Feeding 10 Billion People On a Warming Planet

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@coolfireecology

Cambioscop Meeting, Toulouse, France, November 2019

INSTITUTE ON THE
ENVIRONMENT

University of Minnesota
Driven to Discover℠

Meet the needs of today's 7 Billion

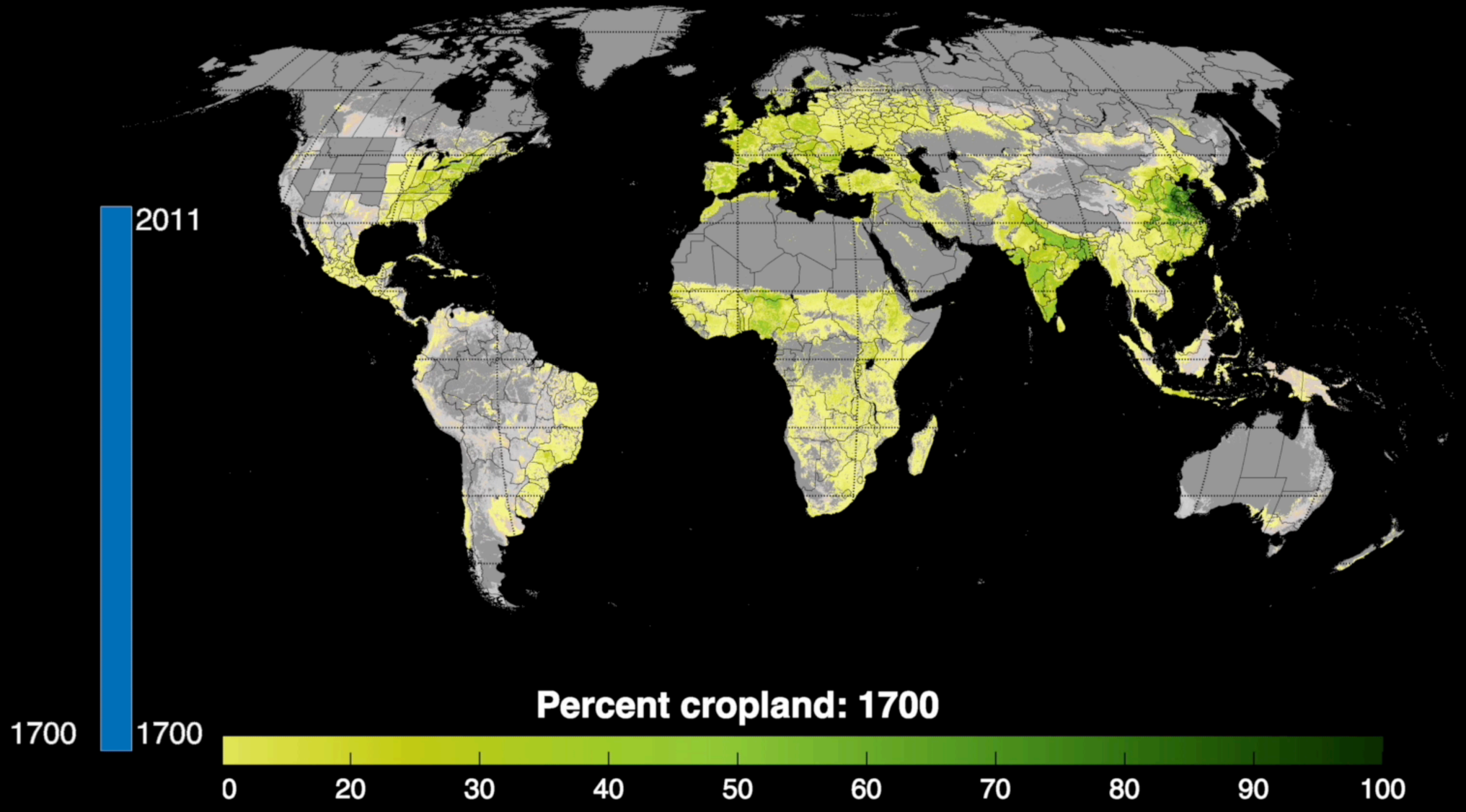
Meet the needs of the Future 10 Billion

....That Eat More Meat

Grow Food Sustainably

all within a changing climate....

570 MILLION



SOURCE: RAMANKUTTY & FOLEY. 1999 (UPDATED)

