Pests and diseases data in the context of yield gaps – the Global Yield Gap Atlas

Martin van Ittersum – Plant Production Systems group

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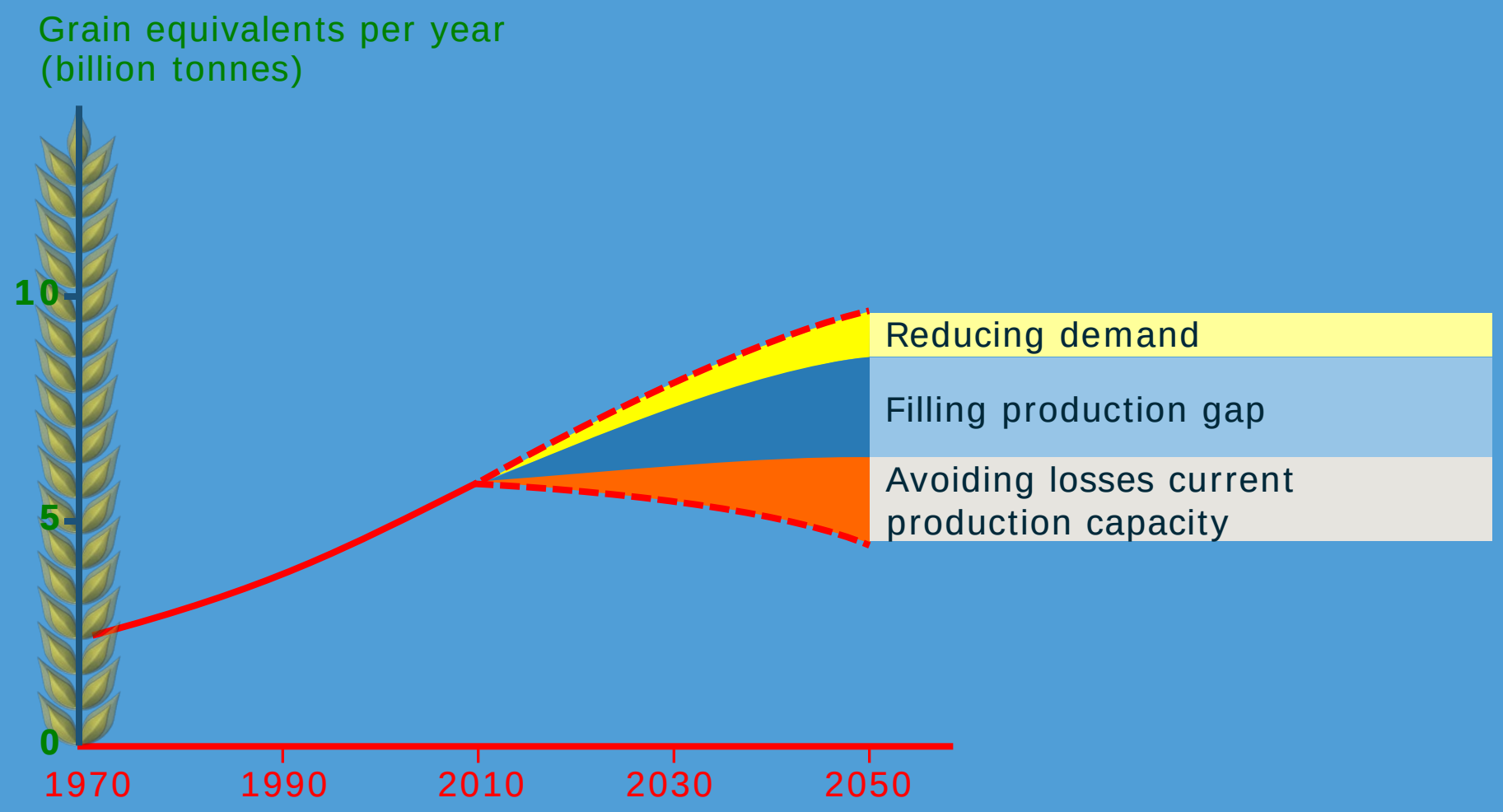
Towards 2050: Pathways to increase availability

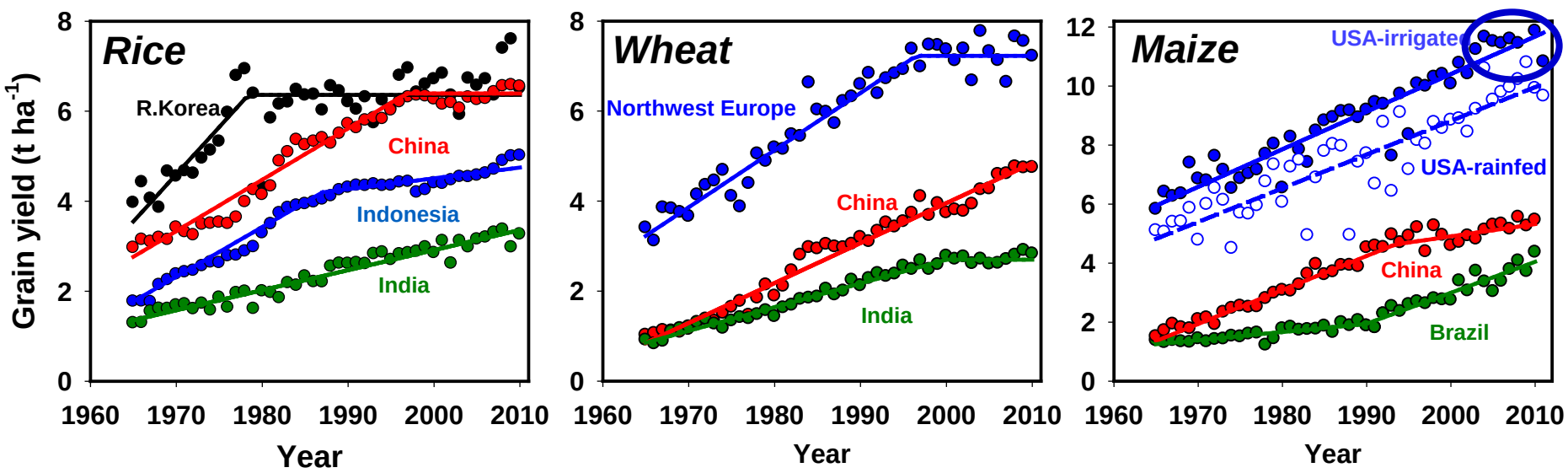


after Keating et al., 2014. Global Food Security

The need for extra food is very region-specific

So, it is crucial to know where production can be increased and how

Slack in cereal yield increases?



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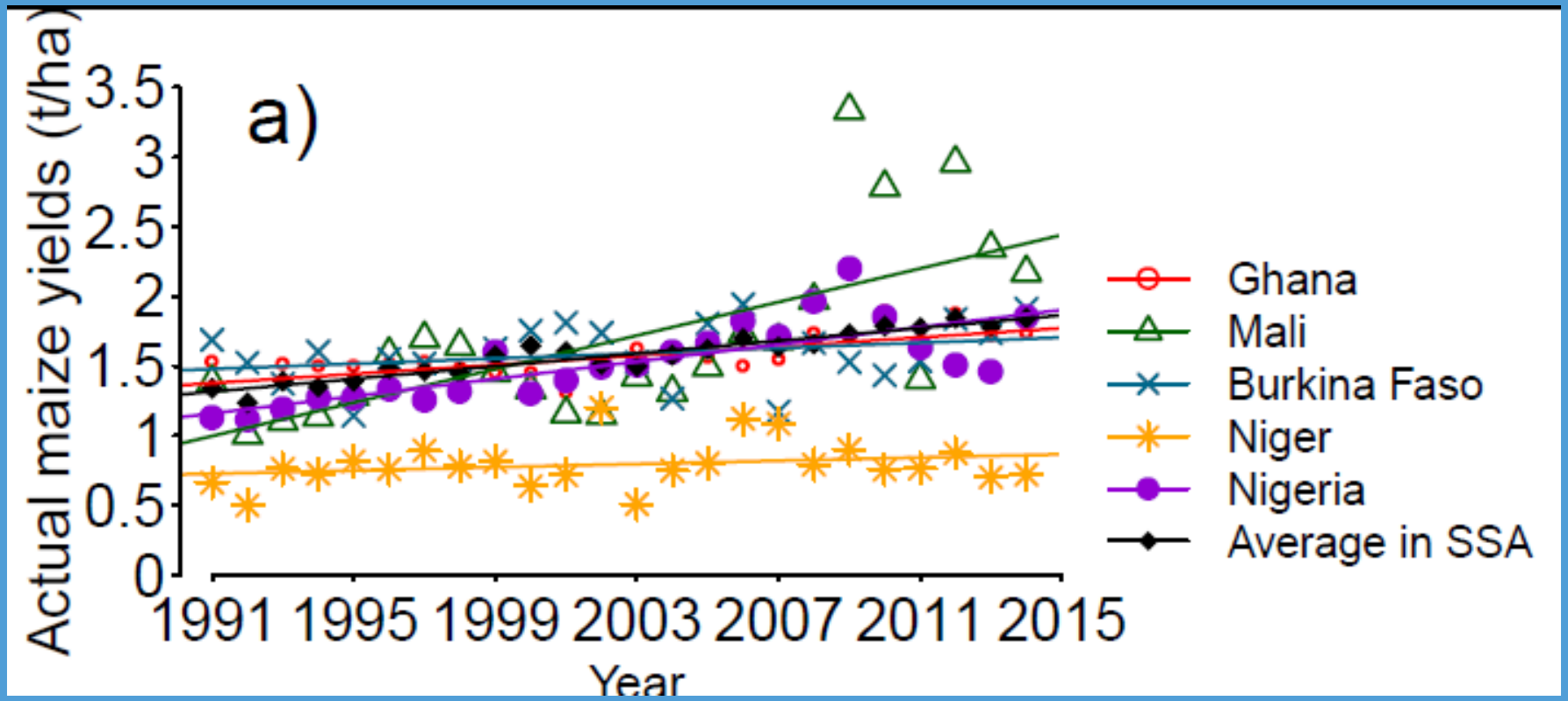
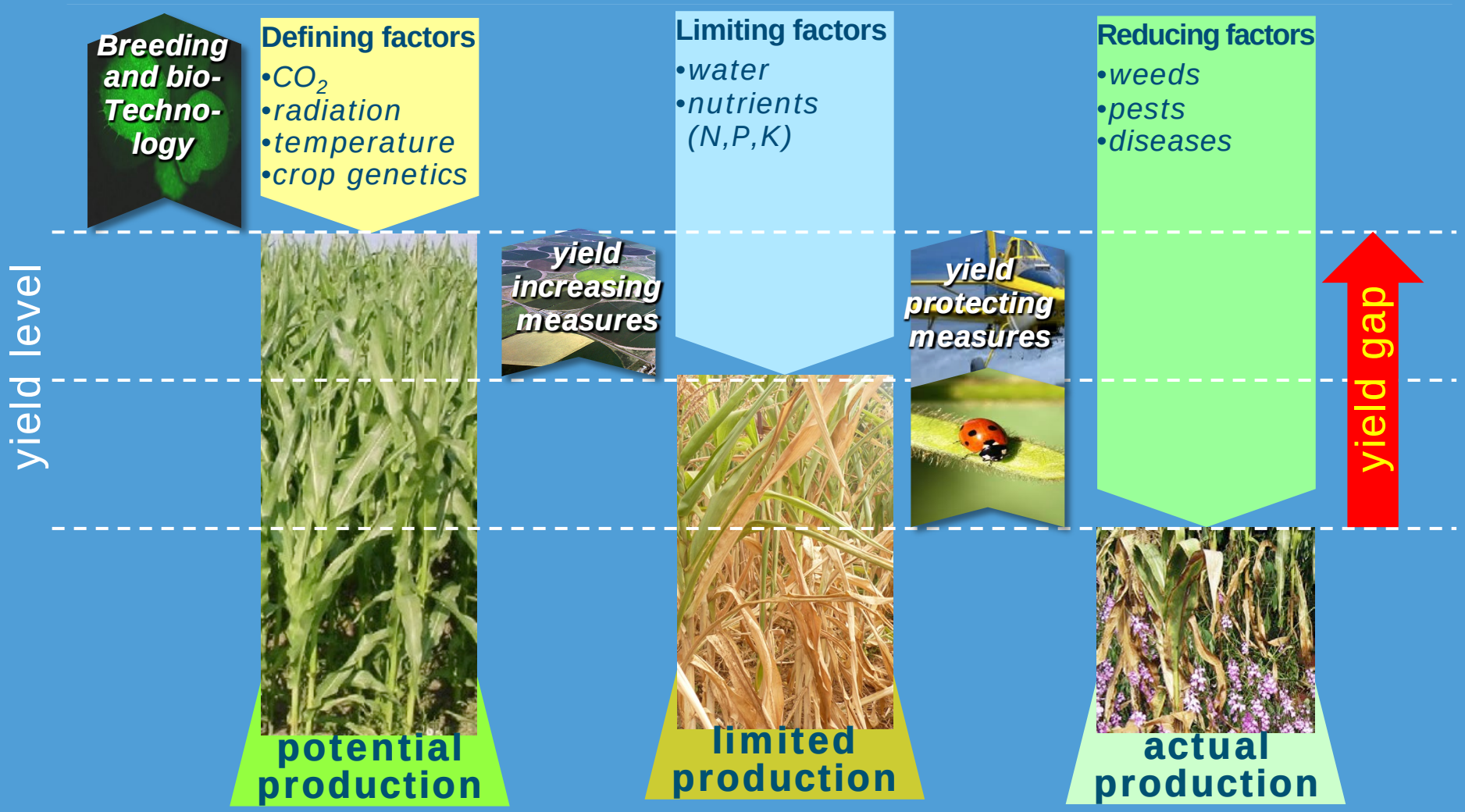
Cassman, 1999; Cassman et al., 2010; Grassini et al., 2011

Slack in cereal yield increases?



