Tight to the ground:
Can sub-Saharan Africa be self-sufficient in food production?

Martin van Ittersum – Plant Production Systems group

Global Yield Gap Atlas team

WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018

Global Yield Gap Atlas

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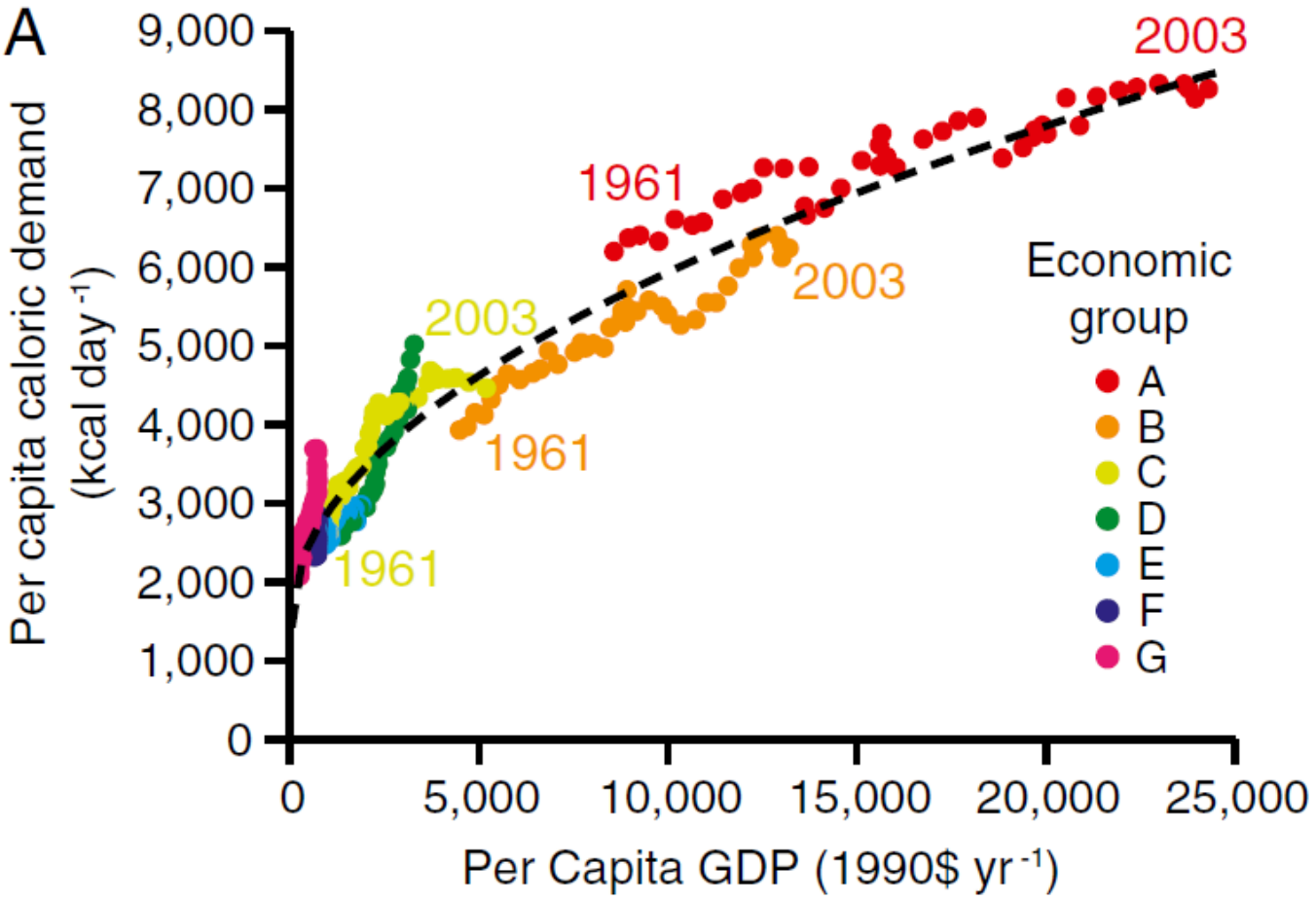
FAO projection: +60% demand (2007-2050)

Population increase

Continent	2015	2050	2100
World	7.4	9.7	11.2
Asia	4.4	5.3	4.9
Africa	1.2	2.5	4.4
Sub-Saharan Africa	**1.0**	**2.1**	**3.9**
North America	0.4	0.4	0.5
Latin America	0.6	0.8	0.7
Europe	0.7	0.7	0.7
Oceania	0.04	0.06	0.07

United Nations, 2017

Dietary changes



Tilman et al., 2011 (PNAS)

The need for extra food is very region-specific

Sub-Saharan Africa's demand will rise fastest because of population growth and dietary change

Growth in population: 2010-2050

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, 2015

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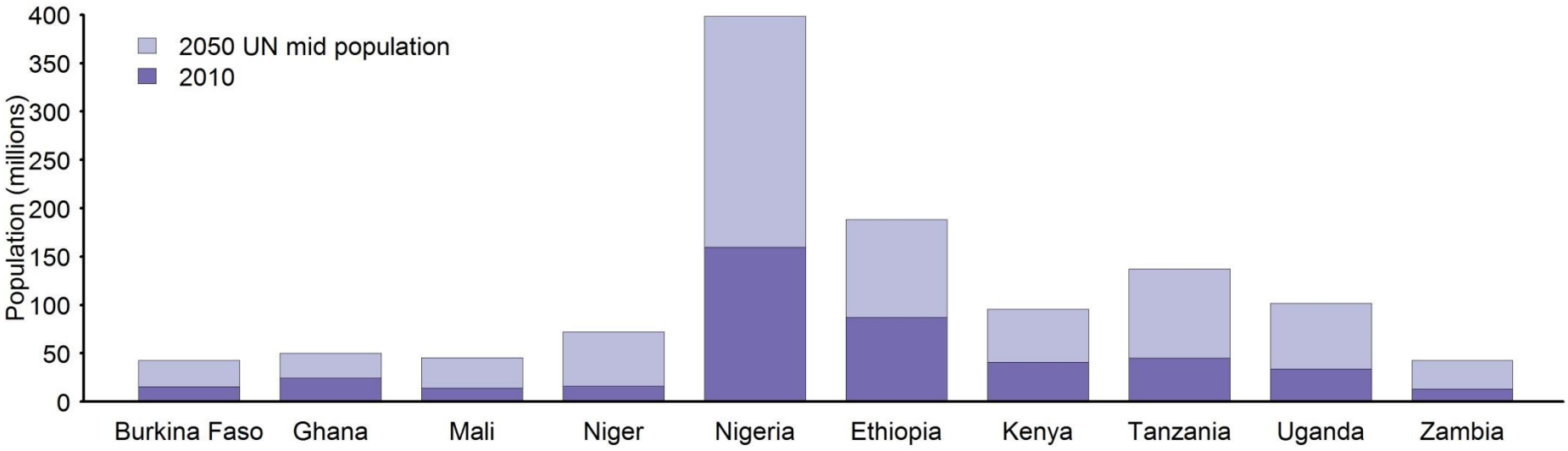
Growth in population 2050



From 0.45 to 1.2 billion (2.6 times)

Van Ittersum et al., 2016 (PNAS)

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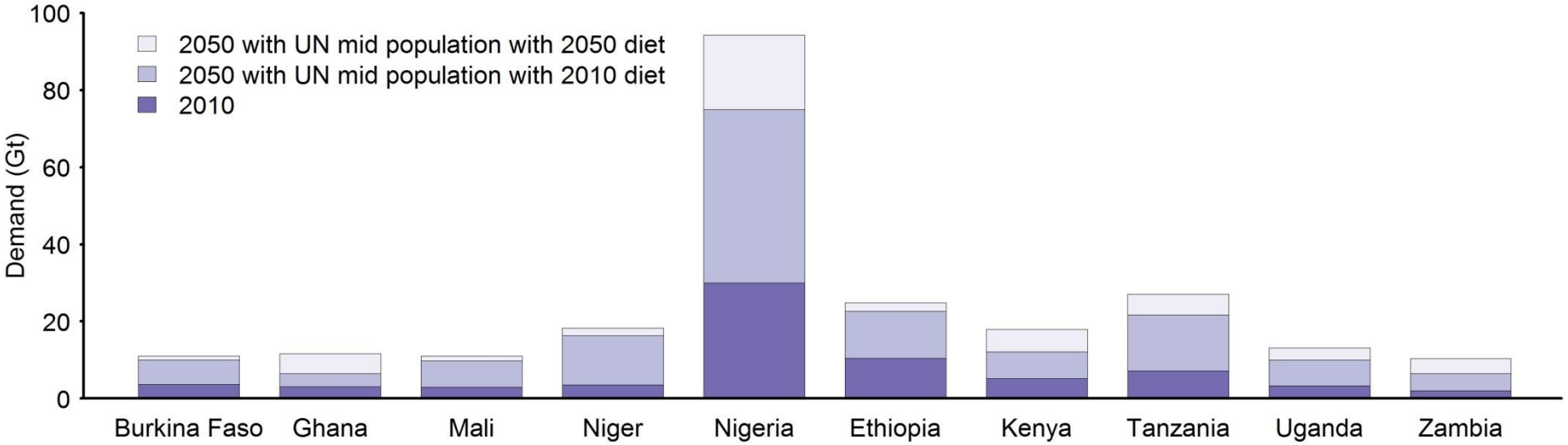
Growth in population and cereal demand - 2050