EATING IN AN INTERCONNECTED WORLD

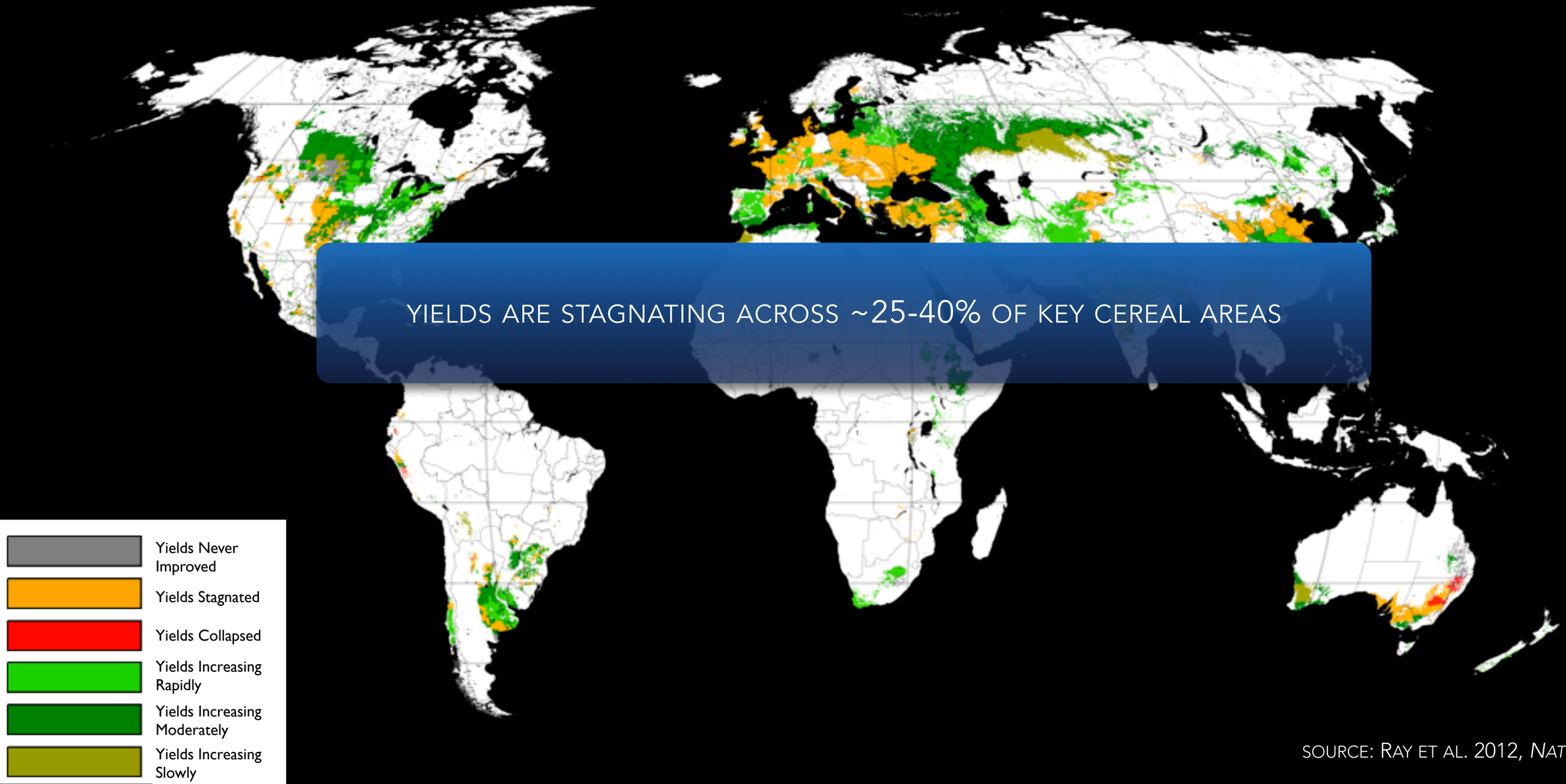
20+% OF GLOBAL CALORIE PRODUCTION IS TRADED

WHEAT, SOY, AND MAIZE = 50% CALORIES TRADED

MACDONALD ET AL. 2015, BIOSCIENCE

1. Grow More Food on Current Croplands

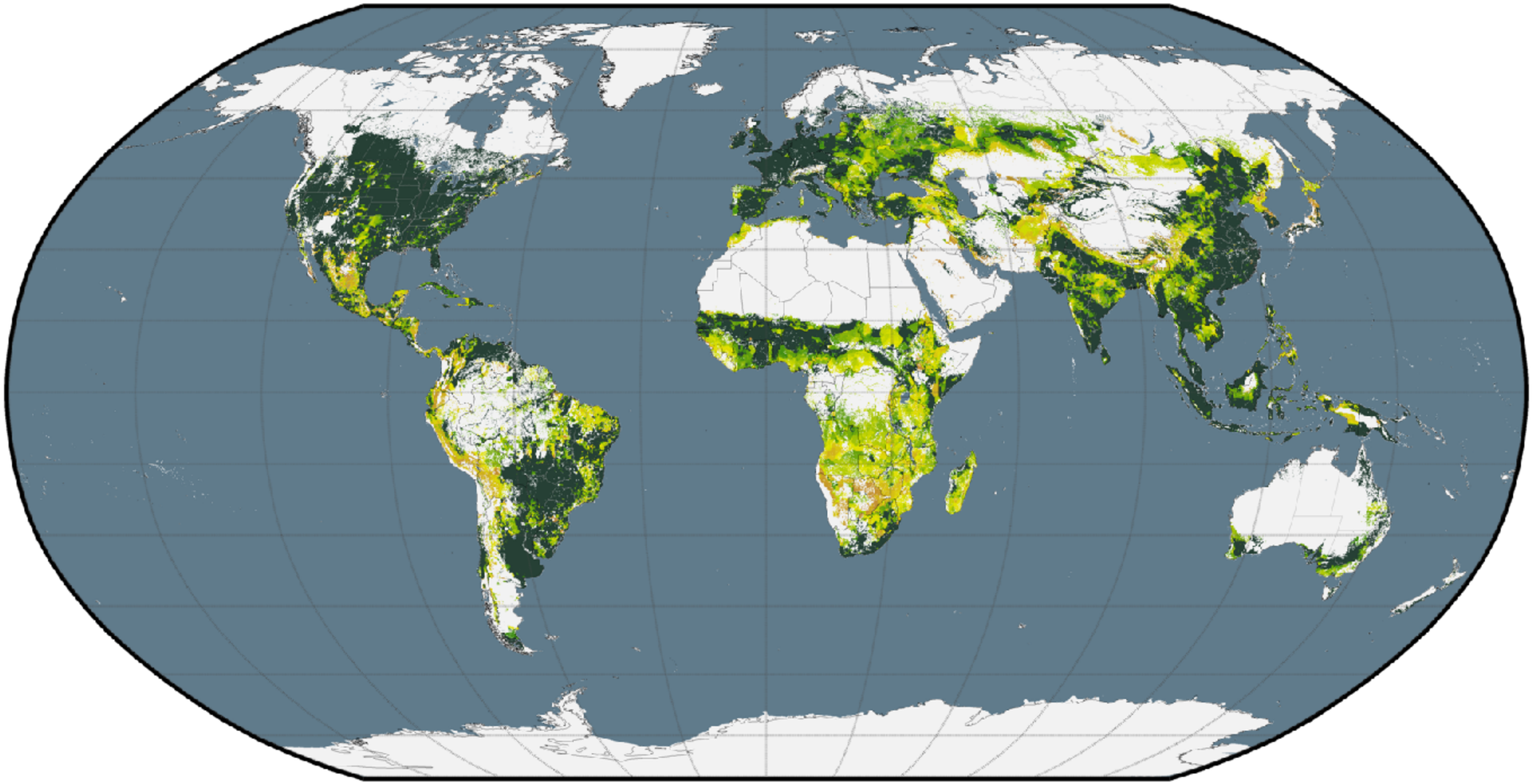
Wheat Yield Trends



YIELDS ARE STAGNATING ACROSS ~25-40% OF KEY CEREAL AREAS

SOURCE: RAY ET AL. 2012, *NATURE COMM.*

Intensifying Food Production

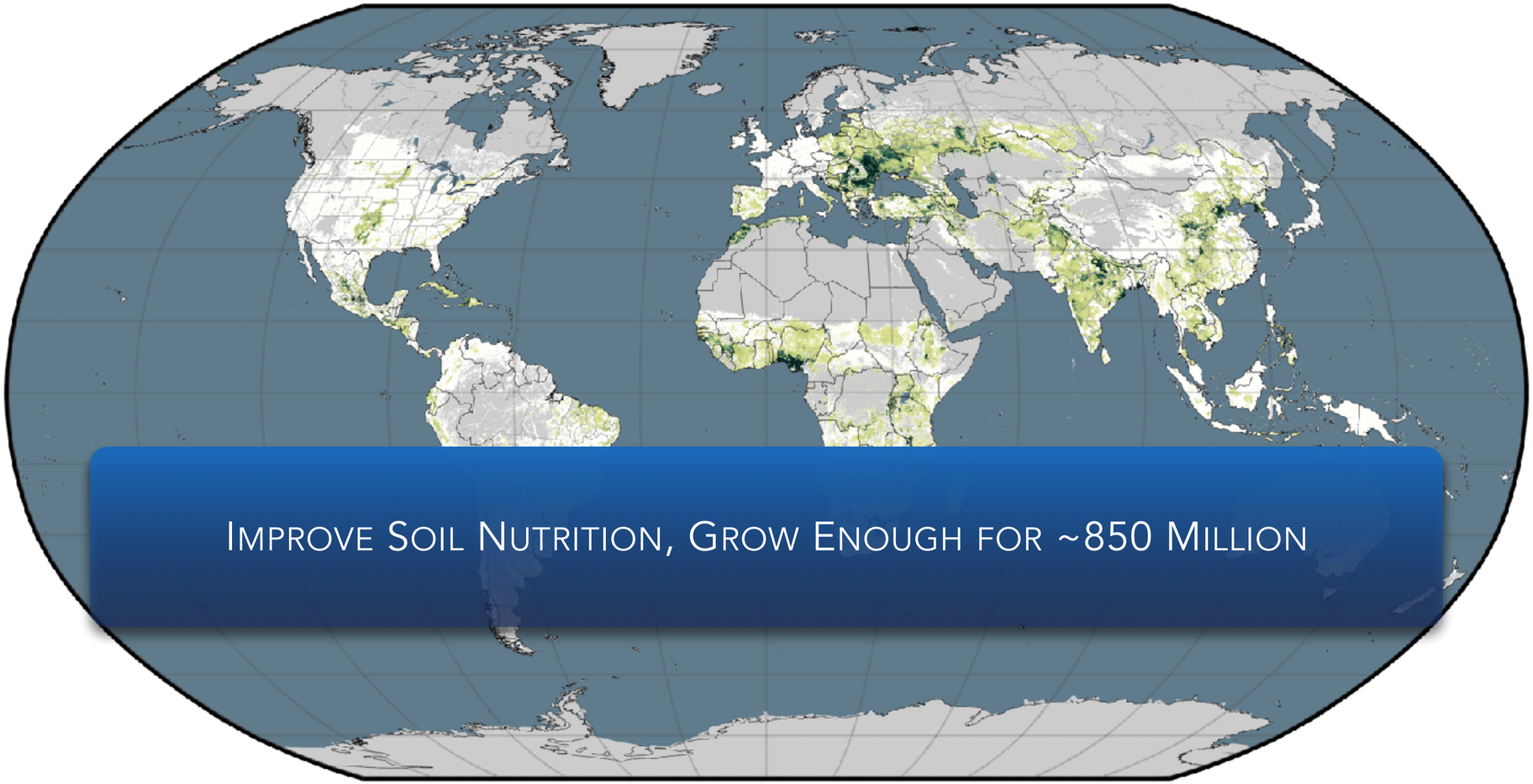


Percent of potential yield attainment - 17 major crops

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

SOURCE: WEST ET AL. 2014, *SCIENCE*

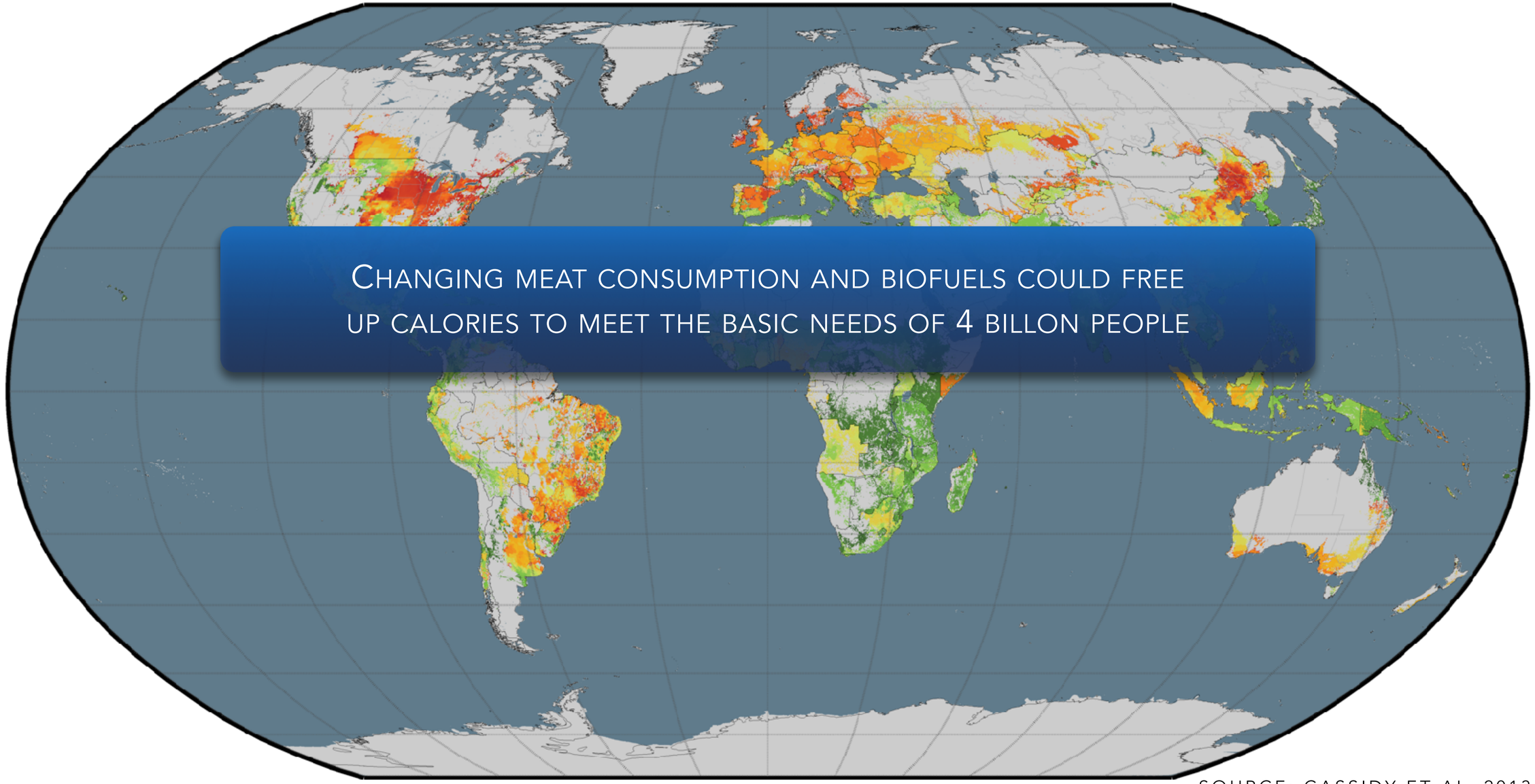
Intensifying Food Production



SOURCE: WEST ET AL. 2014, *SCIENCE*

2. Use What We Grow More Efficiently

Calorie Delivery Fraction



SOURCE: CASSIDY ET AL. 2013, *ERL*
WEST ET AL. 2014, *SCIENCE*

Food Loss and Waste

NOT ALL WASTE IS EQUAL

Table 1. Calories lost to consumer food waste and associated land requirements for key food commodities in the United States, India, and China.

Food	Calorie supply (*29*) (kcal per capita day^{-1})	Consumer food waste (*31*) (% and kcal per capita day^{-1})	Embodied feed in calorie waste (kcal per capita day^{-1})	Harvested area required to support waste (m^2 per capita year^{-1})
United States	**3688***			
Wheat and rice	693	27% (187)	–	65
Vegetables	76	28% (21)	–	8
Beef	110	11% (12)	278	43
Pork	132	21% (28)	356	21
Poultry	193	11% (21)	199	31
China	**3036†**			
Wheat and rice	1380	20% (276)	–	59
Vegetables	205	15% (31)	–	10
Beef	27	8% (2)	33	9
Pork	355	8% (28)	178	47
Poultry	59	8% (5)	30	8
India	**2321‡**			
Wheat and rice	1168	3% (35)	–	14
Vegetables	46	7% (3)	–	3
Beef	5	4% (<1)	3	2
Pork	3	4% (<1)	1	1

