CROSSROADS
ASIA PACIFIC

KUALA LUMPUR
MALAYSIA
20-22 OCTOBER 2015

Bridging the yield gap for food security: a case of Bangladesh

Jagadish Timsina (CIMMYT, Bangladesh & University of Melbourne, Australia)
Akbar Hossain (BARI, Bangladesh)
Saiful Islam (CIMMYT, Bangladesh)
Joost Wolf (WUR, Wageningen, Netherlands)
Martin van Ittersum (WUR, Wageningen, Netherlands)

Outline of the presentation

- Concept of yield potential (Yp) and yield gap (Yg)
- Bridging yield gap for food security: Bangladesh
  - Dynamics of land use, CSs, food habits, etc.
  - GYGA Project: mapping for Yp& Yg
  - Factors affecting current & future food self-sufficiency
  - Cereal demand and supply in (2030 &) 2050
  - Fertiliser demand and supply in (2030 &) 2050
- Tech. and mgt. practices to bridge the Yg
- Conclusions

Definitions

- Potential yield (Yp)→ yield simulated for optimal growing conditions; no water and nutrient stress; no yield losses by weeds, pests and diseases
- Water limited yield (Yw) → Yp but under rainfed
- Actual yield (Ya) → for single field, or average for a specified area
- Attainable/exploitable yield (Yatt): 85% of Yp or 80% of Yw
- Yield gap (Yg)→ (Yp – Ya), or (Yw – Ya)

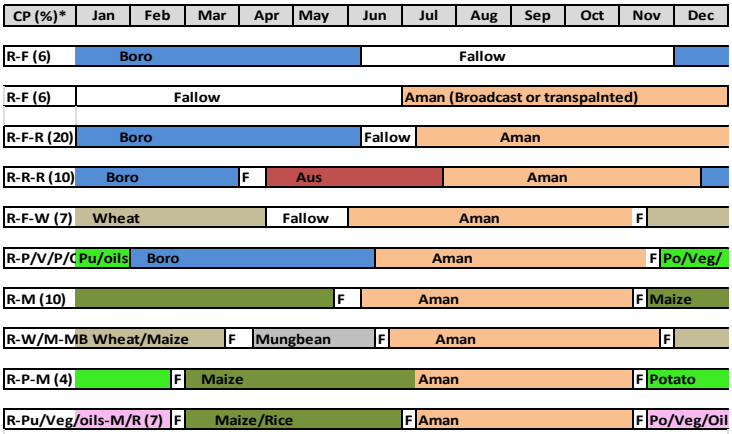
Bridging the yield gap?

- Yg = (Yp or Yw) - Ya
- Attainable/exploitable Yg: Yatt- Ya
- Aim for (bridging the Yg):
  - Increase actual yield to as close as 80-85% of Yp

    and/or
  - 50-85% of exploitable Yg closure = Ya + (Yatt-Ya)*(0.50 to 0.85)

Case study: Bangladesh

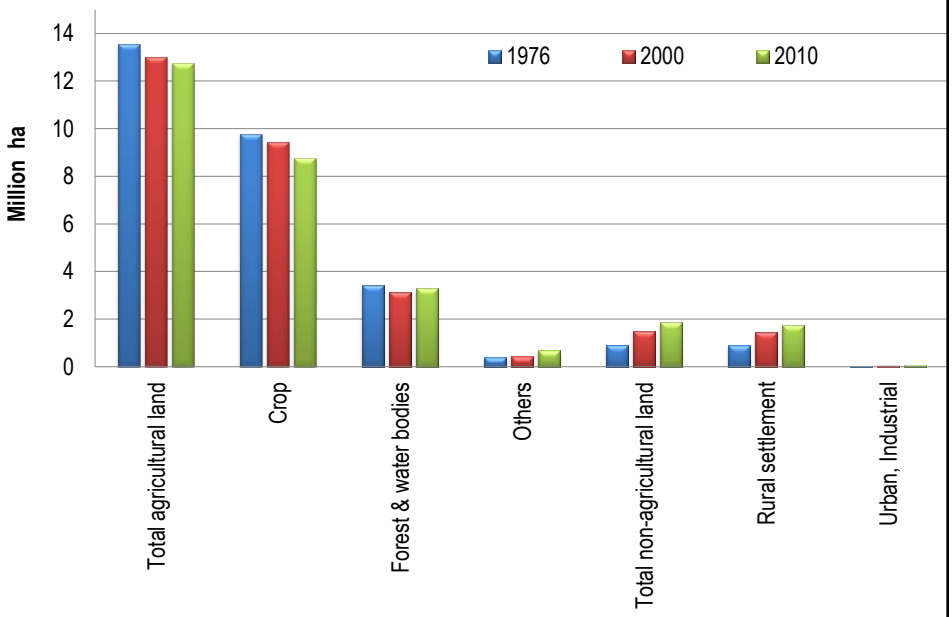
Crop calendar showing major cropping systems in Bangladesh