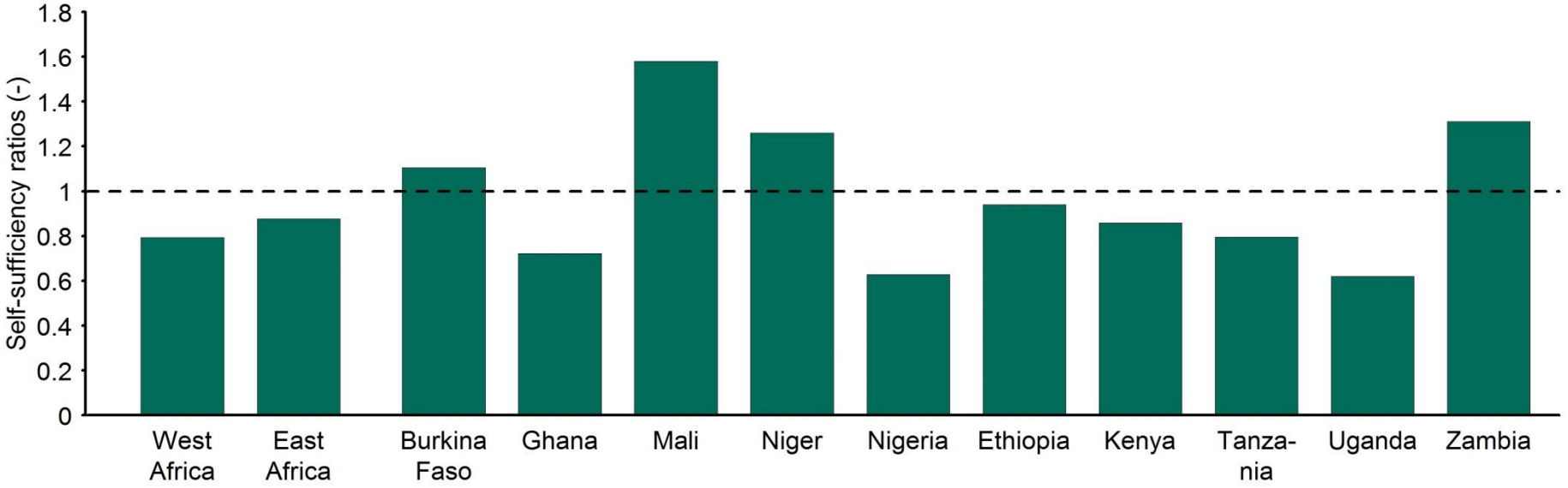


A factor 3.4 increase!

Van Ittersum et al., 2016 (PNAS)

Global Yield Gap Atlas

Current self-sufficiency cereals SSA - 2010



Van Ittersum et al., 2016 (PNAS), based on IMPACT model

Global Yield Gap Atlas

Can sub-Saharan Africa feed itself?

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Van Ittersum et al., 2016 (PNAS)

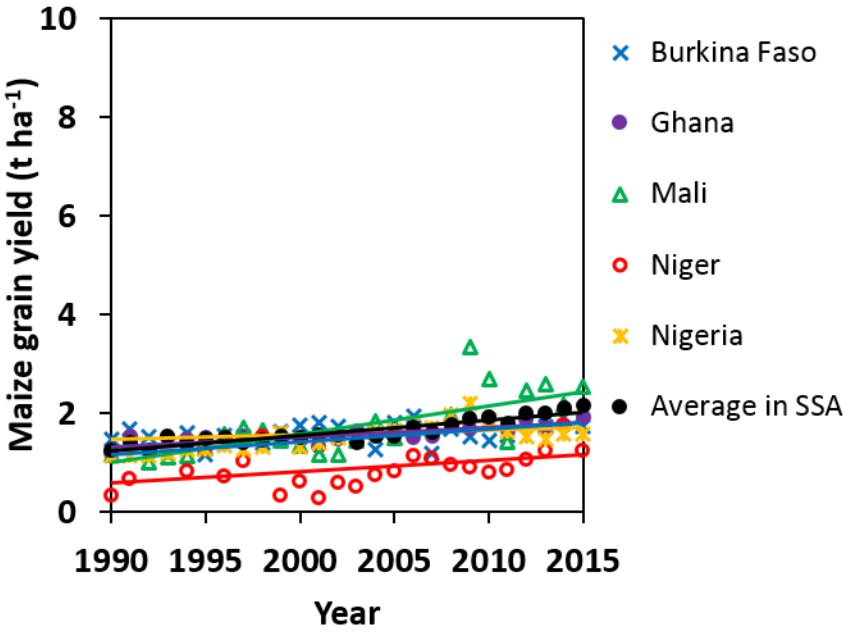
Global Yield Gap Atlas

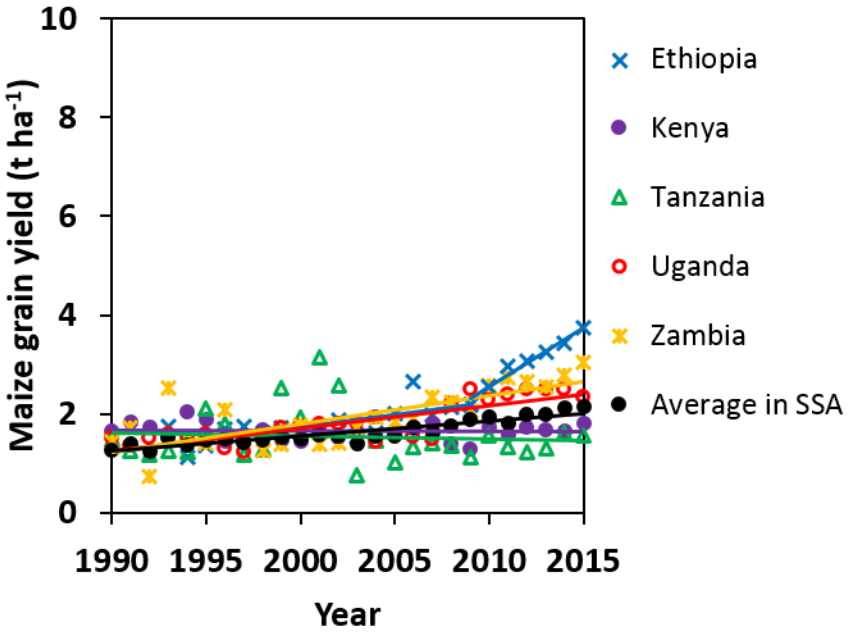
Why is self-sufficiency of low-income countries relevant?

- Countries in SSA meet the criteria listed by Jennifer Clapp
- Many lack adequate foreign exchange reserves to pay for food imports and infrastructure to store and distribute it efficiently
- Economic development of low-income countries to support such imports does not occur without strong agricultural development

Global Yield Gap Atlas

Recent yield progress SSA (rainfed maize)



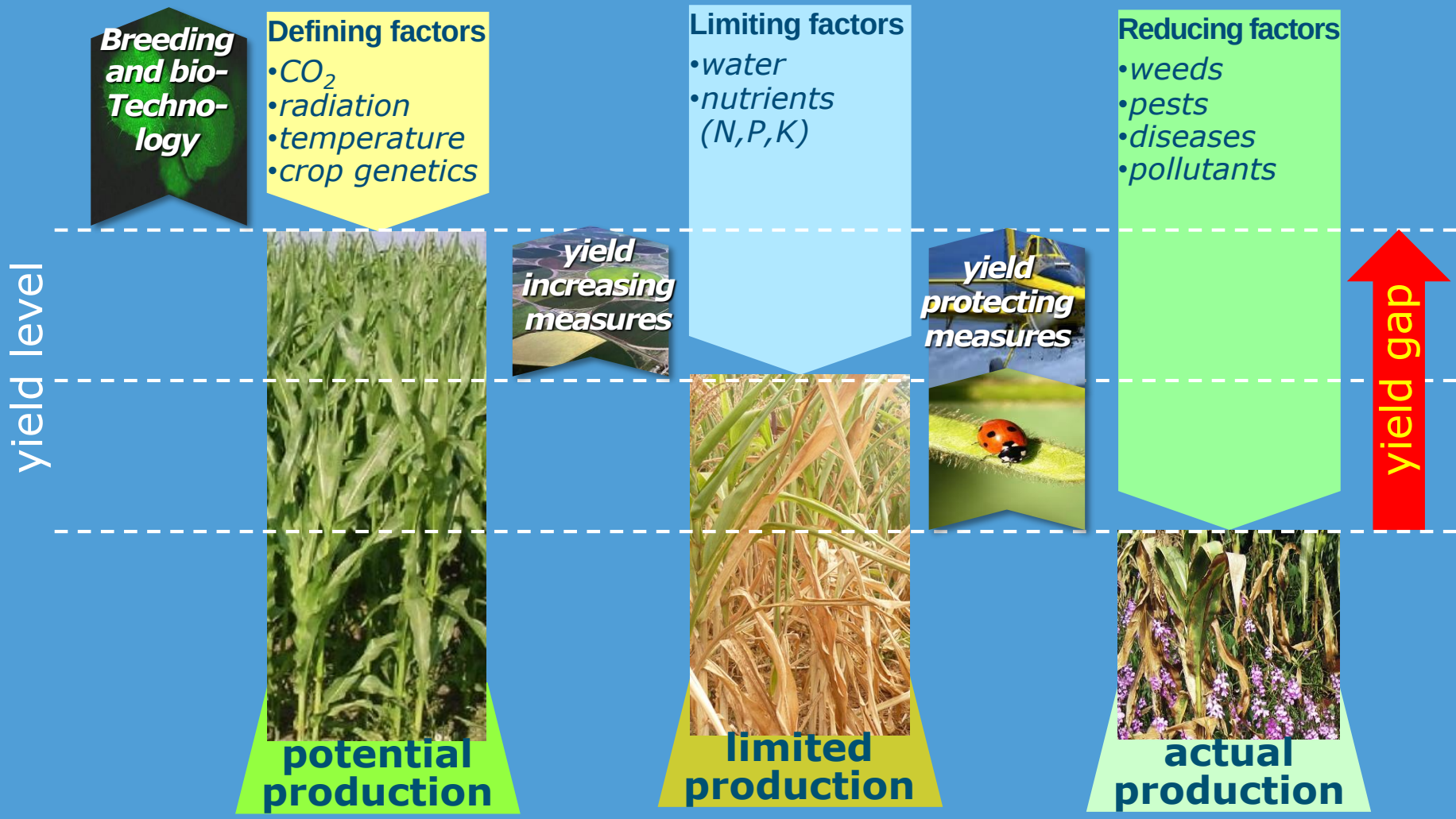


Average annual yield increase maize: ca. 30 kg/ha/yr

FAO and Van Ittersum et al., 2016 (PNAS)