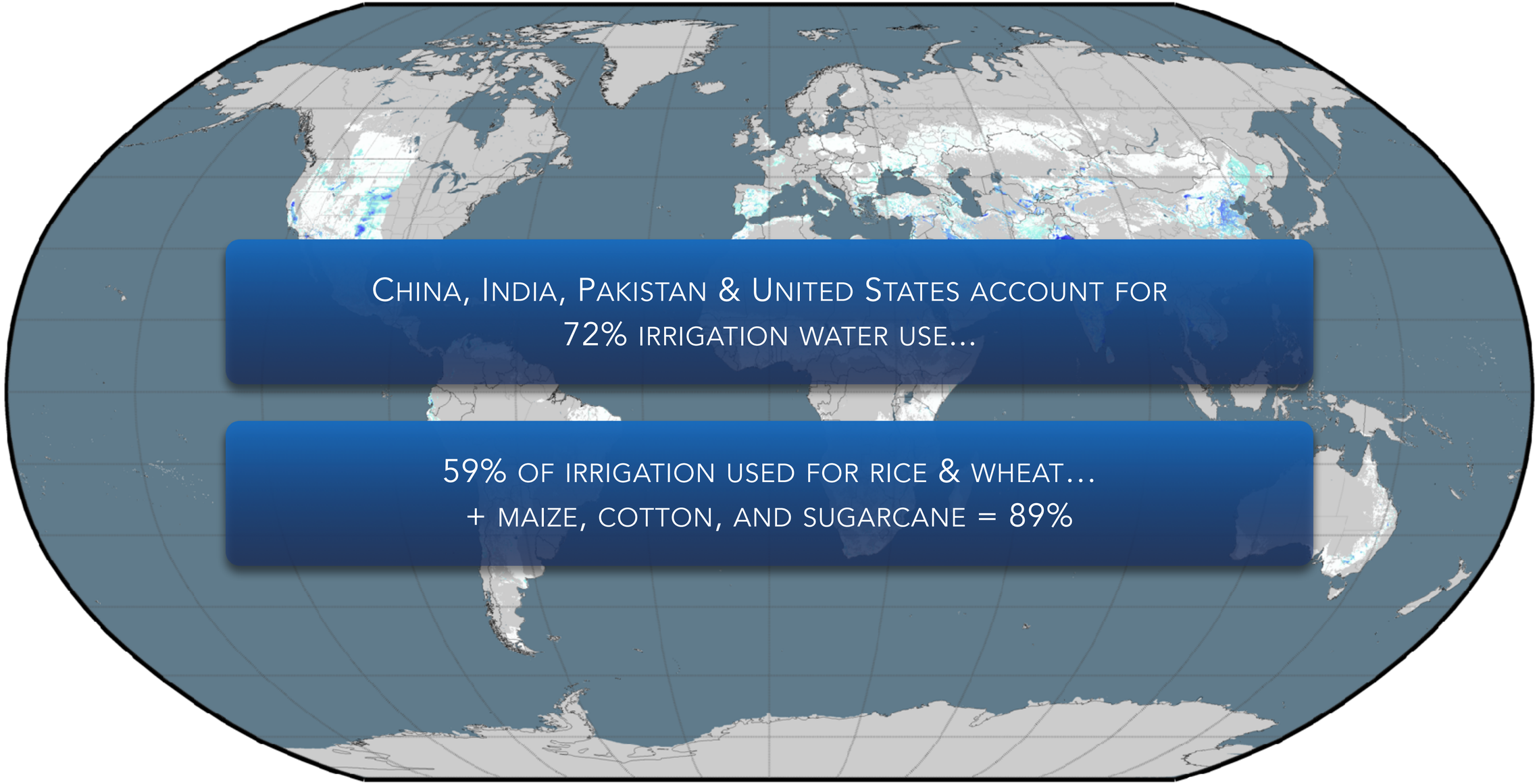
IN THE USA, WASTING 1KG OF BEEF REQUIRES 5X MORE LAND THAN WASTING 1KG OF WHEAT

SOURCE: WEST ET AL. 2014, *SCIENCE*

3. Grow Food More Efficiently

Water

Water Consumption



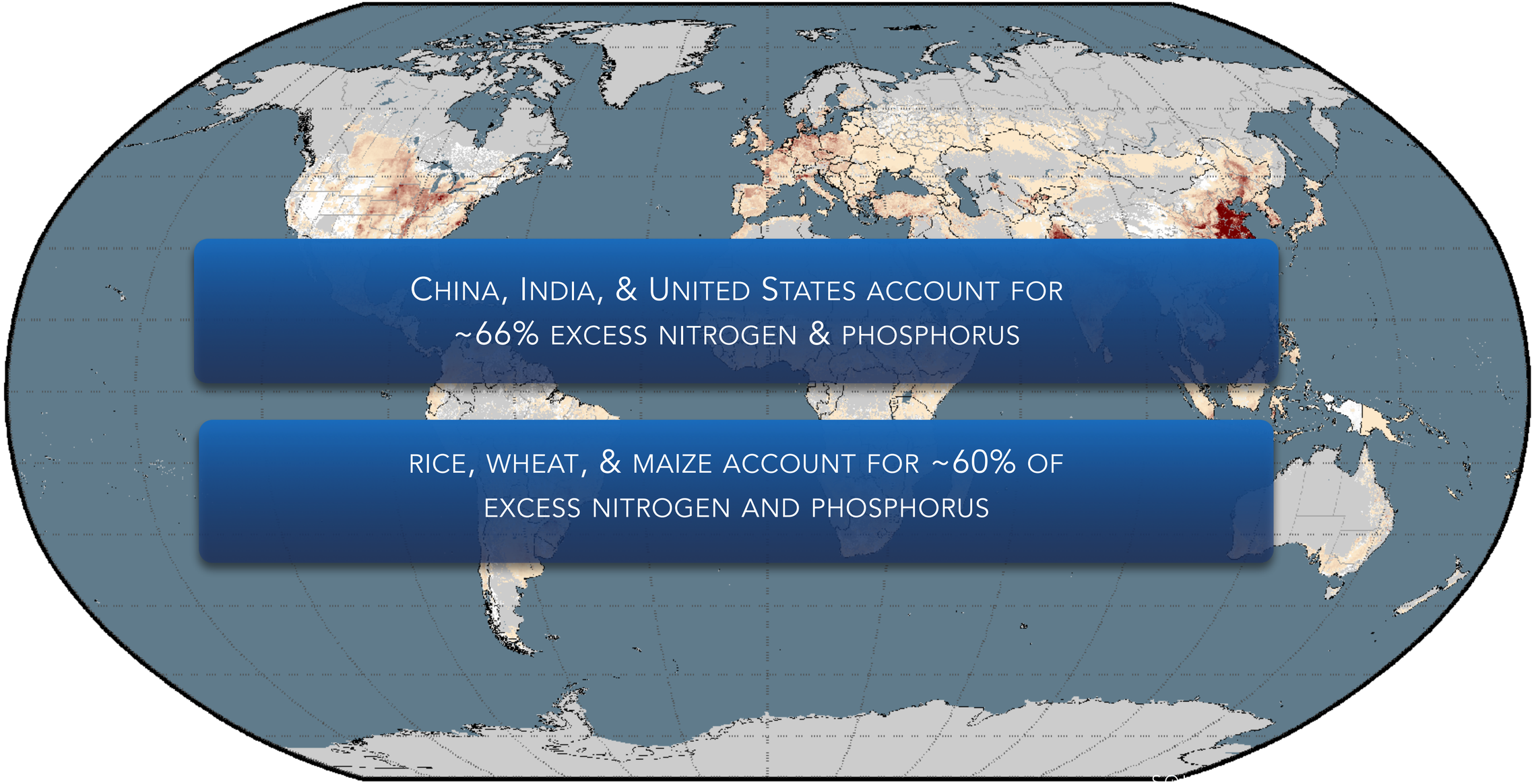
China, India, Pakistan & United States account for 72% irrigation water use…

59% of irrigation used for rice & wheat…
+ maize, cotton, and sugarcane = 89%

SOURCE: WEST ET AL. 2014, *SCIENCE*

Water Quality

WATER QUALITY



SOURCE: WEST ET AL. 2014, *SCIENCE*

Meeting the 2C target

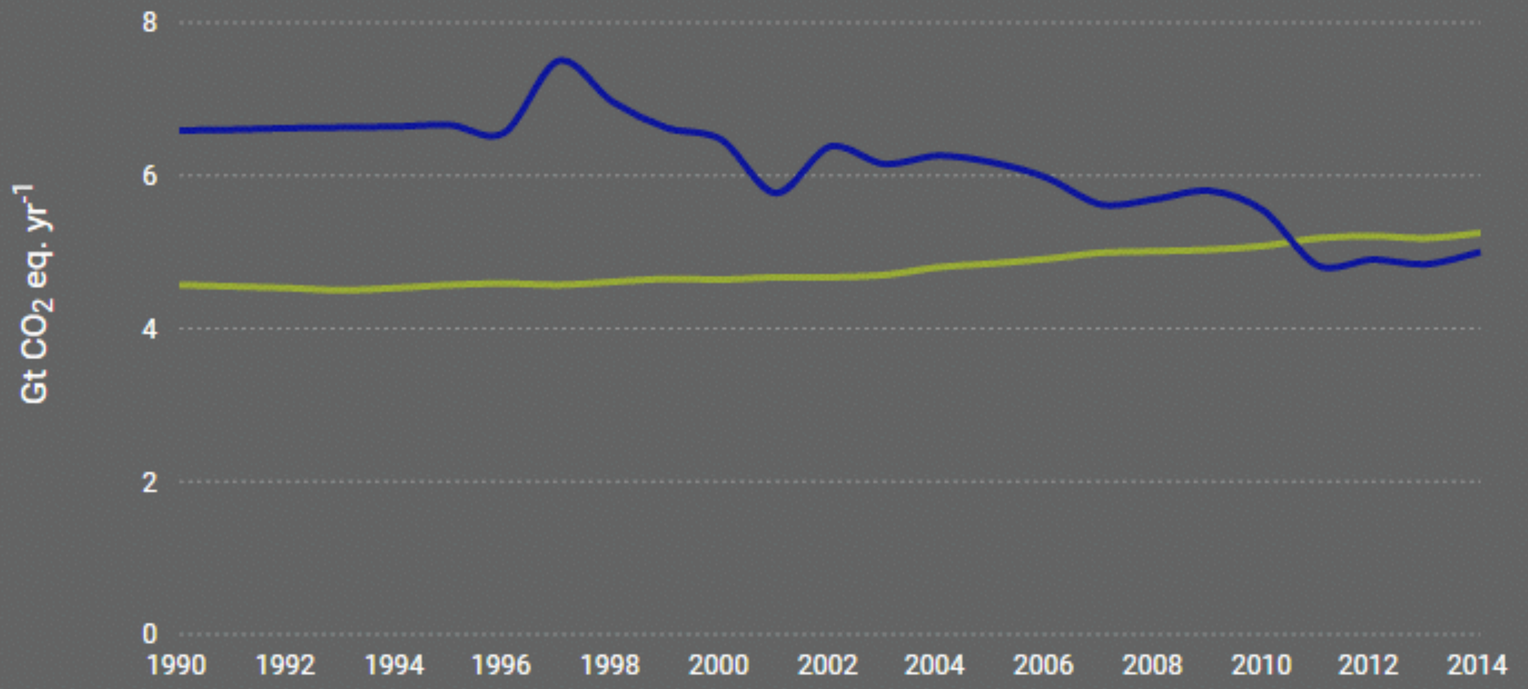
1. Reduce Energy & industry emissions by half, each decade

2. Reduce agriculture & deforestation emissions to zero by 2050

3. remove 5GT CO_2 each year through negative emissions technology by 2050

Rockstrom et al. 2017, *Science*

Agriculture = 20-30% Global GHGs



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Food and Agriculture Organization of the United Nations