FAO and Van Ittersum et al., 2016

Production-ecological principles & practice



PRODUCTION SITUATION

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Van Ittersum and Rabbinge, 1997
Slide: Harrie Lovenstein

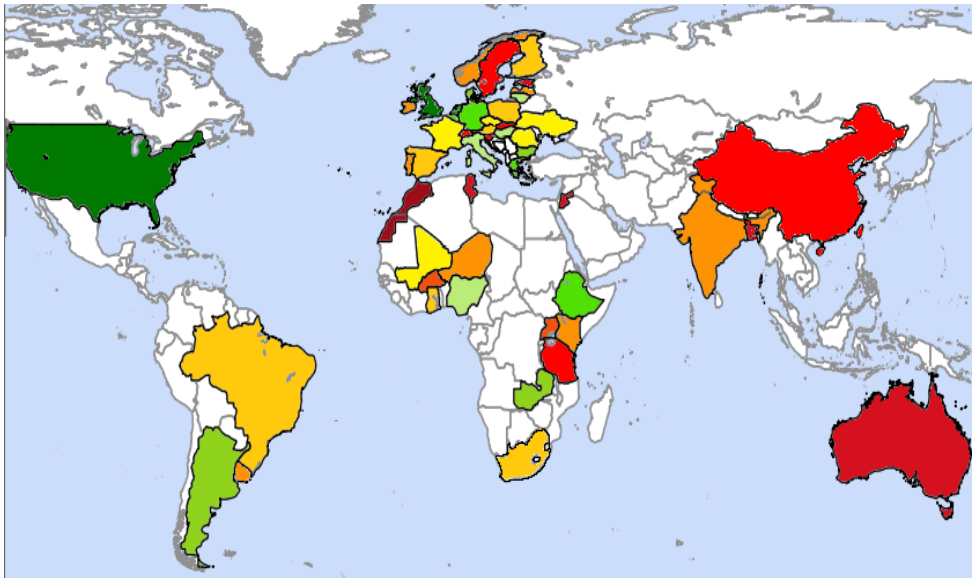
Yield gap analysis

Photo: Ken Giller

Global Yield Gap Atlas

Global Yield Gap Atlas

With University of Nebraska, ICRISAT, AfricaRice, CIMMYT and many regional and national partners



- Major food crops in the world
- Global protocol with local application
- Local data and evaluation
- Strong agronomic foundation

www.yieldgap.org

- Co-financed by Bill and Melinda Gates Foundation

Global Yield Gap Atlas

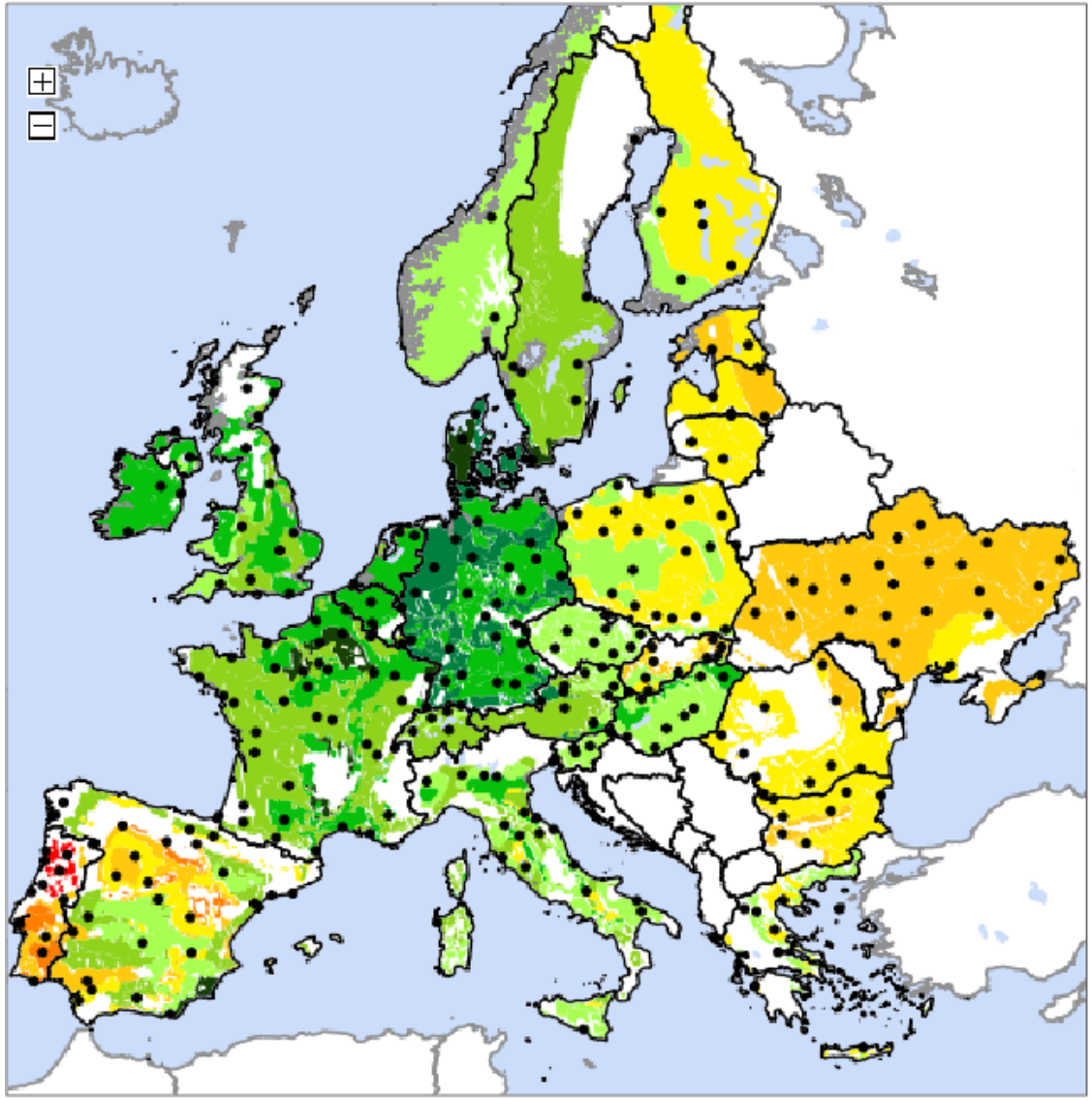
Global coverage thus far (> 50 countries)

Crop	% of global area	% of global production	
Rice	57	60	
Maize	72	82	
Wheat	39	45	

Global Yield Gap Atlas

Yield and supporting data for rainfed wheat

Rainfed wheat



Yields | Map layers

Select crop :

Rainfed wheat

Select aggregation level:

Climate zones

Select yield indicator:

- Relative yield: Ya / Yw x 100%

Select variable:

Mean value

Apply SPAM2005 crop mask: No Yes

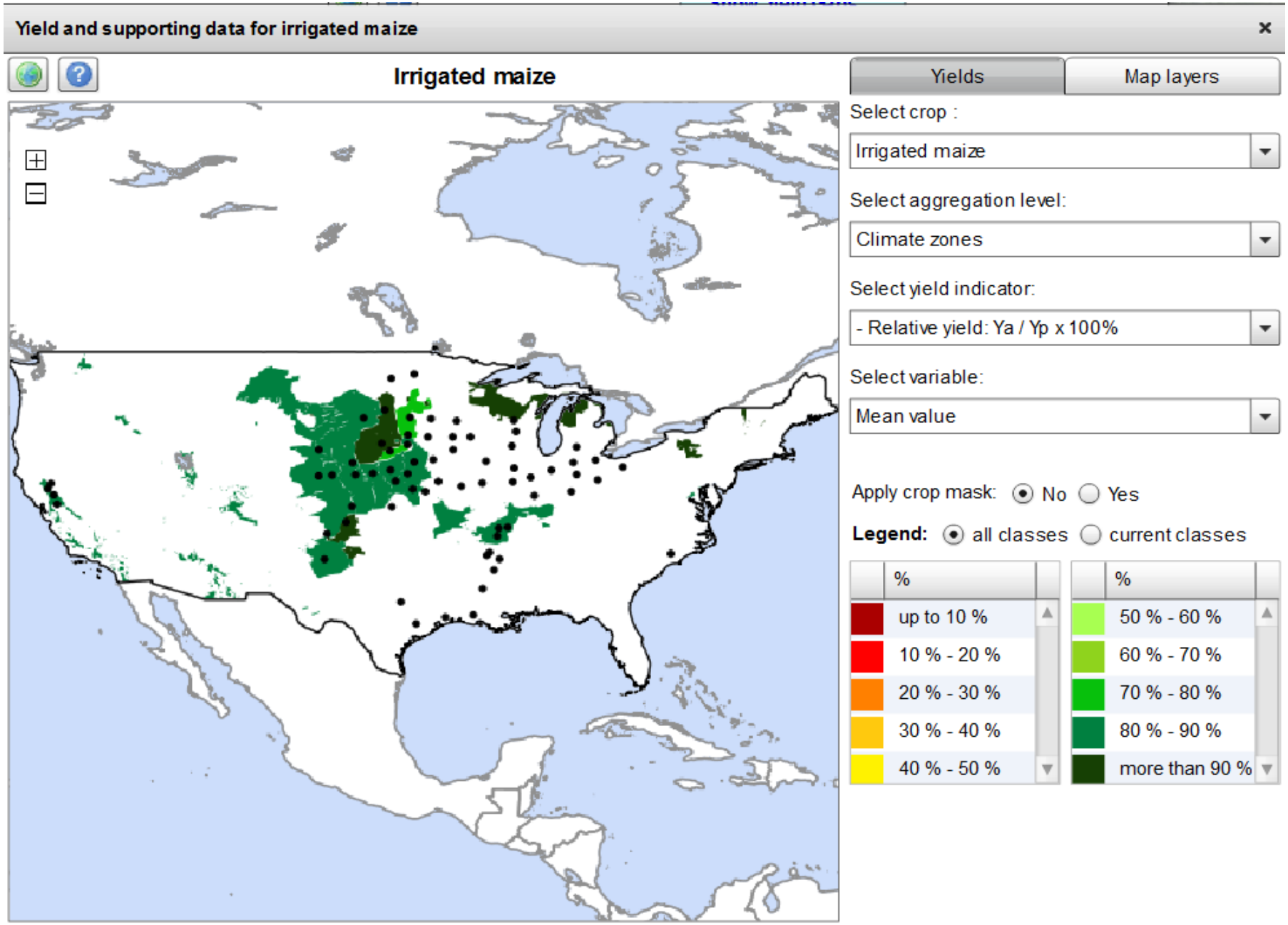
Legend: all classes current classes

%	%
up to 10 %	50 % - 60 %
10 % - 20 %	60 % - 70 %
20 % - 30 %	70 % - 80 %
30 % - 40 %	80 % - 90 %
40 % - 50 %	more than 90 %

To view data details: Click on the map.

www.yieldgap.org

Global Yield Gap Atlas

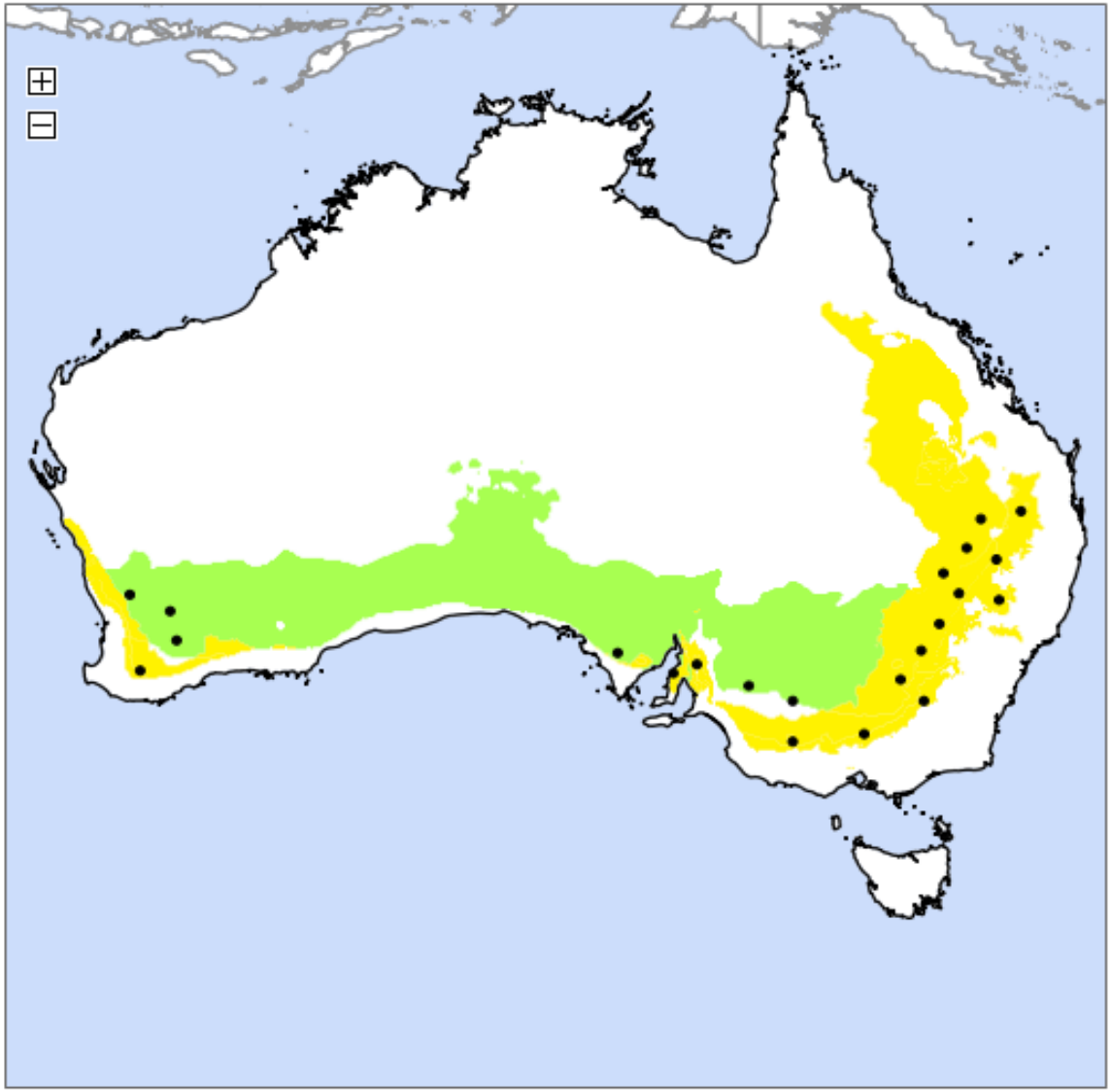


www.yieldgap.org

Global Yield Gap Atlas

Yield and supporting data for rainfed wheat

Rainfed wheat



Yields | Map layers

Select crop :

Rainfed wheat

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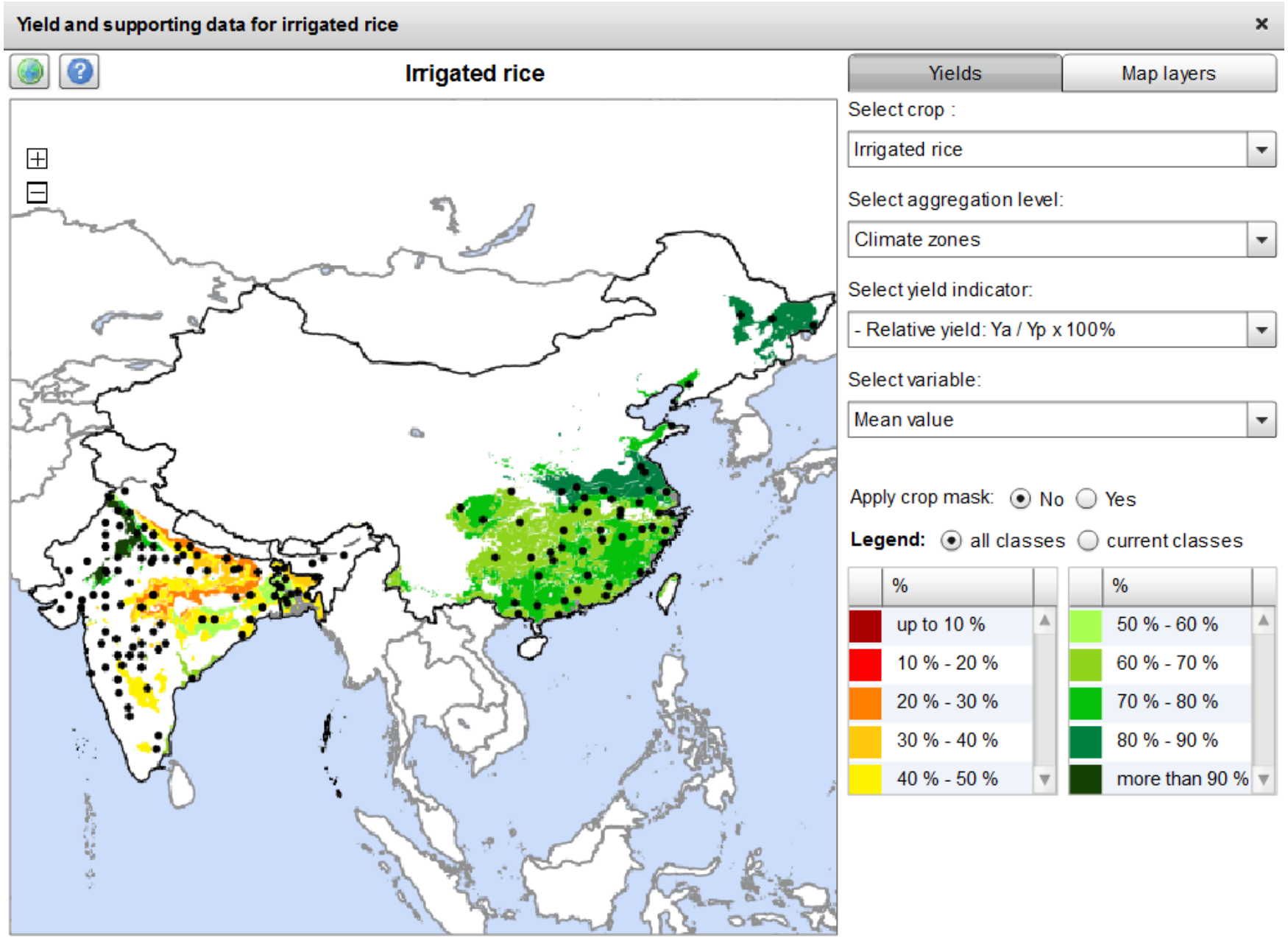
www.yieldgap.org