Global Yield Gap Atlas

Production-ecological principles & practice



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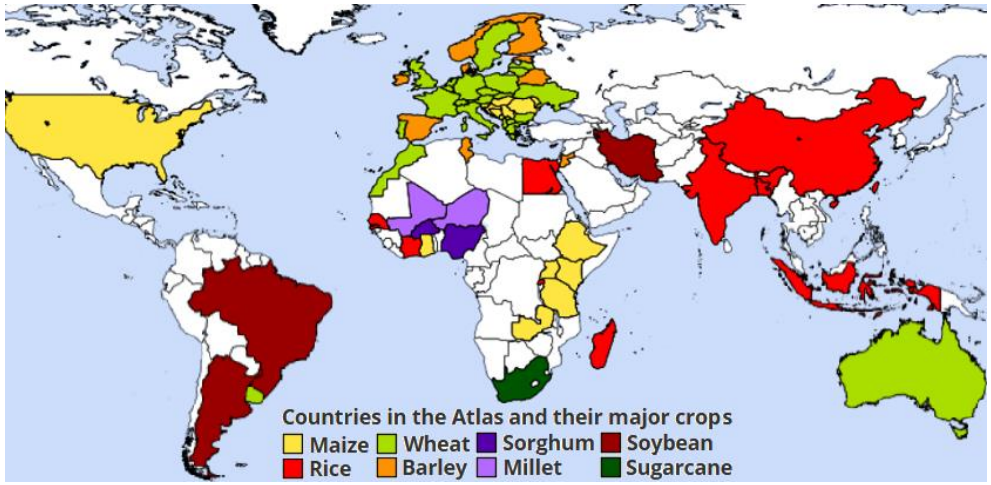
Van Ittersum and Rabbinge, 1997
Slide: Harrie Lovenstein

Global Yield Gap Atlas

62 countries, major food crops, accounting for 70, 84, 45% of rice, maize, and wheat



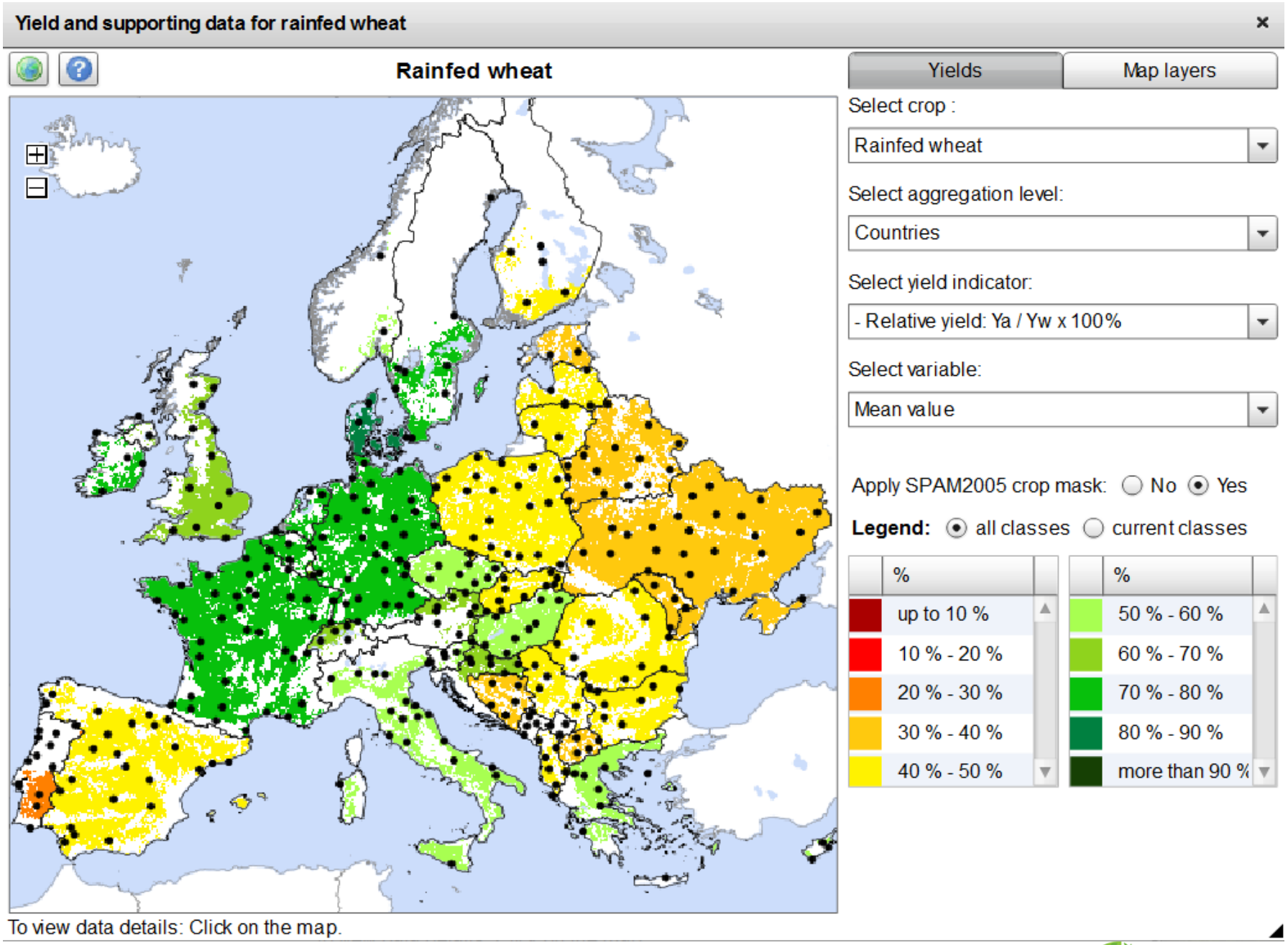
With University of Nebraska, ICRISAT, AfricaRice, CIMMYT and many national partners