DATA SOURCE: FAOSTAT 2016. faostat3.fao.org

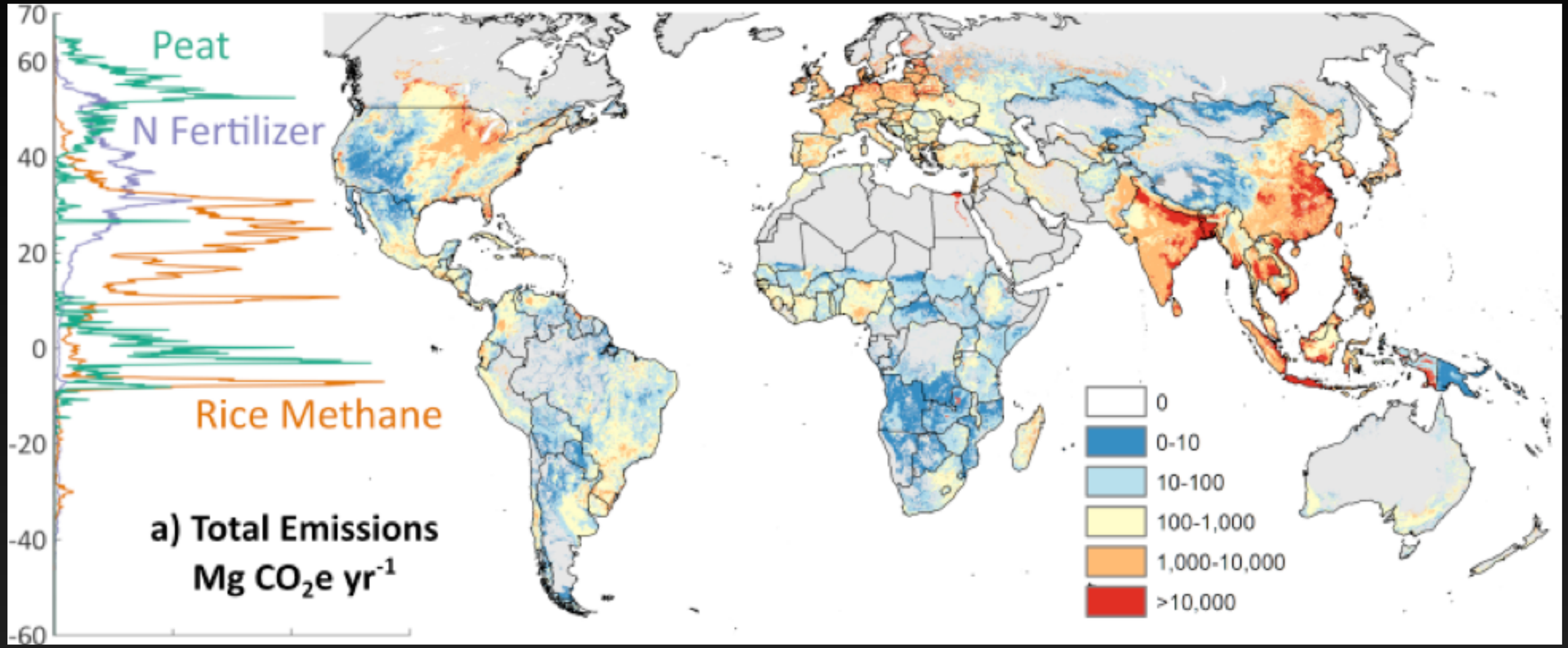
Methane

Photo: Ryan Thompson
Creative Commons v2.0, 2008

Global emissions

1945±720 Tg CO_2e yr^{-1}

50% Rice Methane
29% Peatlands
21% N Fertilizer



Carlson et al 2015 *Nature Climate Change*

DRAINING PEATLANDS IS LEAST EFFICIENT

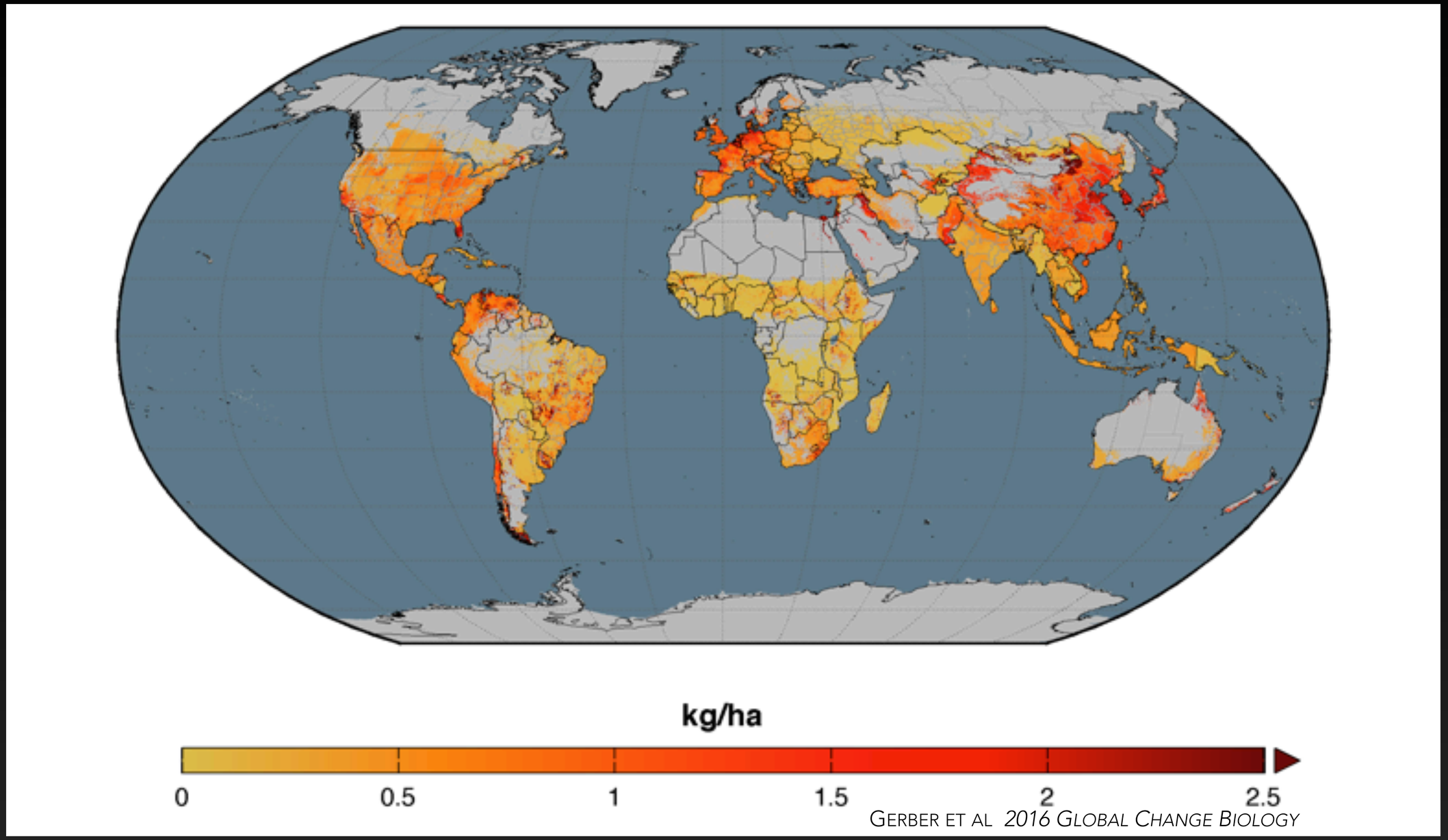
PER AREA, PEAT EMISSIONS 8-12X HIGHER THAN RICE CH_4 OR N_2O

CARLSON ET AL 2015 *NATURE CLIMATE CHANGE*

N_2O

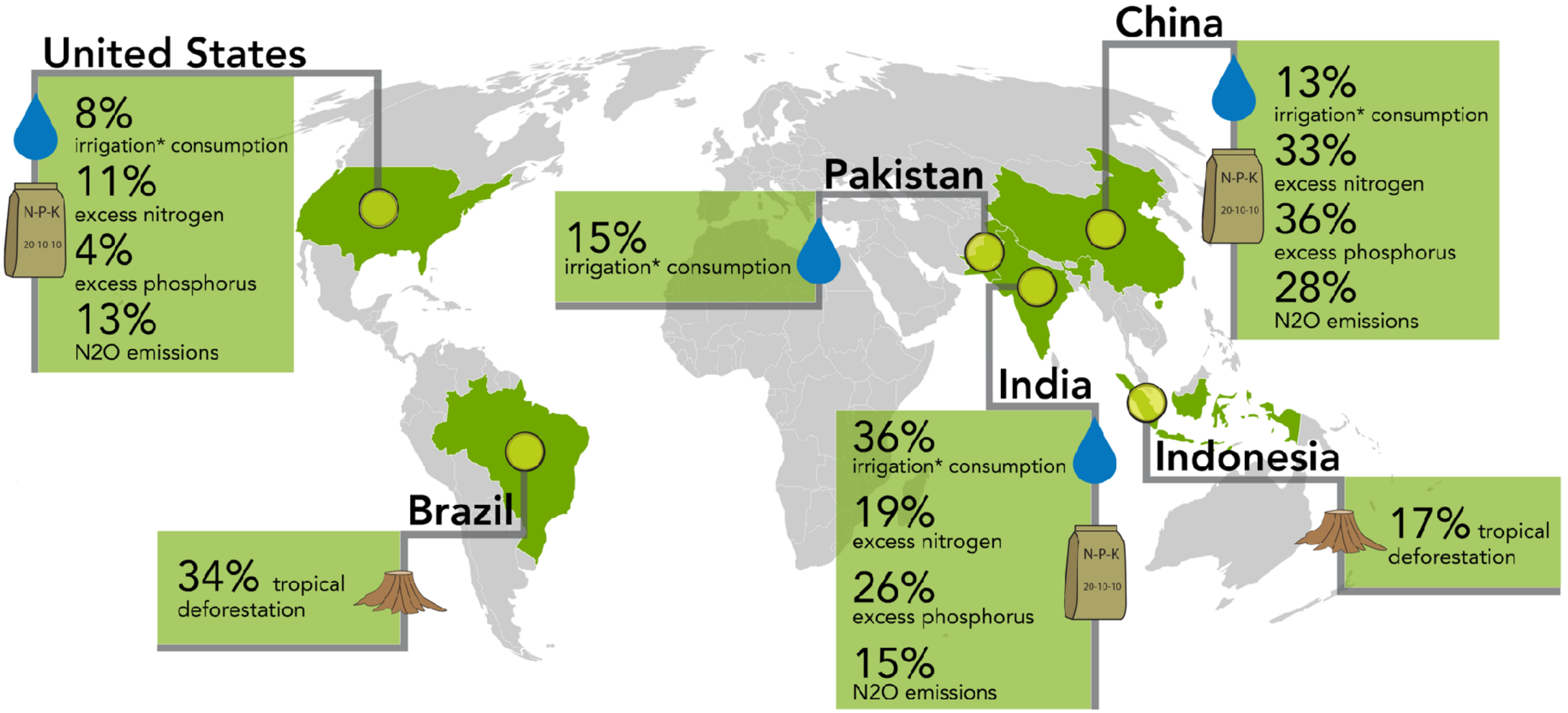
NO LAUGHING MATTER

