Nitrogen management for future food security: sub-Saharan Africa case study

Masso et al. 2016

ARC-INI

Melbourne (Australia), 05 December 2016

Take home message from SSA

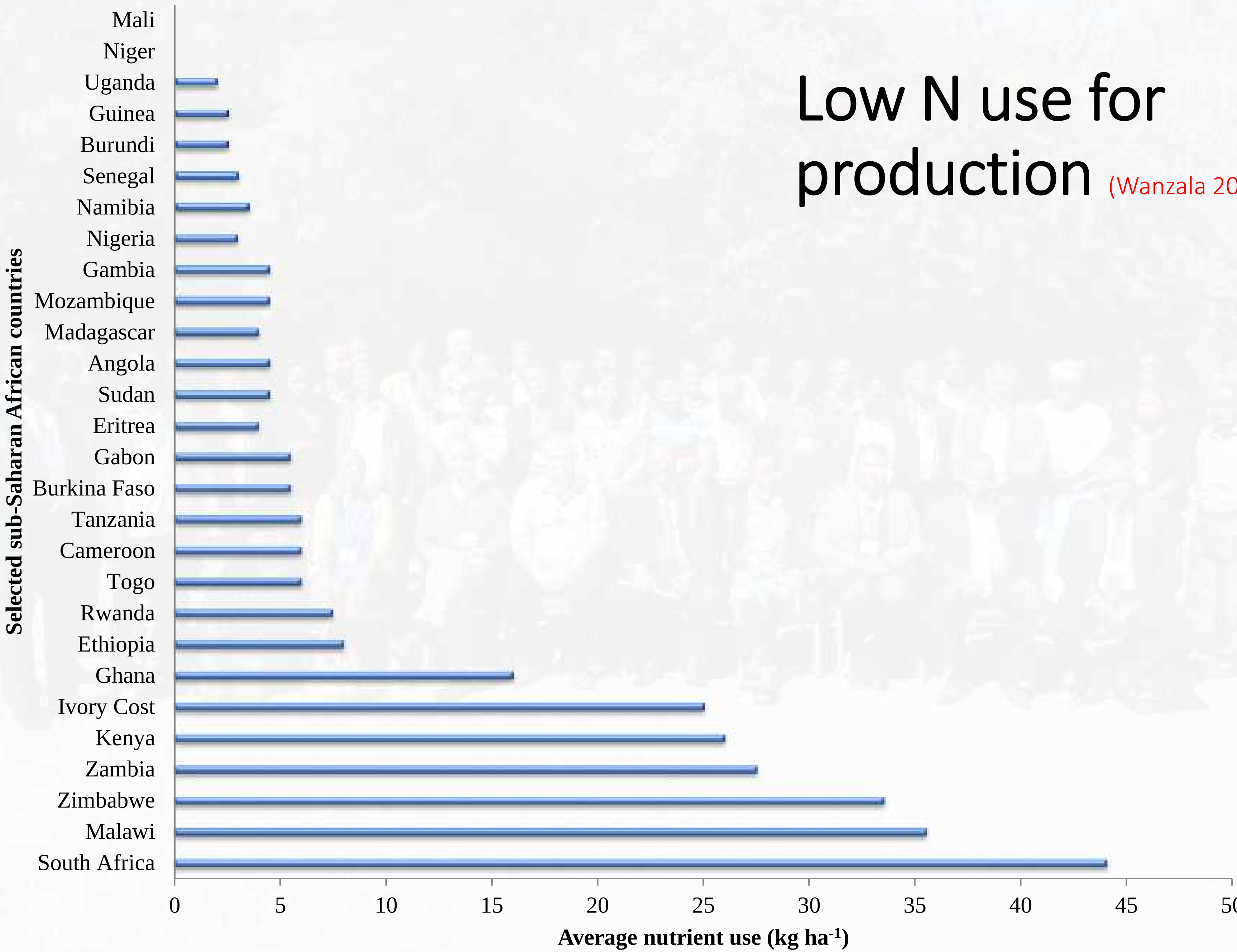
- Too little N for food production
- Too much N losses to the environment
- Excessive yield gaps due to land degradation i.e. poor N agronomic use efficiency
- Many opportunities available to reverse the trend
    - Provided supportive policies
    - Provided significant research
- Highest population growth

Food security (White et al. 2012)

- Sufficient food (quantity)
- Nutritious food (quality)
- Safe (tolerable level of contaminants)
- Balanced diets (diversity)

Challenges related to too little N

Low N use for production (Wanzala 2011)