- 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

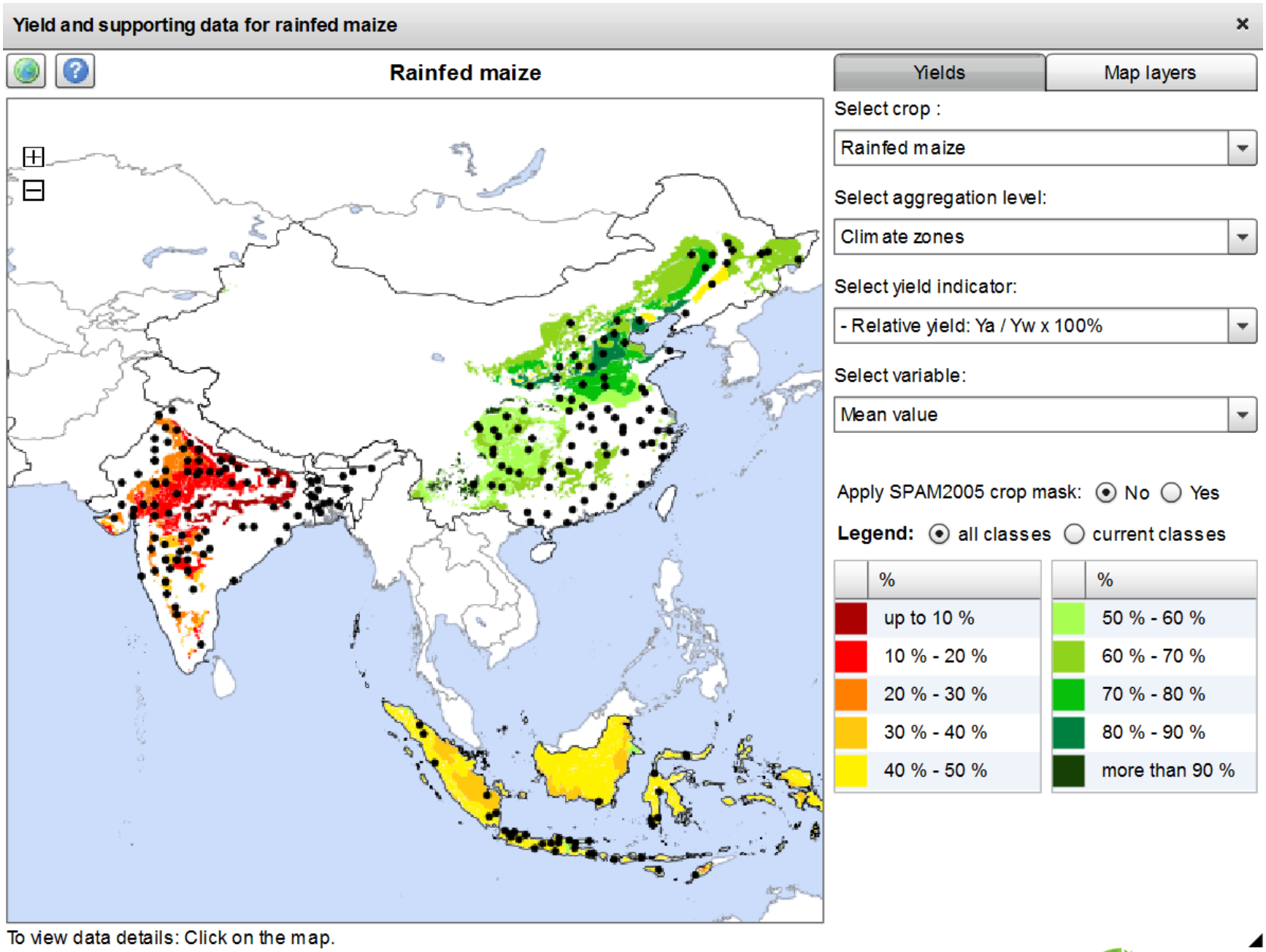
Global Yield Gap Atlas

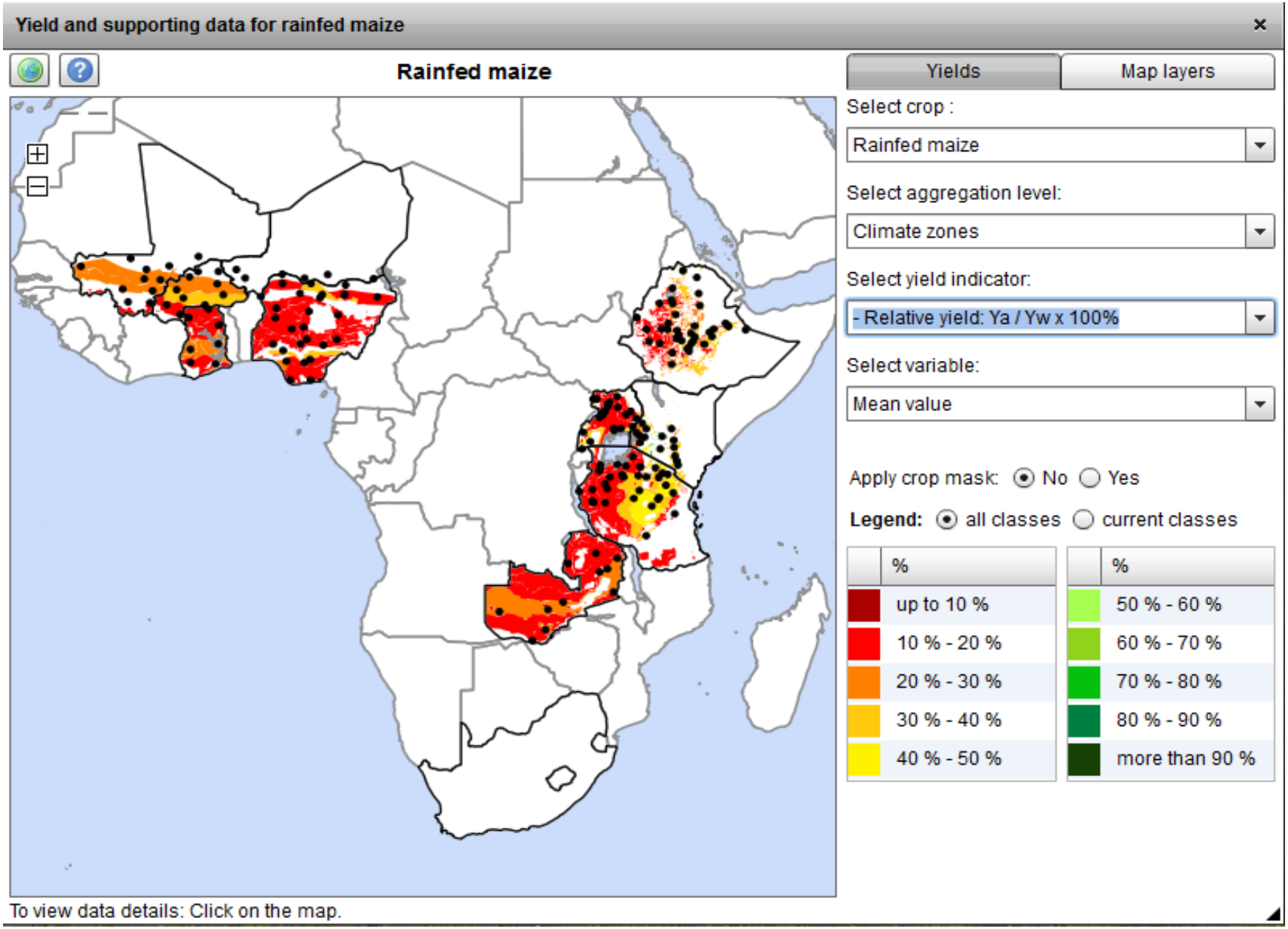


Schils et al., in review

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 SPAM2005 crop mask: No Yes
Legend: all classes current classes
%
up to 10 %
10 % - 20 %
20 % - 30 %
30 % - 40 %
40 % - 50 %
%
50 % - 60 %
60 % - 70 %
70 % - 80 %
80 % - 90 %
more than 90 %
To view data details: Click on the map.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%
50 % - 60 %
60 % - 70 %
70 % - 80 %
80 % - 90 %
more than 90 %
To view data details: Click on the map.

10 countries in SSA and five main cereals

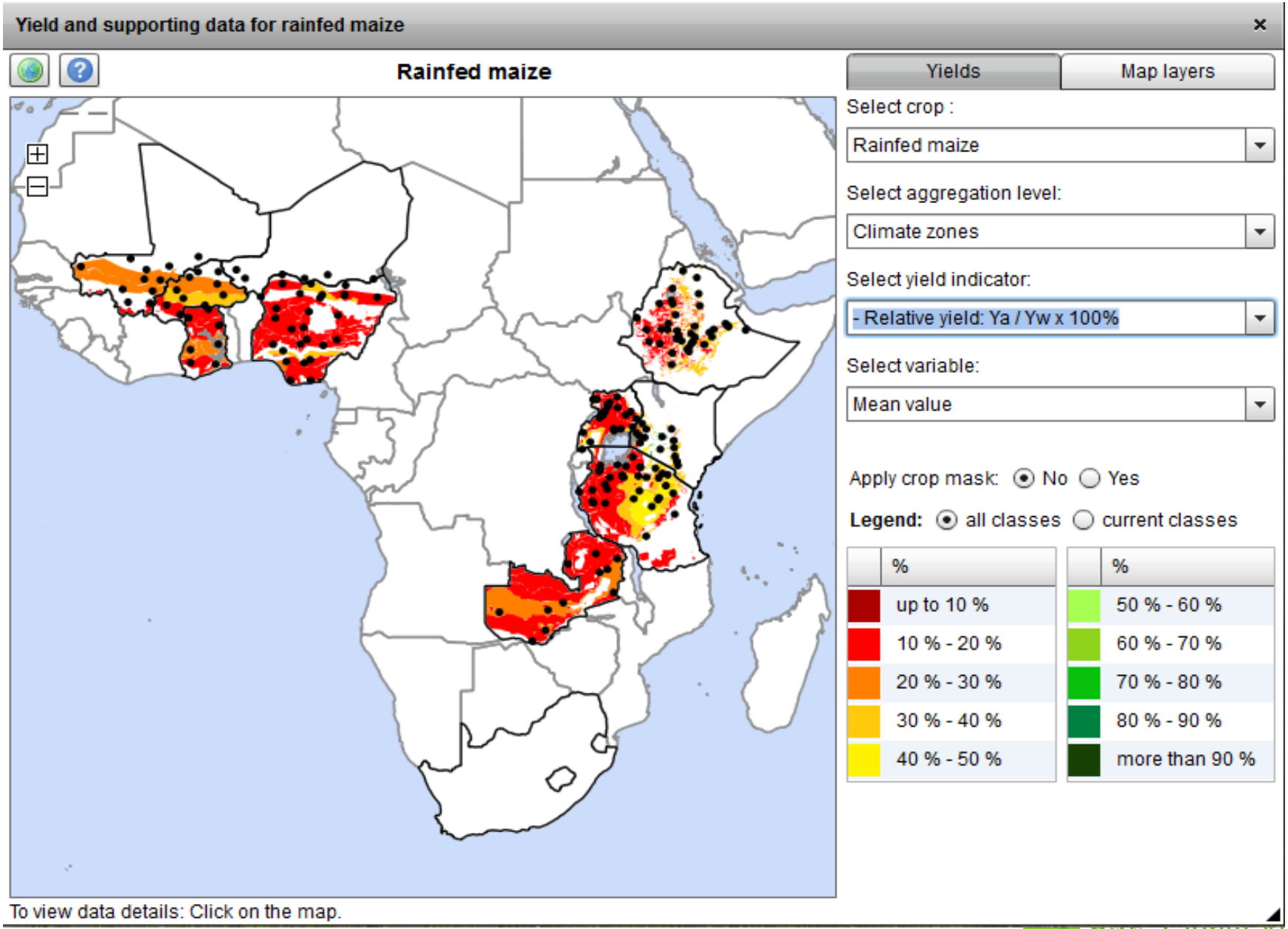
10 countries:

- 54% of population in SSA
- 58% of the arable land in SSA
  - thus relatively high land/capita ratio

Maize, wheat, rice, sorghum and millet

- Cereals ca. 50% of crop area in SSA
- Cereals ca. 50% of caloric intake in SSA

Global Yield Gap Atlas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%
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70 % - 80 %
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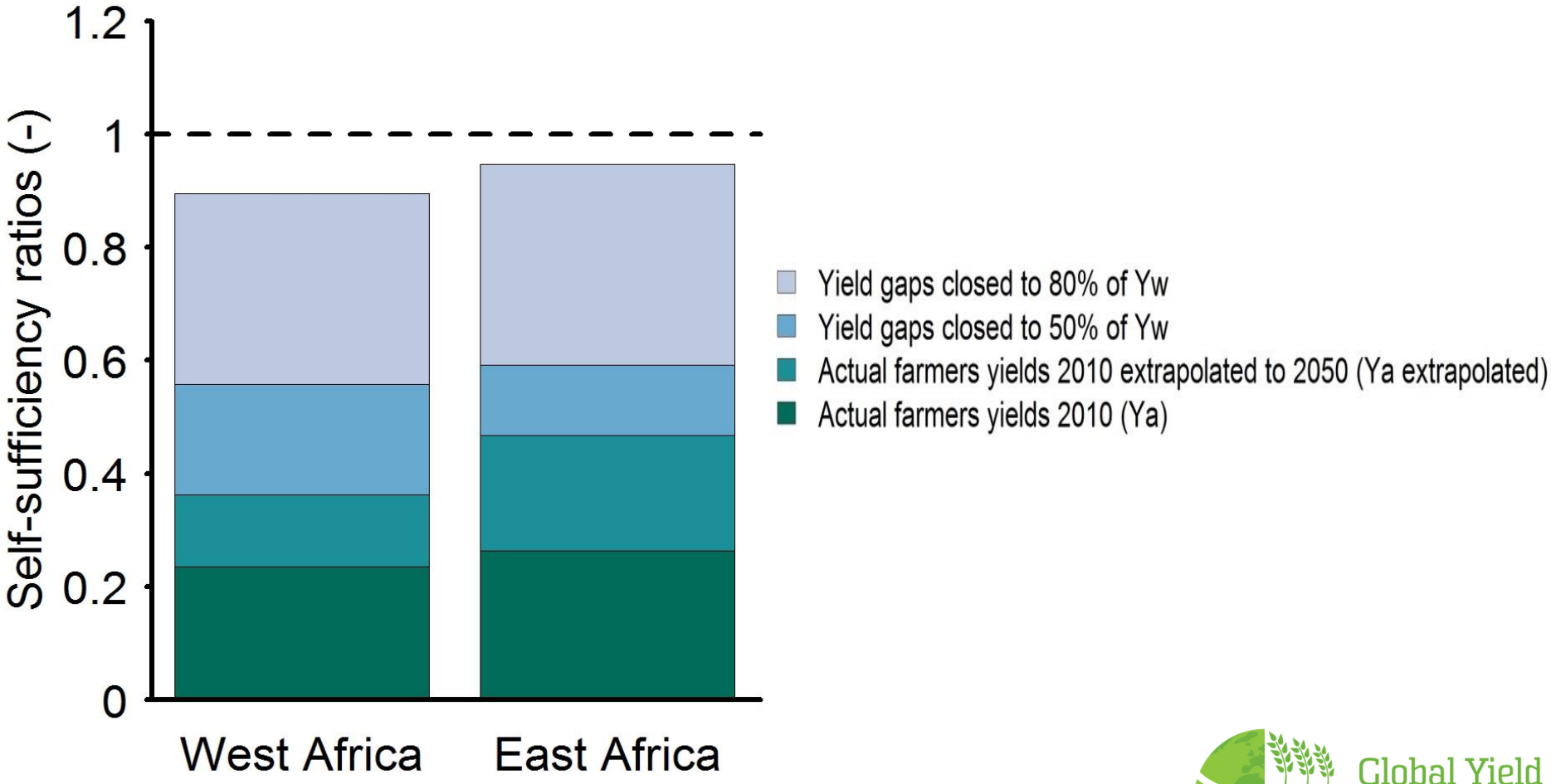
more than 90 %
To view data details: Click on the map.

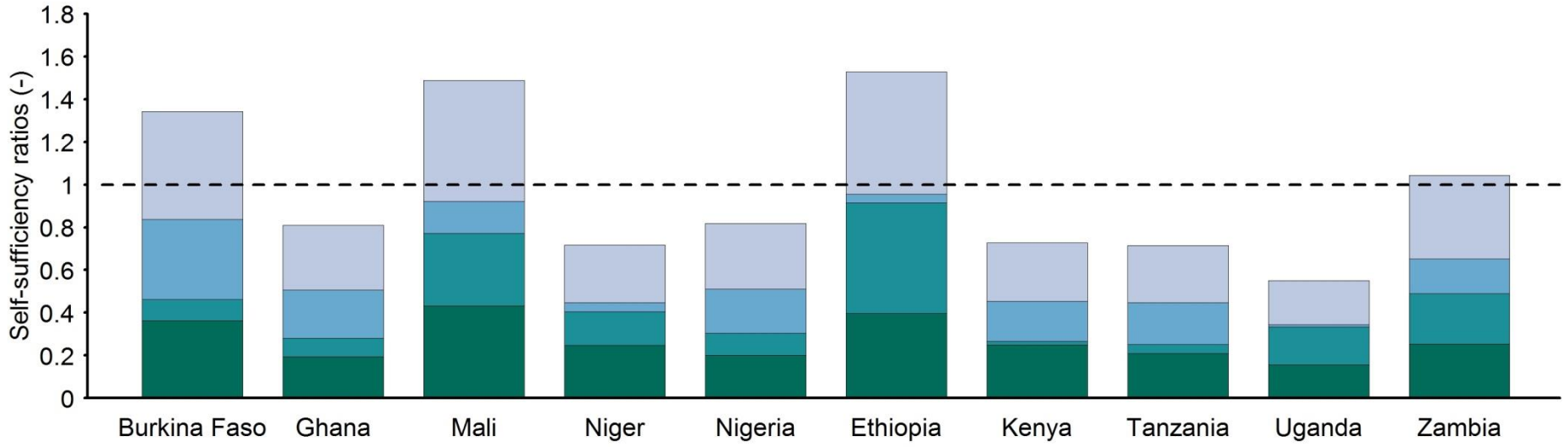
Can SSA feed itself? – five main cereals



Van Ittersum et al., 2016 (PNAS)

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)

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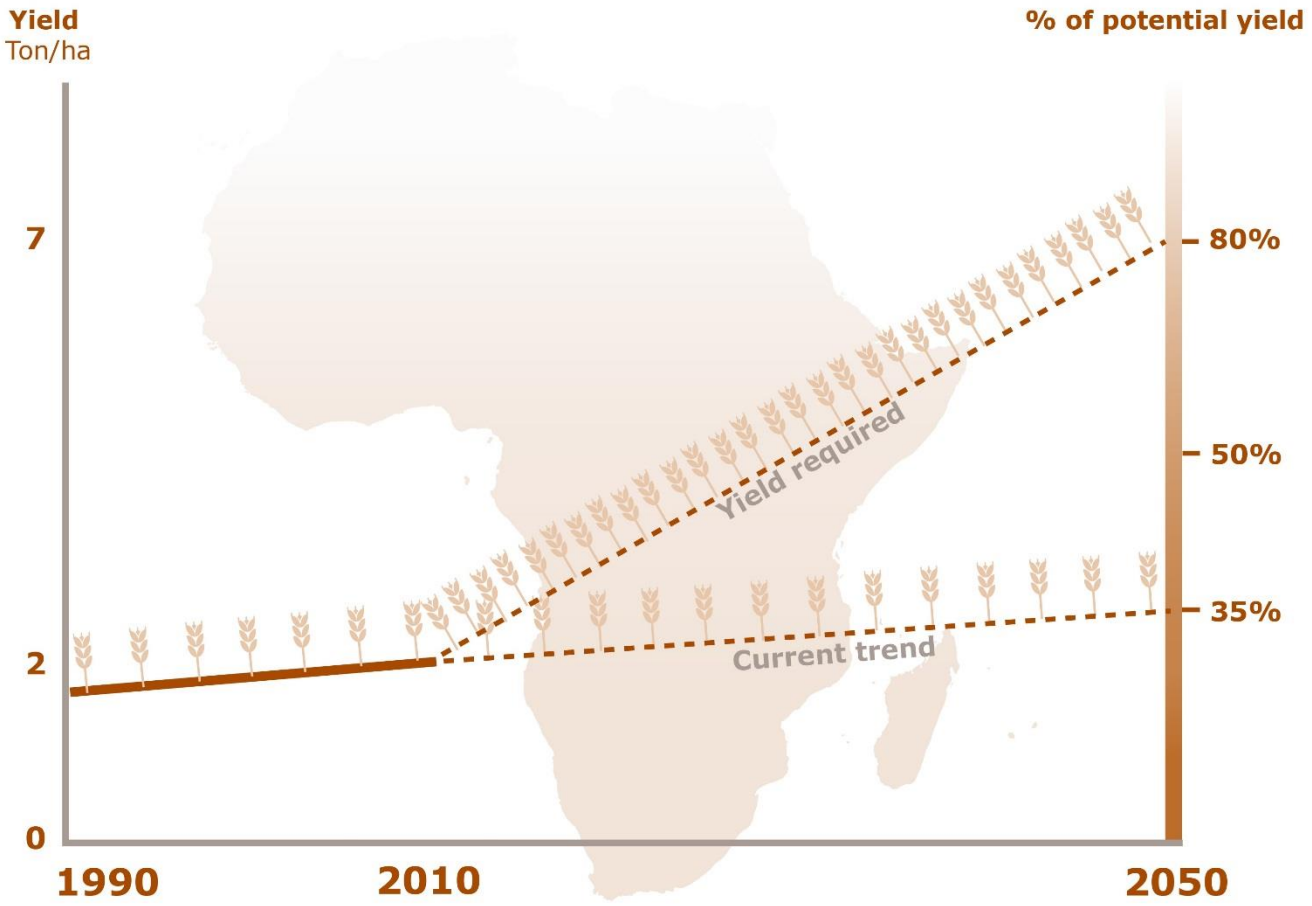
Required trend change