Nitrous oxide emissions

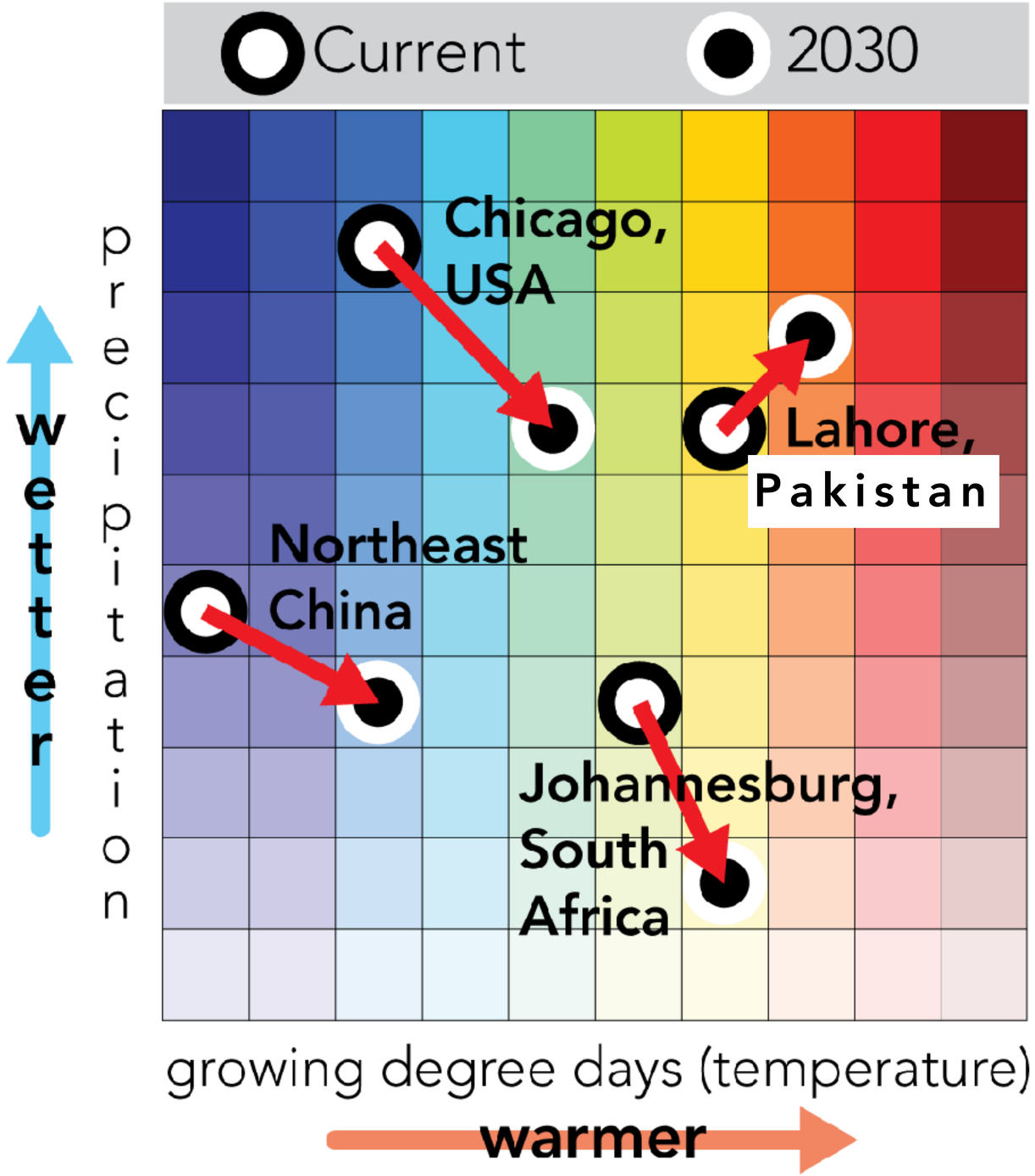


Gerber et al *2016 Global Change Biology*

4. Focus on Leverage Points



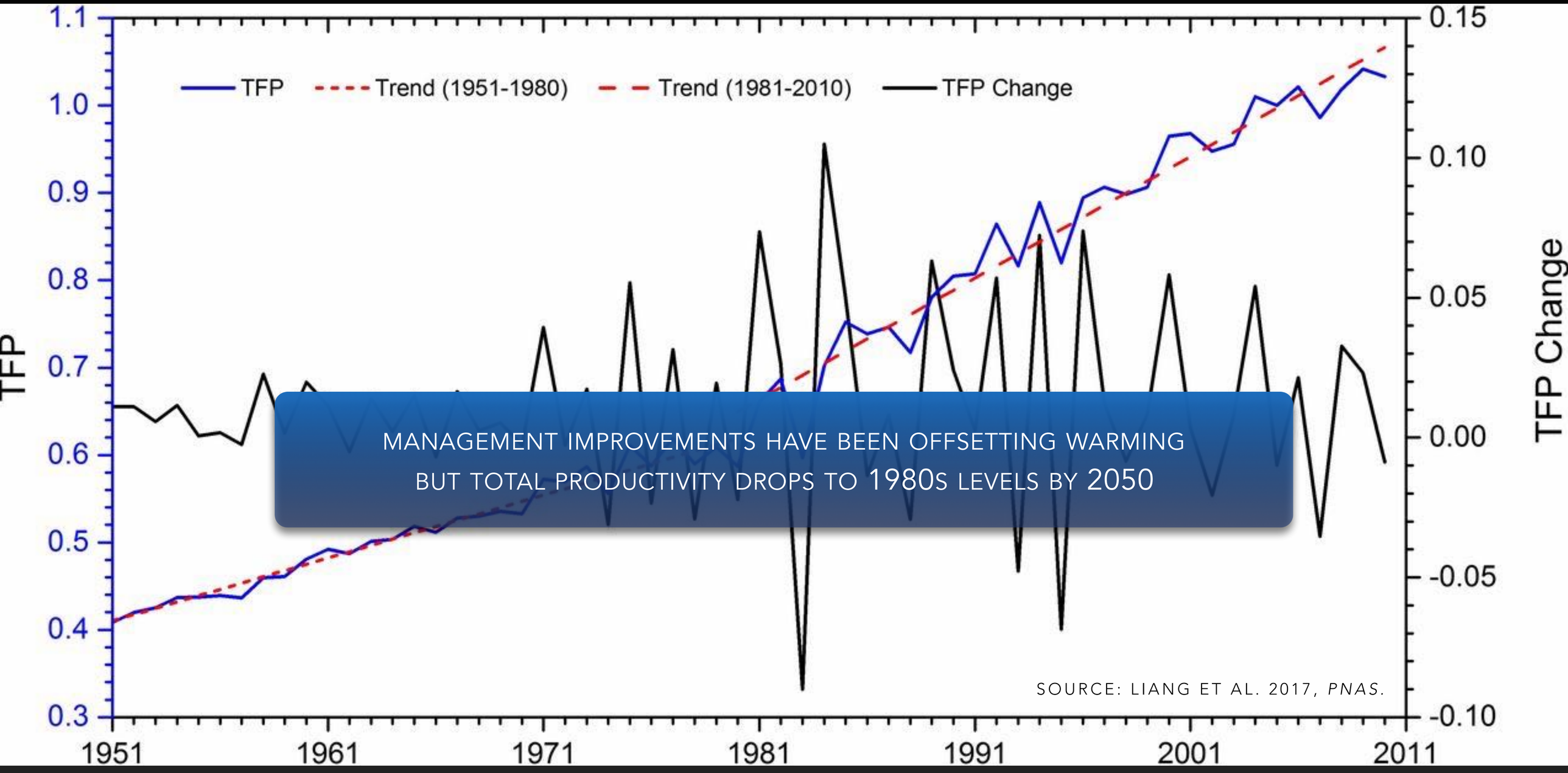
SOURCE: WEST ET AL. 2014, *SCIENCE*



SOURCE: INSTITUTE ON THE ENVIRONMEN

"WINNERS" & LOSERS

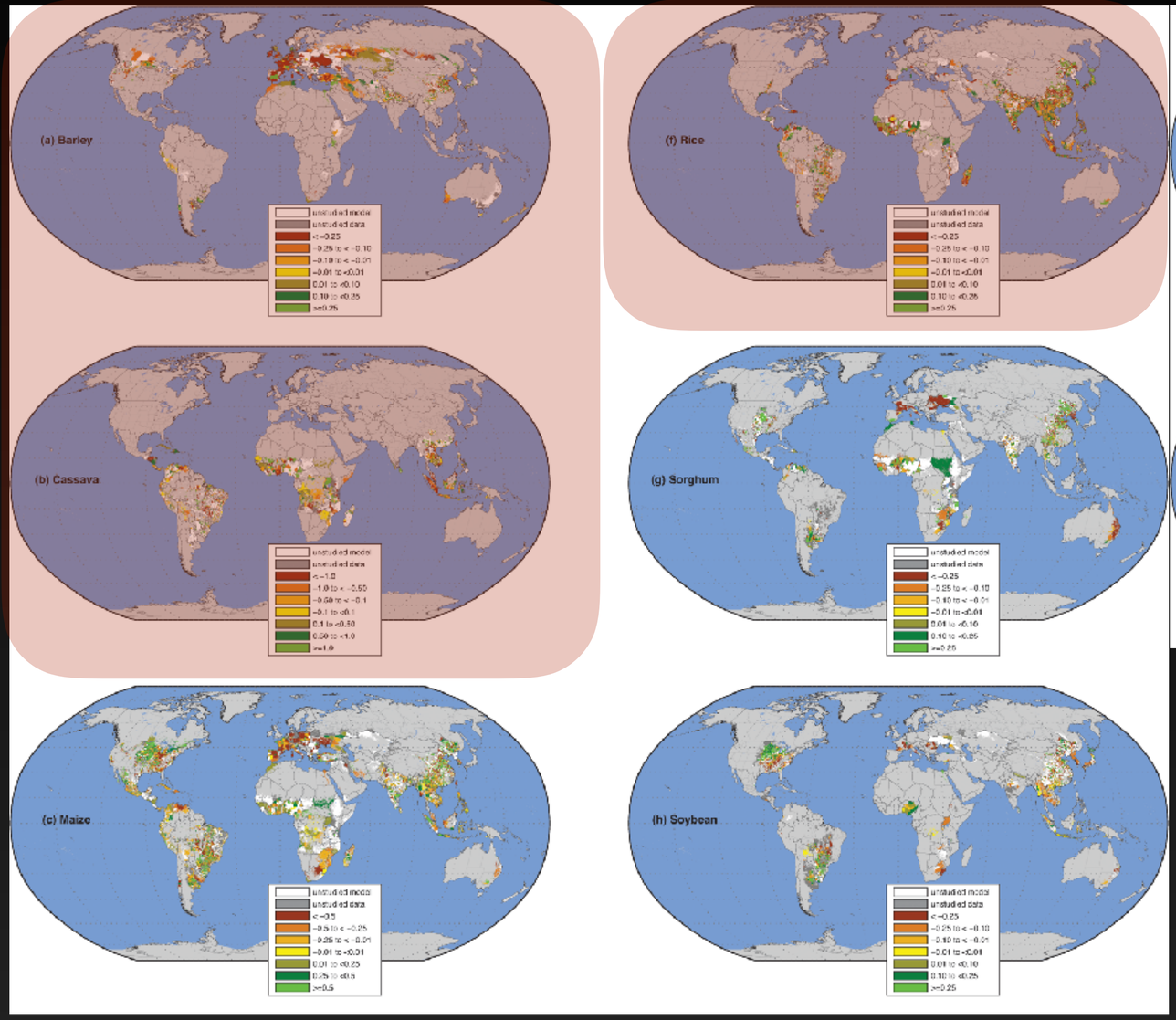
USA - Total Factor Productivity

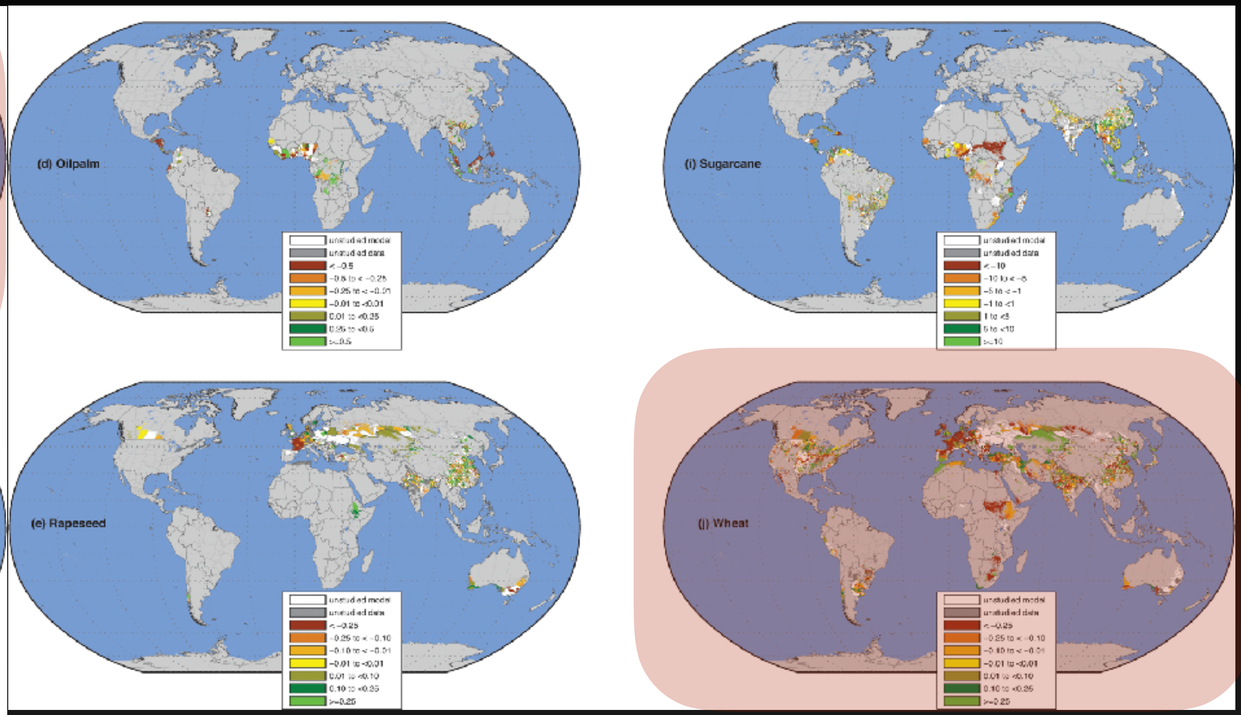


MANAGEMENT IMPROVEMENTS HAVE BEEN OFFSETTING WARMING
BUT TOTAL PRODUCTIVITY DROPS TO 1980S LEVELS BY 2050

SOURCE: LIANG ET AL. 2017, *PNAS*.