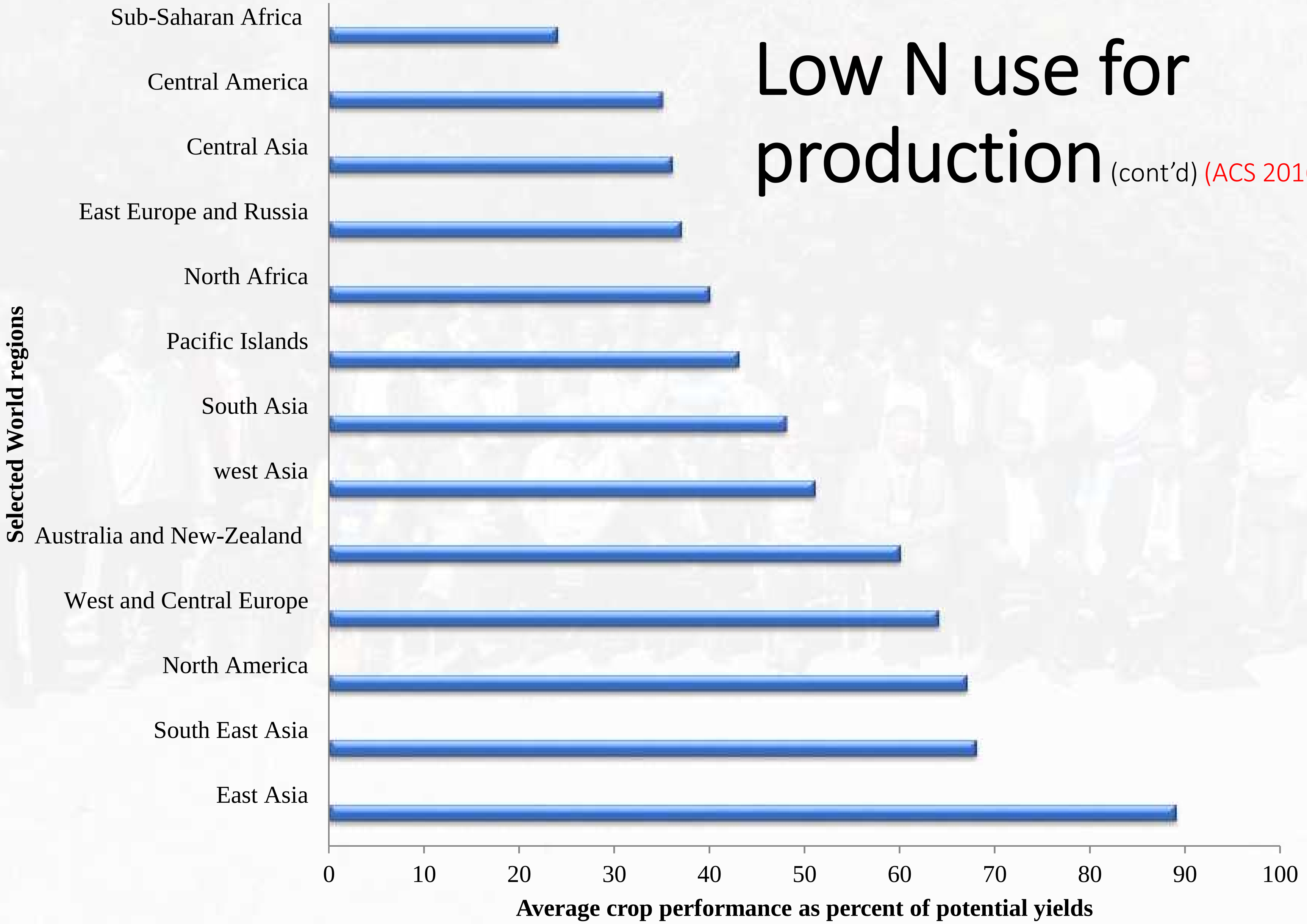


Low N use for production (cont'd)

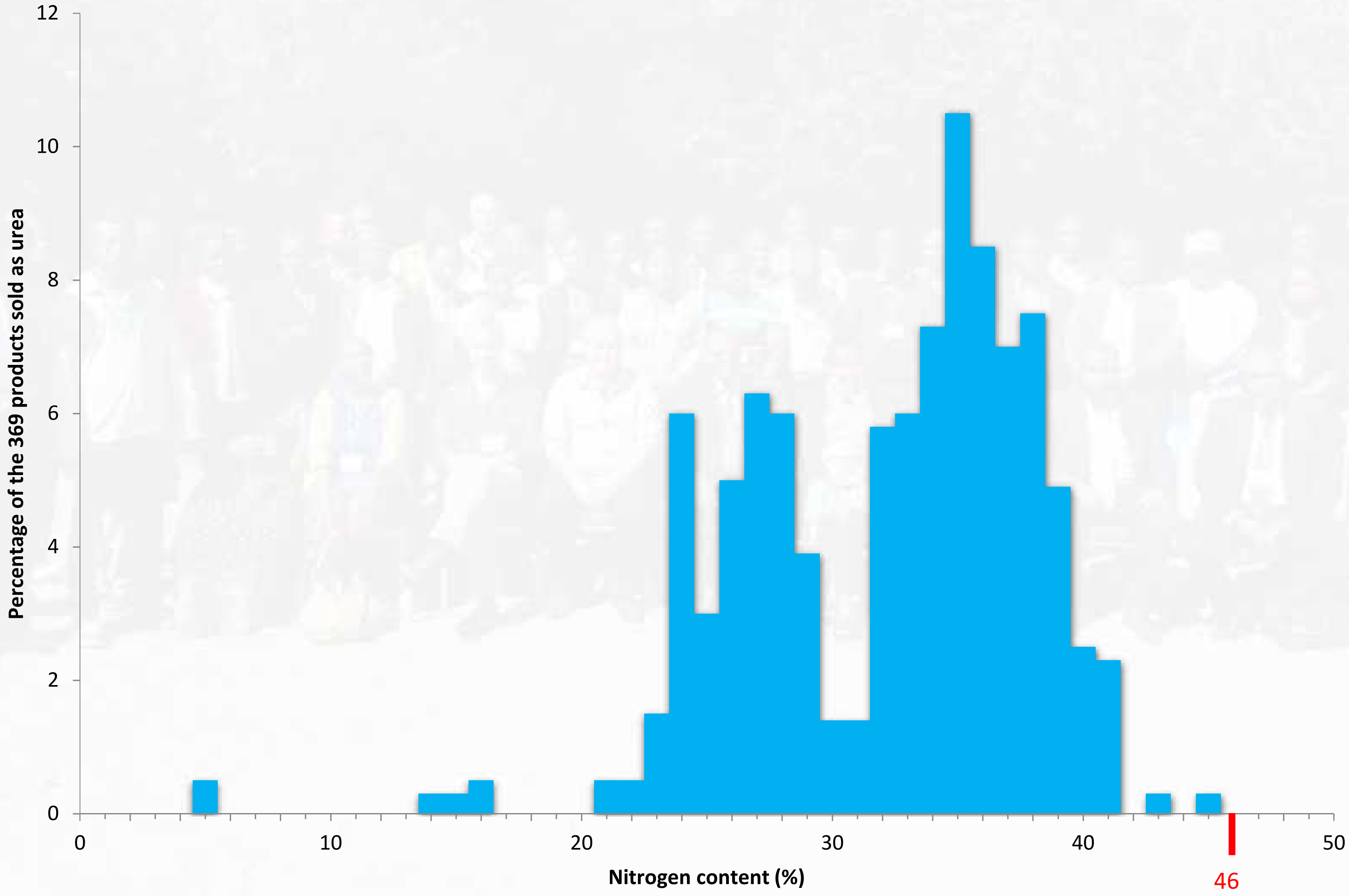
Country	kg N ha^{-1} yr^{-1}	Country	kg N ha^{-1} yr^{-1}
Benin	-16	Mali	-11
Botswana	-2	Nigeria	-37
Cameroon	-21	Rwanda	-60
Ethiopia	-47	Senegal	-16
Kenya	-46	Tanzania	-32
Malawi	-67	Zimbabwe	-27

Chianu et al. 2012

Low N use for production (cont'd) (ACS 2016)