***CP** : Cropping patterns, **R-F** : Boro/Aman rice - Fallow; **R-F-R** : Boro rice-Fallow- Aman rice; **R-R-R**: Boro rice -Aus rice (Broadcast/transplanted)- Aman rice; **R-F-W** : Boro rice -Fallow-Wheat; **R-P/V/P/O-R** : Aman rice-Potato/Vegetables/Pulses/Oil seeds- Boro rice; **R-M** : Aman rice -Rabi Maize; **R-W/M-MB**: Aman rice-Wheat/Maize-Mungbean; **R-P-M** : Aman rice-Potato-Kharif Maize; **R-Pu/Veg/oils-M/R**: Aman rice- Pulses/Vegetables/Oil seeds- Kharif maize/Aus rice; **Po**: Potato, **Pu**: Pulses, **Veg**: Vegetables, **Oils**: Oil seeds. Aman rice in all above cropping patterns is transplanted (called T. aman) while in some southern areas deep water aman is either broadcast or transplanted ; Boro rice is always transplanted. % inside parenthesis denotes approximate % of area under th given cropping pattern in the country. Remaining % is for cropping patterns involving minor crops such as cotton, jute, sugarcane, soybean, sunflower, tobacoo, etc.

Global Yield Gap Atlas

Land use change (M ha)



Current and future food demand

(Med. pop. projections by UN. & demand by IFPRI's IMPACT model)

Projections	Demand/cap./annum (kg grain)				% Change, future annual demand/ cap.	National demand/annum (M ton grain)				% Change, future annual national demand
	Maize	Wheat	Milled rice	All-grain		Maize	Wheat	Milled rice	All-grain	
2010	9.9	25.9	170.5	198.9	-	1.50	3.91	25.8	30.1	-
2030	12.5	29.6	162.7	196.2	**-1.36**	2.31	5.47	30.1	36.3	**+20.6**
2050	14.0	34.7	145.8	184.5	**-7.24**	2.83	7.01	29. 5	37.3	**+23.9**

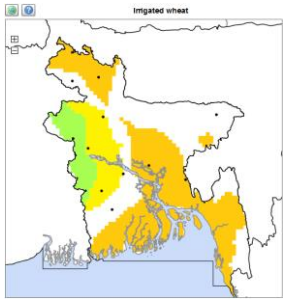
Global Yield Gap Atlas

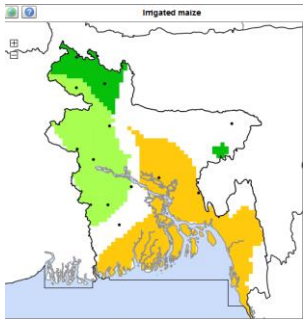
Actual and future yield levels for cereals

Yield levels (t ha^{-1})	Maize		Wheat		Rice		
	Irrigated, rabi	Rainfed, K-1 & rabi	Irrigated	Rainfed	Irrigated, boro	Rainfed, aman	Rainfed, aus
Yield potential (Yp and Yw)	12.0	9.0	5.5	3.0	**9.0**	**6.0**	**5.0**
Actual yield – Ya	6.2	4.5	2.8	1.8	5.9	3.4	2.9
Yield gap - Yg	5.8	4.5	2.7	1.2	3.1	2.6	2.1
Yatt (85% of Yp or 80% of Yw)	10.2	7.2	4.7	2.4	7.7	4.8	4.0
Y-50% CI (50% gap closure)	8.2	5.9	3.7	2.1	6.8	4.1	3.4
Y-80% CI (80% gap closure)	9.4	6.7	4.3	2.3	7.3	4.5	3.8

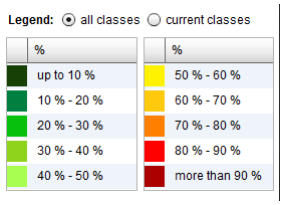
Global Yield Gap Atlas

Relative yield gaps





www.yieldgap.org



Global Yield Gap Atlas

Current status of cereal self-sufficiency

- Bangladesh is self sufficient in rice production (Supply-Demand ratio - SDR - in 2010 = 1.09) but cannot meet the rice demand in some years
- SDR for maize = 0.67
- SDR for wheat = 0.21
- SDR for all grain crops = 0.99

Factors reducing future food sufficiency

- Increase in population
  - 2010: 151 million;
  - 2030: 185 million;
  - 2050: 202 million
- Increase in food demand
  - population
  - Change in food consumption pattern due to increasing income & urbanization (e.g., poultry)
- Decrease in arable lands due to urbanization, increasing risk for flooding and salinization by sea level rise, etc.

Ways to improve future food sufficiency

- Increase crop yields
- Increase crop intensity: already approx. 200% at present
- Increase in cereal imports

A priori: best option seems to be to increase crop yields

Global Yield Gap Atlas

Food security analysis for Bangladesh

- Assess the degree of food self-sufficiency for different scenarios (for 2030) and 2050, considering
  - Increase in population
  - Changes in diet
  - Possible decreases in arable land areas
  - Changes in cropping patterns
  - Possible increase in yield levels

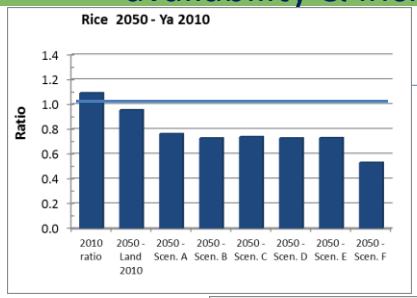
Global Yield Gap Atlas

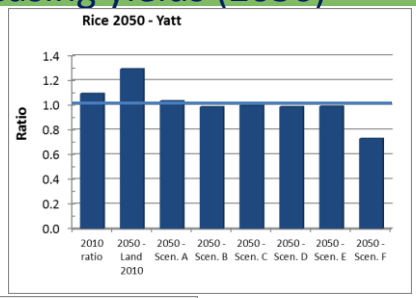
Scenarios for future land use change (2050)

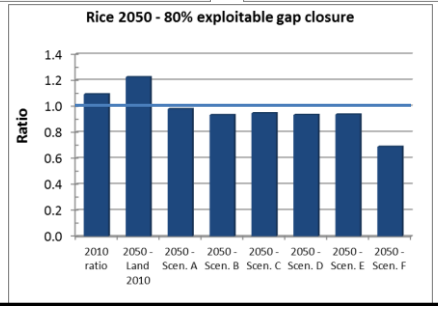
Scenario	Description
A	20% decrease in arable land (across the country)
B	+ 20% decrease in boro rice and 10% increase in rabi maize & wheat areas (in north)
C	+ 40% of fallow areas cropped with boro rice and 30% with maize & wheat (in south)
D	+ 10% decrease in aman rice areas due to sea level rise (in south)
E	+ 10% increase in aus rice areas (in south) and 20% increase in kharif-1 maize areas (in north)
F	+ 50% decrease in boro rice areas => high value crops (across the country)

Global Yield Gap Atlas

Rice supply-demand ratios – effect of decreasing land availability & increasing yields (2050)

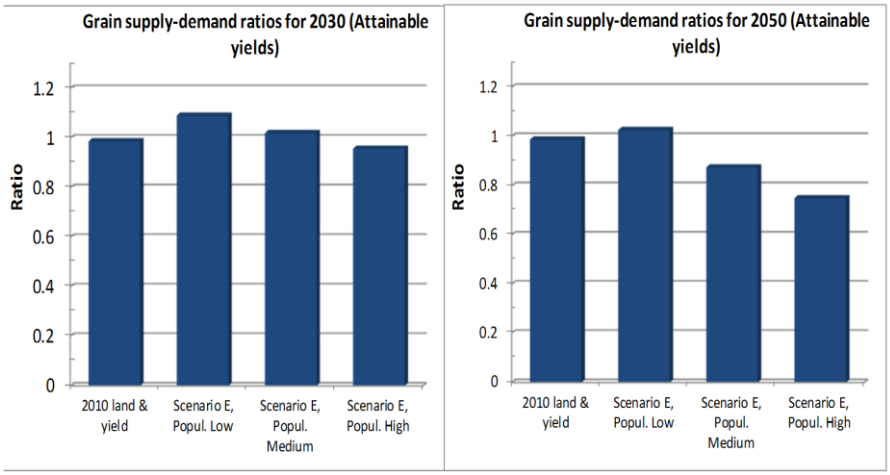






Global Yield Gap Atlas

Supply-demand ratios: effect of population projection (2030 & 2050)



Global Yield Gap Atlas

Total production estimates for 2050 (m tons)

Year	Scenarios	Maize	Wheat	Rice
2010	Base	1.01	0.83	28.3
2010 Yield levels	A	0.81	0.66	22.6
	B	1.23	0.86	21.6
	F	1.54	0.97	15.8
2050 (80-85%of Yp)	A	**1.33**	**1.08**	30.6
	B	**2.02**	**1.40**	29.2
	F	2.52	1.55	21.6
2050 (50% Yg closure)	A	1.07	0.87	26.6
	B	1.63	1.13	25.4
	F	2.03	1.26	18.7

Demand (med. Pop.), m tons (2050): Maize: 2.8; Wheat: 7.0; Rice: 29.5

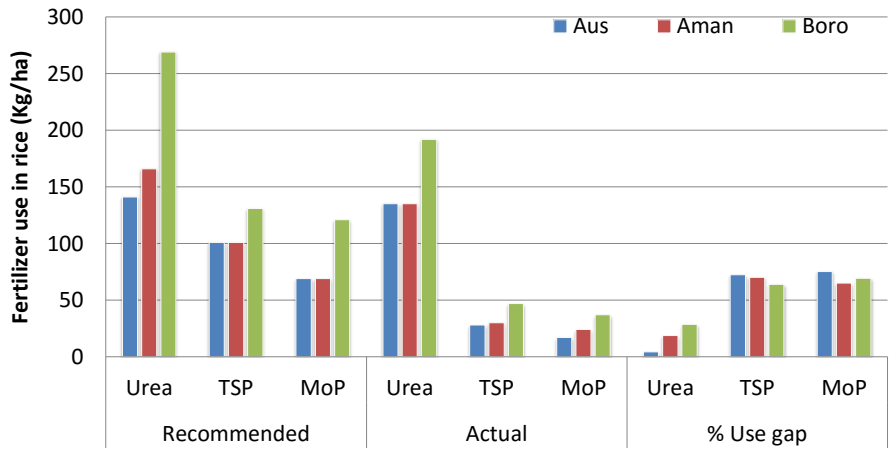
Global Yield Gap Atlas

Calculations of fertilizer demand

- Fertilizer recommendations in BD developed for various yield goals & soil fertility levels across country
- Current (actual) fertilizer use, fertilizer demands for Yatt levels, & fertilizer use gaps calculated
- Fertilizer demands for various yield levels & scenarios under medium fertility (62% area) & low fertility (38%) for the whole country calculated
- Domestic fertilizer supplies were estimated
- Import = Domestic supply – demand

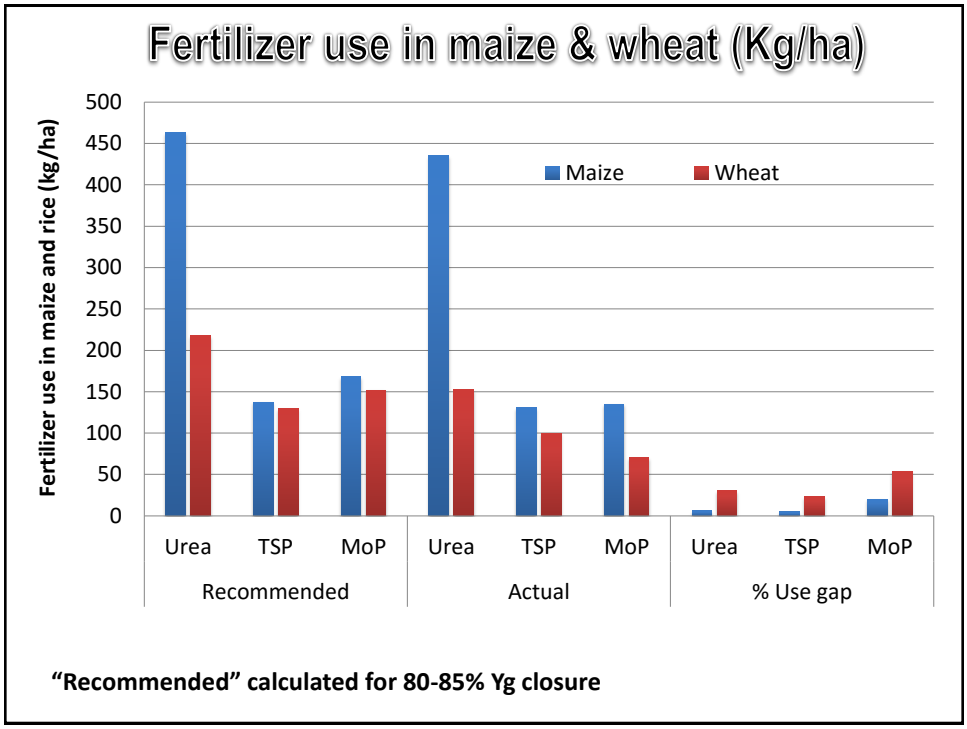
Global Yield Gap Atlas

Fertilizer use in rice (Kg/ha)

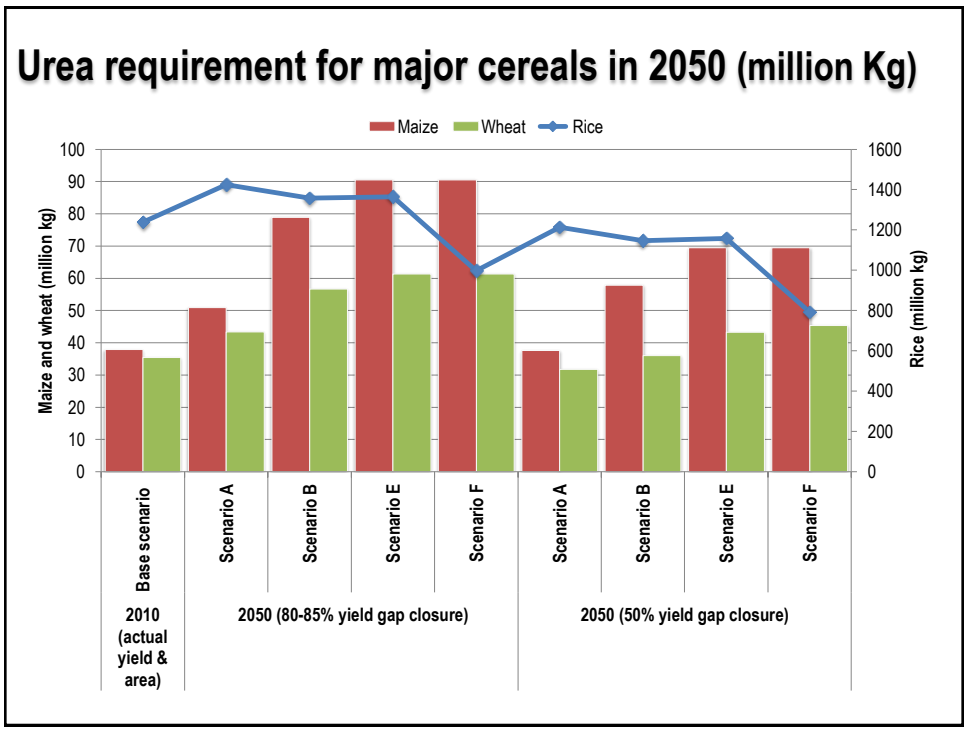


"Recommended" calculated for 80-85% Yg closure

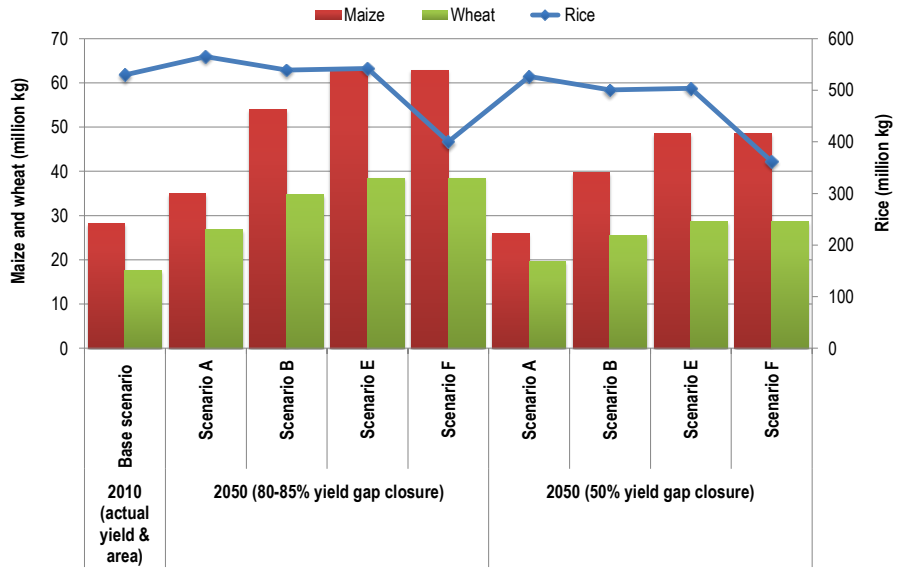
Global Yield Gap Atlas



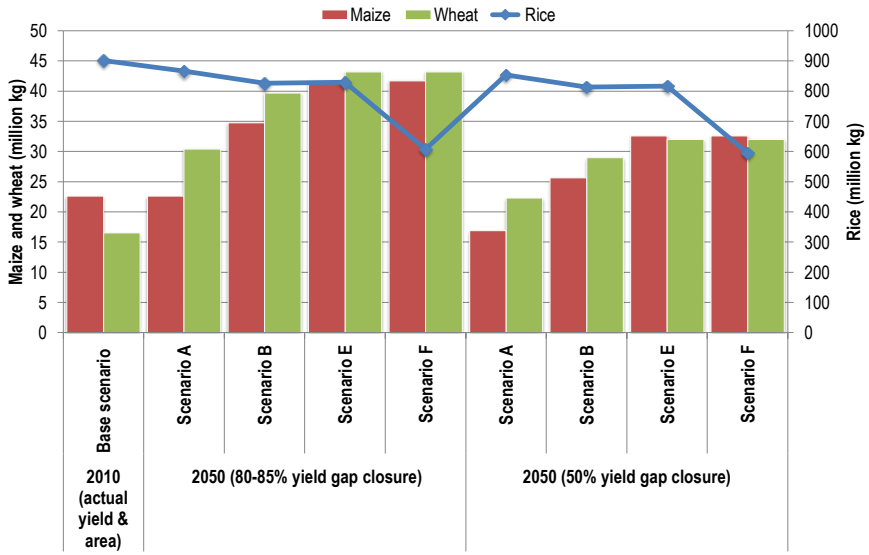
"Recommended" calculated for 80-85% Yg closure



TSP requirement for major cereals in 2050 (million Kg)



MoP requirement for major cereals in 2050 (million Kg)



Fertilizer requirements for major cereals (80-85% Yg closure)

- **Requirements (total; 2012-13)**:
  - Urea: 2500 million Kg; TSP: 700 million Kg
  - MoP: 870 million Kg; DAP: 600 million Kg
- **Requirements (R, W, M; 2050: Scenario A)**:
  - Urea: 1518 million Kg; TSP: 627 million Kg
  - MoP: 919 million Kg
- **Current domestic production**: ~40% urea, <10% TSP & DAP, and 0% MoP (for all; total).
- **Large imports will be needed in future**.

Source: Fertilizer Association of Bangladesh

Global Yield Gap Atlas

Technologies & mgt. practices to bridge the Yg

- Variety
- Management
  - **Optimize fertilizer/nutrient use: e.g., SSNM**
  - **Water**
  - Weed
  - Pest and diseases
- Upscaling of fertilizer technologies: e.g., Nutrient Expert, Nutrient Manager

Global Yield Gap Atlas

Conclusions

- Supply-demand ratios cereals (SDRs) in 2010:
  - <<1 for maize and wheat
  - ~1 for rice
- National demands from 2010 to 2050:
  - will almost double for maize and wheat
  - increase by 15% for rice
- Supply-demand ratios cereals from 2010 to 2050:
  - will decrease for all three crops
  - will only be ~1 for rice in 2050 if 80 (Yw) or 85% (Yp) Yg closure will be achieved
  - population growth important driver

Global Yield Gap Atlas

Conclusions

- High system production potential (e.g., R-M; ~20.0 t/ha) demands for high amount of fertilizer application
- Rice: Largest (65-75%) use gap for K; lowest gap (4-29%) for N.
- Maize & wheat: Largest (20-50%) use gap for K; lowest gap (5-23%) for P.
- Bridging yield gap & meeting food security currently & in future requires increased fertilizer use. Policy priority should be given for increasing domestic production but also imports to meet demand.

Global Yield Gap Atlas


Global Yield
Gap Atlas
Thank you for your attention
Nebraska
Lincoln
WAGENINGEN UNIVERSITY
WAGENINGEN UR
Water for Food
ICRISAT
Science with a human face