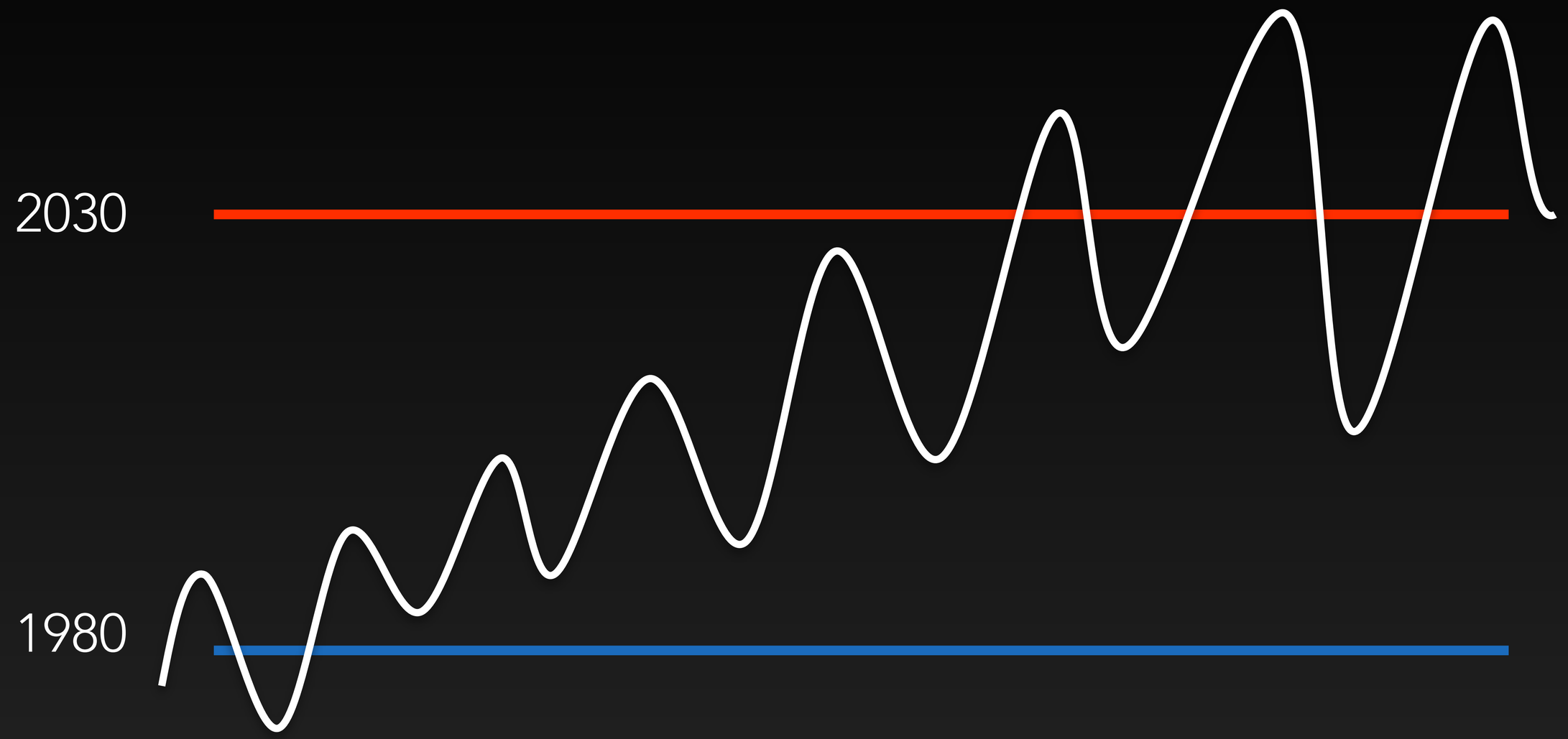
Climate Change(d)