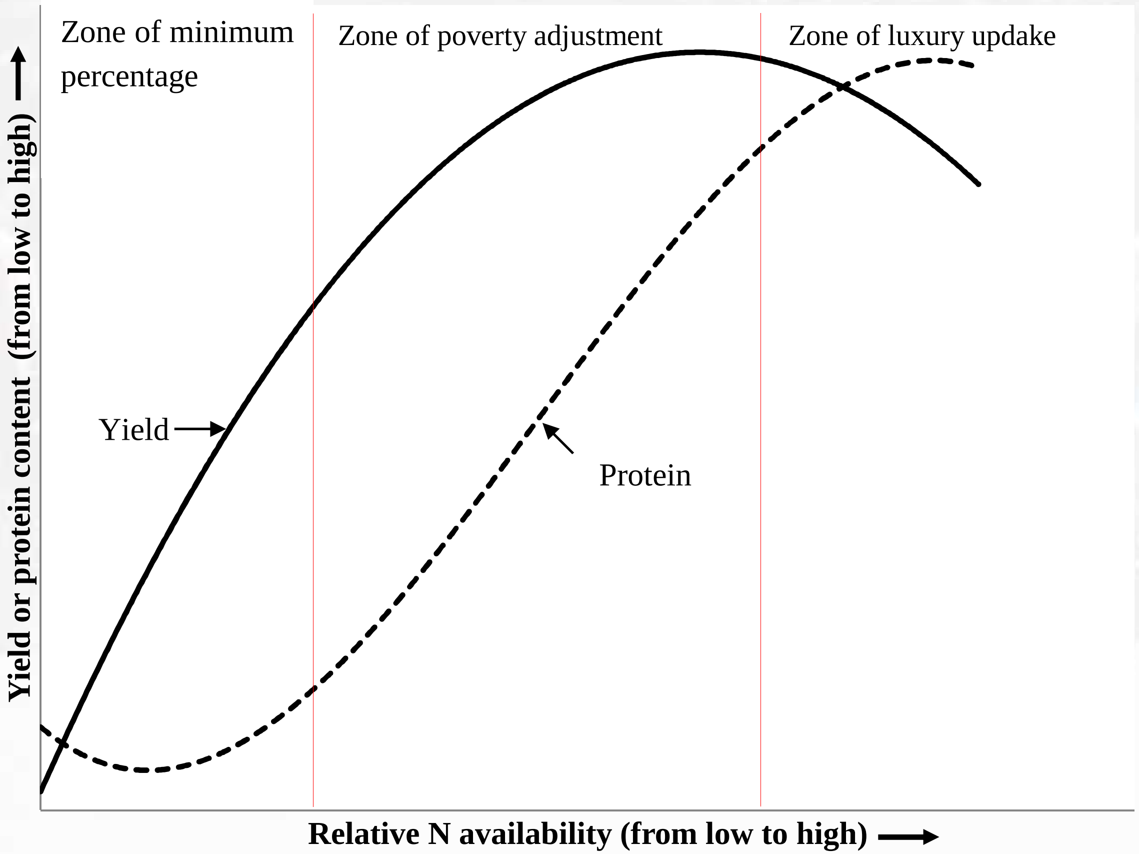
Poor quality of N inputs (Bold et al. 2015)



Poor input and output markets (Guo et al. 2009)

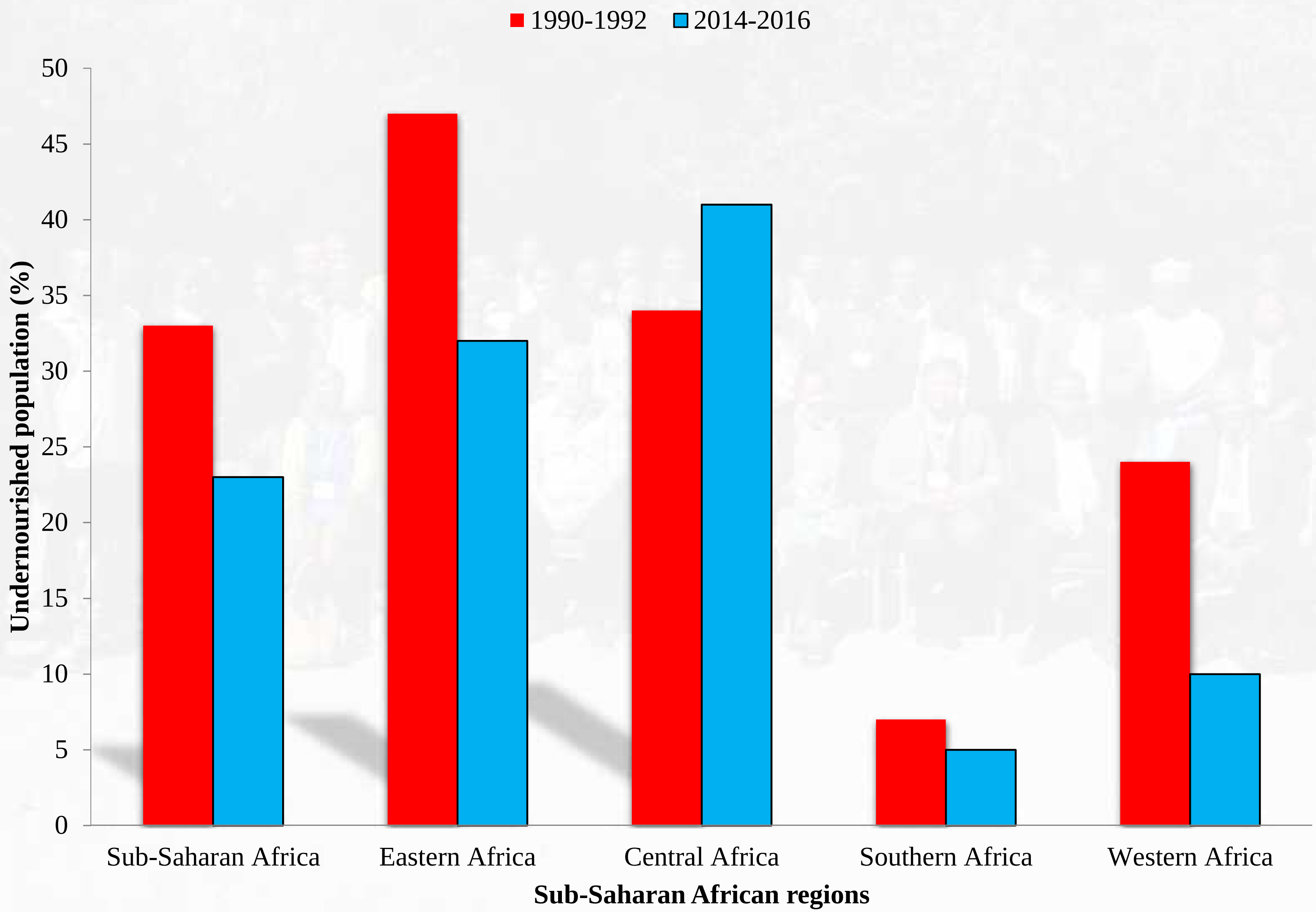
Country	Farm-gate urea costs[A]			Farm-gate maize prices[B]			Value-cost ratio		
	Market access								
	USD (metric ton)$^{-1}$								
	High	Med	Low	High	Med	Low	High	Med	Low
Burundi	659	684	693	234	200	185	2.5	2.0	2.0
Kenya	458	486	522	288	238	182	2.8	2.3	1.5
Rwanda	647	675	699	236	209	178	2.0	1.5	1.5
Tanzania	526	552	622	245	214	128	3.3	2.8	1.3
Uganda	553	577	613	244	202	168	3.0	2.1	1.8