Global Yield Gap Atlas

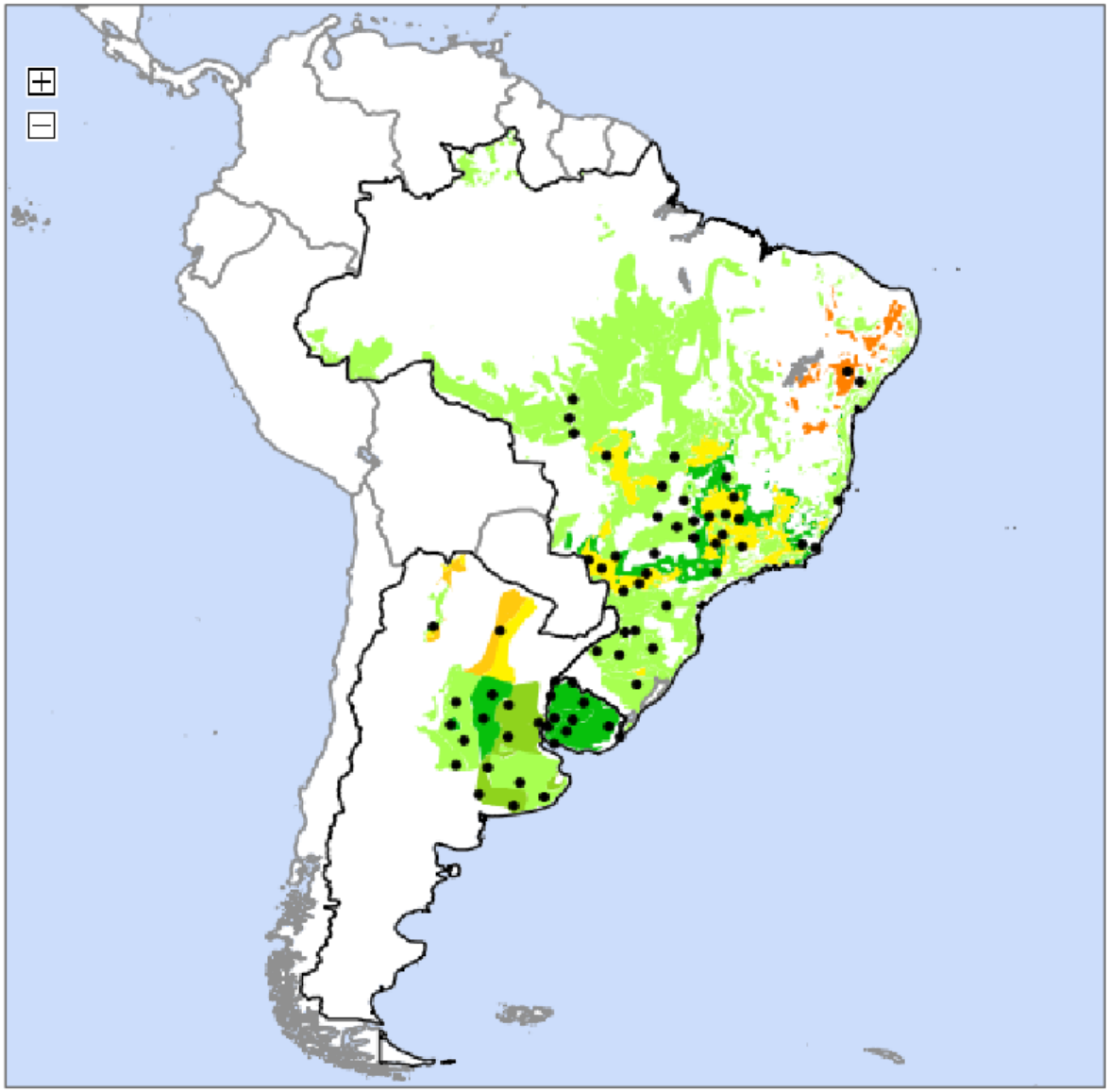


www.yieldgap.org

Global Yield Gap Atlas

Yield and supporting data for rainfed maize

Rainfed maize



Yields | Map layers

Select crop :

Rainfed maize

Select aggregation level:

Climate zones

Select yield indicator:

- Relative yield: Ya / Yw x 100%

Select variable:

Mean value

Apply crop mask: No Yes

Legend: all classes current classes

%	%
up to 10 %	50 % - 60 %
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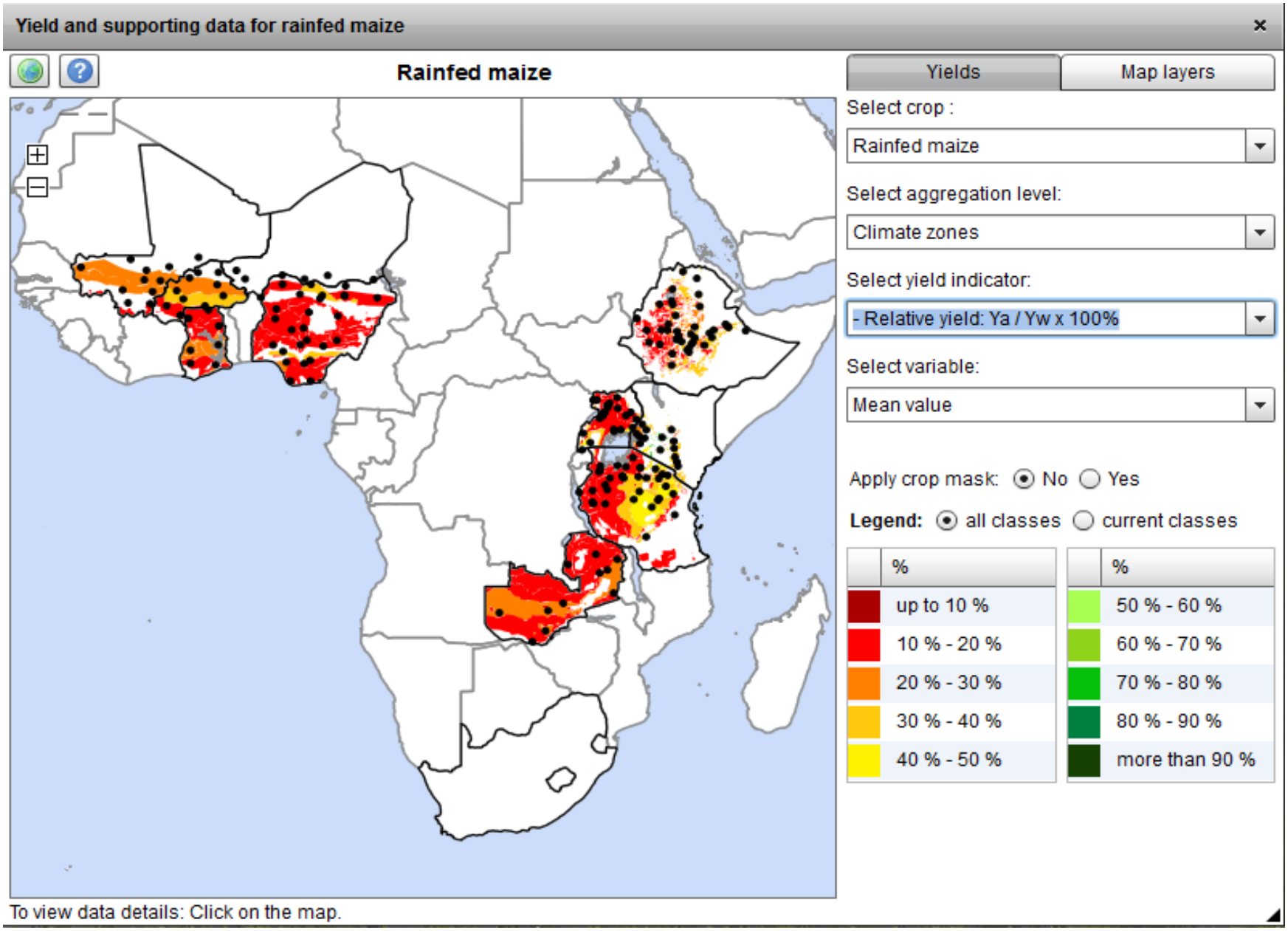
40 % - 50 %	more than 90 %

www.yieldgap.org

Global Yield Gap Atlas



www.yieldgap.org

Global Yield Gap Atlas

Applications

1. Food security analyses
2. Ex-ante (and ex-post) impact assessment
3. Biophysical factors explaining yield gaps (and RUE)
   a) Water
   b) Nutrients
   c) Pests and diseases?
4. Explaining yield gaps from an integrated perspective and identify interventions

Global Yield Gap Atlas

Global Yield Gap Atlas

1. Can sub-Saharan Africa feed itself?

Martin van Ittersum, Lenny van Bussel – Plant Production Systems group
Patricio Grassini, Ken Cassman – University of Nebraska-Lincoln
GYGA team, including ten country agronomists from SSA

PNAS14964–14969 | PNAS | December 27, 2016 | vol. 113 | no. 52

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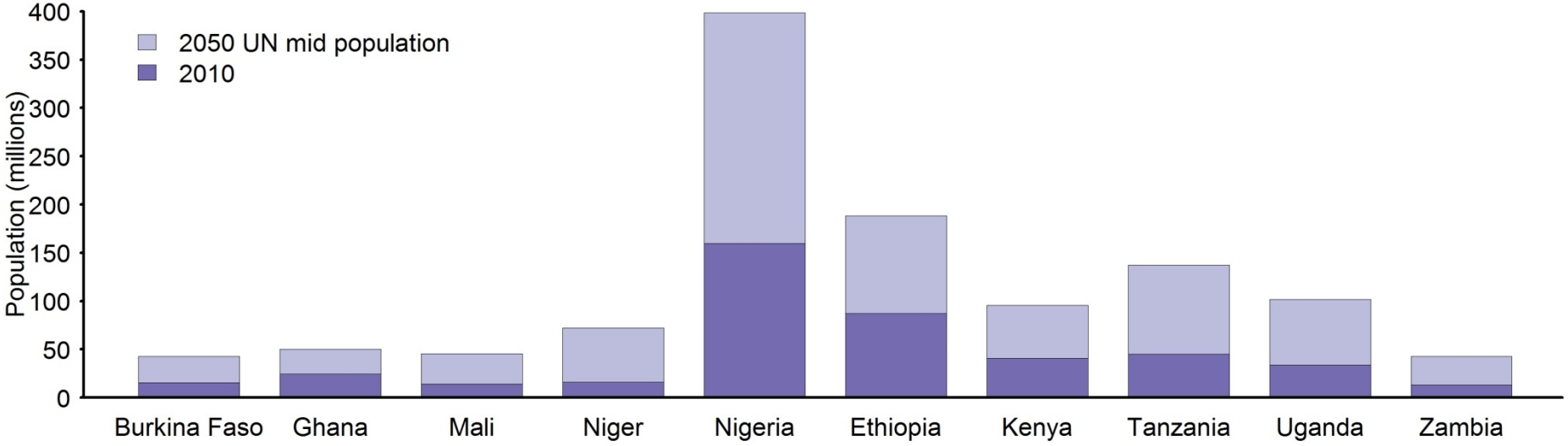
Growth in population and cereal demand - 2050

Country	Population 2010 (million)	Population 2050 (million)	% Population increase
Burkina Faso	16	41	256
Ghana	24	46	192
Mali	14	45	321
Niger	16	69	431
Nigeria	159	440	277
Ethiopia	87	188	216
Kenya	41	97	237
Tanzania	45	129	287
Uganda	33	104	315
Zambia	13	44	338

UN, 2012 and IMPACT, 2012 (and 2015)

Global Yield Gap Atlas

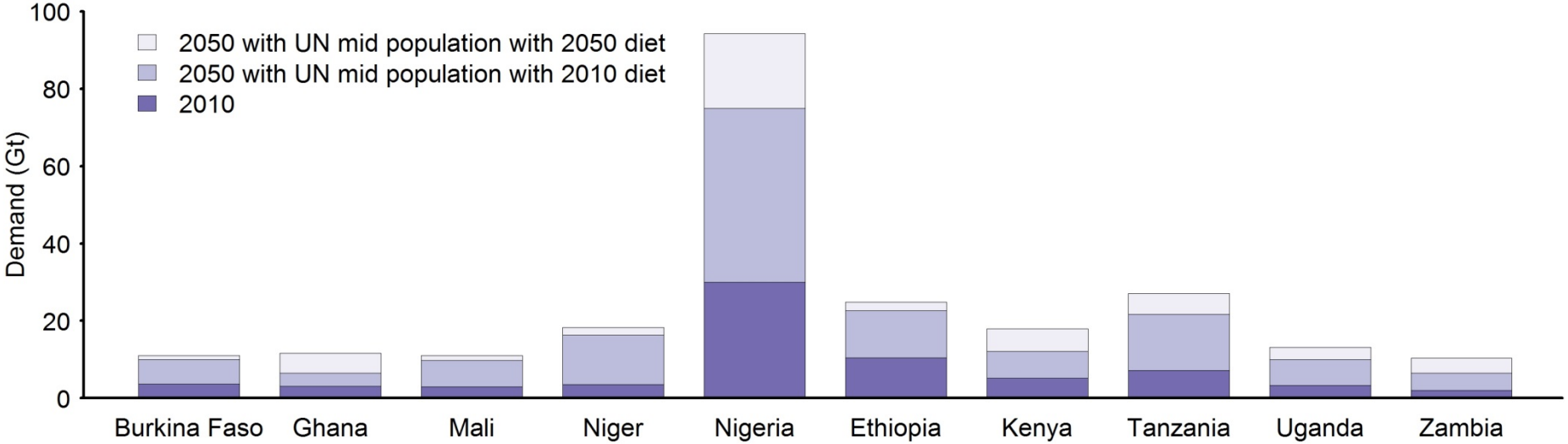
Growth in population 2050



From 0.45 to 1.2 billion (2.6 times)

Global Yield Gap Atlas

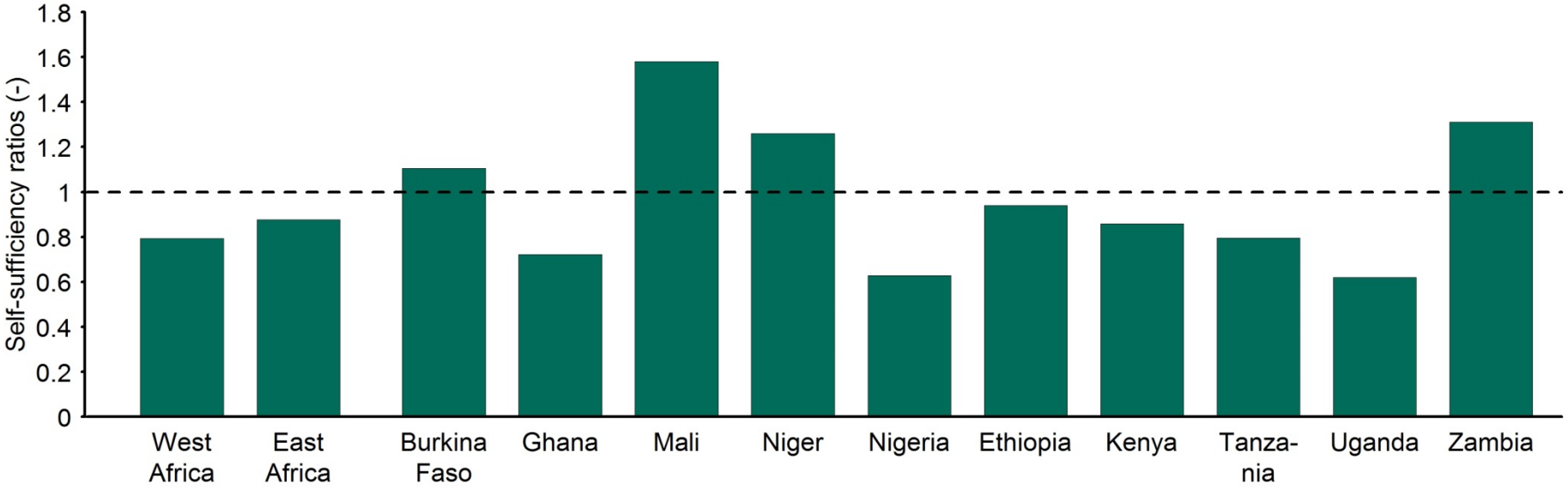
Growth in population and cereal demand - 2050



A factor 3.4 increase!

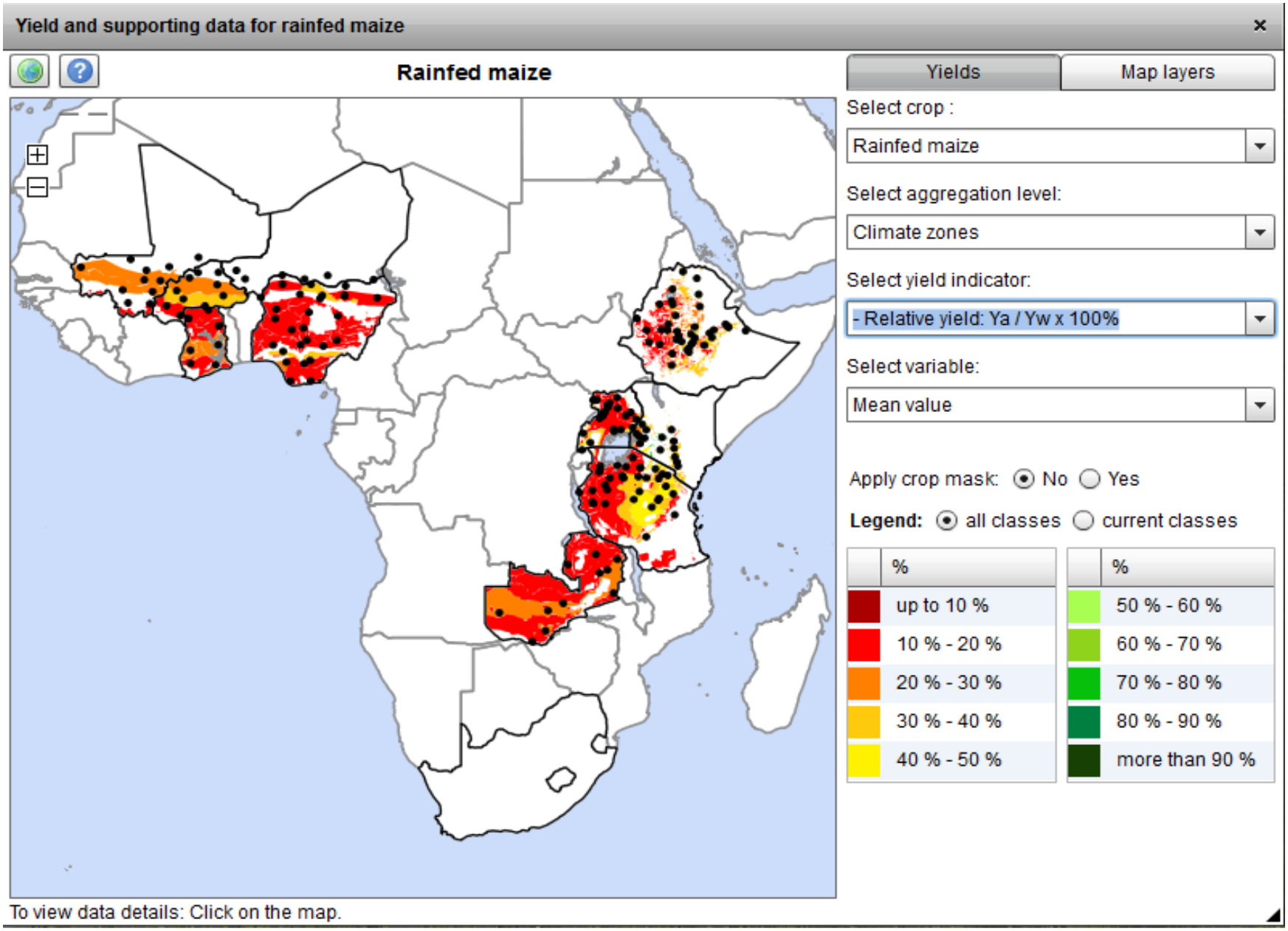
Global Yield Gap Atlas

Current self-sufficiency cereals SSA - 2010



Source: IMPACT model

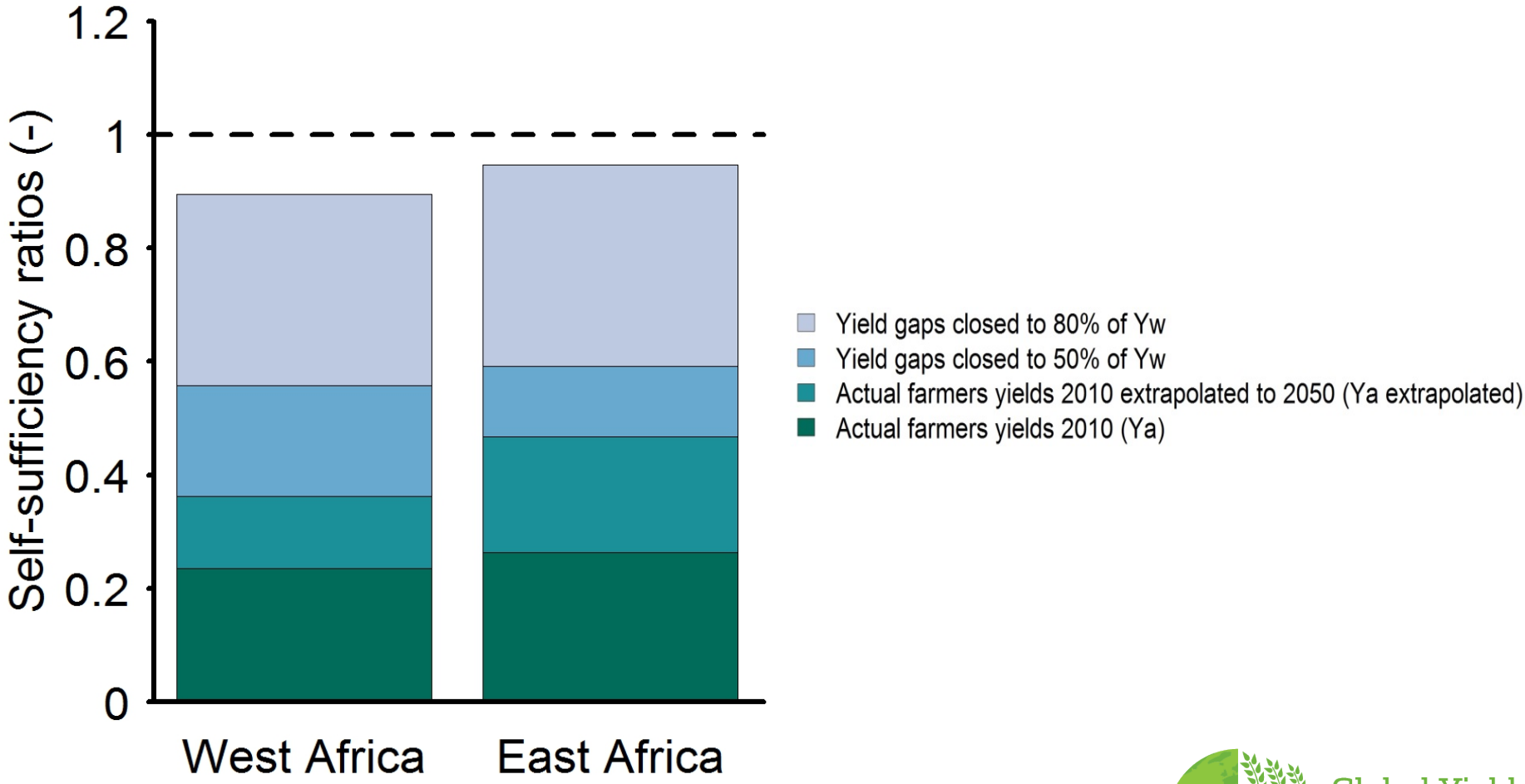
Global Yield Gap Atlas



www.yieldgap.org

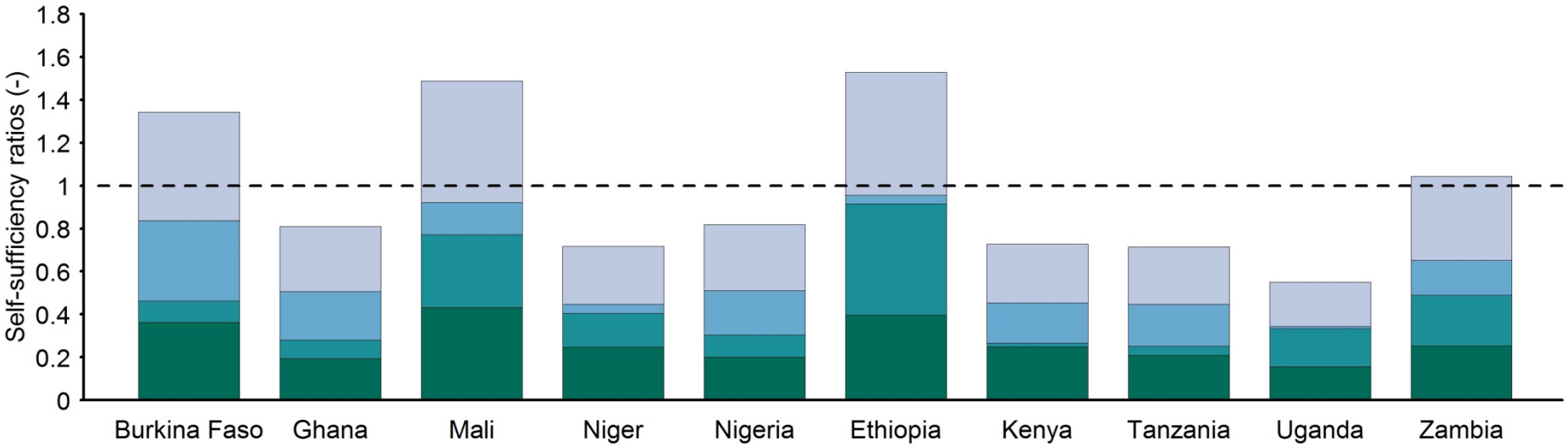
Global Yield Gap Atlas

West and East Africa aggregated



Global Yield Gap Atlas

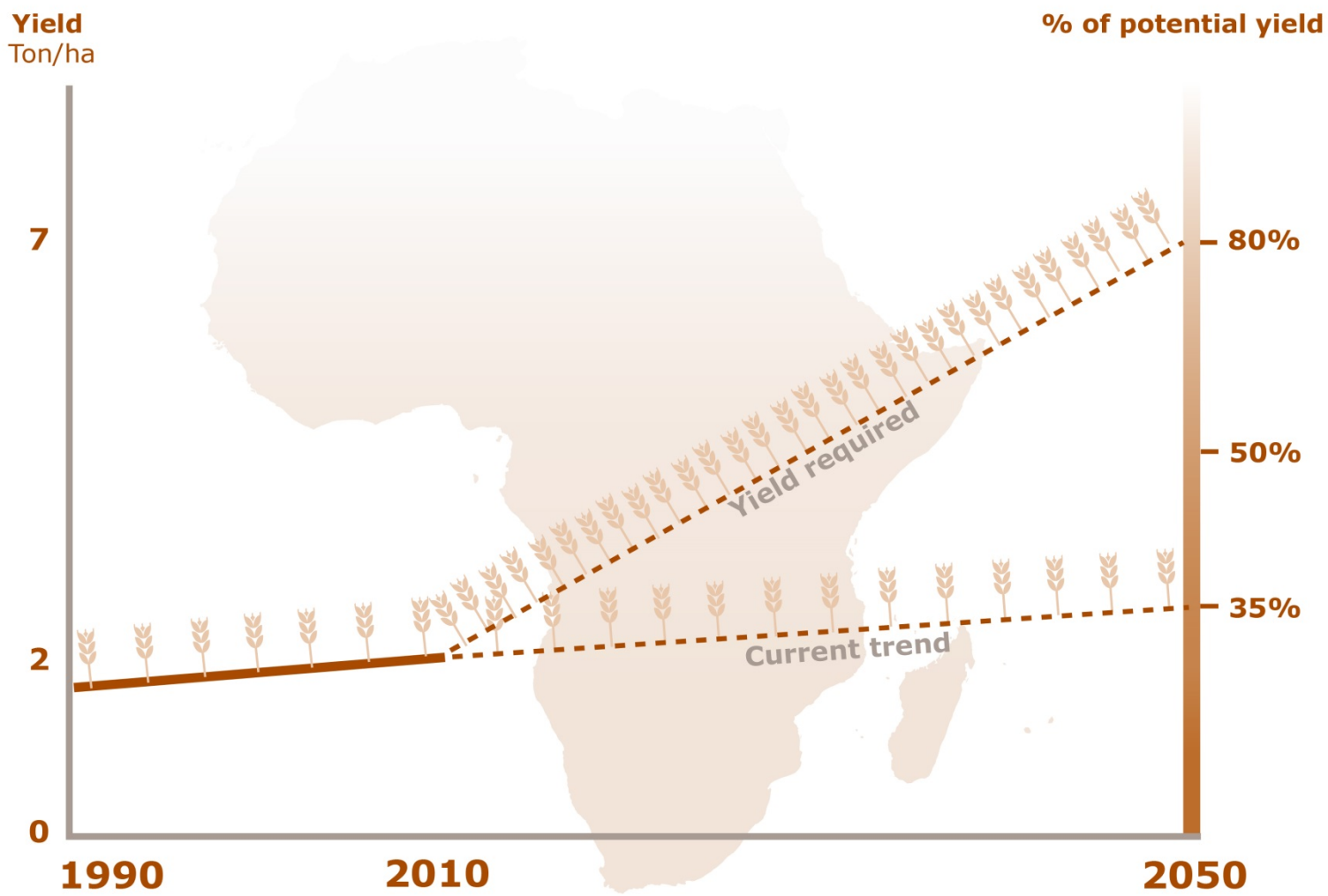
Self-sufficiency 2050: 10 countries



- Yield gaps closed to 80% of Yw
- Yield gaps closed to 50% of Yw
- Actual farmers yields 2010 extrapolated to 2050 (Ya extrapolated)
- Actual farmers yields 2010 (Ya)

Global Yield Gap Atlas

Food production in Africa in 2050



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Global Yield Gap Atlas

Historical maize yield increases (kg/ha/year)

Country	1961-1990	1991-2013
Argentina	68	131
Brazil	25	122
China	107	56
Ethiopia	n.a.	79
France	130	61
Ghana	0.7	17
India	15	48
Indonesia	43	130
Kenya	26	6
Nigeria	21	39
Spain	168	196
USA	112	111

FAOSTAT

Global Yield Gap Atlas

If a successful intensification is not achieved ....