Global Yield Gap Atlas

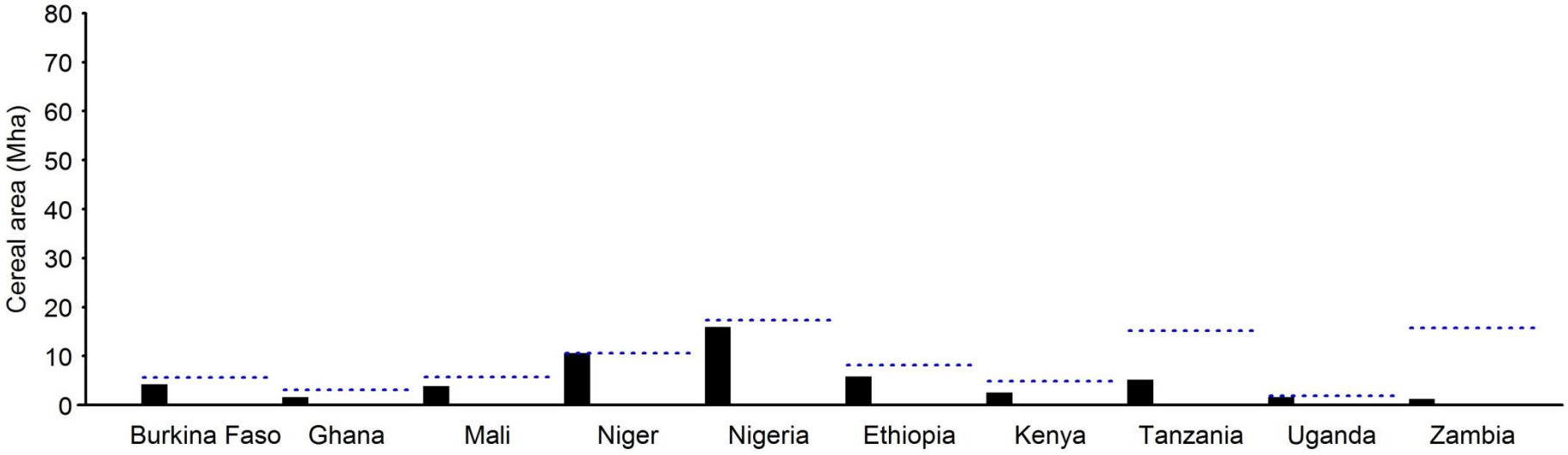
Historical maize yield increases (kg/ha/year)

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

Based on FAOSTAT

Global Yield Gap Atlas

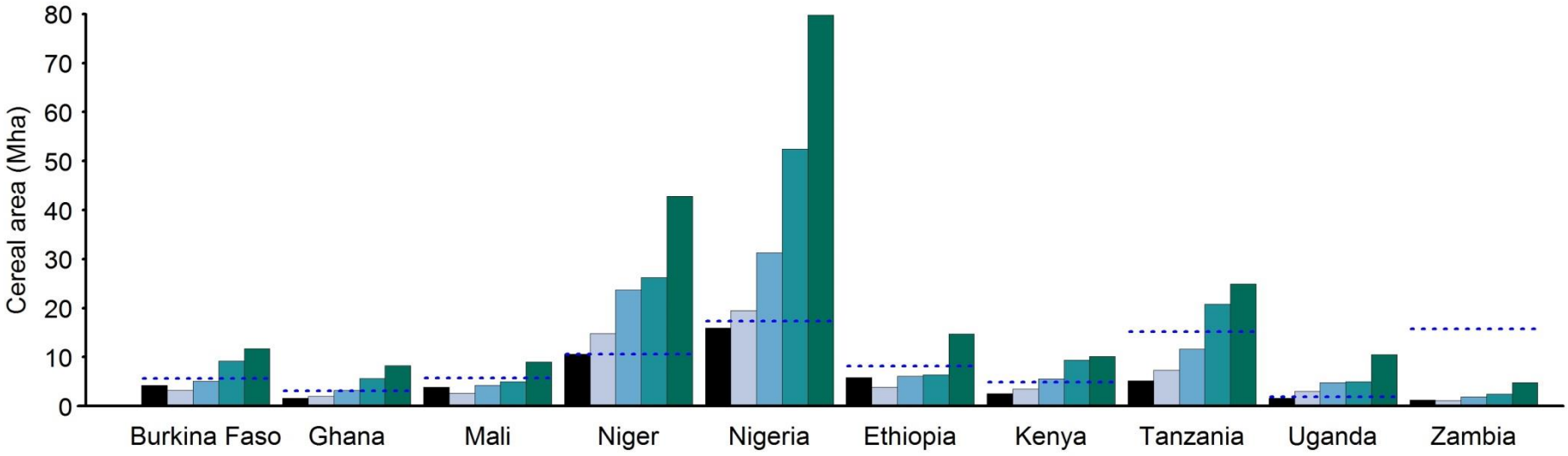
Current and potentially available cereal area



Based on: Chamberlin et al., 2014
Van Ittersum et al., 2016

Global Yield Gap Atlas

Many countries lack the land reserves



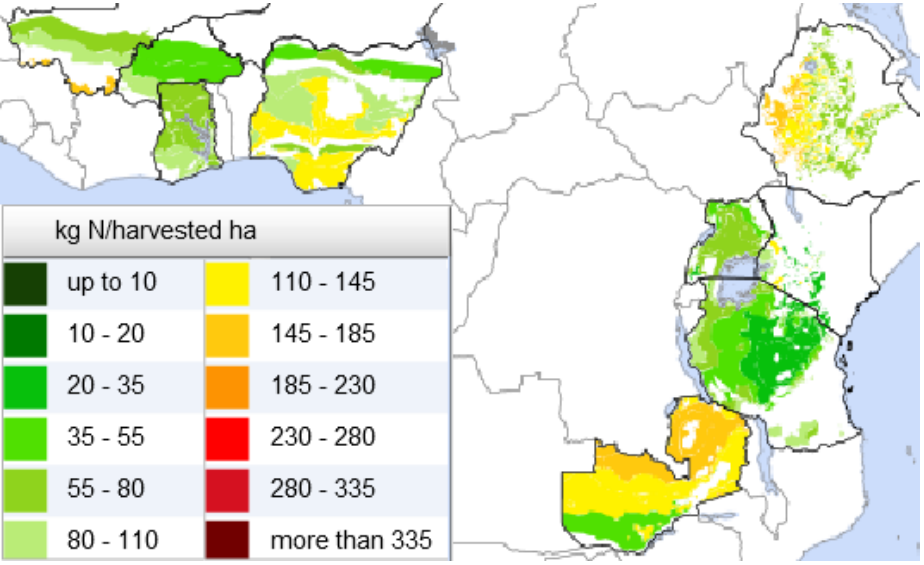
- Yield gaps closed to 80% of Yw
- Yield gaps closed to 50% of Yw
- Actual farmers yields 2010 extrapolated to 2050 (Ya extrapolated)
- Actual farmers yields 2010 (Ya)

Van Ittersum et al., 2016

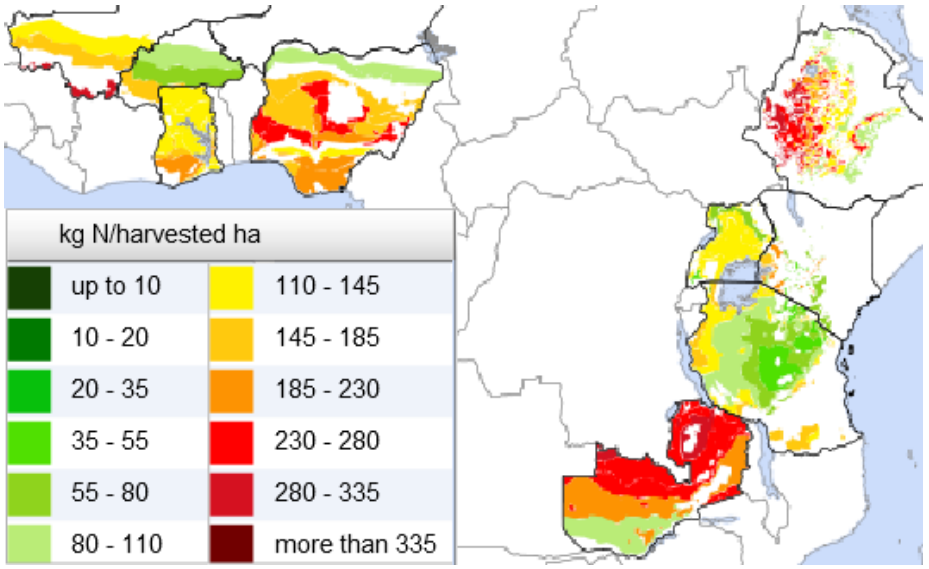
Global Yield Gap Atlas

Estimating nutrient requirements - maize

50% Y_w



80% Y_w



www.yieldgap.org

Ten Berge, De Vries, Van Loon, Hijbeek, Rattallino Edreira and Van Ittersum, 2018. In preparation