Low protein content in food crops



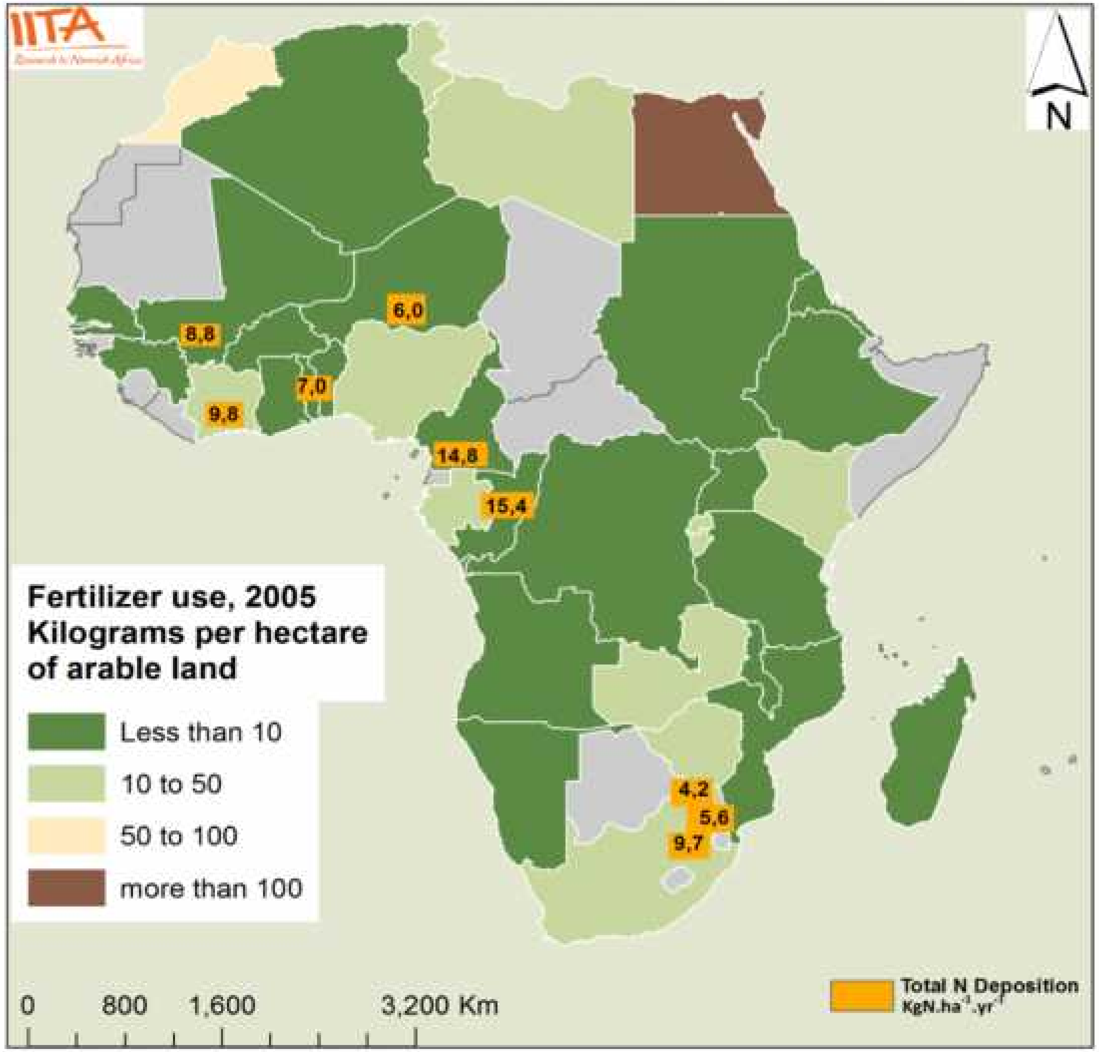
Wheat (Selles and Zentner 1998)

Undernourishment (ACS 2016)