The consequences in terms of:

- cereal self-sufficiency and/or
- area expansion (GHG, biodiversity!)

will be huge!

Global Yield Gap Atlas

Global Yield Gap Atlas

2. Yield gap analysis for impact assessment?

van Oort, Saito, Dieng, Grassini, Cassman, van Ittersum, 2017. Global Food Security, 12, 109-118.

Rattalino Edreira, Cassman, Hochman, van Ittersum, van Bussel, Claessens, Grassini. Env. Res. Letters, under review

Guilpart, Grassini, van Wart, Haishun, van Ittersum, van Bussel, Wolf, Claessens, Leenaars and Cassman. Env. Res. Letters, in press

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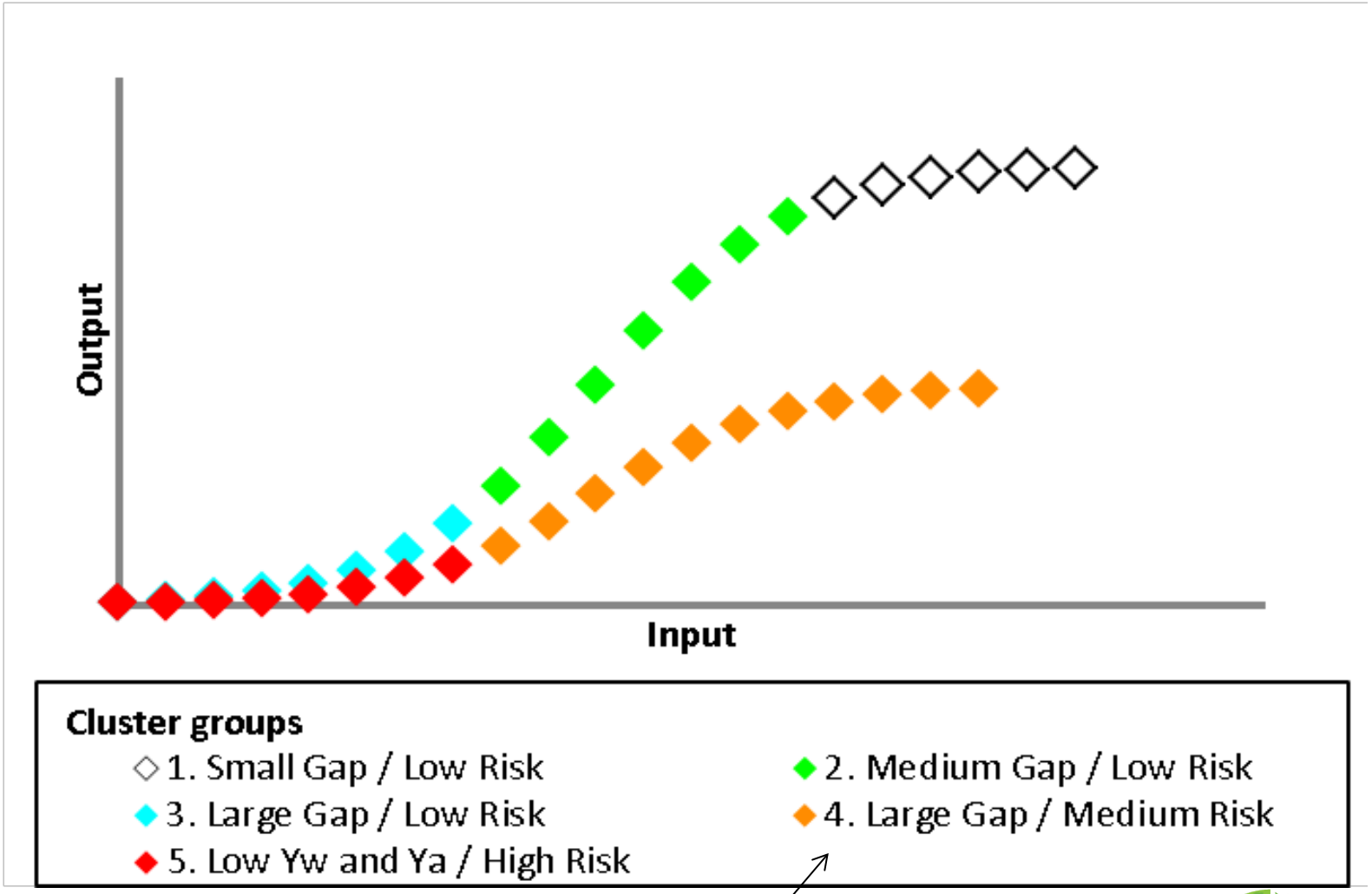
Critique yield gap analysis

- How to translate yield gaps into meaningful policy recommendations? (Sumberg, 2012)
  - Economic perspective: return on investment
  - Humanitarian perspective: food security

Global Yield Gap Atlas

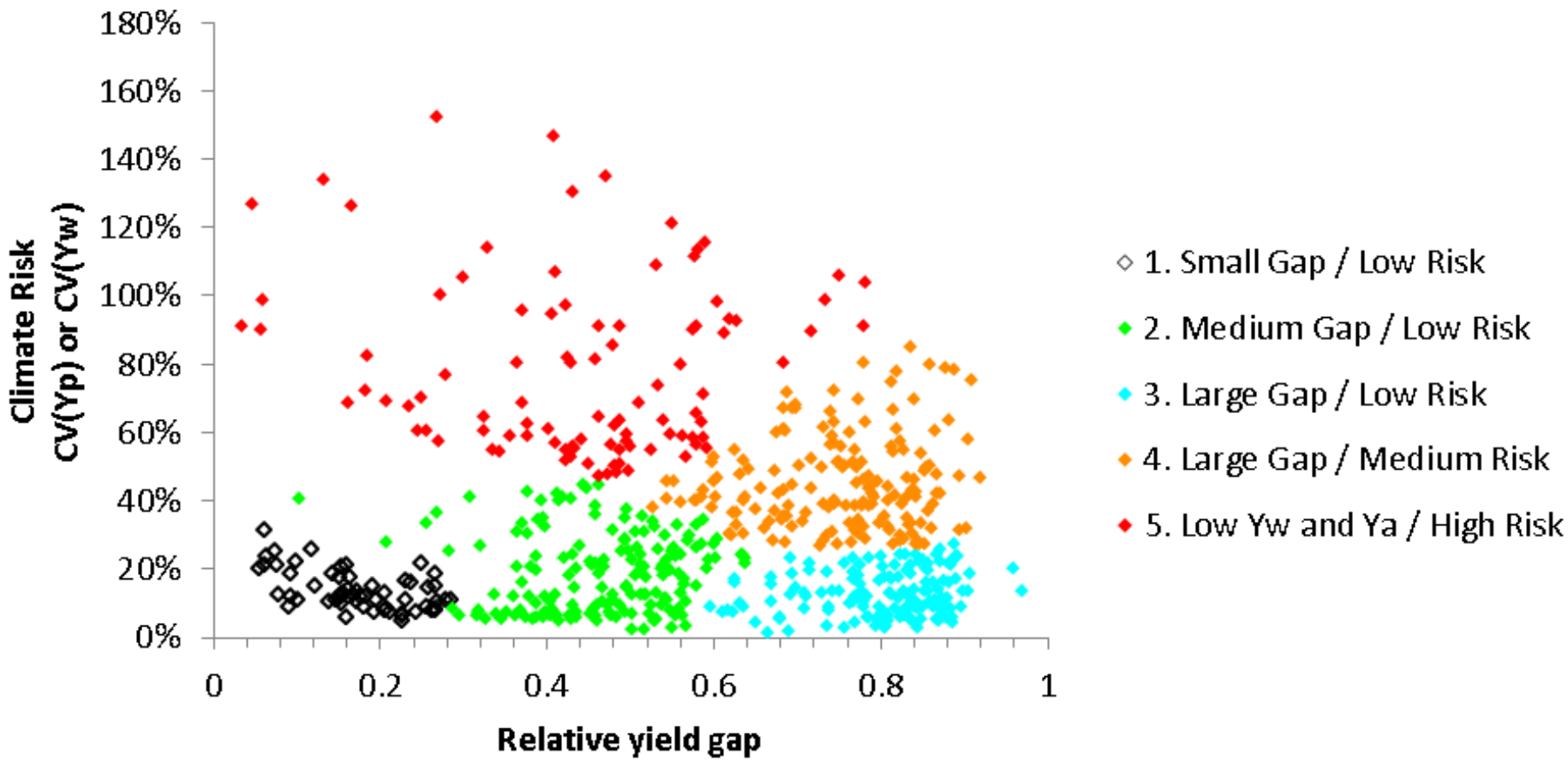
Five classes of relative yields and risk (% CV Yw)



Biggest bang for the buck: green and orange

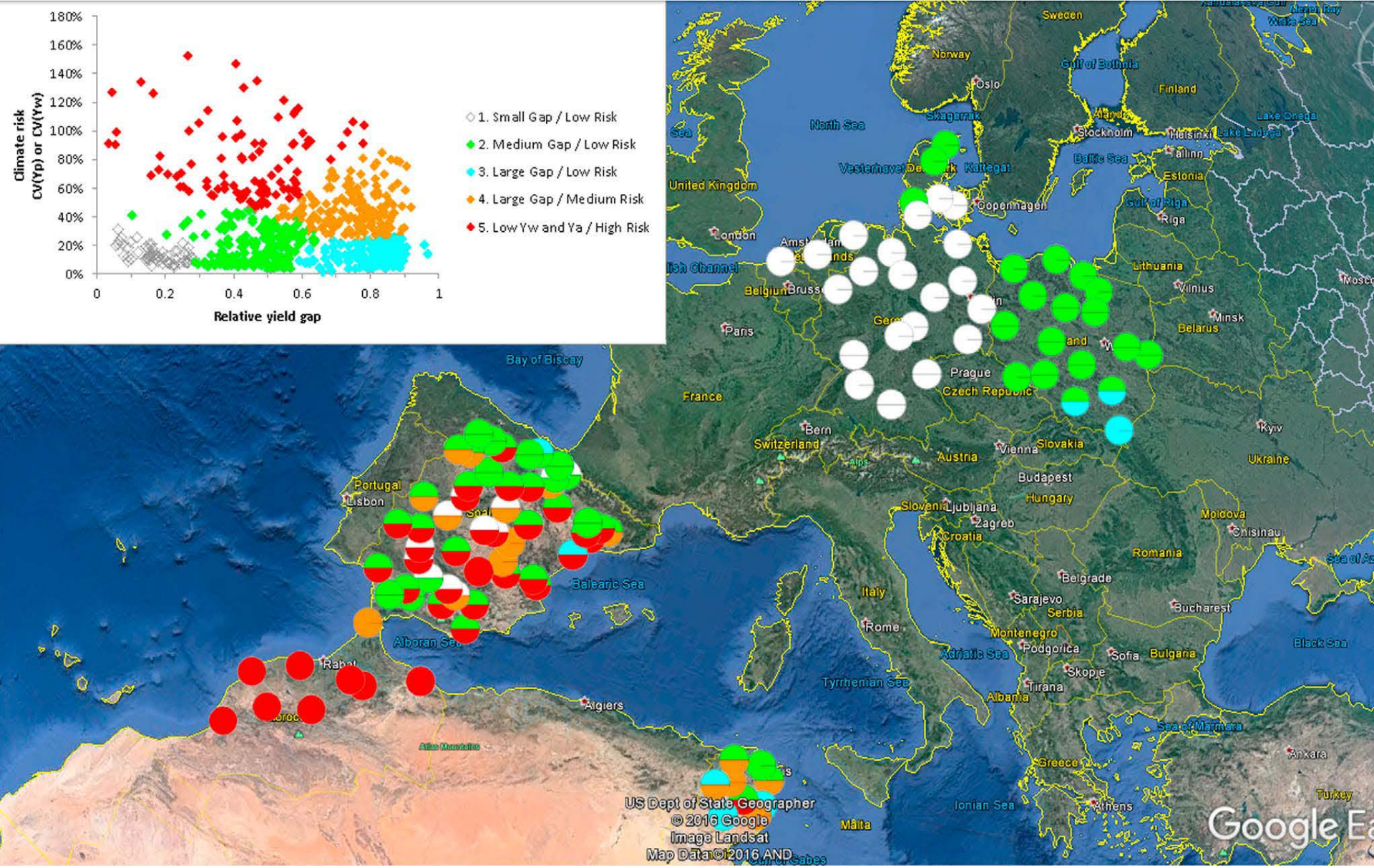
Global Yield Gap Atlas

Five clusters of GYGA data (November 2015)

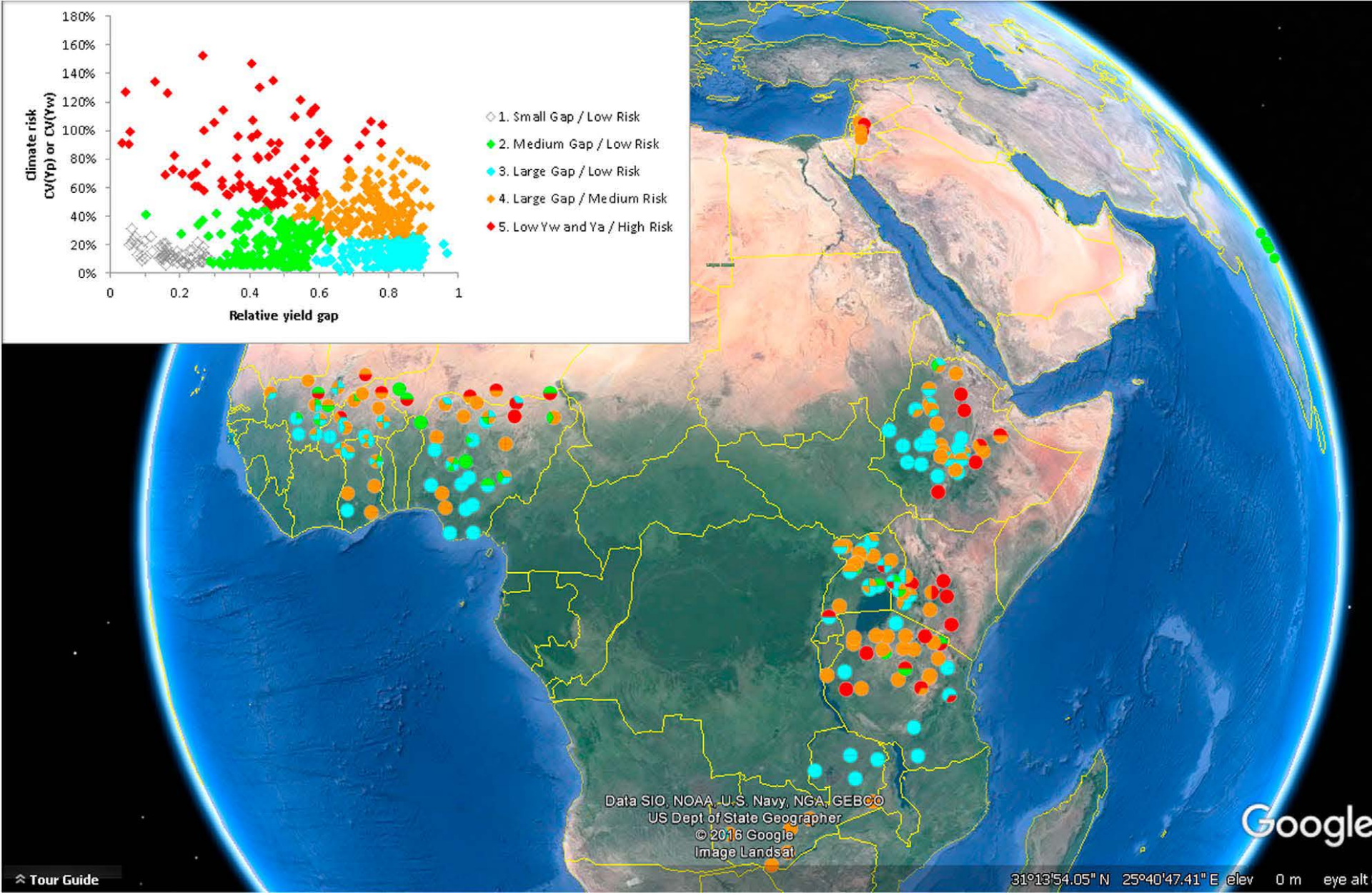


Biggest bang for the buck: green and orange

Global Yield Gap Atlas

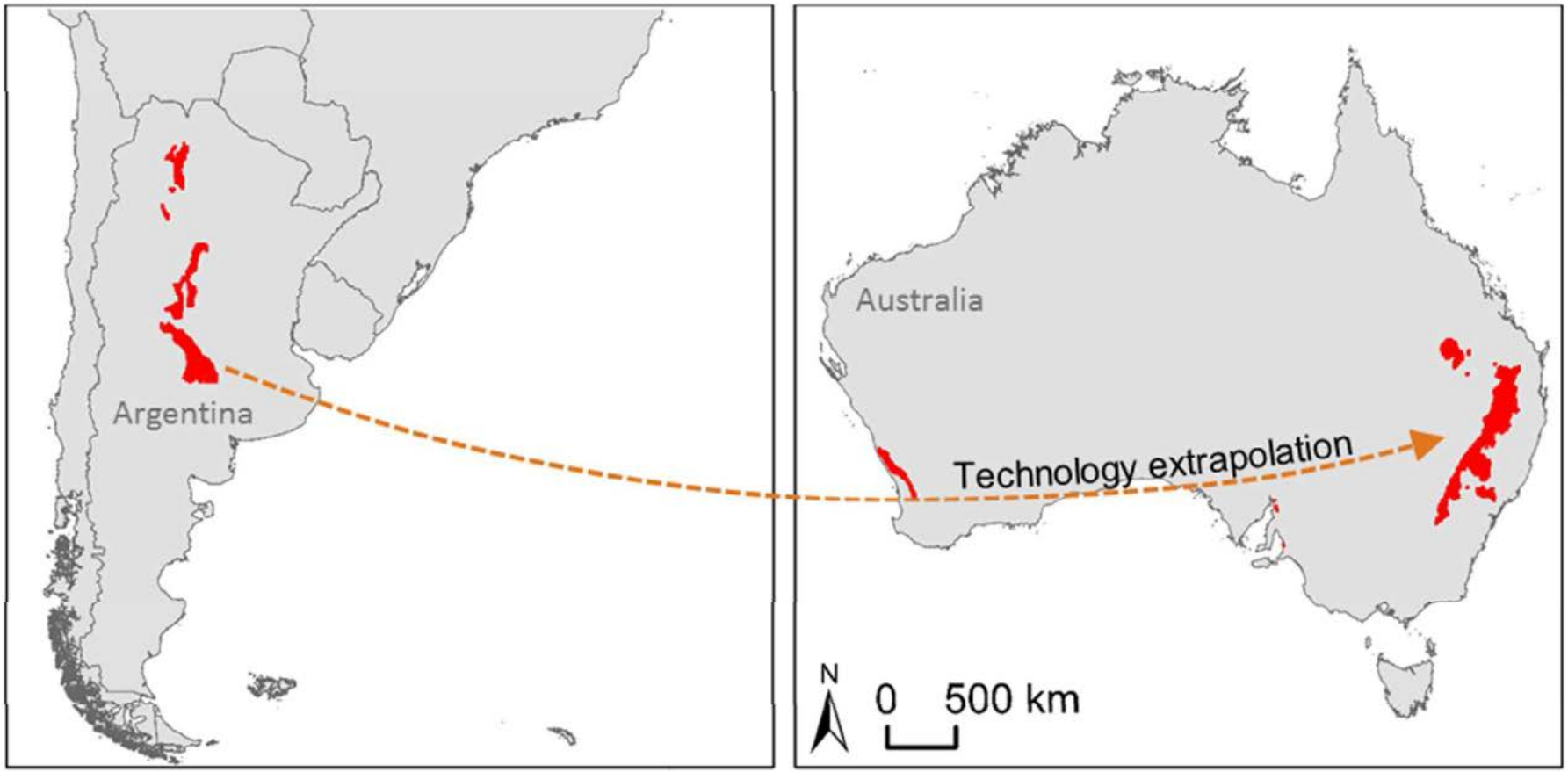


Global Yield Gap Atlas



Global Yield Gap Atlas

Learning from homologues



Australian cropping system	Cropping intensity (crops yr^{-1})	Wheat yield (Mg ha^{-1})	Mungbean yield (Mg ha^{-1})	Net income (USD ha^{-1} yr^{-1})
Continuous wheat	0.9	4.8 (12%)	-	481 (14%)
Wheat-mungbean	2	4.5 (14%)	1.5 (32%)	841 (37%)
Wheat-mungbean (60 mm threshold)	1.9	4.5 (13%)	1.6 (22%)	841 (34%)

Global Yield Gap Atlas

3. Biophysical factors explaining yield gaps (and RUE)

University of Nebraska Lincoln

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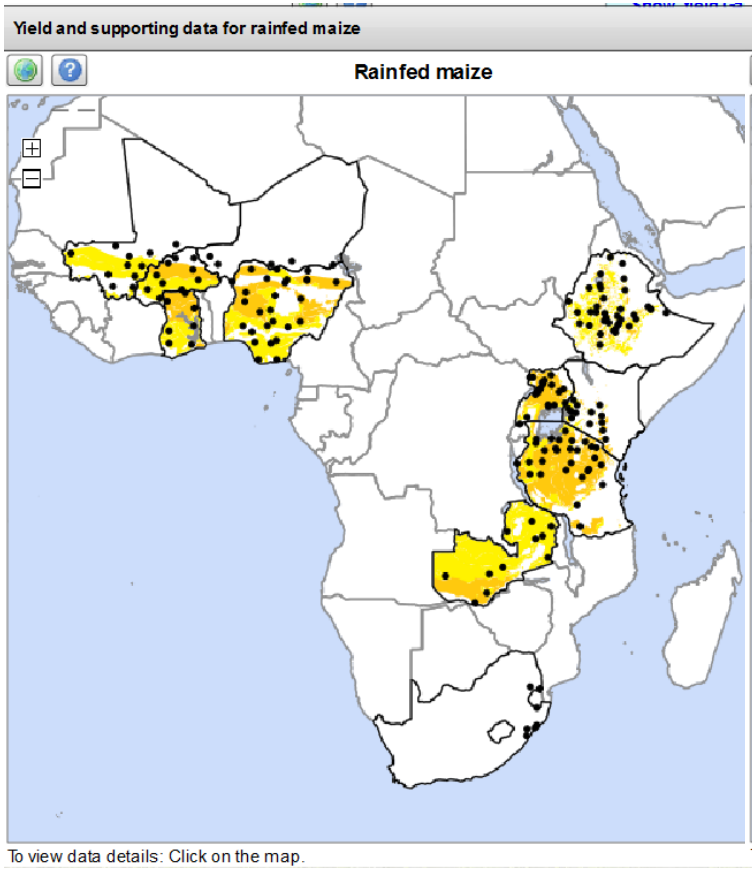
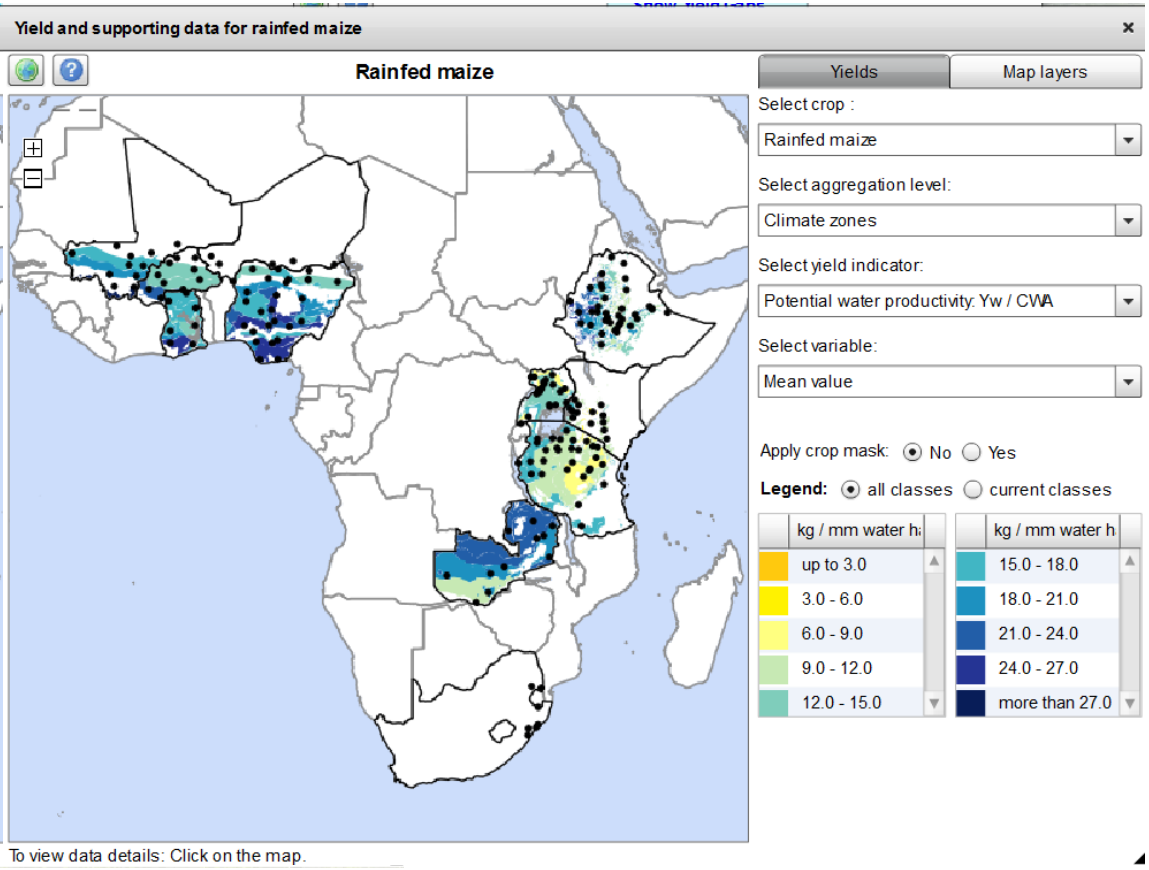
ICRISAT Science with a human face

Actual and potential water productivity

Actual



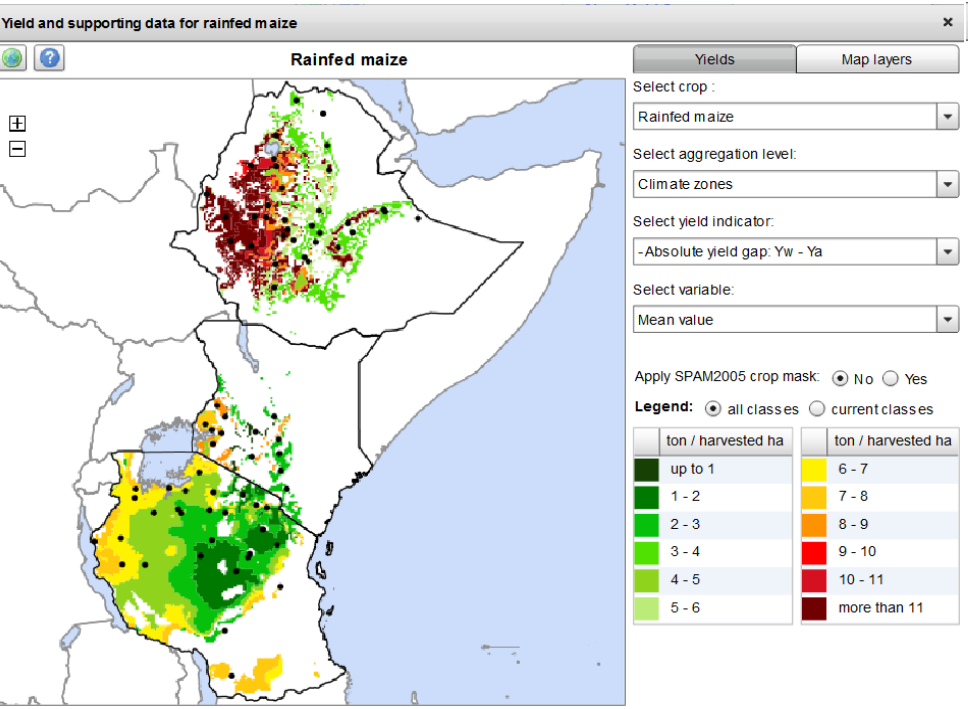
Potential

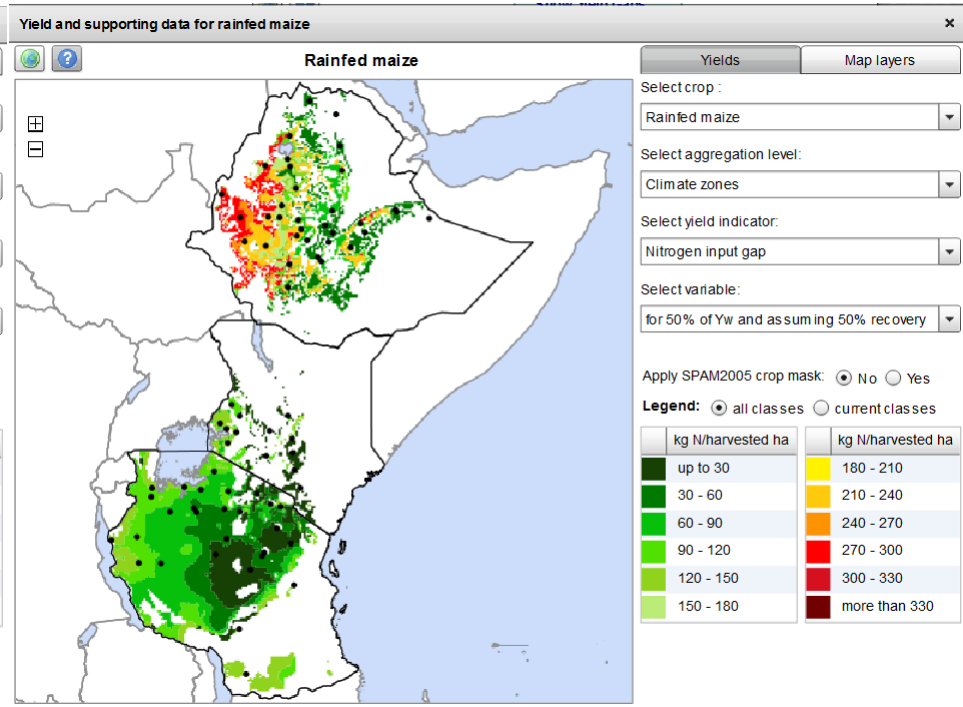


www.yieldgap.org

Global Yield Gap Atlas

From yield gaps to nutrient gaps





Yield gap: Yw – Ya: t/ha

Nutrient uptake gap for 50%Yw-Ya: kg N/ha

www.yieldgap.org

CGIAR

RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

Global Yield Gap Atlas

Pests and diseases?

Global Yield Gap Atlas

Global Yield Gap Atlas

4. Explaining yield gaps from an integrated perspective and identify interventions

Silva, Reidsma, van Ittersum, 2017. Agricultural Systems 158, 78-92.

van Dijk, Morley, Jongeneel, van Ittersum, Reidsma, Ruben, 2017. Agricultural Systems 154, 90-99.

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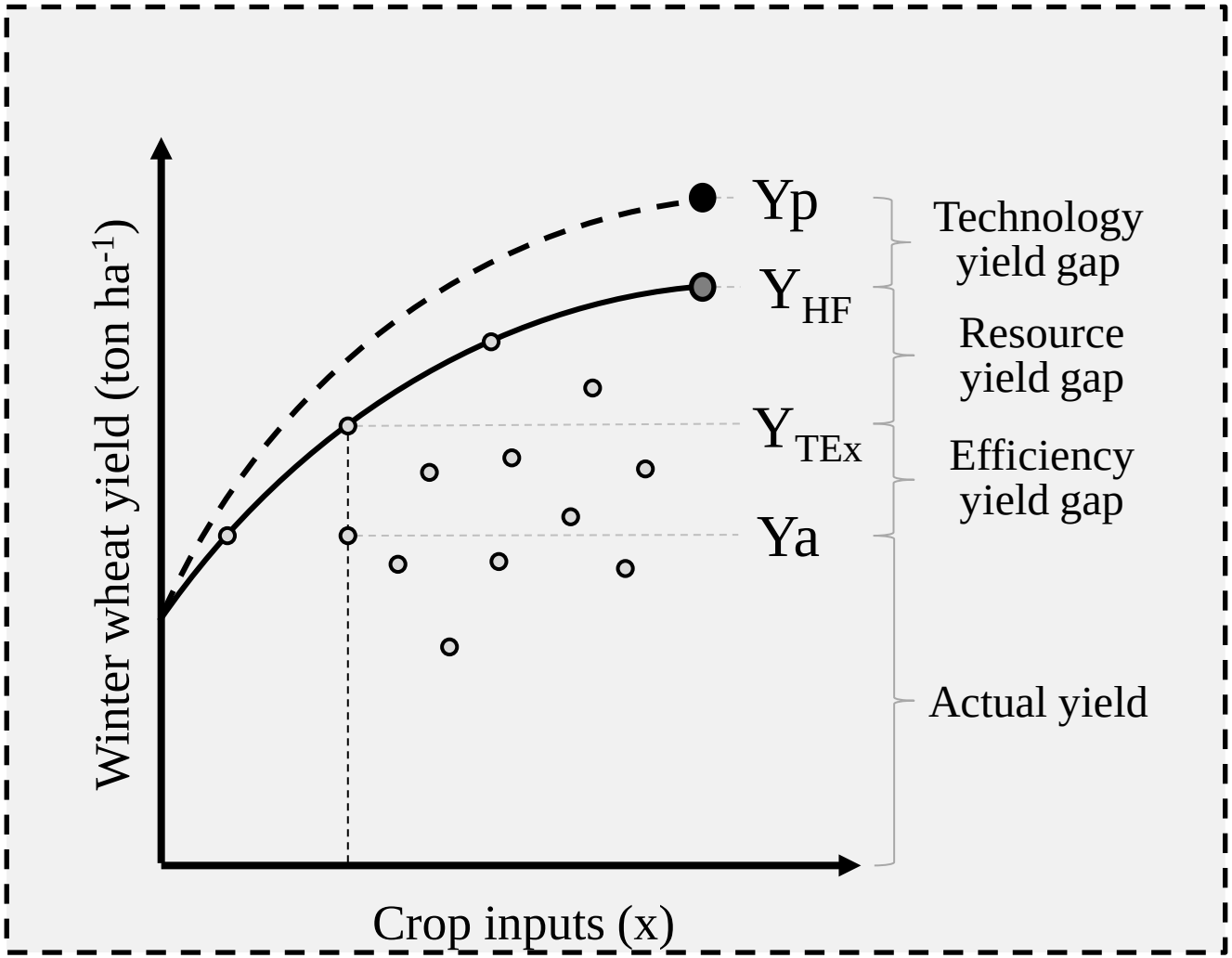
Critique yield gap analysis

- YGA is a purely biophysical exercise (Snyder et al., 2016)
  - See Silva et al. – Eur. Journal of Agronomy, 2017
    - Yield gaps decomposed into efficiency, resource and technology gaps
  - See Van Dijk et al. – Agricultural Systems, 2017
    - Yield gaps decomposed into biophysical and economic factors and related to interventions

Global Yield Gap Atlas

Decomposing the yield gap



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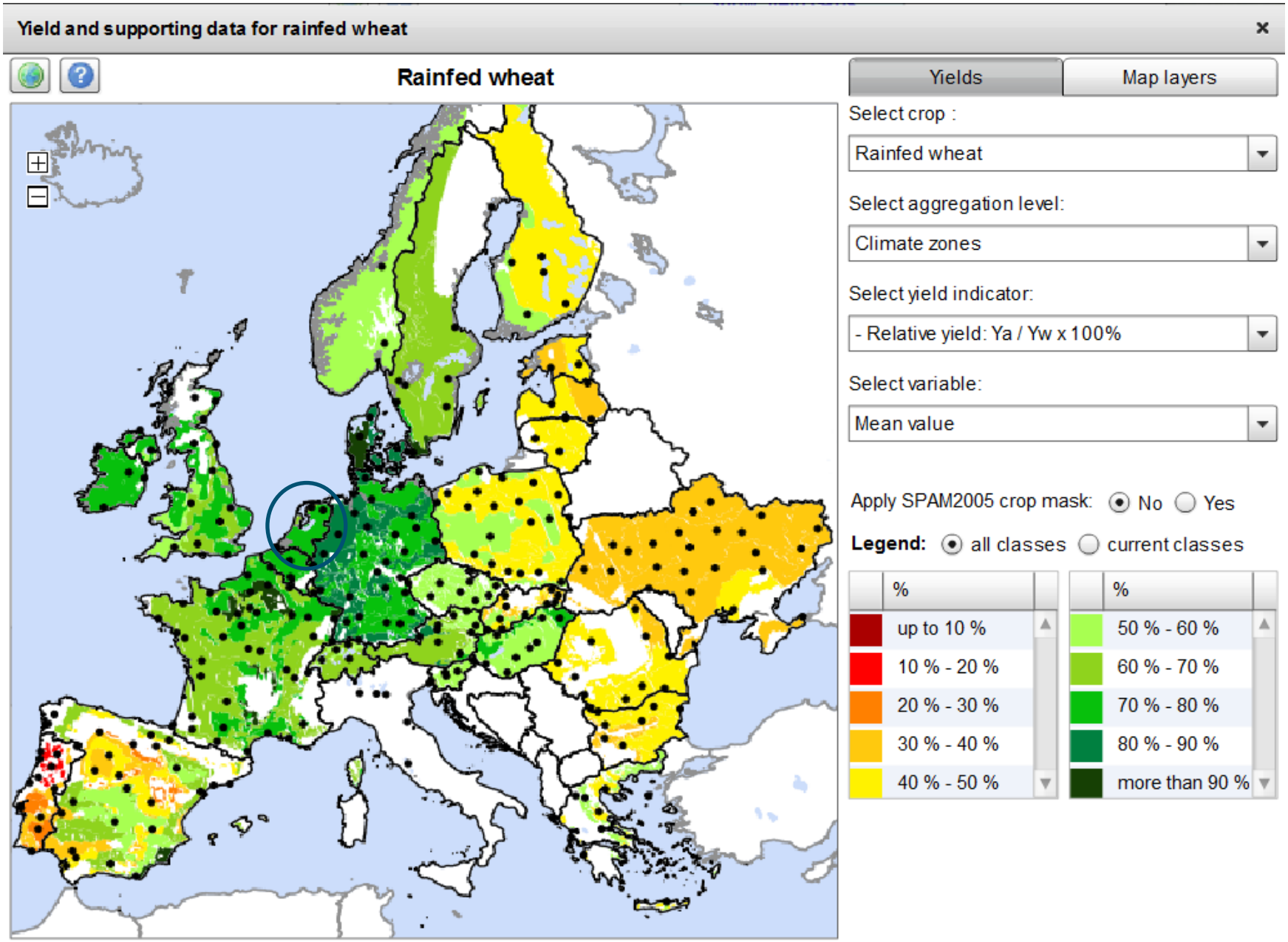
Silva et al., 2017. Eur. J. of Agron.



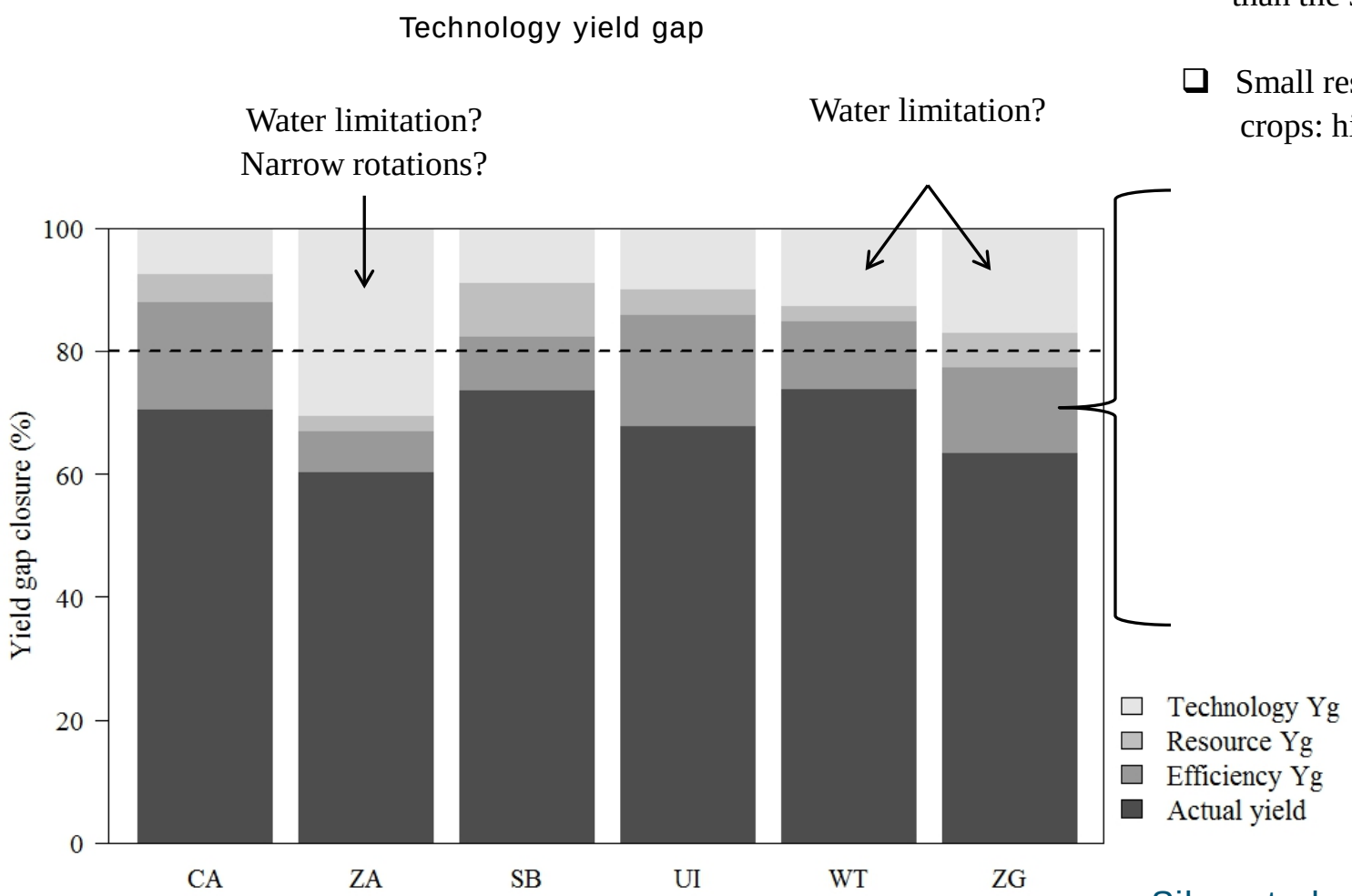
To view data details: Click on the map.

www.yieldgap.org

Global Yield Gap Atlas

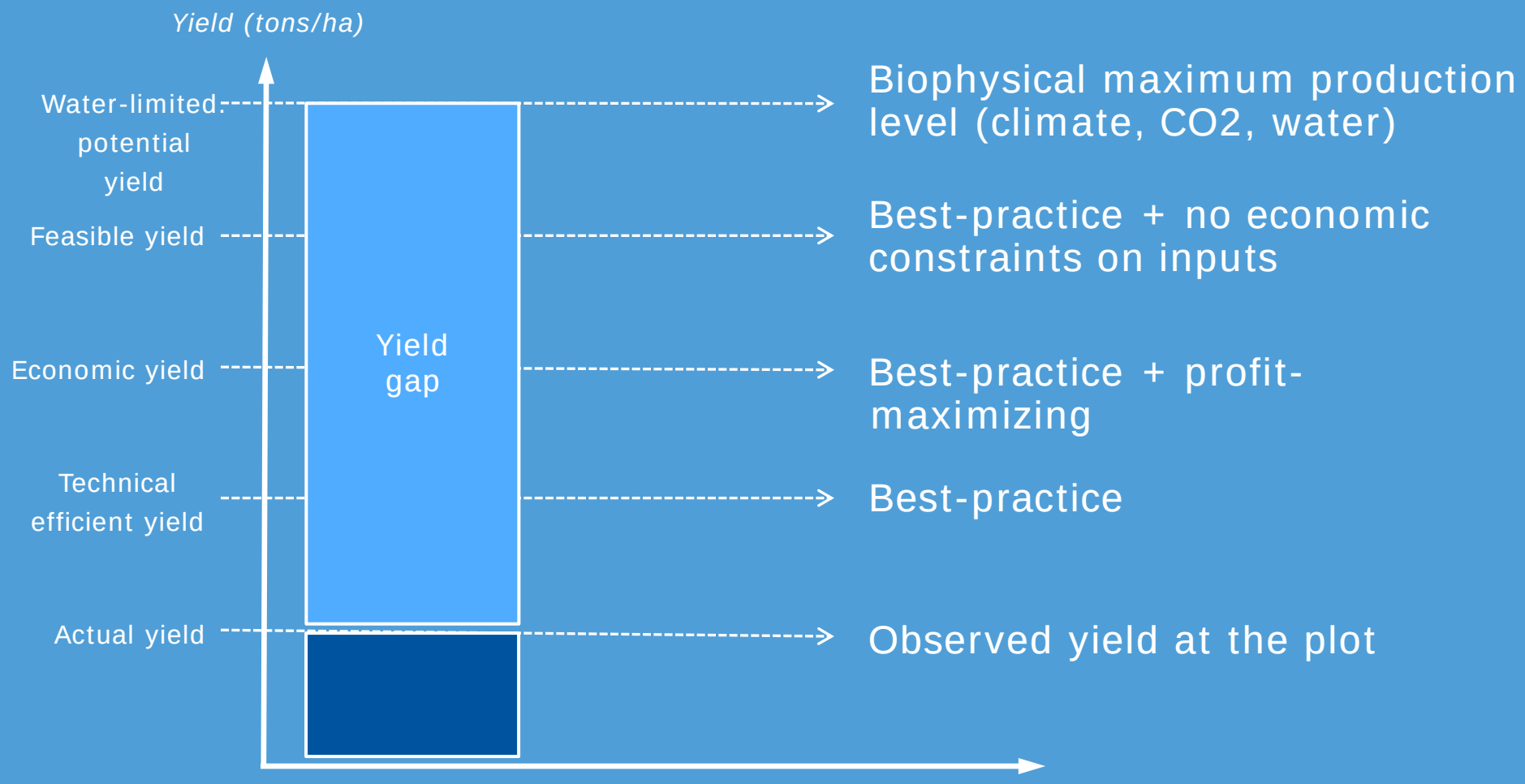
Magnitude of yield gaps for major arable crops in NLs

- Crop yields slightly lower than the suggested 80% Yp
- Small resource Yg for all crops: high input levels



Silva et al., 2017. Ag. Systems

Five different yield levels to benchmark farmer performance



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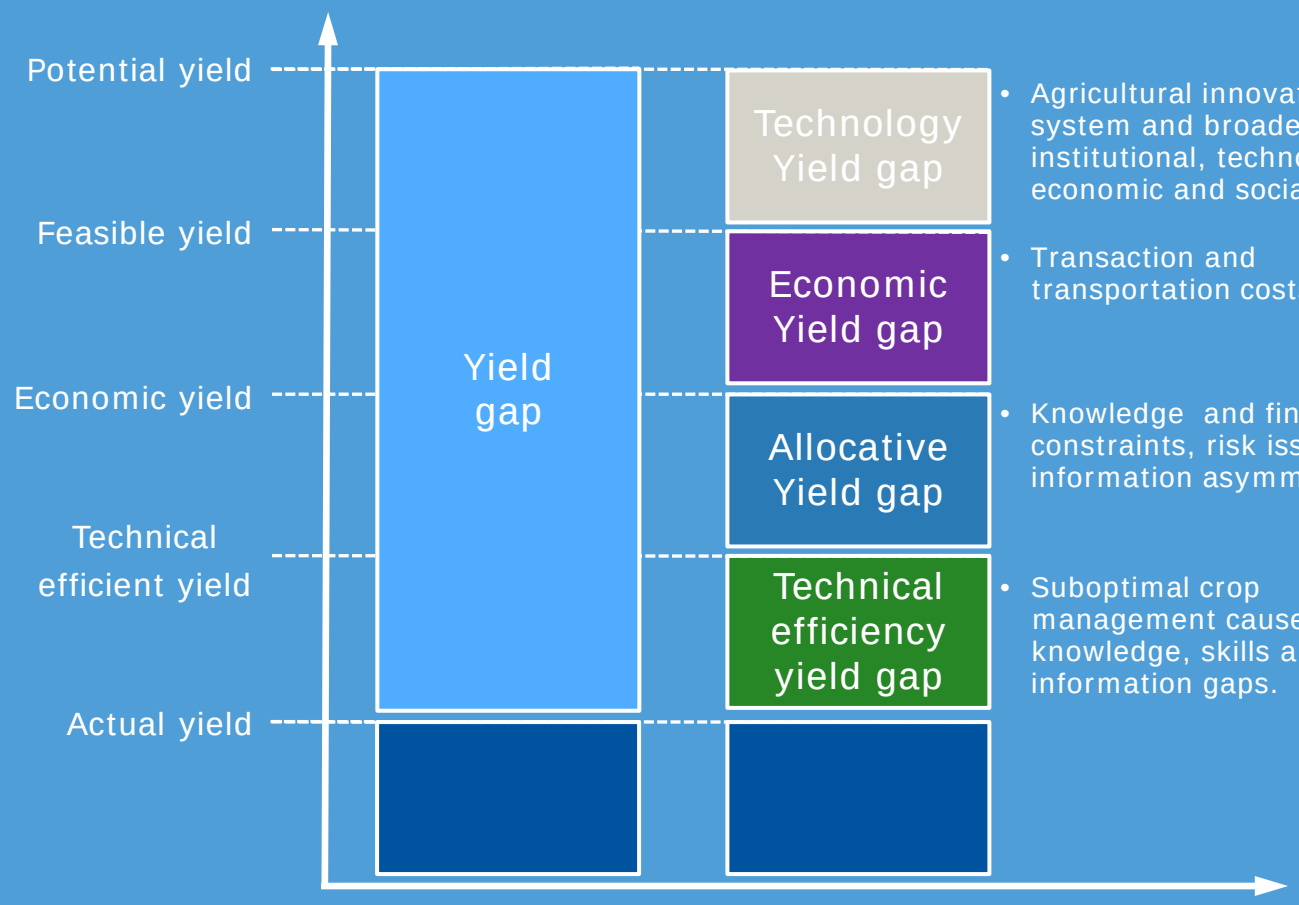
Sliva et al., 2017
Van Dijk et al., 2017

Policies to close the yield gap(s)



Main causes

- Agricultural innovation system and broader institutional, technological, economic and social factors
- Transaction and transportation costs
- Knowledge and financial constraints, risk issues and information asymmetries
- Suboptimal crop management caused by knowledge, skills and information gaps.

Policies

- Investment in applied agricultural research and development programs
- Investment in rural roads
- Policies to decrease transaction costs
- Credit & insurance
- Expand agro-dealer networks
- Support market information
- Land tenure systems
- Smart input subsidies
- Improve extension services
- Stimulate knowledge transfer from best practice to average farmers

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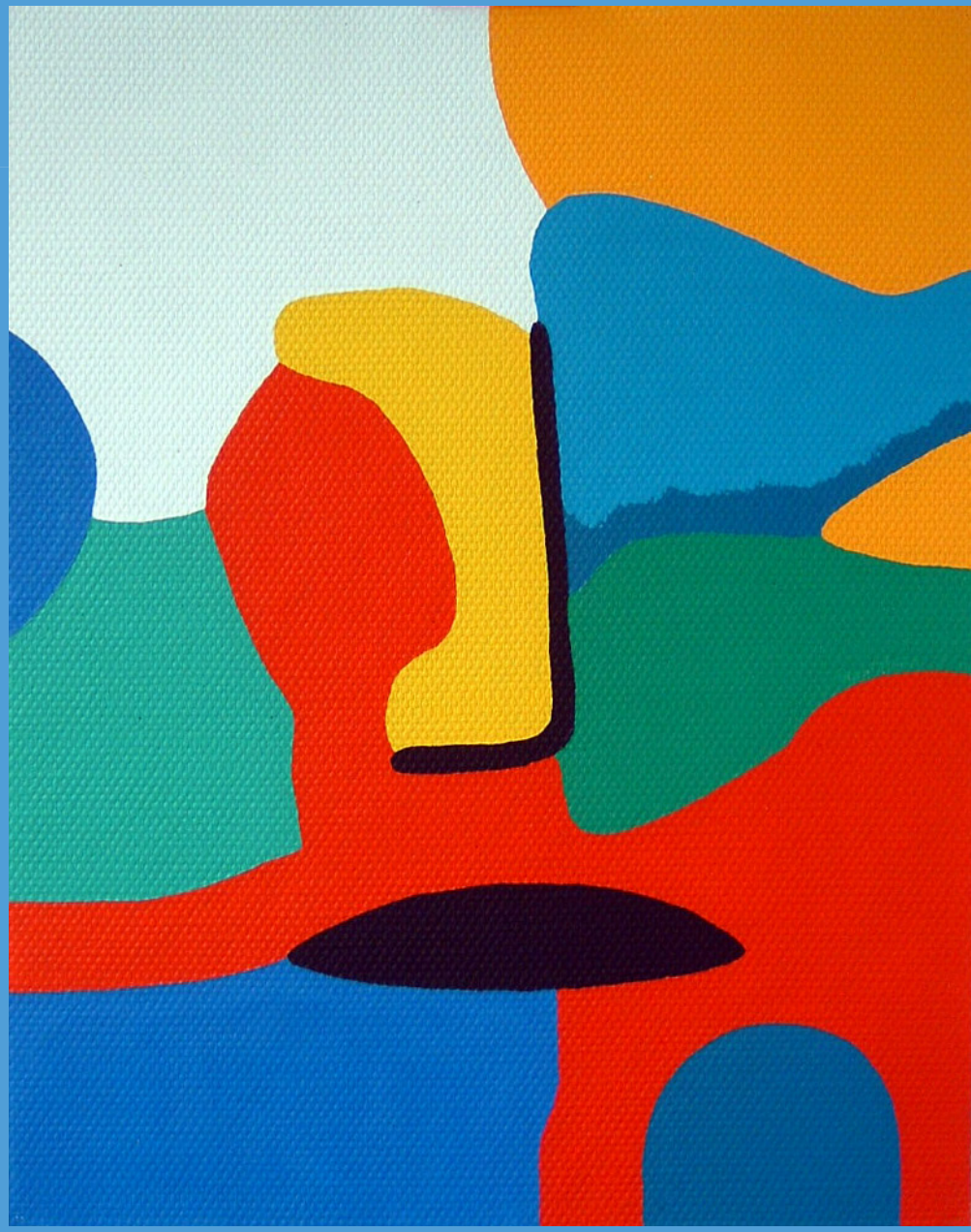
Sliva et al., 2017
Van Dijk et al., 2017

Summary

- GYGA: global approach with local agronomic relevance to estimate yield gaps
  - Scenario analysis on food security
  - Impact assessment of R&D
  - Explaining yield gaps (and RUE)
  - Explaining yield gaps from an integrated perspective and identify interventions

- A platform for agronomic data for scientists and stakeholders on food security
- 28,418 users of website; 4,401 downloads over past 12 months

Future harvest



Thank you for your attention!

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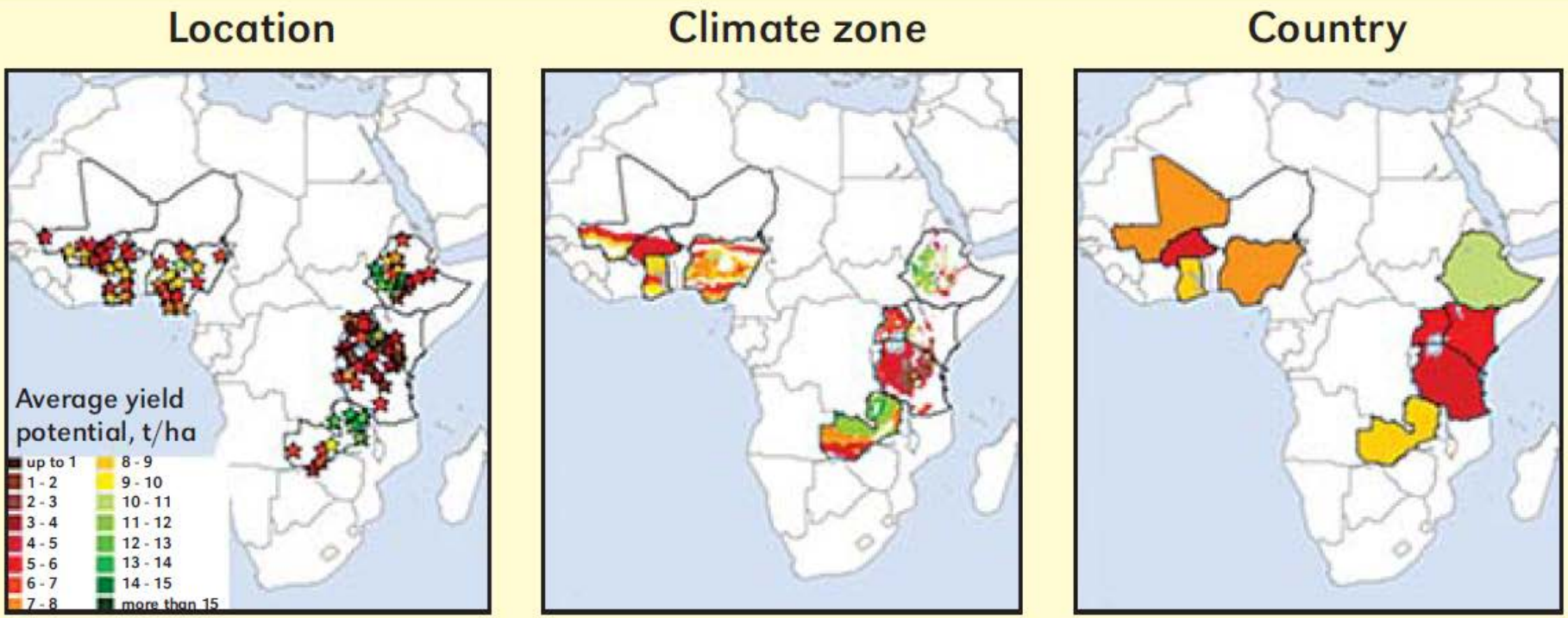
Spatial framework



Van Bussel et al., 2015