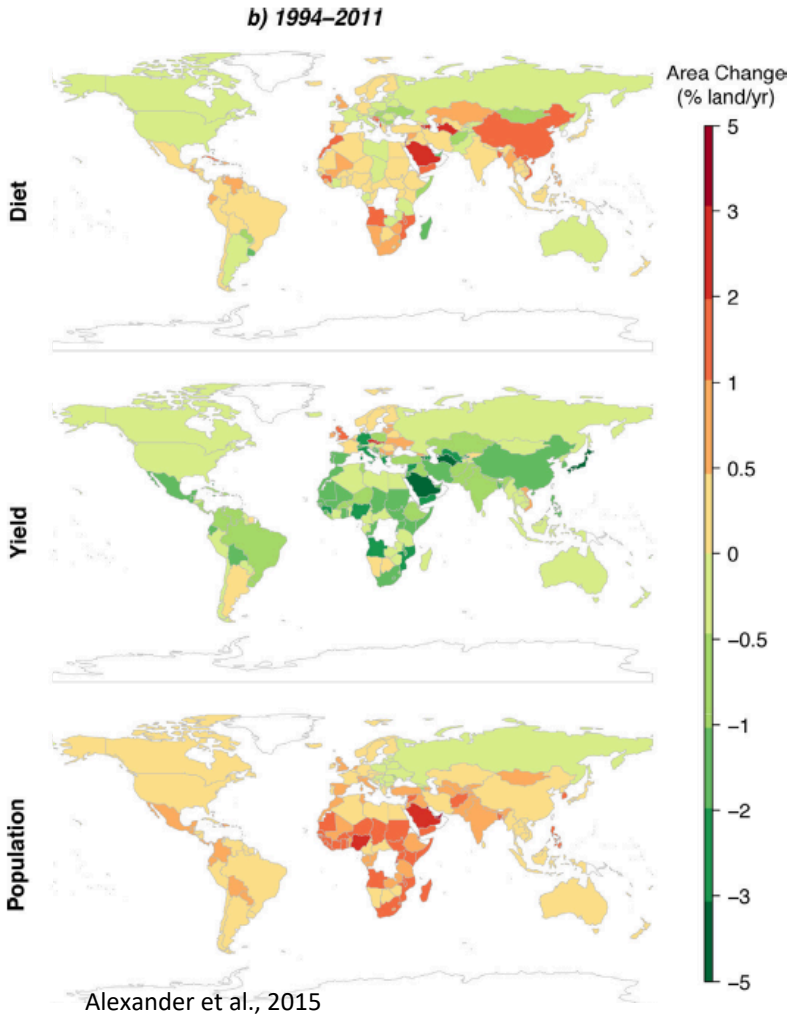




Agriculture and Food Security Considerations: Governance Transformations

Animal product demand have largely driven recent landuse changes, but much regional heterogeneity exists. Biofuels landuse is more modest but could challenge food security if current dietary trends are considered alongside mitigation



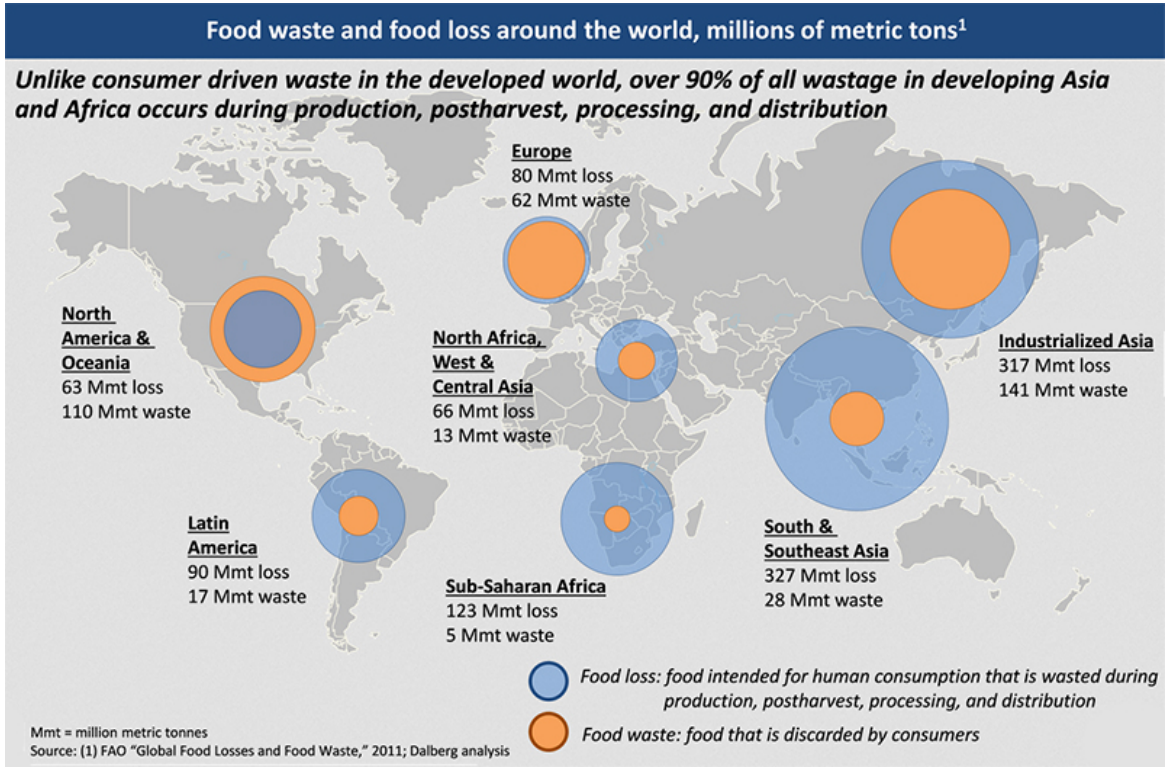


Alexander et al., 2015

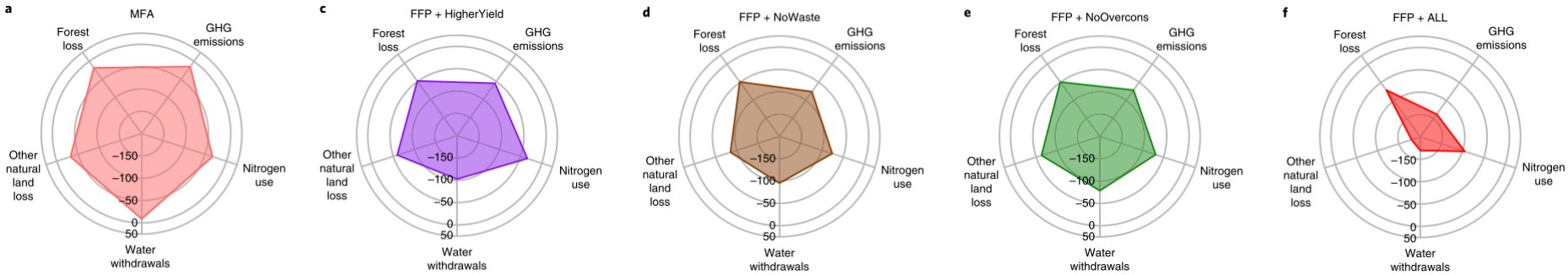
Agriculture and Food Security Considerations: Governance Transformations

Minimizing food waste will allow for improved environmental health and climate mitigation alongside gains in food security.

Some food waste issues are hard to solve than others, particularly under changed climate conditions



Hasegawa et al., 2019



Agriculture and Food Security Considerations: Food System Transformations

Mitigation is required across each one of the "planetary boundaries", but these need to also be regionally contextualized.

To achieve this, need to marry environmental, production, consumption, and public health policies

Land surface modeling can help us to more explicitly capture feedbacks

			GHG emissions	Cropland use	Water use	Nitrogen application	Phosphorus application	Biodiversity loss
Food production boundary			5.0 (4.7–5.4)	13 (11.0–15.0)	2.5 (1.0–4.0)	90 (65.0–140.0)	8 (6.0–16.0)	10 (1–80)
Baseline in 2010			5.2	12.6	1.8	131.8	17.9	100–1000
Production (2050)	Waste (2050)	Diet (2050)						
BAU	Full waste	BAU	9.8	21.1	3.0	199.5	27.5	1,043
BAU	Full waste	Dietary shift	5.0	21.1	3.0	191.4	25.5	1,270
BAU	Halve waste	BAU	9.2	18.2	2.6	171.0	23.2	684
BAU	Halve waste	Dietary shift	4.5	18.1	2.6	162.6	21.2	885
PROD	Full waste	BAU	8.9	14.8	2.2	187.3	25.5	206
PROD	Full waste	Dietary shift	4.5	14.8	2.2	179.5	24.1	351
PROD	Halve waste	BAU	8.3	12.7	1.9	160.1	21.5	50
PROD	Halve waste	Dietary shift	4.1	12.7	1.9	151.7	20.0	102
PROD+	Full waste	BAU	8.7	13.1	2.2	147.6	16.5	37
PROD+	Full waste	Dietary shift	4.4	12.8	2.1	140.8	15.4	34
PROD+	Halve waste	BAU	8.1	11.3	1.9	128.2	14.2	21
PROD+	Halve waste	Dietary shift	4.0	11.0	1.9	121.3	13.1	19

Willet et al 2019; Springmann et al 2018

Agriculture and Food Security Considerations: Food System Transformations

Needs for evaluating approaches to achieve Planetary Health

- Sustainable intensification or producing more food (even if “efficient”) is perhaps necessary, but not sufficient. There is no “silver bullet” solution.
- Better explore potential pathways for combined public health, resilience, and environmental restoration goals (incentives, taxes, subsidies, support)
- Better understand drivers of food waste and implications for prices and landuse
- Rebalance our approach to animal product consumption; if we’re going to eat more legumes we’ll need to get better at growing them
- Better represent/consider combined management and climate change effects
- We need to better resolve regional heterogeneities in the above, inclusive of barriers to achieving food and nutrition security that extend beyond the biophysical domain (access and utilization)

Agriculture and Food Security Considerations: Topics and Questions

Modeling for Planetary Health:

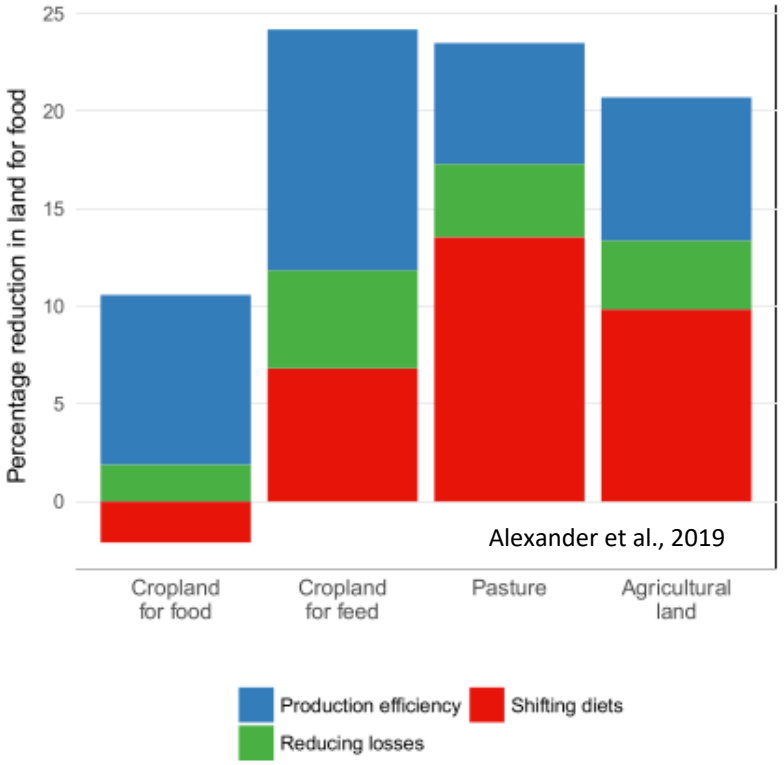
Do alternative management and cropping systems deliver gains in nutrition, climate resilience, and environmental health?

Do we maintain very intensive food production systems, just with reduced animals?

What is the role for biofuels/afforestation in alternative diet scenarios that meet nutrition and climate goals?

We are considering modeling high ambition climate mitigation scenarios. What about high ambition planetary health scenarios (or combined)?

Effect of "Marginal Changes"



Thanks! And References:

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