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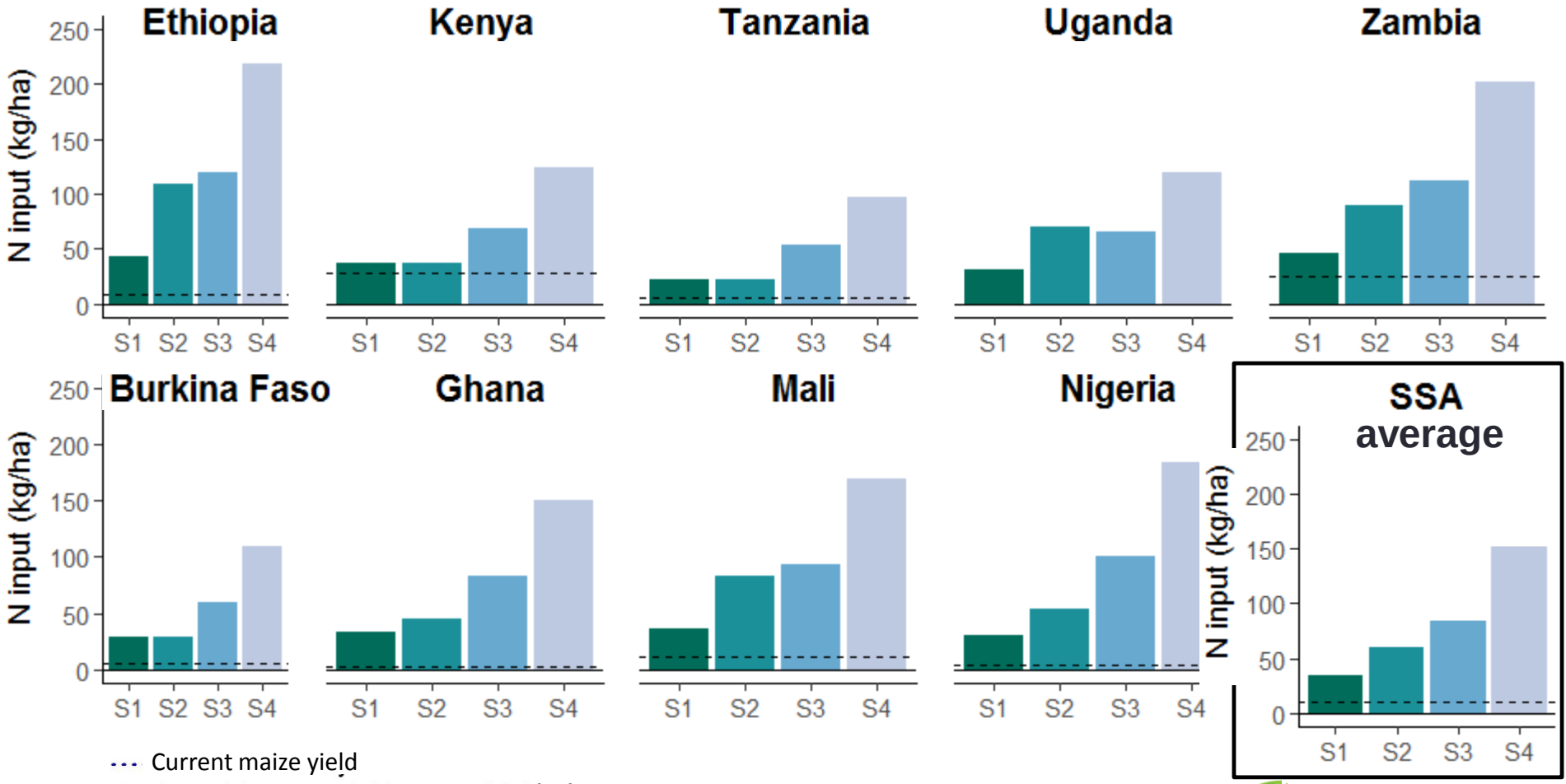
Estimating minimum nutrient requirements - maize



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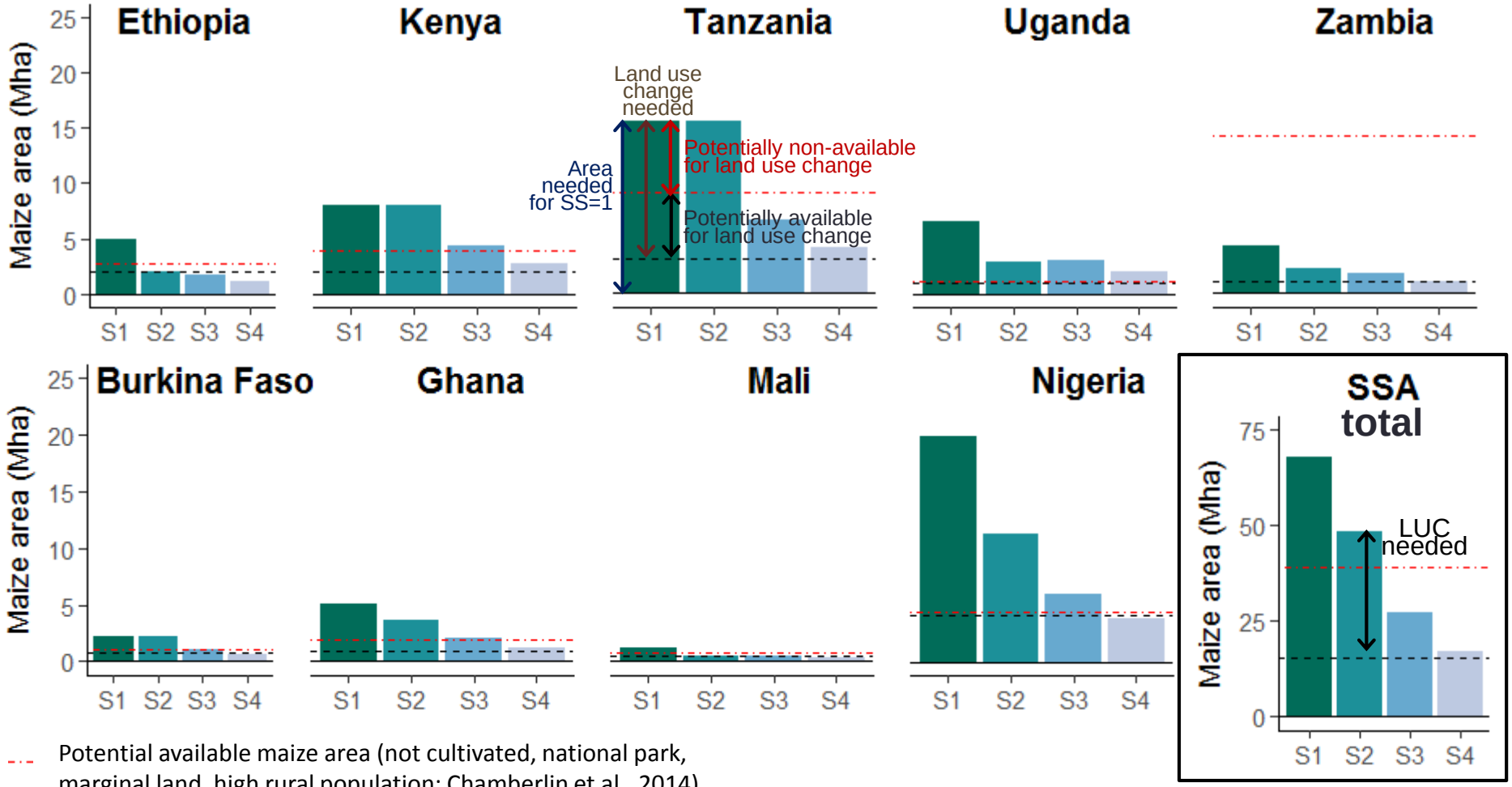
Consequences for land use change per scenario (SS=1)



Potential available maize area (not cultivated, national park, marginal land, high rural population; Chamberlin et al., 2014)

Current maize area

- Actual farmers yields 2010 (Ya) **(S1)**
- Actual farmers yields 2010 extrapolated to 2050 (Ya extrapolated) **(S2)**
- Yield gaps closed to 50% of Yw **(S3)**
- Yield gaps closed to 80% of Yw **(S4)**

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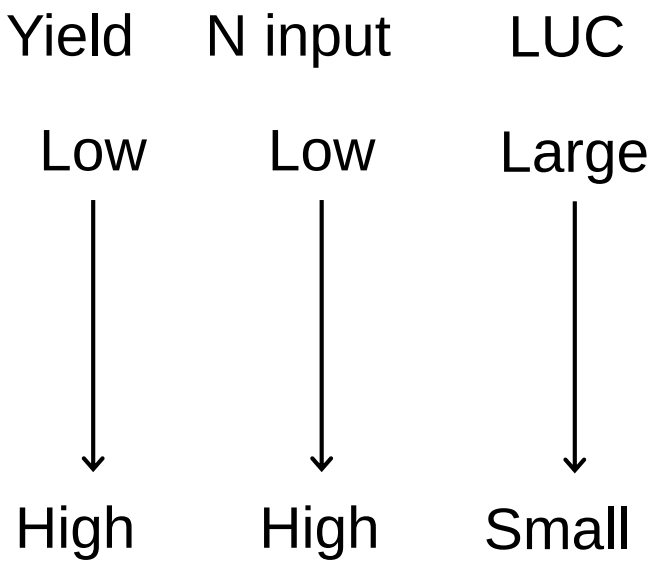
Consequences for each scenario