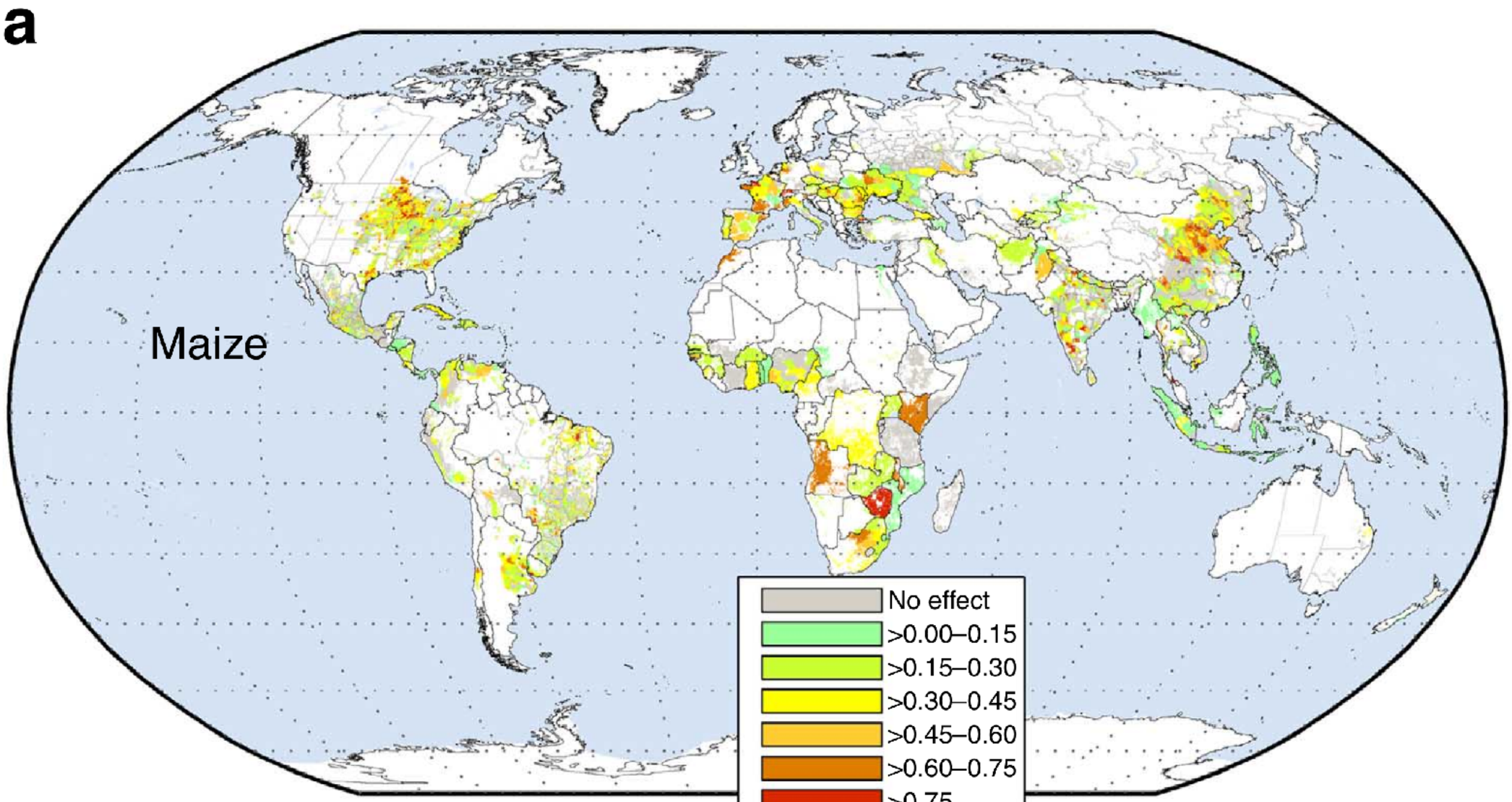


SOURCE: RAY ET AL. 2019, *PLOS ONE*

CHANGE IN THE MEAN VS. VARIABILITY

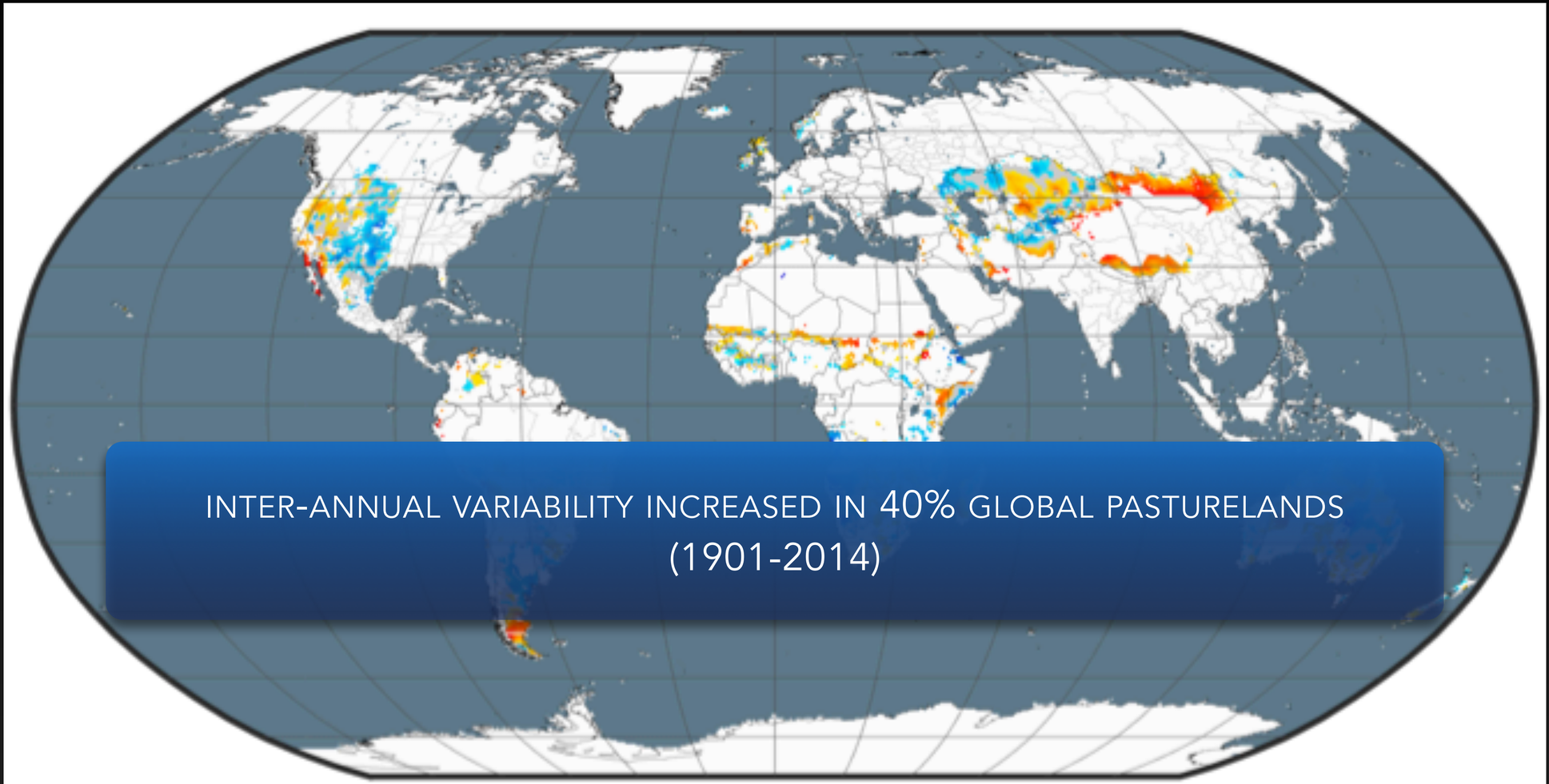


Climate variability explains 1/3 of yield variability



SOURCE: RAY ET AL. 2015, *NATURE COMMS.*

INTER-ANNUAL PRECIPITATION VARIABILITY



SLOAT ET AL. 2018. *NAT CLIM CHNG*

FOOD - CLIMATE - NUTRITION

Fish, 150 g fillet
>100% Vitamin B12
100% Selenium
71% Protein
14% Energy

Broccoli, 1 c
>100% Vitamin C
42% Folate
7% Protein
3% Energy

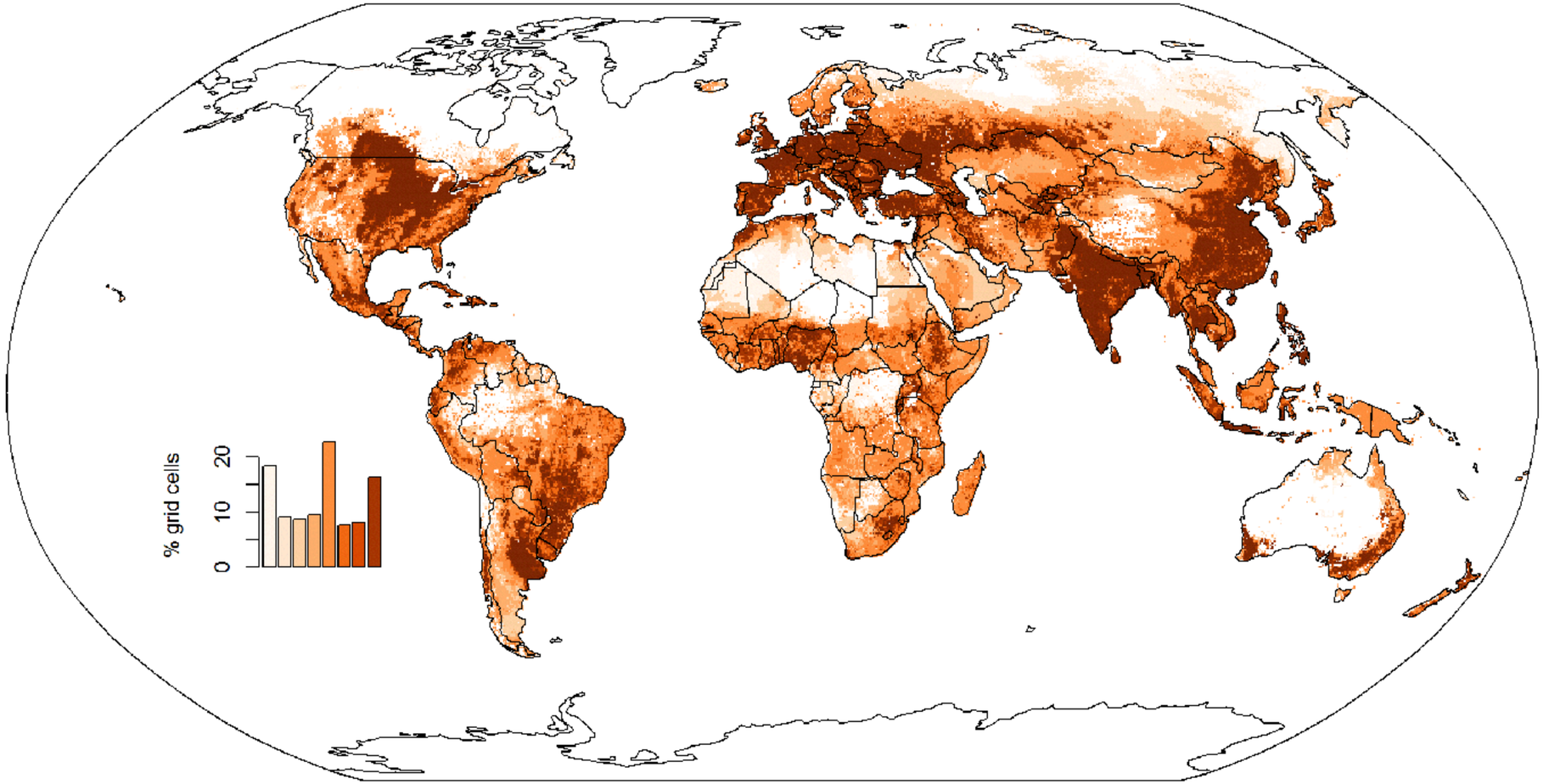
Sweet Potato, 1 c
>100% Vitamin A
25% Iron
12% Energy
8% Protein

Brown Rice, 1.5 c
45% Thiamin
31% Zinc
19% Energy
15% Protein

Healthy Food = Healthy Planet

Tilman & Clark 2014, *Nature*
Springmann et al. 2018, *Nature*
Willets et al. 2019, *Lancet*

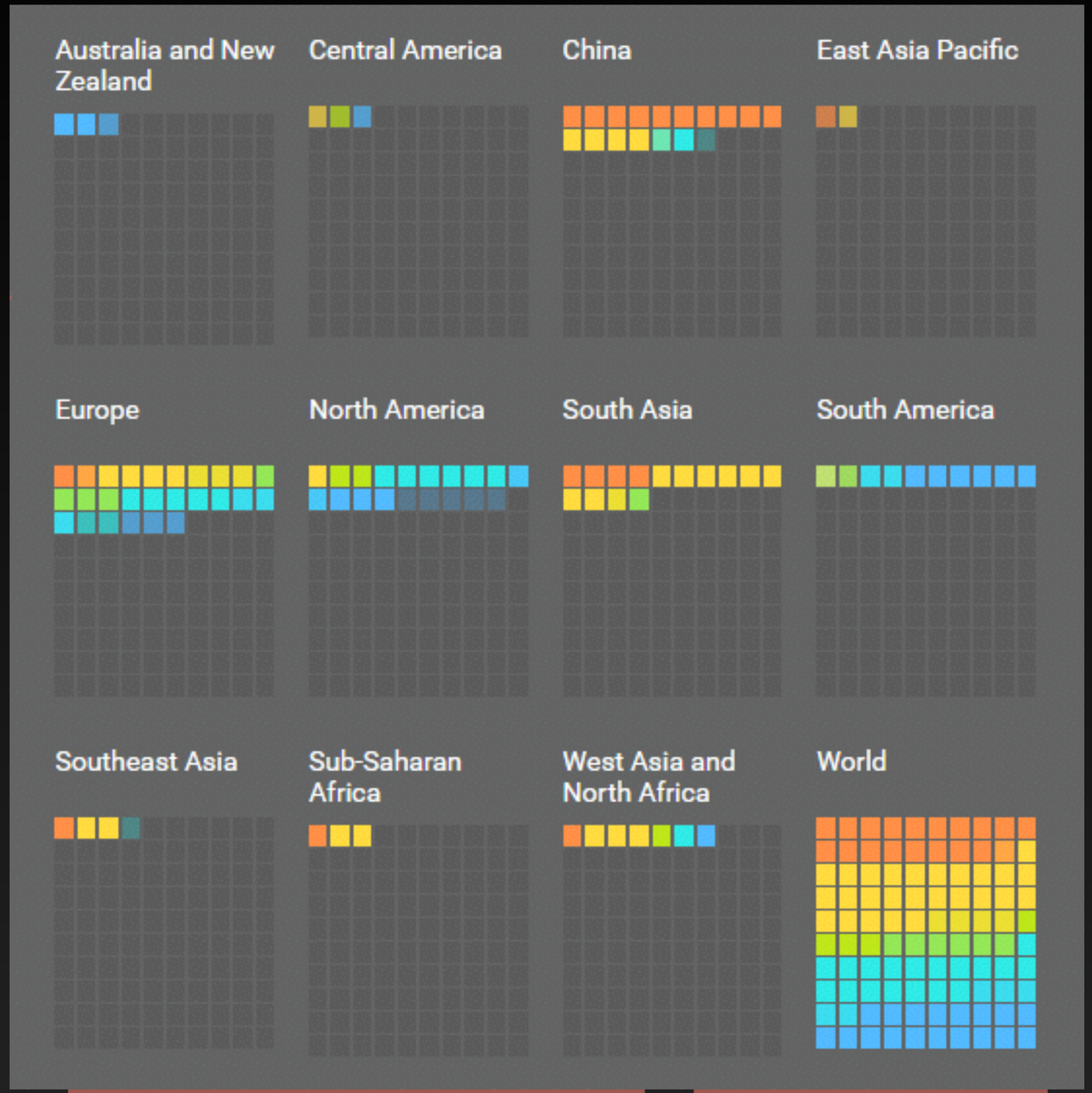
WHERE IS ZINC PRODUCED?



HERRERO ET AL. 2017, LANCET PLANETARY HEALTH

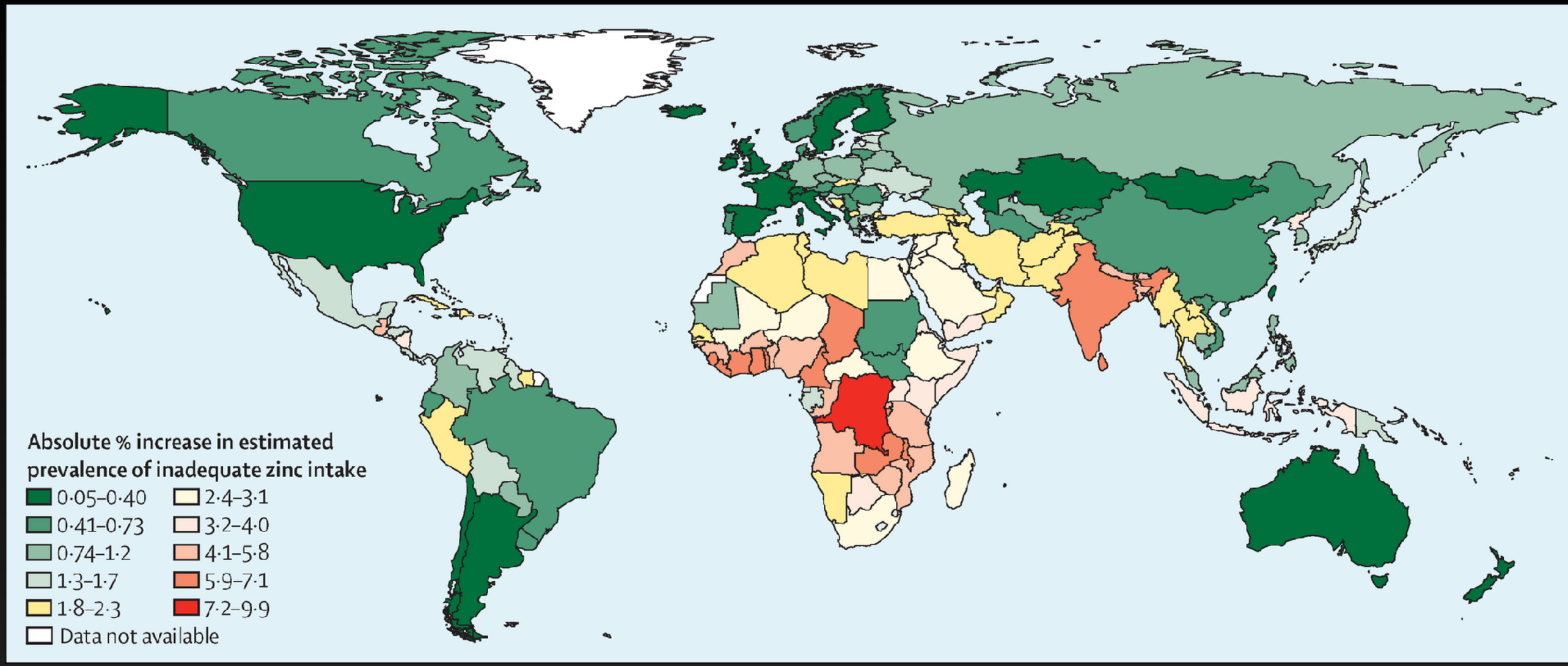
ENVIRONMENTREPORTS/FOODMATTERS

WHO PRODUCES WHAT?



DATA: HERRERO ET AL. 2017, LANCET PLANETARY HEALTH
GRAPHIC: ENVIRONMENTREPORTS/FOODMATTERS

ELEVATED CO_2 REDUCES ZINC, IRON, PROTEIN CONTENT



MYERS ET AL. 2015. LANCET GLOBAL HEALTH

Image: NASA, ASTER Science Team

Seeds of Success

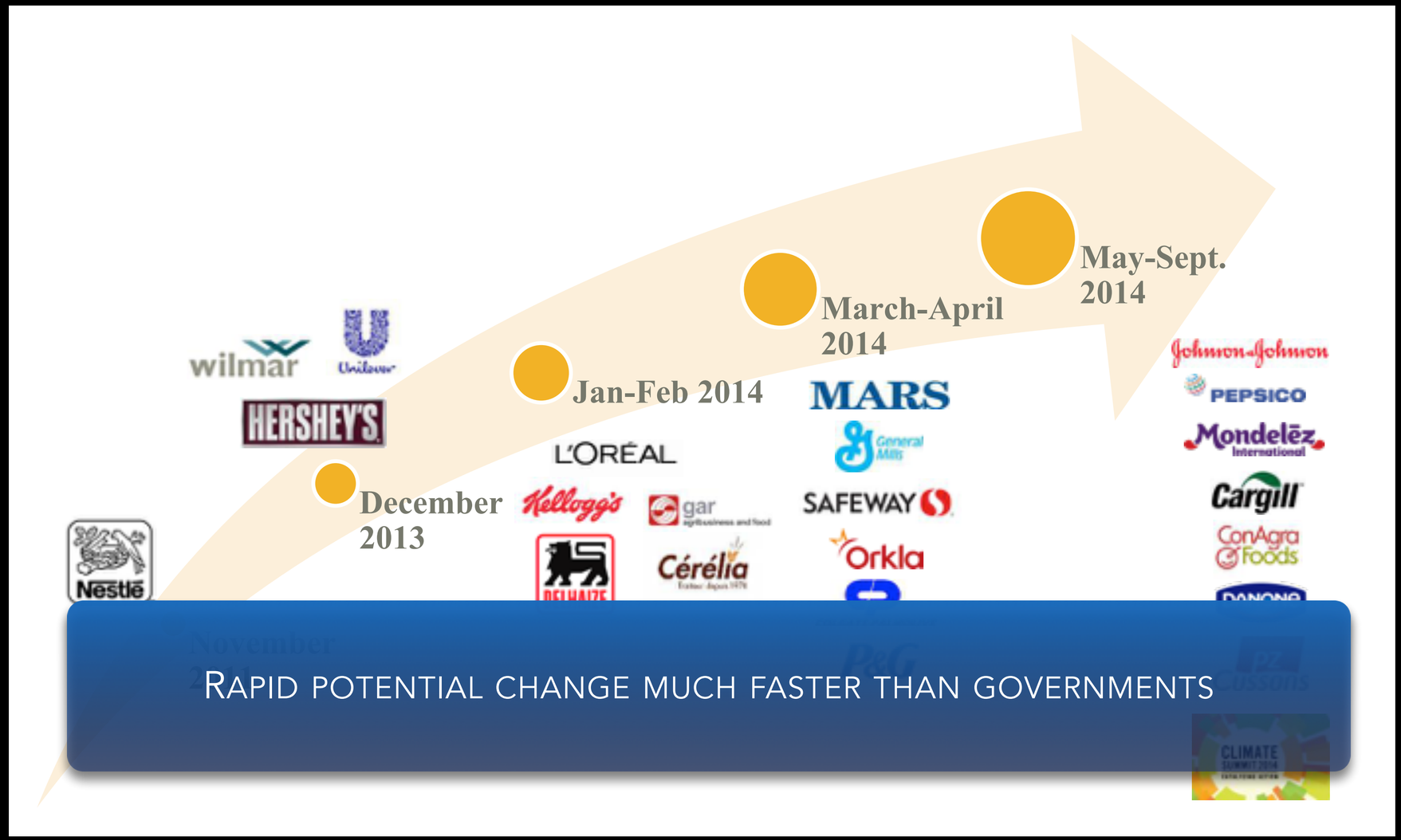
Photo: Neil Palmer / CIAT
Creative Commons v2.0, 2009

PRECISION FARMING

PROMOTING COVER CROPS, CONSERVATION TILLAGE, & NUTRIENT MANAGEMENT
HIGHER YIELDS IN DROUGHT & GOOD WEATHER

IMAGE: UNITED SOYBEAN BOARD

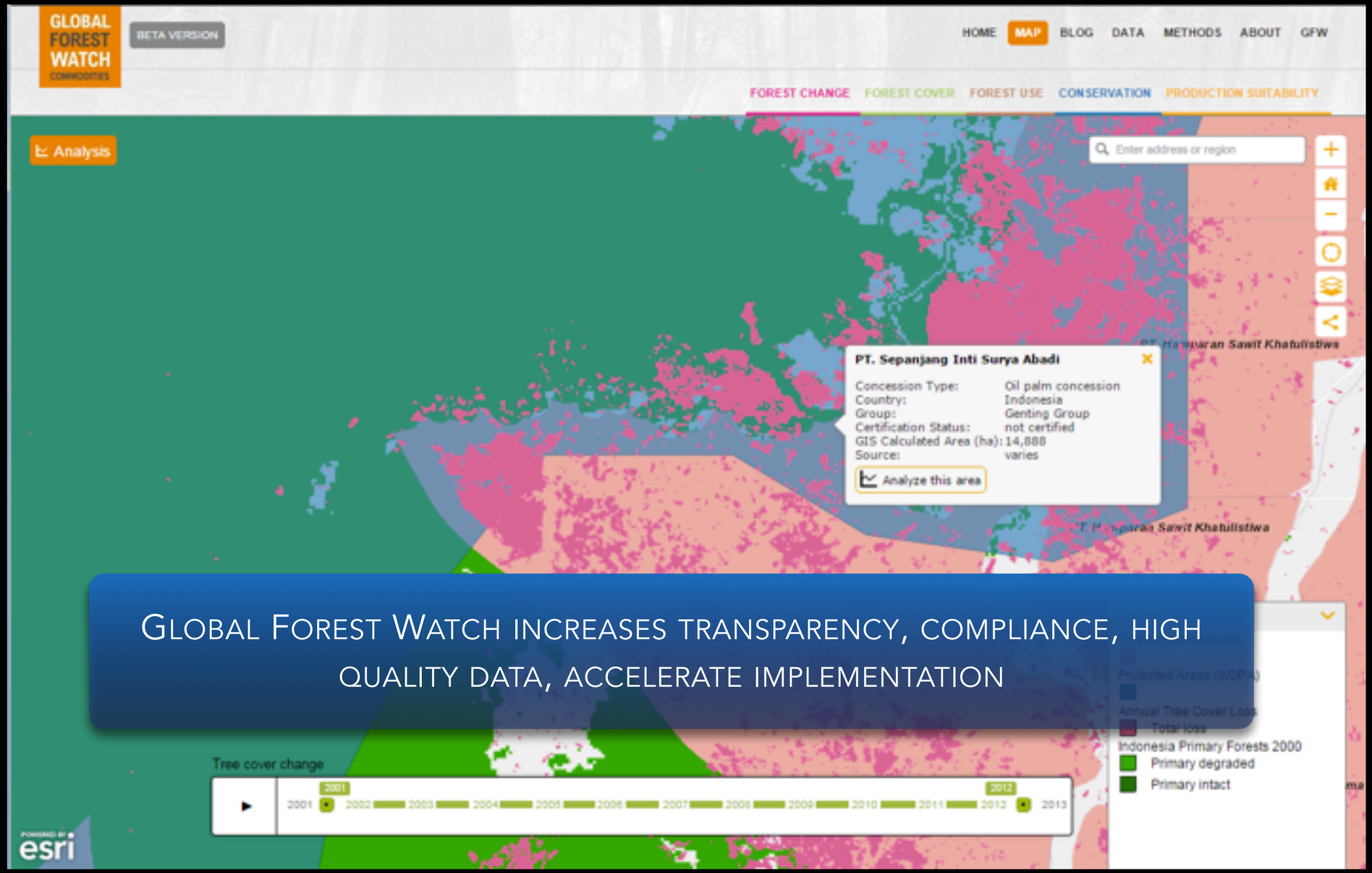
Zero deforestation commitments: oil palm



Data from: CLUA 2014

Slide courtesy of WRI

Monitoring effectiveness



Global Forest Watch, World Resources Institute

Climate Adaptation: Kenya

Increasing yields / Reducing loss through investing drought tolerant, fast maturing varieties, soil health, & knowledge networks

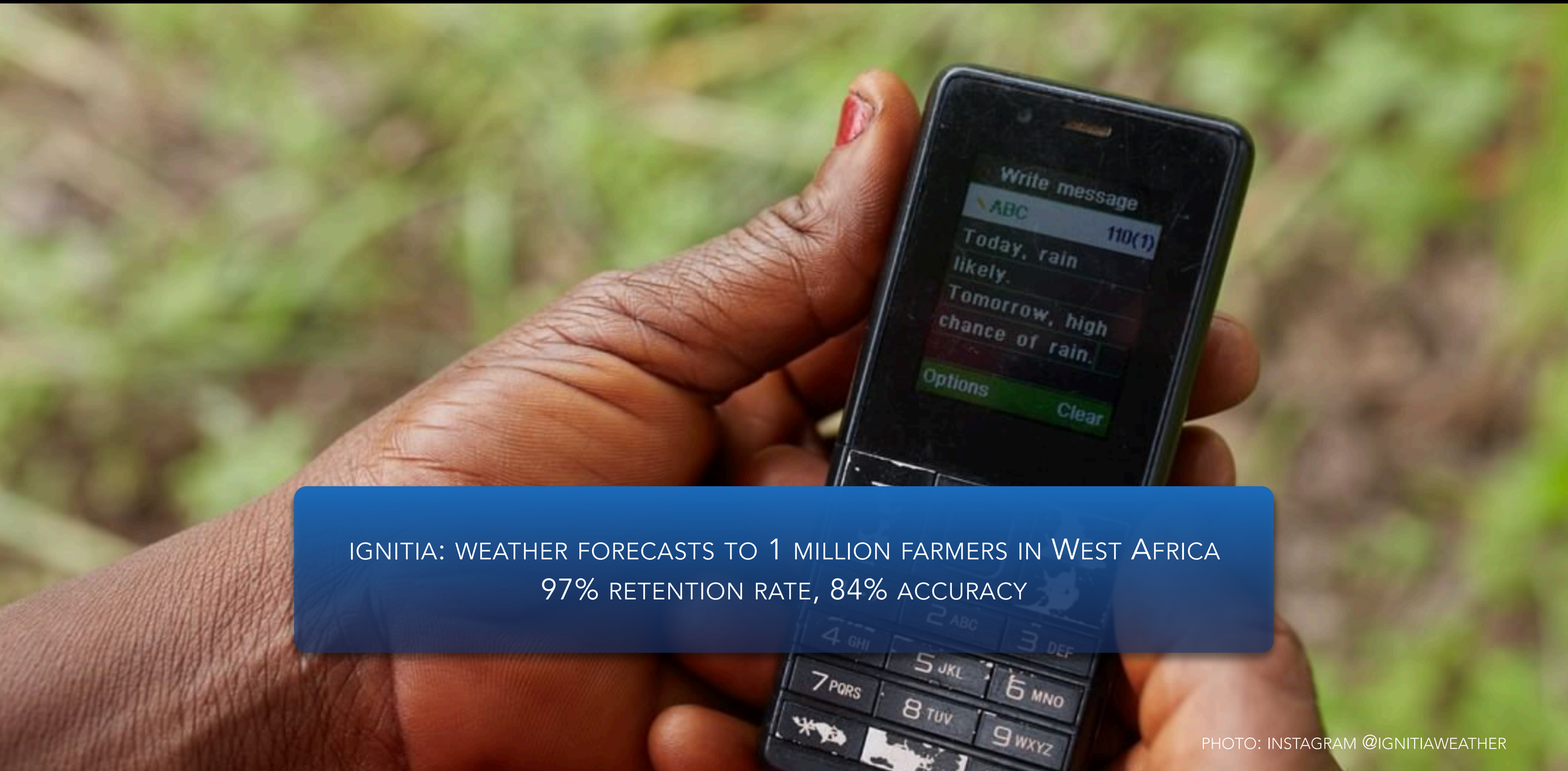
S.Kilungu /CCAFS 2015

Empowering smallholders: One Acre Fund

Access to credit, seeds, fertilizer, & knowledge

615,000+ farming families served, ~65% gain in farmer income

Climate Adaptation: data access



IGNITIA: WEATHER FORECASTS TO 1 MILLION FARMERS IN WEST AFRICA
97% RETENTION RATE, 84% ACCURACY

PHOTO: INSTAGRAM @IGNITIAWEATHER

Climate Adaptation: India

Direct seeding, modified rice intensification, wetting/drying = higher yields, reduced labor, 40% water savings

Rapid adoption: during 2012 drought, direct seeding increased from 200ha to 35,000has

source: CCAFS blog

Photo: Michael Foley
Creative Commons, 2008

Is Climate Change a Risk to Global Grazing Lands?

Continue reading

Thank You

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