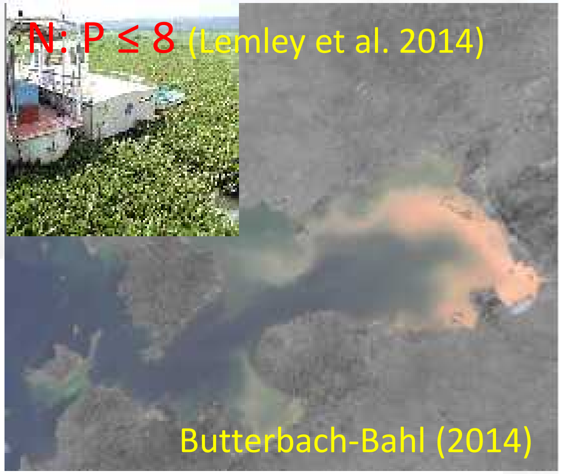
Challenges related to too much N

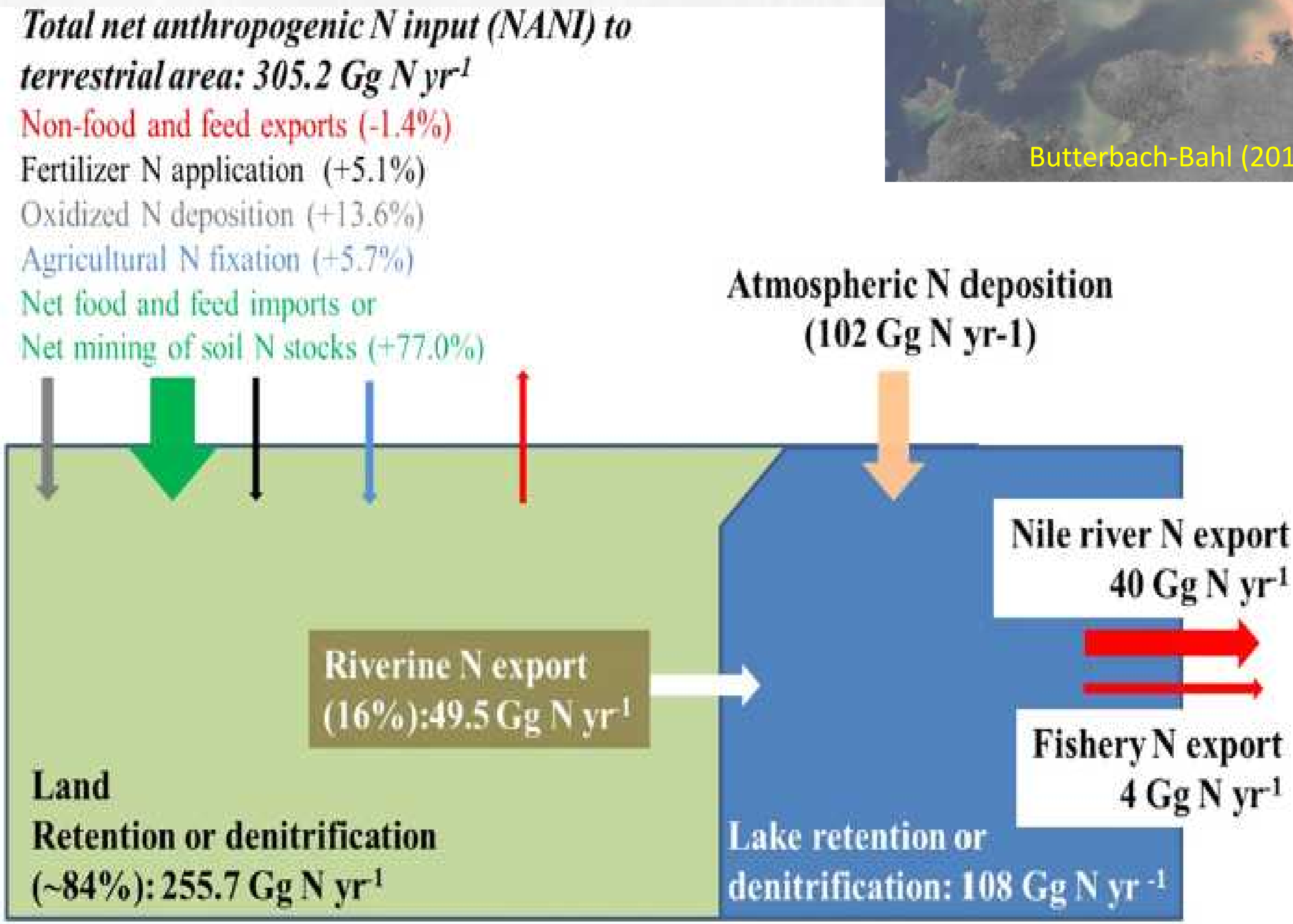
N deposition ≈ Fertilizer rate



Galy-Lacaux and Delon (2014); Vet et al. (2014)

Eutrophication (Zhou et al. 2014)





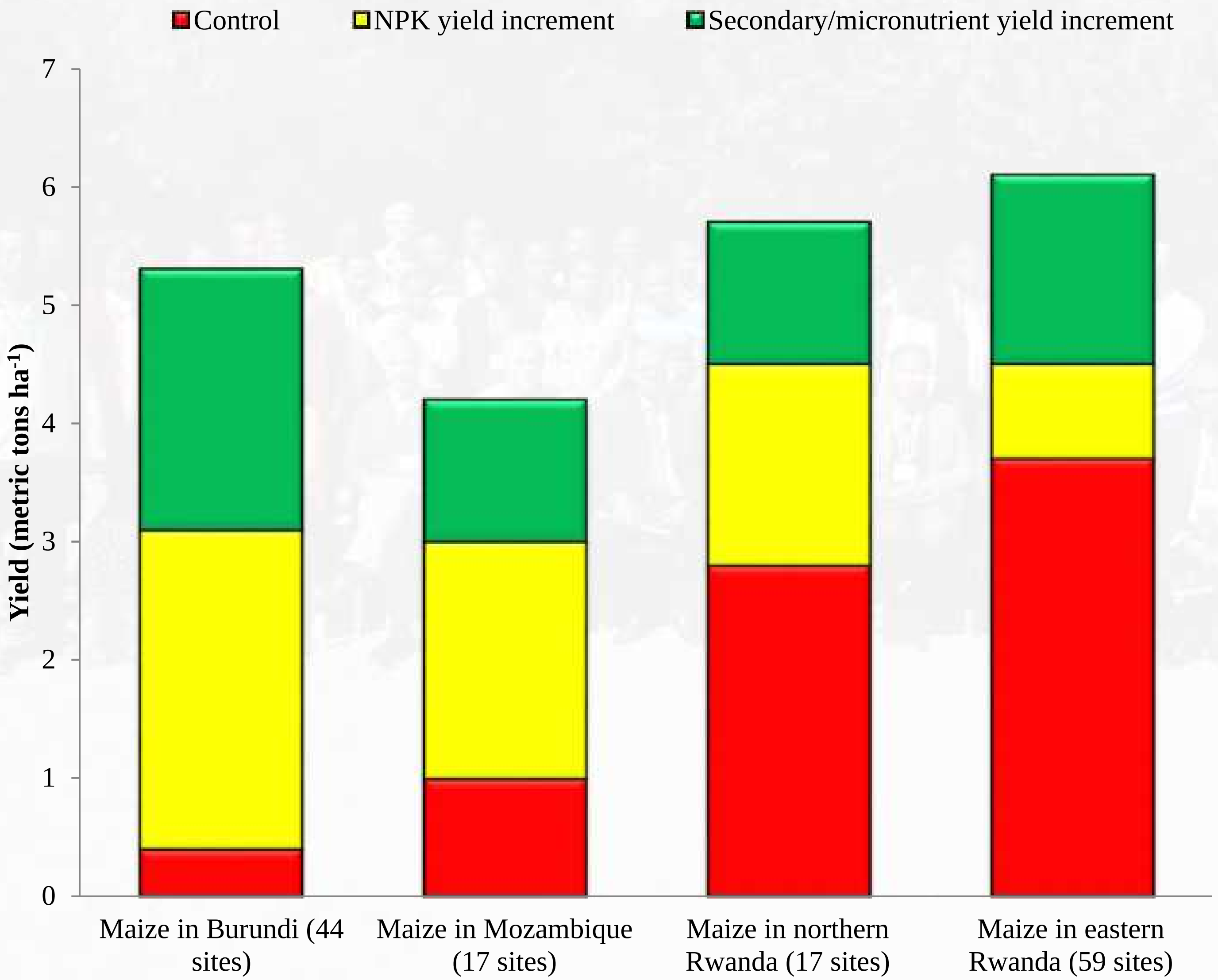
Opportunities for better N Management

N agronomic use efficiency (Ghosh et al. 2015)

Crop	Yield (t ha^{-1})		Agronomic efficiency (kg grain kg N^{-1})	
	N alone	N+PK	N alone	N+PK
Rice (wet season)	3.28	3.82	13.5	27
Rice (summer)	3.03	6.27	10.5	81
Wheat	1.45	2.25	10.8	20
Pearl millet	1.05	1.65	4.70	15
Maize	1.67	3.23	19.5	39
Sorghum	1.27	1.75	5.30	12

- Dobermann (2005)
  - ✓ $RE_N = (U_N - U_0)/F_N$ (Systems with sufficient N use for production)
  - ✓ $AE_N = (Y_N - Y_0)/F_N$ (Systems with too little N use for production)

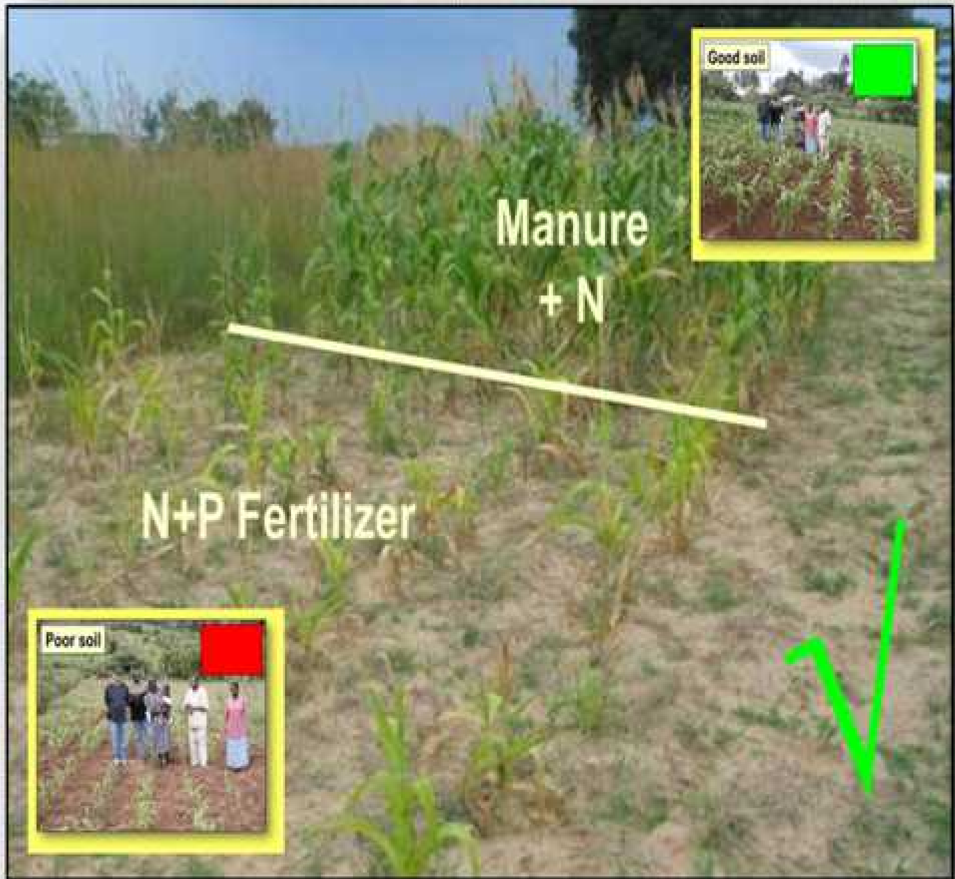
Balanced fertilization (Wendt, personal communication)



N fertilizer fractionation (Perez et al. 1996)

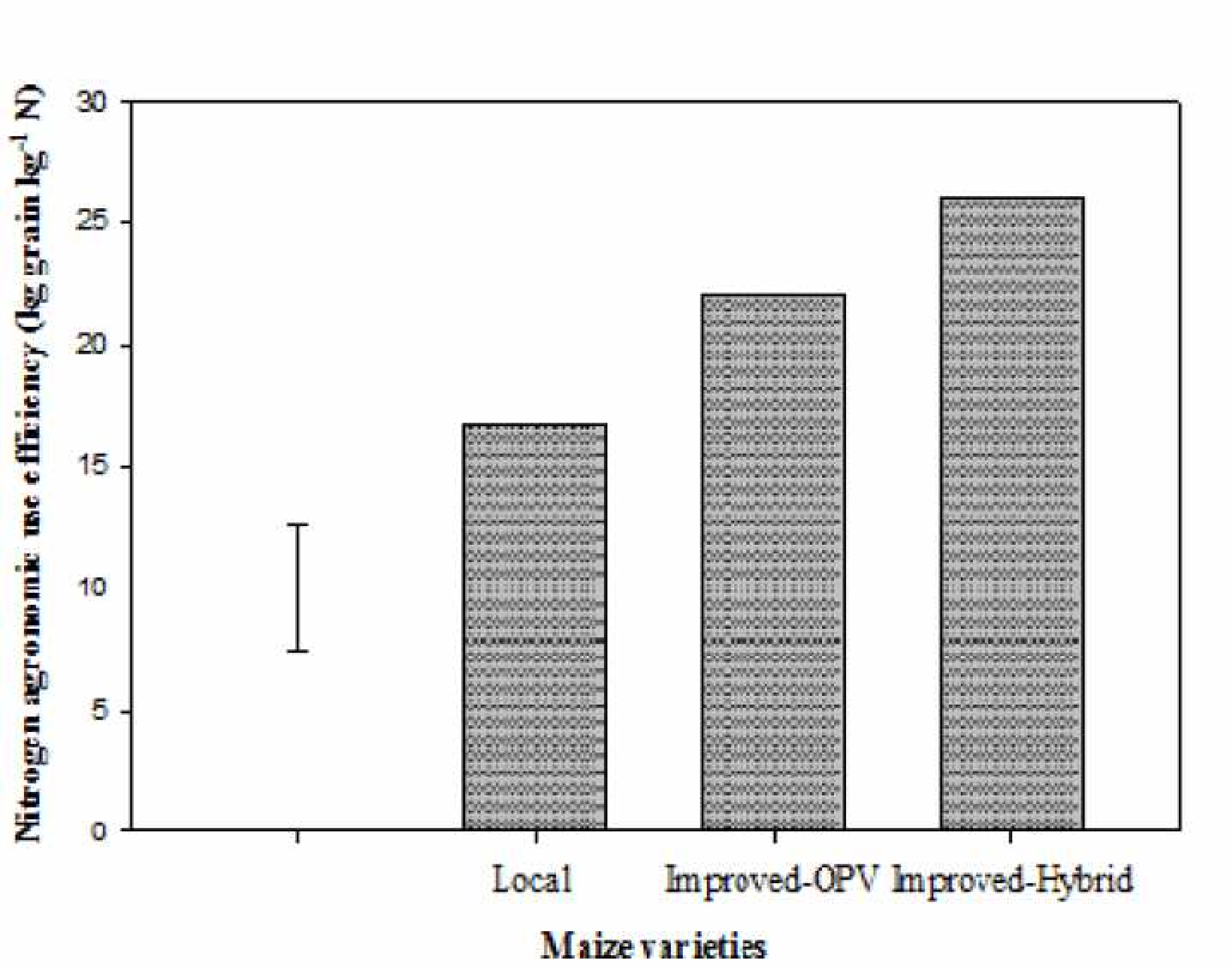
N Fertilizer treatment (kg N ha^{-1})					**Head rice yield**	**Protein**
Basal	Maximum tillering	Panicle initiation	Flowering	Total	**(t ha^{-1})**	**content (%)**
0	0	0	0	0	1.97	5.62
120	0	60	0	180	4.39	7.58
60	60	60	45	225	5.69	9.56

Organic amendment and erosion control

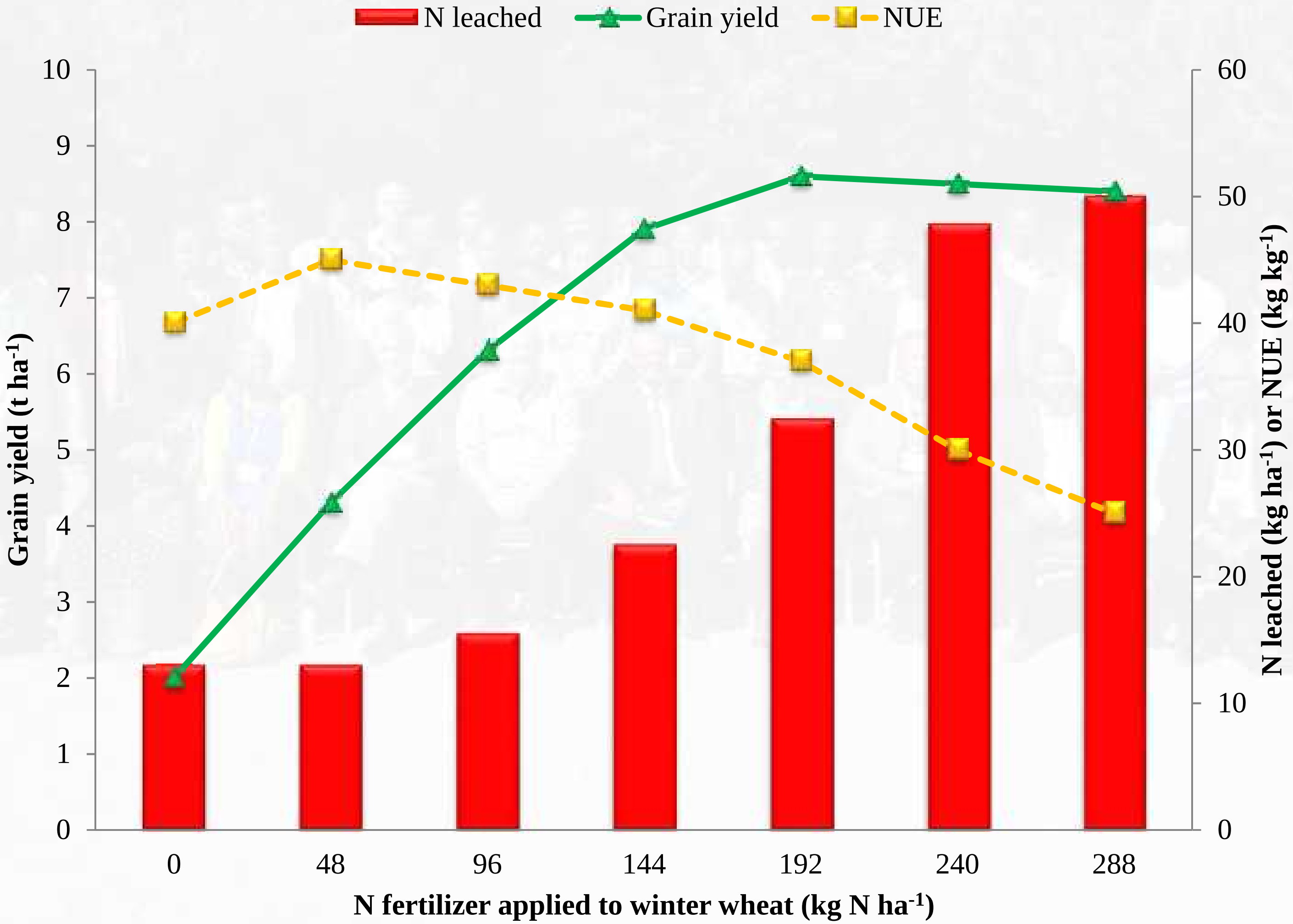


Vanlauwe, personal communication

Improved varieties (Vanlauwe et al. 2011)



Caution (Hawkesfold 2014)



Limiting factor: Resource-constrained smallholder farmers

Innovation (Wendt, personal communication)

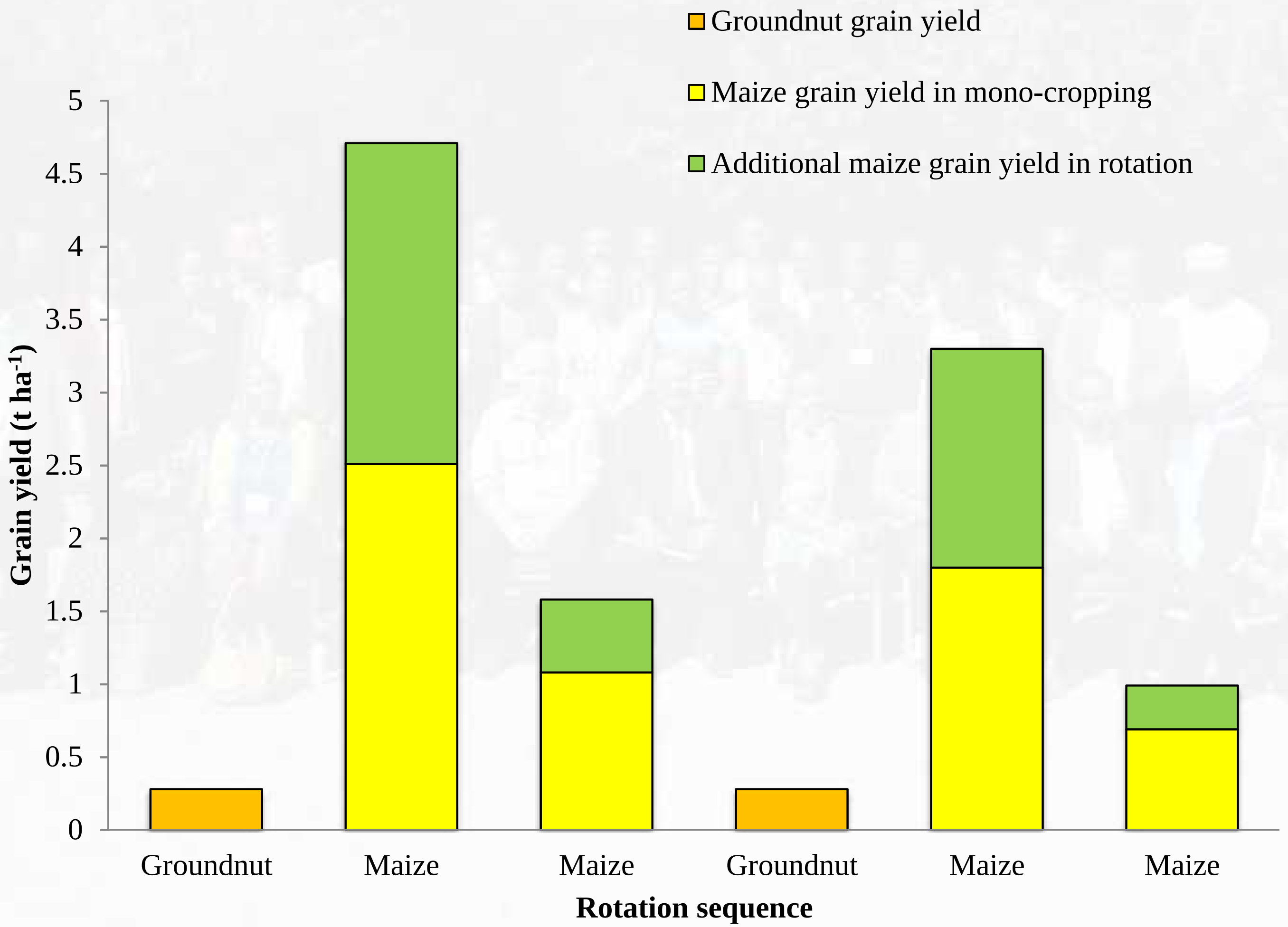
Country	Crops	Yield Increment (t ha^{-1})	Gross margin (USD ha^{-1})
Burkina Faso	Rice	1.7	NS
Ethiopia	Maize	1.3	NS
Madagascar	Rice	2.0	NS
Mali	Rice	1.6	NS
Niger	Rice	1.5	NS
Nigeria	Rice	2.5	NS
Rwanda	Rice	1.1	NS
	Maize	1.1	NS
Senegal	Rice	1.6	NS
Togo	Rice	1.0	NS
Bangladesh	Cabbage	NS^A	960
	Tomato	NS	1622

Urea briquette

BNF & rhizobia inoculants (Bouaziz, personal communication)

Legume crop	Range of N fixed (kg ha^{-1} yr^{-1})
Faba bean	54-200
Sesbania	45-552
Alfalfa	290-299
Lentil	165-189
Pea	52-77
Vicia	80-102
Common bean	40-70

Rotation (Waddington et al. 2004)



Smallholder farmers' performance (often): BNF < 5 kg ha^{-1} (Mapfumo 2011)

Policy considerations

✓Agronomic policies

- Extension services for promotion of GAP
- Operationalization of regulatory frameworks for inputs
- Improved fertilizer recommendations (balanced fertilization)

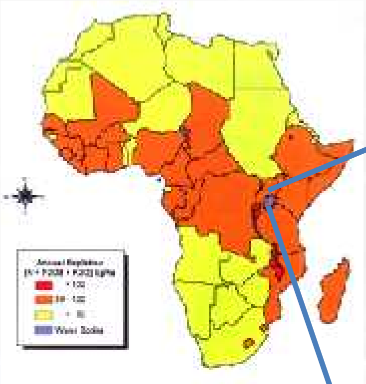
✓Socio-economic policies

- Input and output markets for profitability
- Infrastructure: accessibility to markets
- Financing mechanisms for smallholder farmers
- Land tenure systems

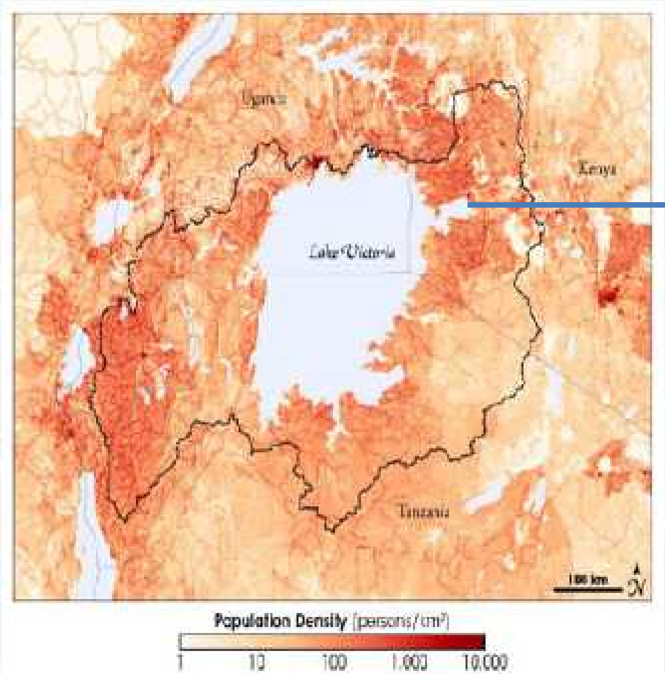
Research

- Fine-turn crop specific N application rates & ISFM
- Identify smart subsidies for N inputs
- Assess market policy for profitability
- Assess national, regional and continental N budgets to inform policies
- Address N inefficiencies in the food supply chain
- Analyse the feasibility of organic waste recycling i.e. from cities to farming communities
- Determine the threshold values of nitrates and nitrites in food commodities for health benefits vs. risks

Concluding remarks: Towards INMS



Henao & Banante (1999)



LVBC (2012)

Butterbach-Bahl (2014)

Thank you for the attention