S1: Actual farmers maize yield 2010

S2: Actual farmers maize yield 2010 extrapolated to 2050

S3: Maize yield is 50% of Y_w

S4: Maize yield is 80% of Y_w



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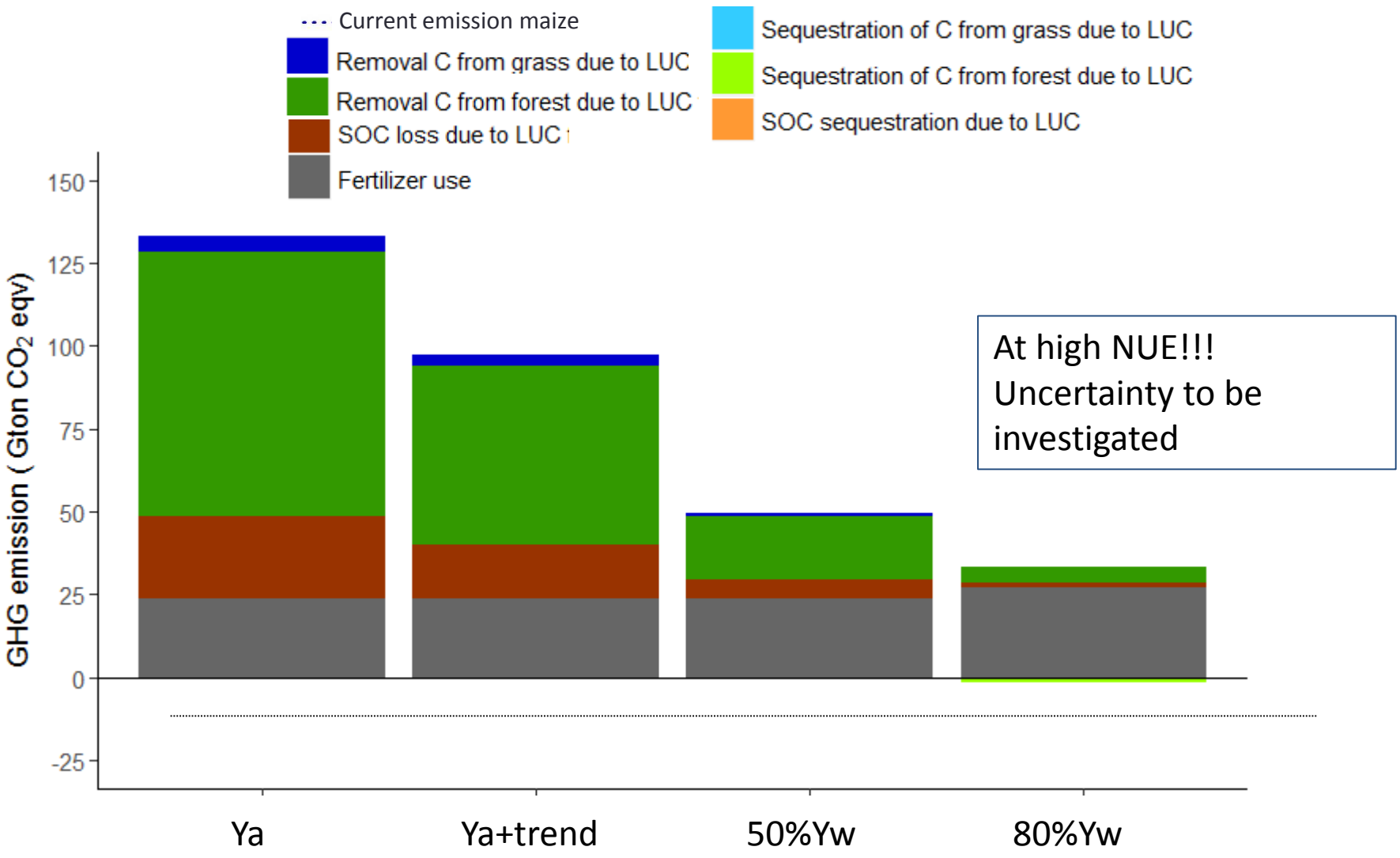
Total GHG emission for maize in 2050 (SS=1; 9 countries)

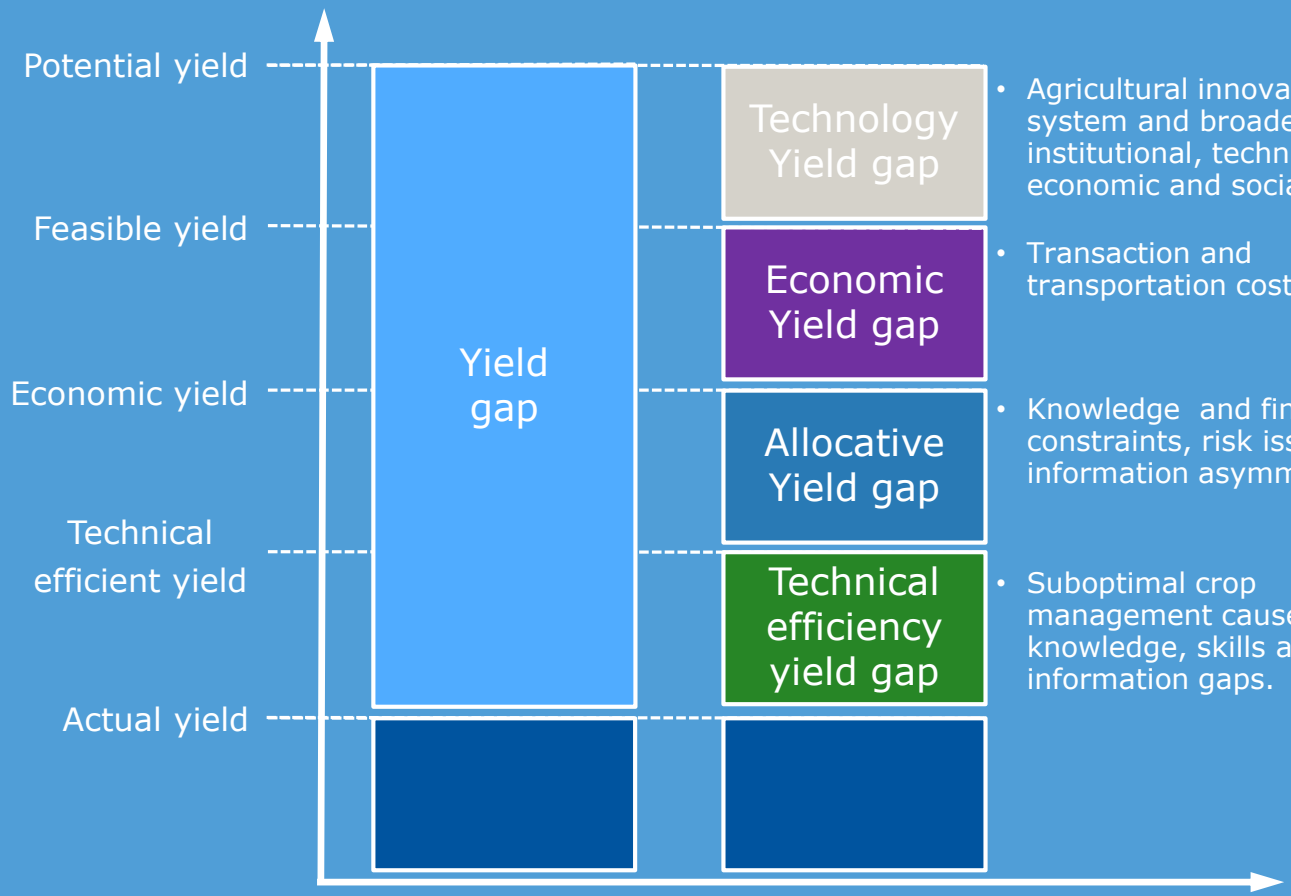


Van Loon, Hijbeek, Ten Berge, Van Ittersum, in preparation

Conclusions

- To keep up with enormous increase in cereal demand and to avoid massive crop area expansion or import dependency yield gap closure is essential
- Intensification maize production requires large increase in nutrient (and thus N) application
- Resulting increase in GHG emissions:
  - Keep emission intensity constant through good agronomy
- Meeting food demand through land use change, instead of intensification, will result in more GHG emissions
  - Land area for such expansion not available in most SSA countries
  - And competition for biodiversity

Interventions to close the yield gap(s)



Main causes	*Policies*
• Agricultural innovation system and broader institutional, technological, economic and social factors	• Investment in applied agricultural research and development programs
• Transaction and transportation costs	• Investment in rural roads • Policies to decrease transaction costs
• Knowledge and financial constraints, risk issues and information asymmetries	• Credit & insurance • Expand agro-dealer networks • Support market information • Land tenure systems • Smart input subsidies
• Suboptimal crop management caused by knowledge, skills and information gaps.	• Improve extension services • Stimulate knowledge transfer from best practice to average farmers

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

Future harvest

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This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements