

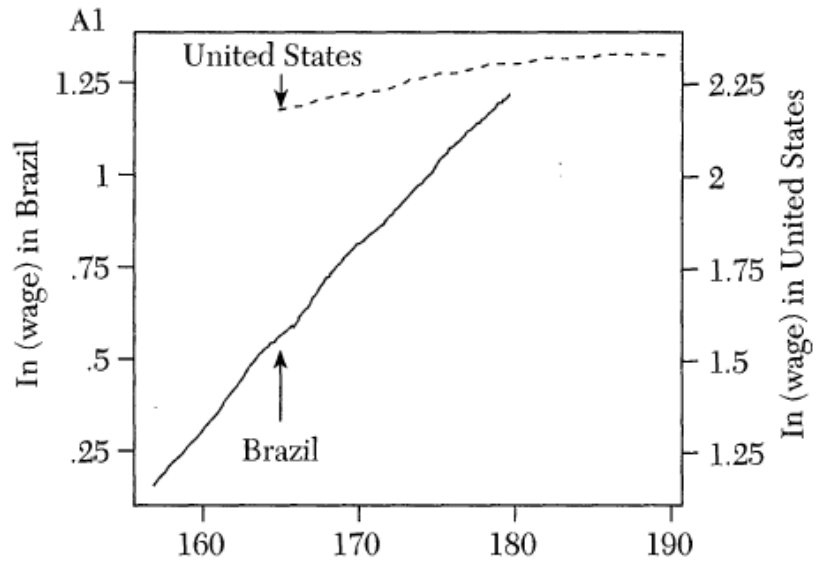
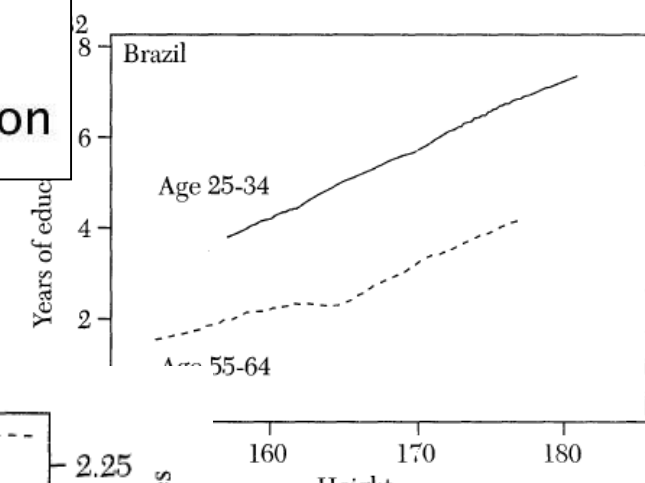
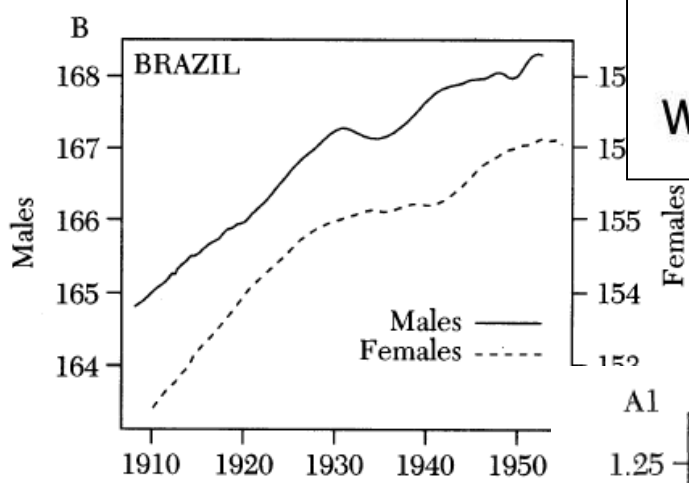
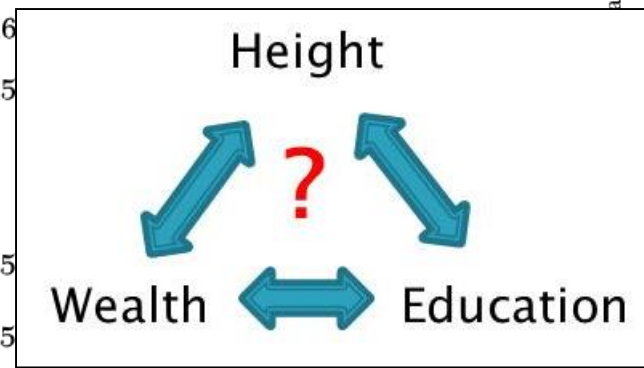
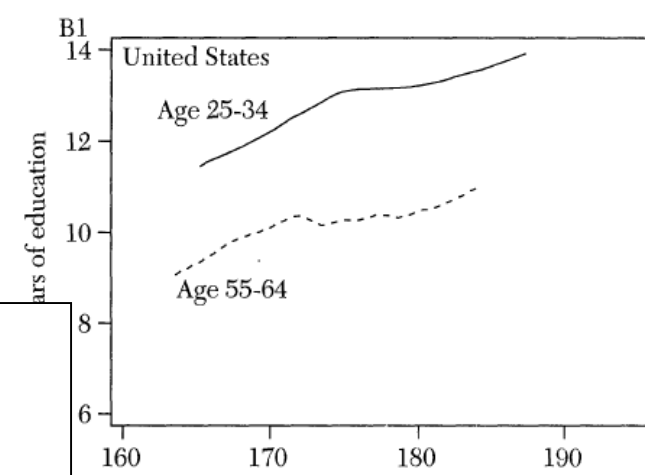
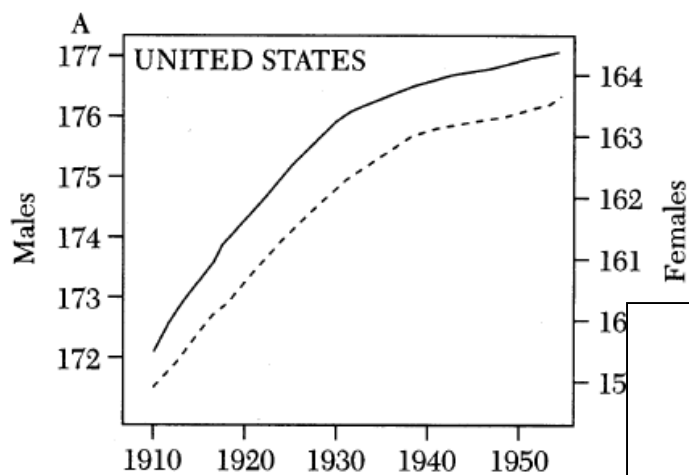
Healthier Food for a Healthier and (More Equitably) Wealthier World

Agriculture for nutrition, health and
poverty alleviation

Kevin Pixley

k.pixley@cgiar.org

Texas A&M University, 18 February 2016



Strauss & Thomas, 1998



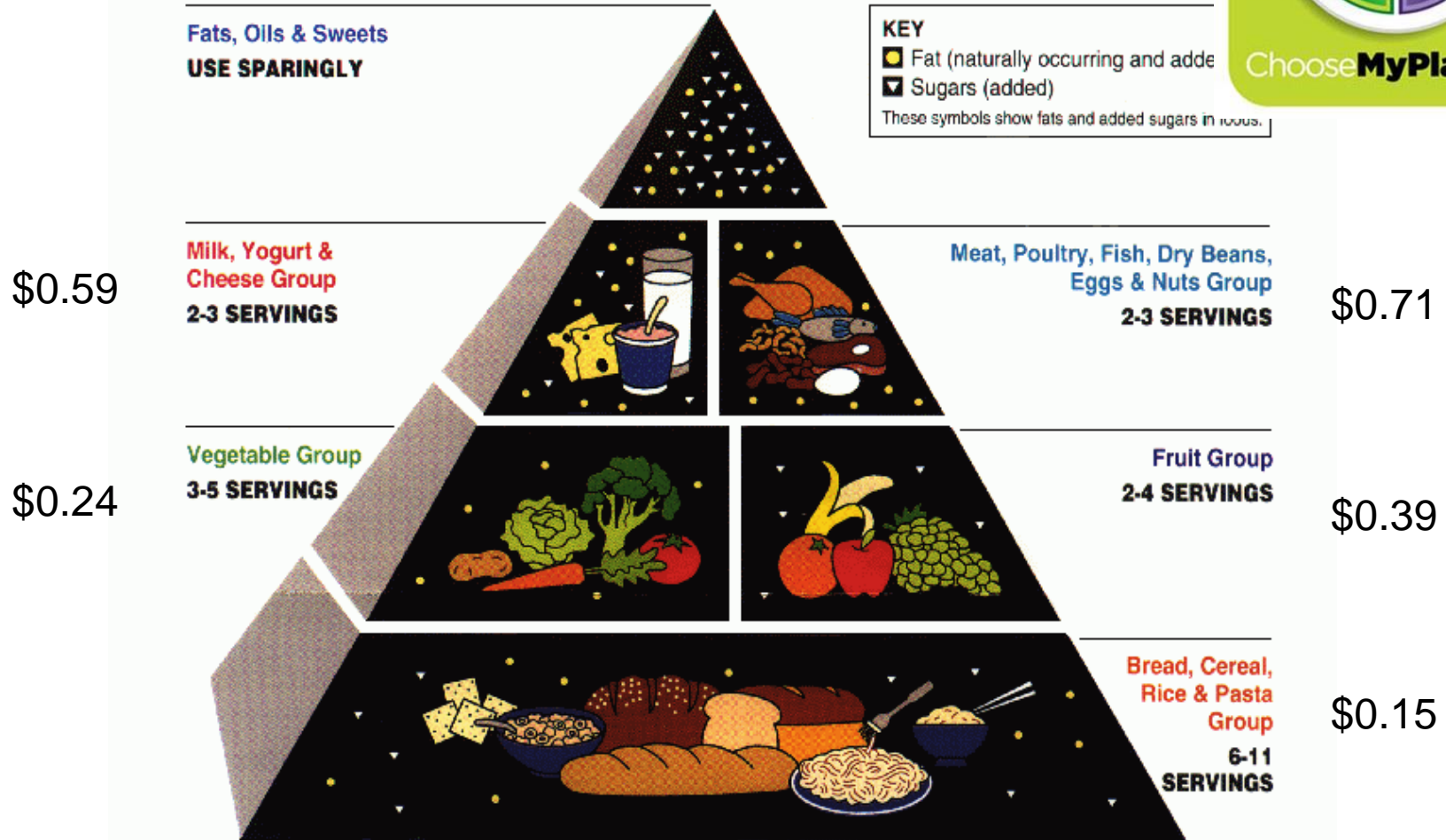
Nutrition → height* → income

- Height, which is an indicator of investments in human capital made during childhood, is also related to educational attainment.
- There is a powerful association between height and wages in Brazil. Taller men earn more
- Taller men tend to be better educated in both USA and Brazil, although the correlation is substantially larger in Brazil.

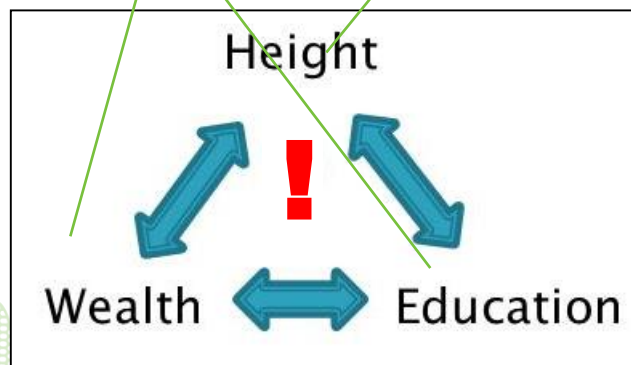
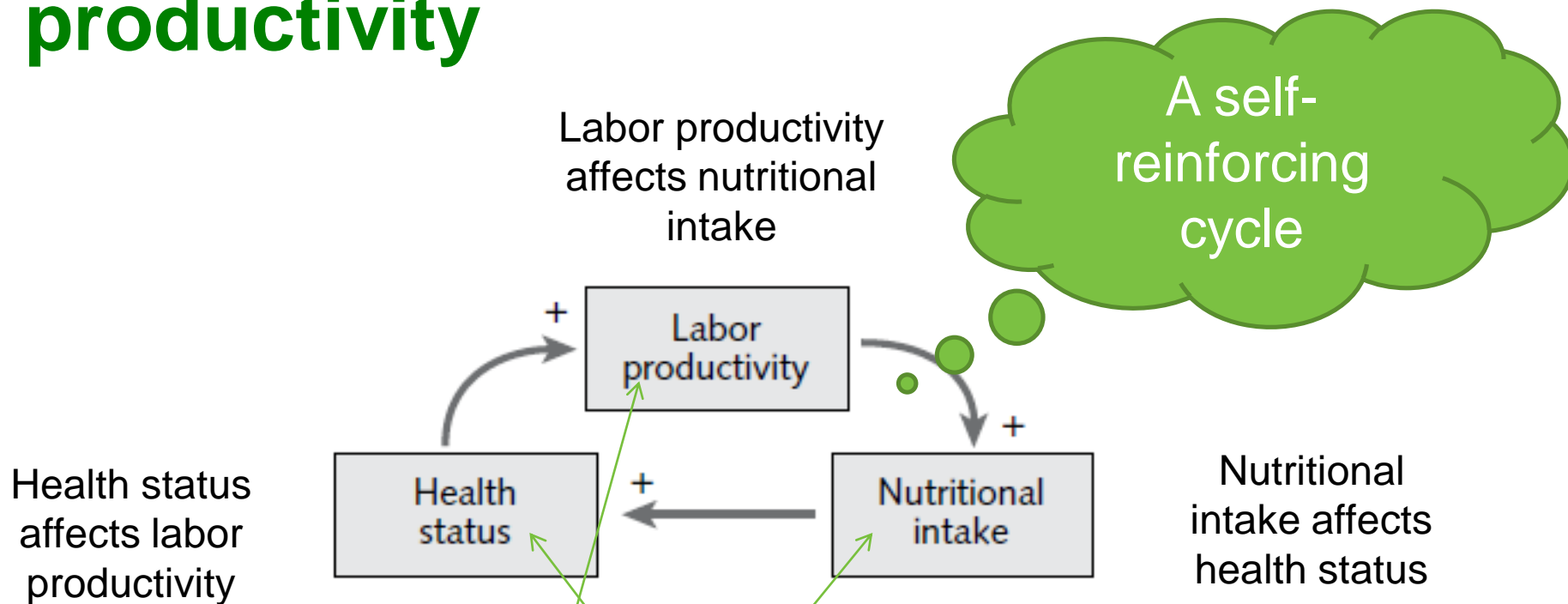
*Stunting is a much-used indicator...
important, lasting effects

Strauss & Thomas, 1998

Healthy food: nutritious diets



Health, nutrition and economic productivity

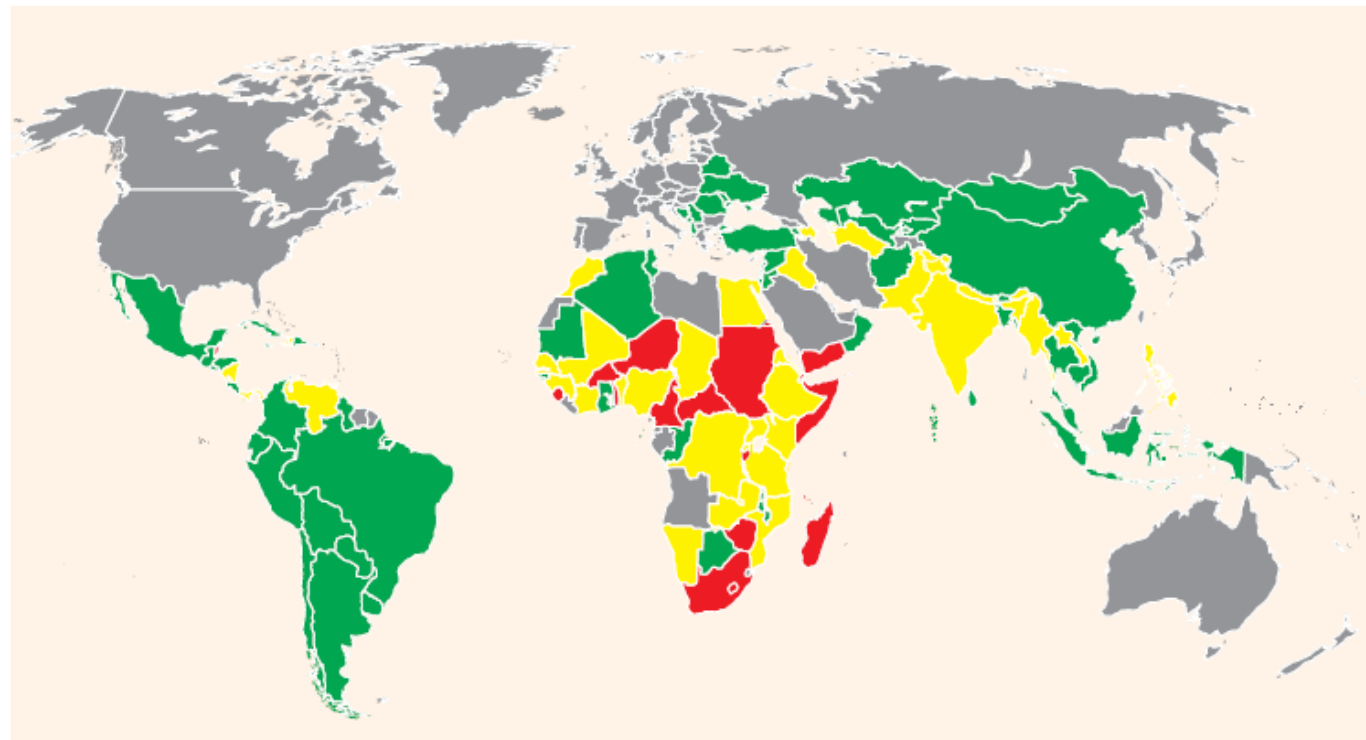


Joffe, 2007

Underweight prevalence: Children under 5

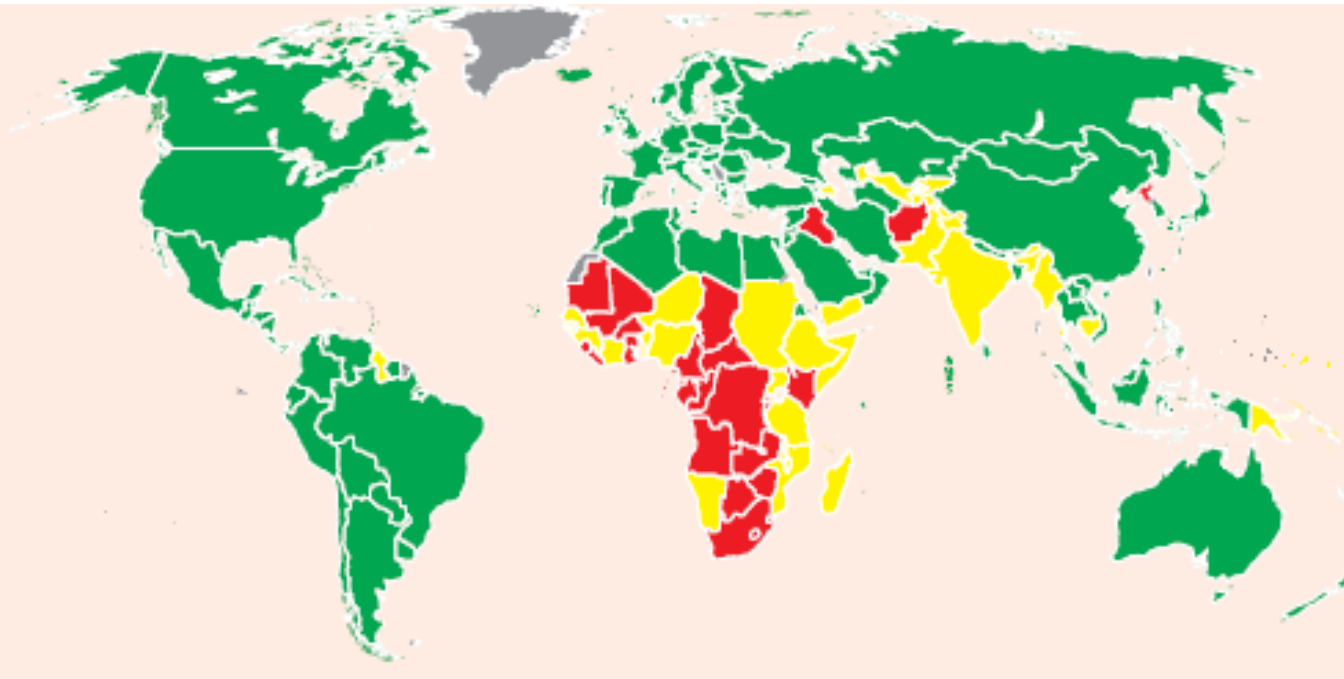
MDG 1 ERADICATE EXTREME POVERTY AND HUNGER
MDG target: Halve, between 1990 and 2015, the proportion of people who suffer from hunger

- 58 countries on track to reach MDG1 target (green)
- Progress in 33 is insufficient (yellow)
- 18 have made no progress (red)



Under 5 mortality

MDG4 – reduce by 2/3 the under-five mortality rate
(Mortality per 1000 live births)



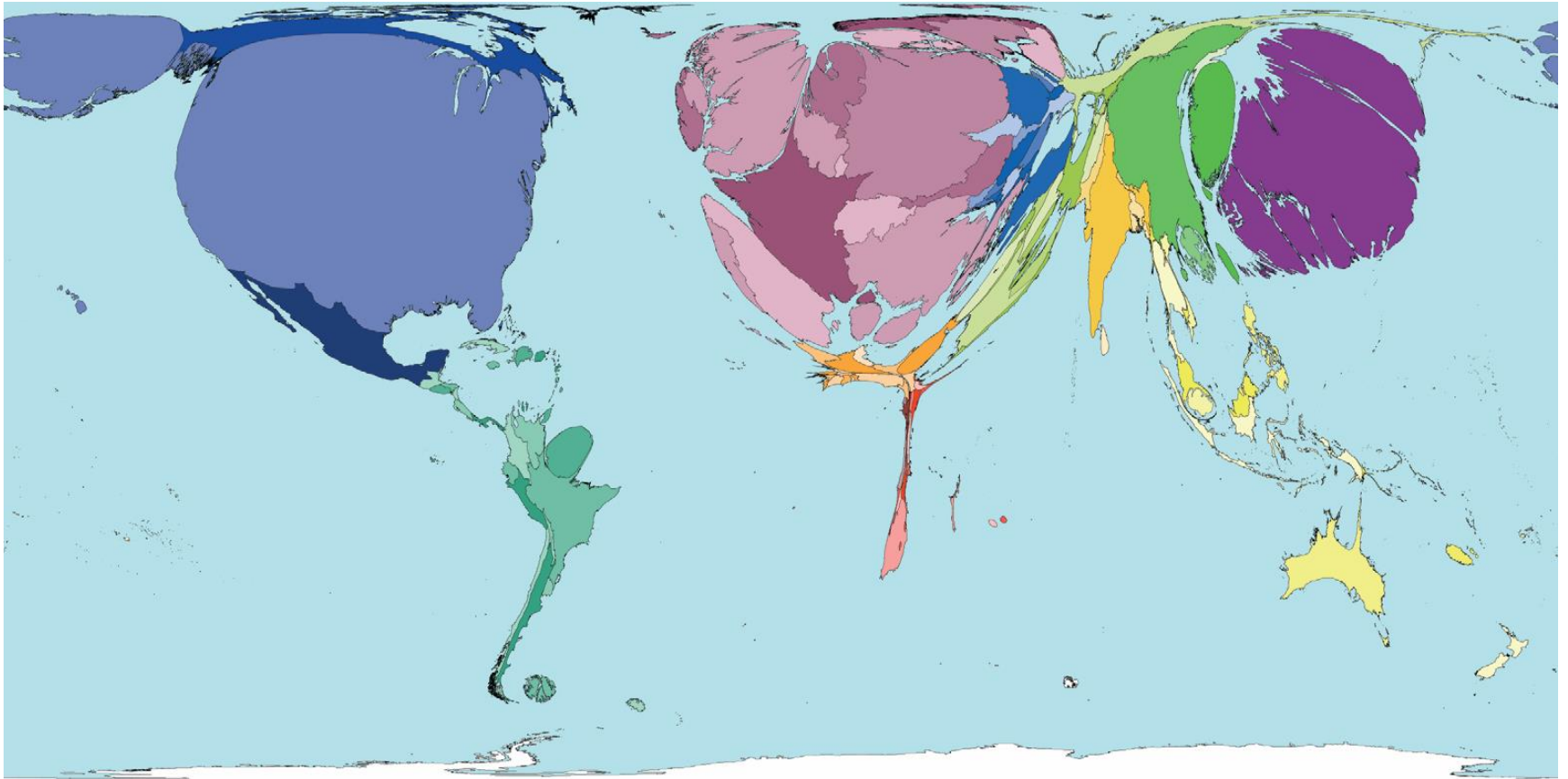
Undernutrition is
an underlying
cause in about
half of all under-
five deaths

UNICEF. (2007) *Progress for Children: A world fit for children.*
Statistical review no 6. UNICEF, New York, NY.



Wealth prevalence

“The World as you’ve never
seen it before”

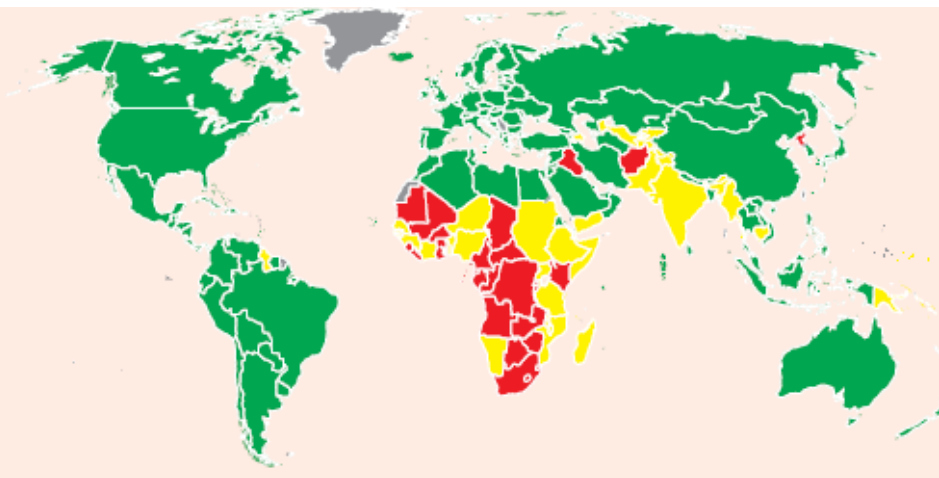
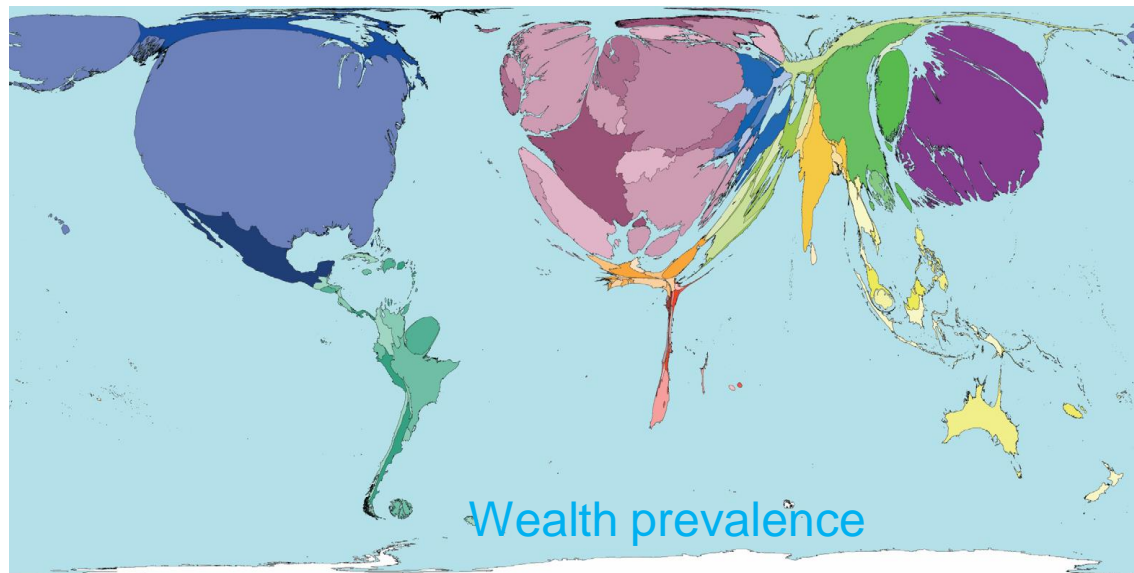


[http://www.worldmapper.org/display.php?
selected=169#](http://www.worldmapper.org/display.php?selected=169#)

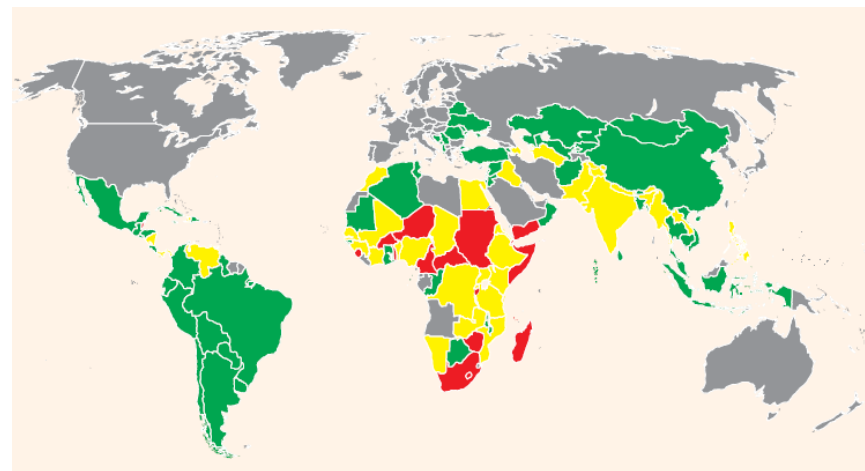


Wealth and nutrition

Can you find the yellow and red countries on the wealth map?

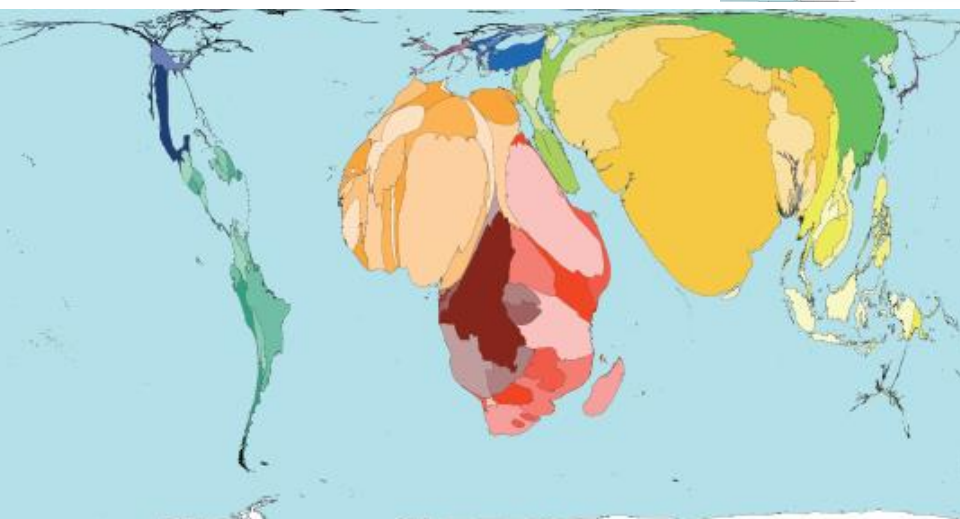
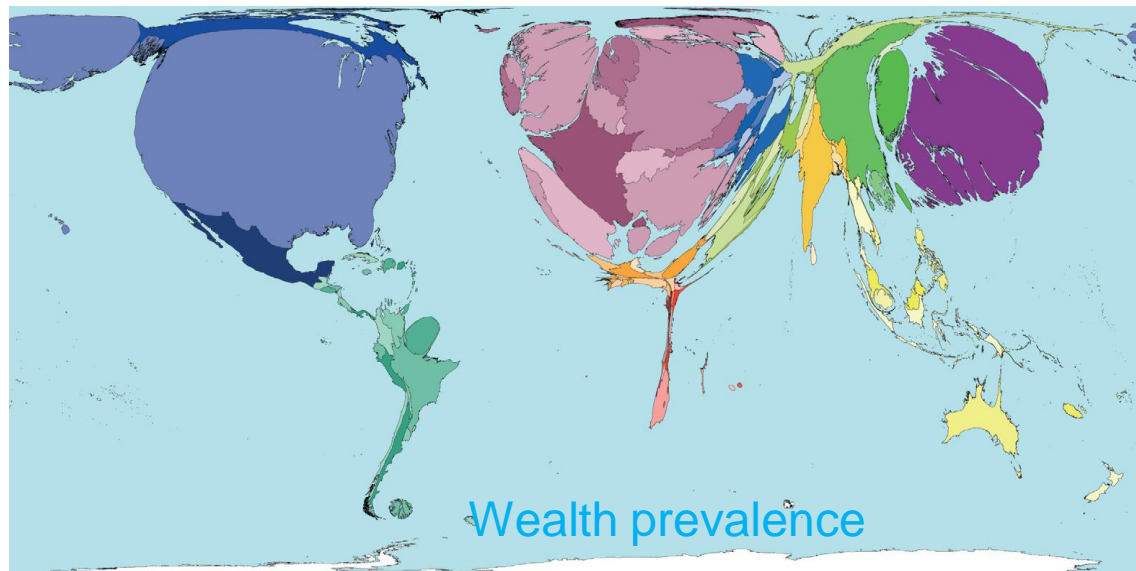


Under-5 mortality

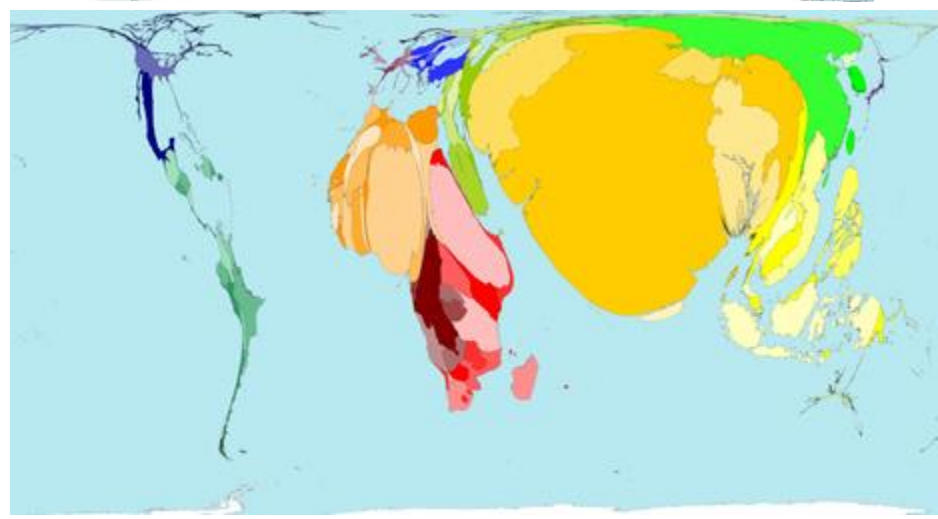


Underweight prevalence

Wealth and nutrition

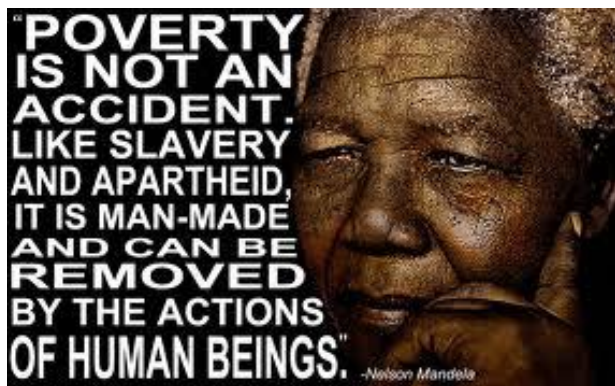
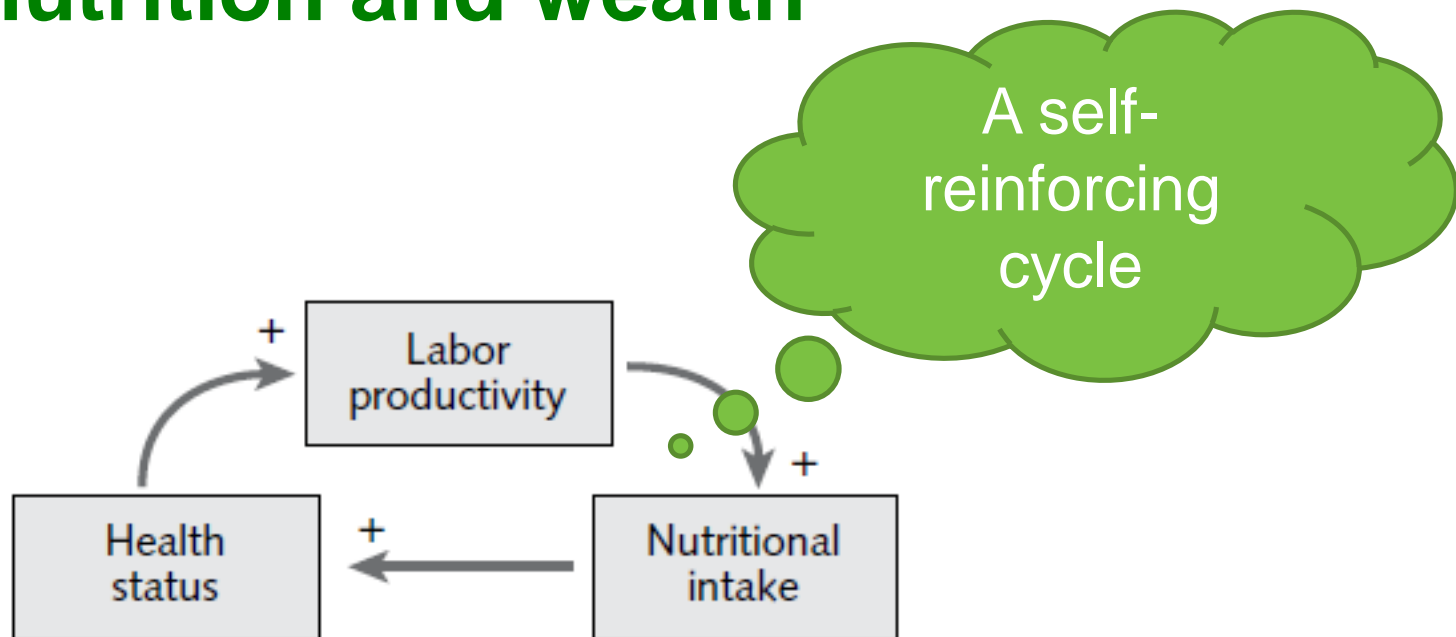


Under-5 mortality



Underweight prevalence

Health, nutrition and wealth



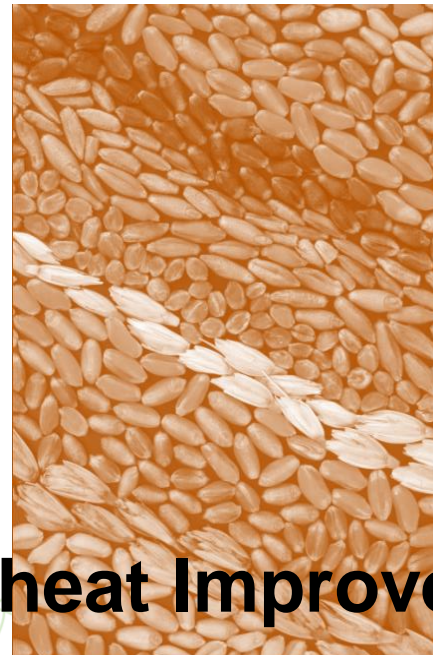
Nelson Mandela (1918-2013)



2014 Gates Annual Letter
Bill and Melinda Gates

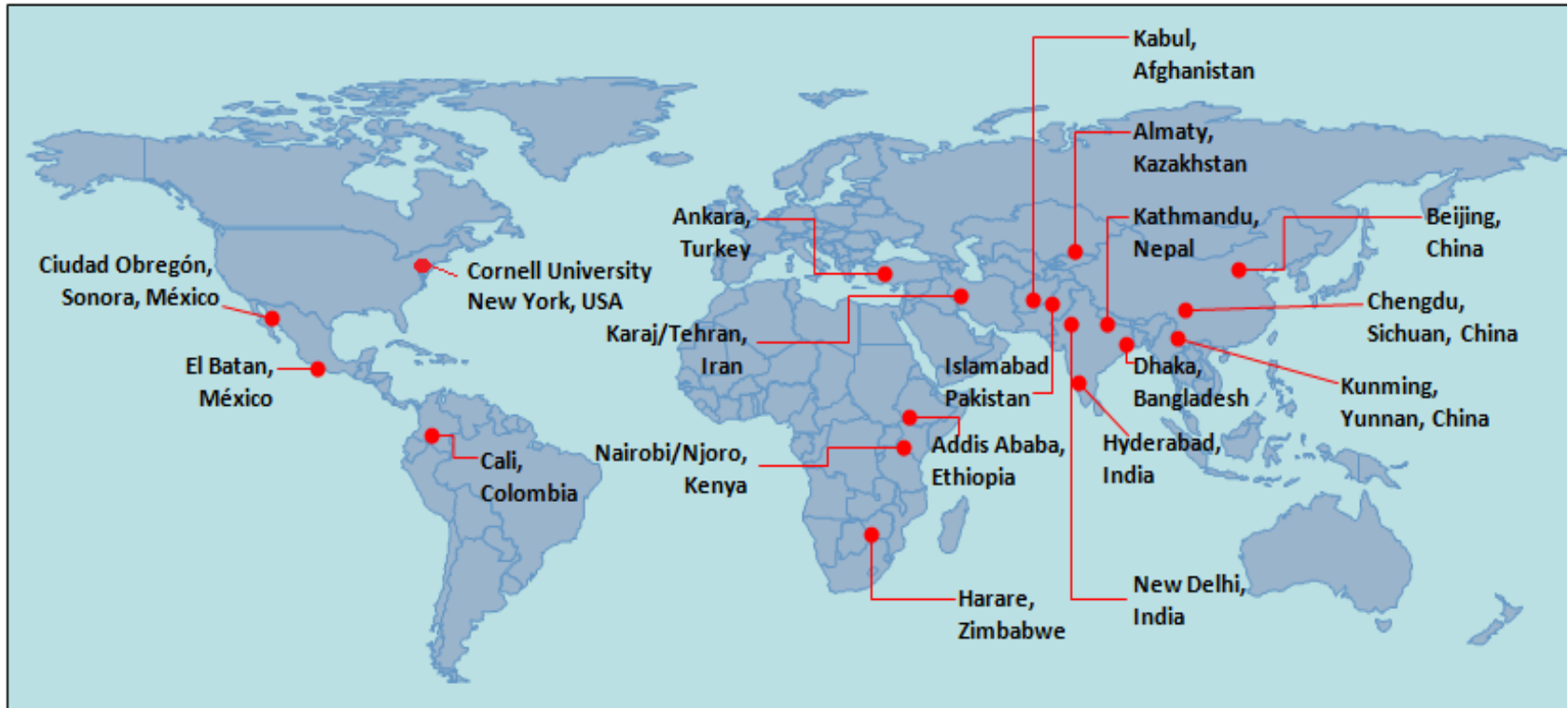
CIMMYT's Mission

Sustainably increase the productivity of
maize and wheat systems for
global food security and
poverty reduction



International Maize and Wheat Improvement Center

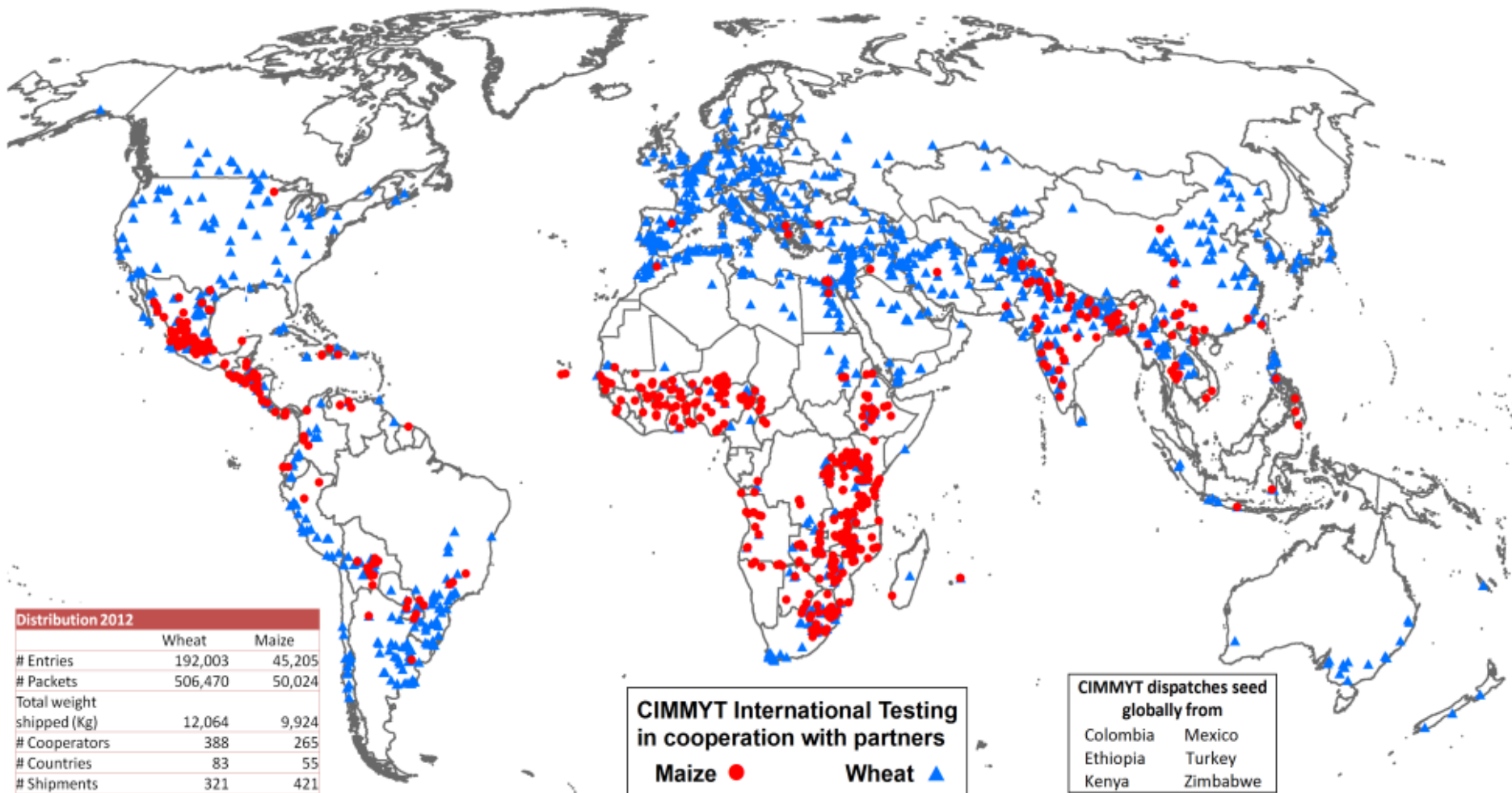
Key Facts about CIMMYT



- Headquartered in Mexico, CIMMYT is an international organization with 22 offices worldwide.
- CIMMYT employs more than 220 scientists from 50 nations.
- Holds 28,000 maize and 140,000 wheat accessions.

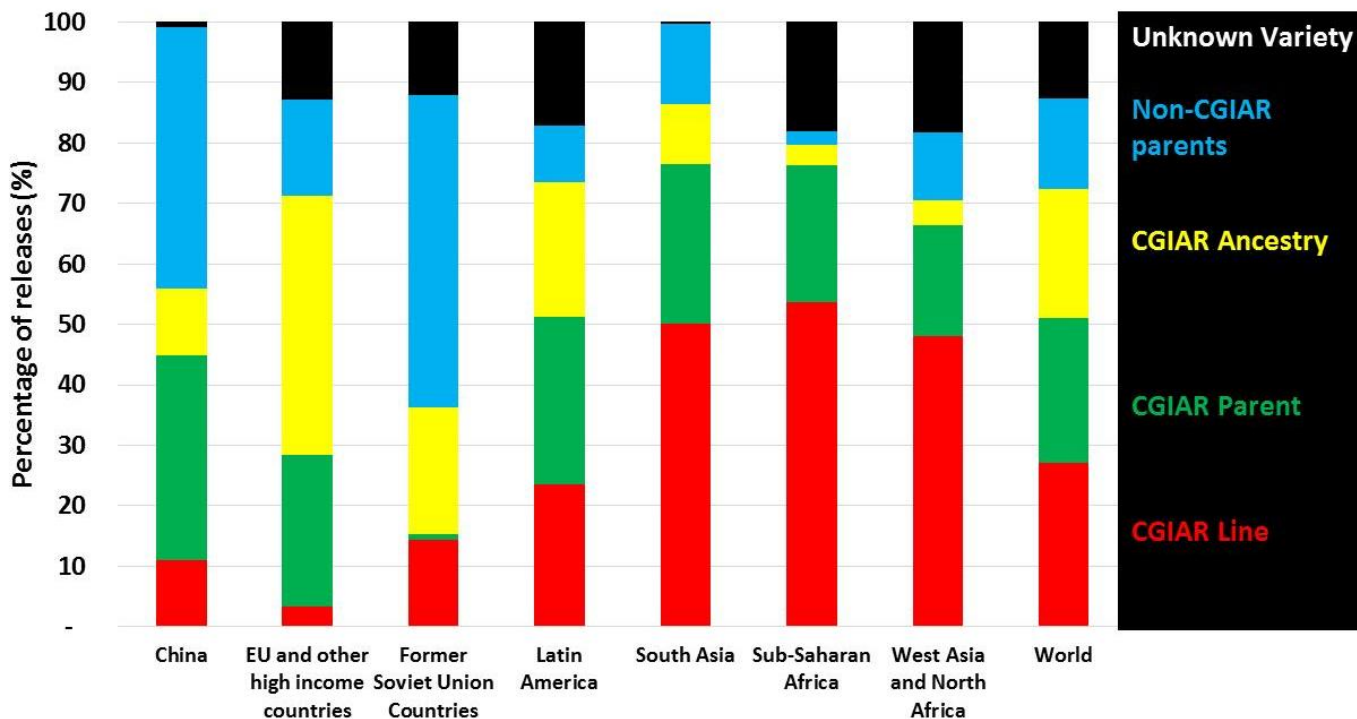


CIMMYT Varieties are Grown ALL Over the World



Examples of CIMMYT's Global Impact

Spring bread wheat releases by region and origin
1994-2014



Source: Lantican et al., 2015

- >50% maize varieties in the **developing world** developed using CIMMYT genetic materials.
- Over 10,000 scientists trained.



Borlaug's 1969 prophecy



“The seriousness or magnitude of the world food problem should not be underestimated. Recent success in expanding wheat, rice and maize production in Asian countries offers the possibility of buying 20-30 years of time”

N.E. Borlaug, 1969 – A Green Revolution Yields a Golden Harvest



...40 years later

India's Prime Minister
Independence Day, 15 Aug 2010



“... Our government wants a food safety net in which no citizen of ours would go hungry.

This requires enhanced agricultural production which is possible only by increasing productivity.

Our country has not witnessed any big technological breakthrough in agriculture after the Green Revolution.

We need technology which would address the needs of dry land agriculture.

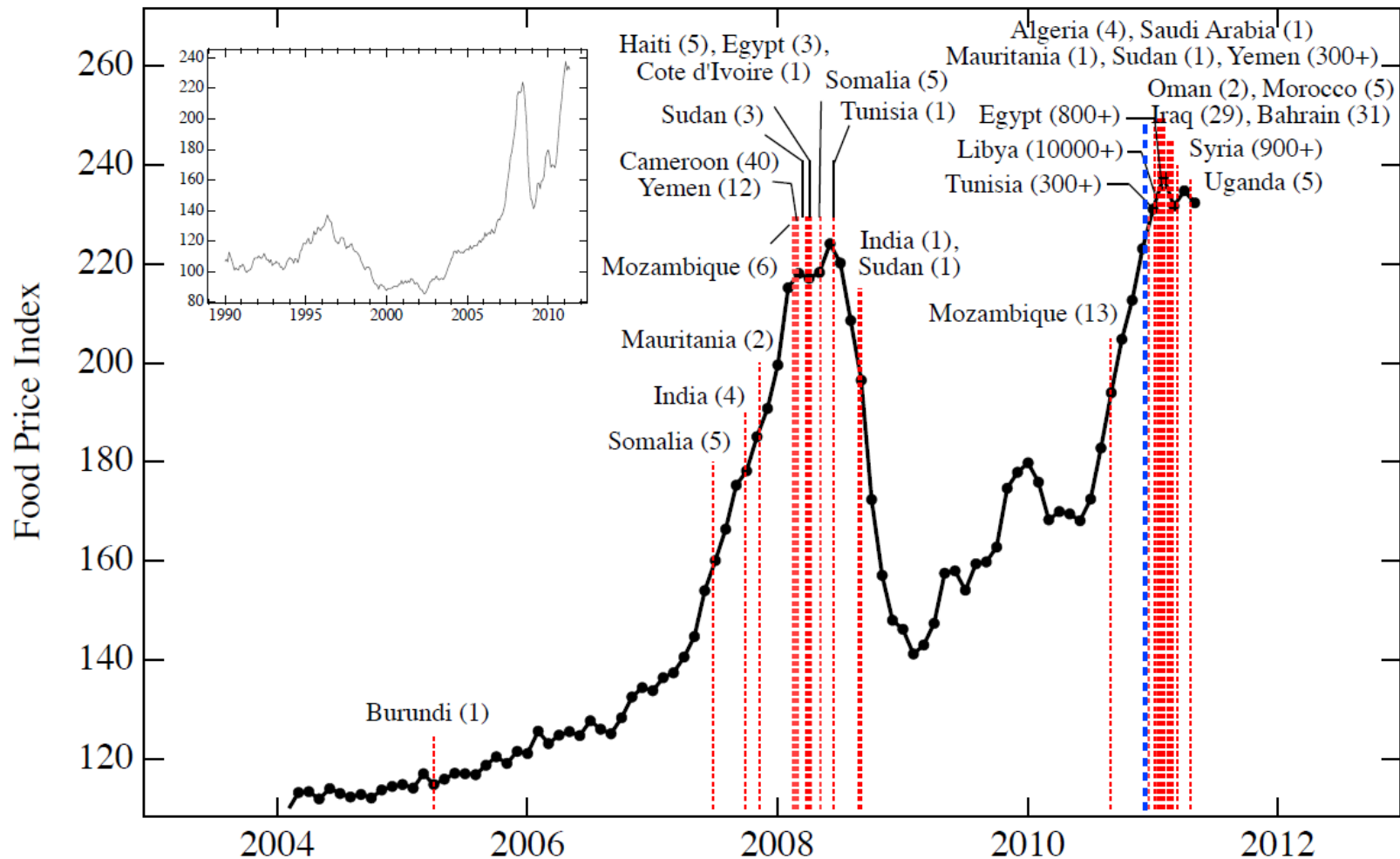
In addition, our agriculture should also be able to deal with new challenges like climate change, falling levels of ground water and deteriorating quality of soil.”

Constitutional and Legal Protection of the Right to Food around the World

- 23 Countries:
Explicit as right
- 56 Countries:
Explicit, implicit and as directive principle

<http://www.fao.org/docrep/016/a/p554e/ap554e.pdf>

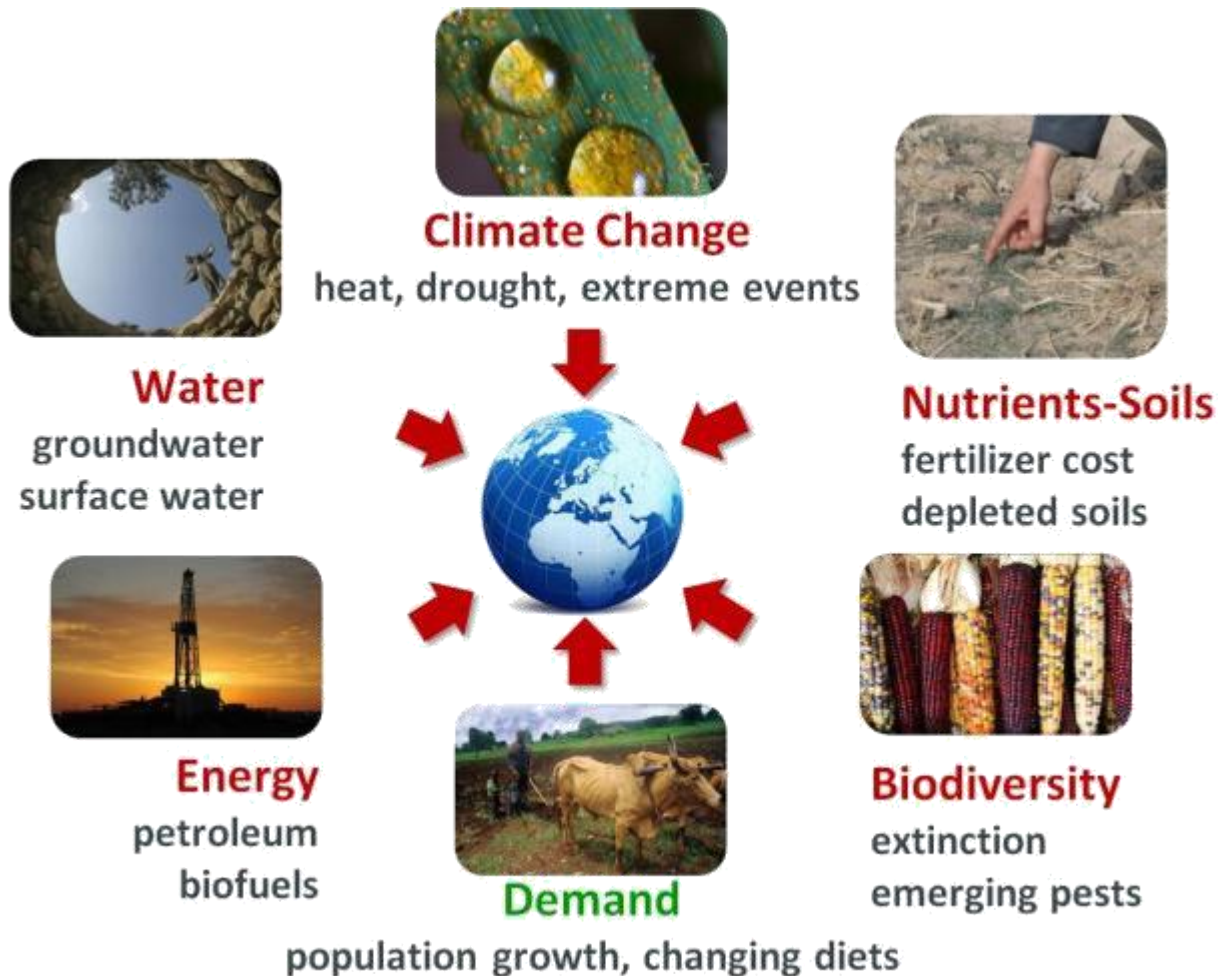
Food prices and social unrest



Red dashed vertical lines correspond to beginning dates of “food riots” and protests associated with overall death toll reported in parentheses.



Converging Challenges to Global Food Security



“In the next 50 years we will need to produce as much food as has been consumed over our entire human history.” Megan Clark, CSIRO CEO

Utilizing biodiversity: Seeds of Discovery



> 150,000 ancestral
genotypes in 27,000 pop's

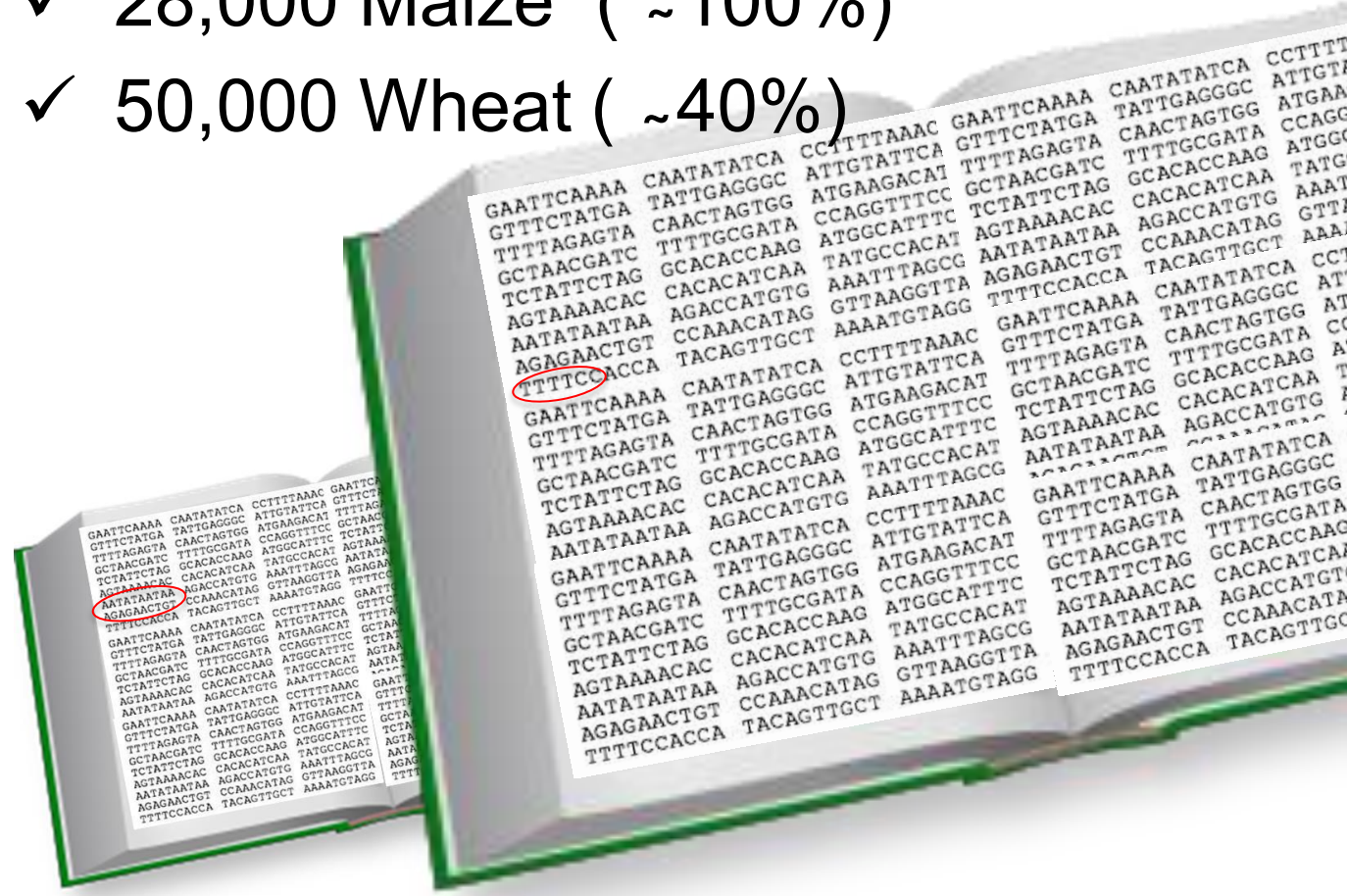
> 180,000 ancestral
genotypes

Maize and wheat in CIMMYT's (World's) germplasm bank



SeeD – high-density genetic profiles

- ✓ 28,000 Maize (~100%)
- ✓ 50,000 Wheat (~40%)





Impact of heat on wheat

- ~ 10% yield loss per 1°C increase in temperature
- **By 2050**, 20-30% yield loss in South Asia alone, affecting over 1 billion people

SeeD: ~70,000 wheat gene bank lines screened under heat stress (2011-2013)



Genebanks = supermarket



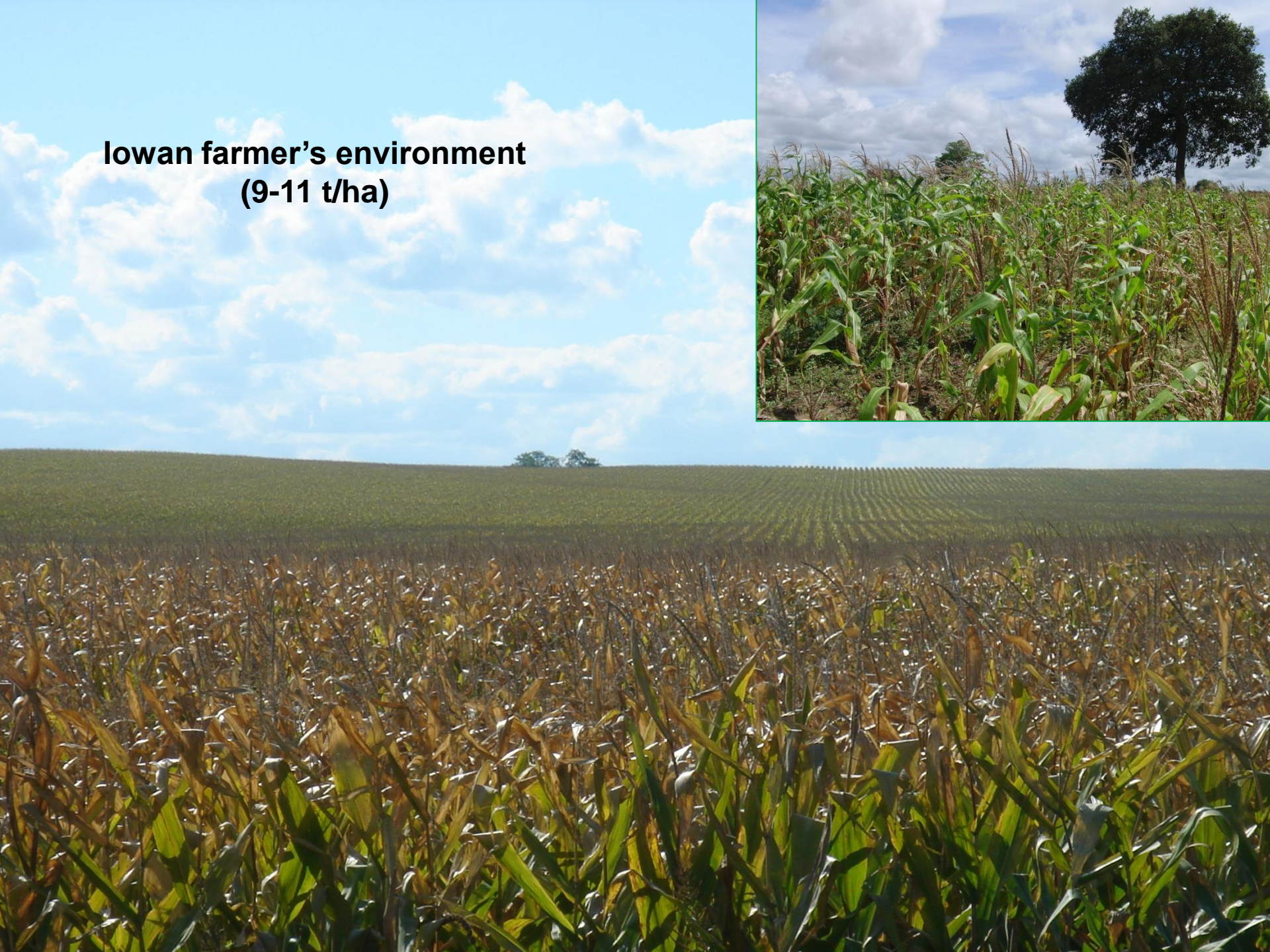
Label the genebank cans with rich information that helps breeders make use of this biodiversity



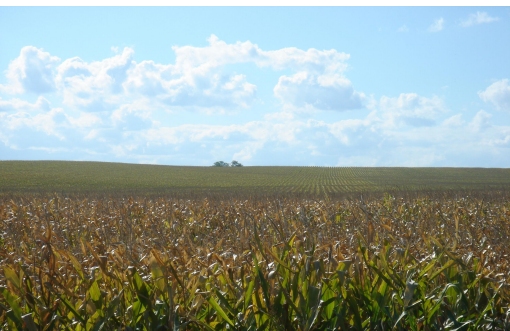
**Zambian farmer's environment
(1-2 t/ha)**



**lowan farmer's environment
(9-11 t/ha)**



Germplasm Development: N stress tolerance



Sub-Saharan Africa: Average 9 kg fertilizer, 1.3 t maize per hectare

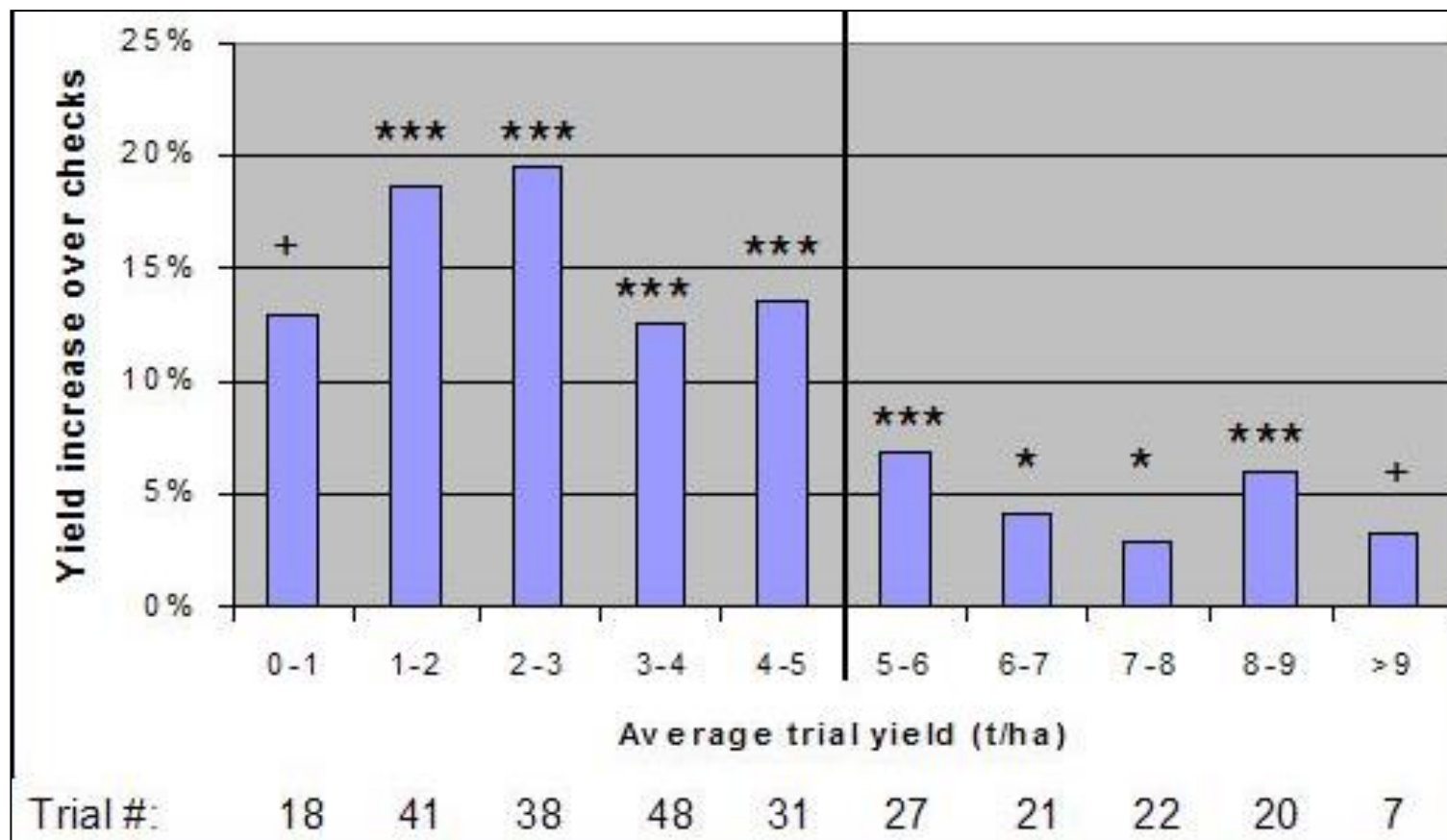
Germplasm Development: Drought tolerant maize



Edmeades, Lafitte, Bolaños, Bänziger



Average yield increases of CIMMYT hybrids across E&S Africa



Bänziger, 2005

Agriculture for nutrition, health and poverty alleviation

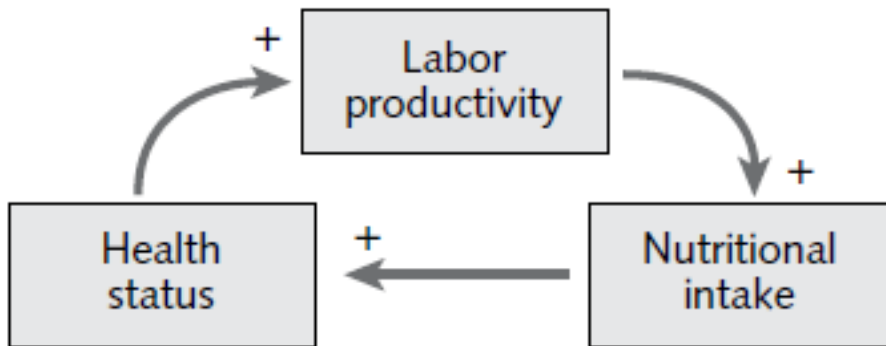
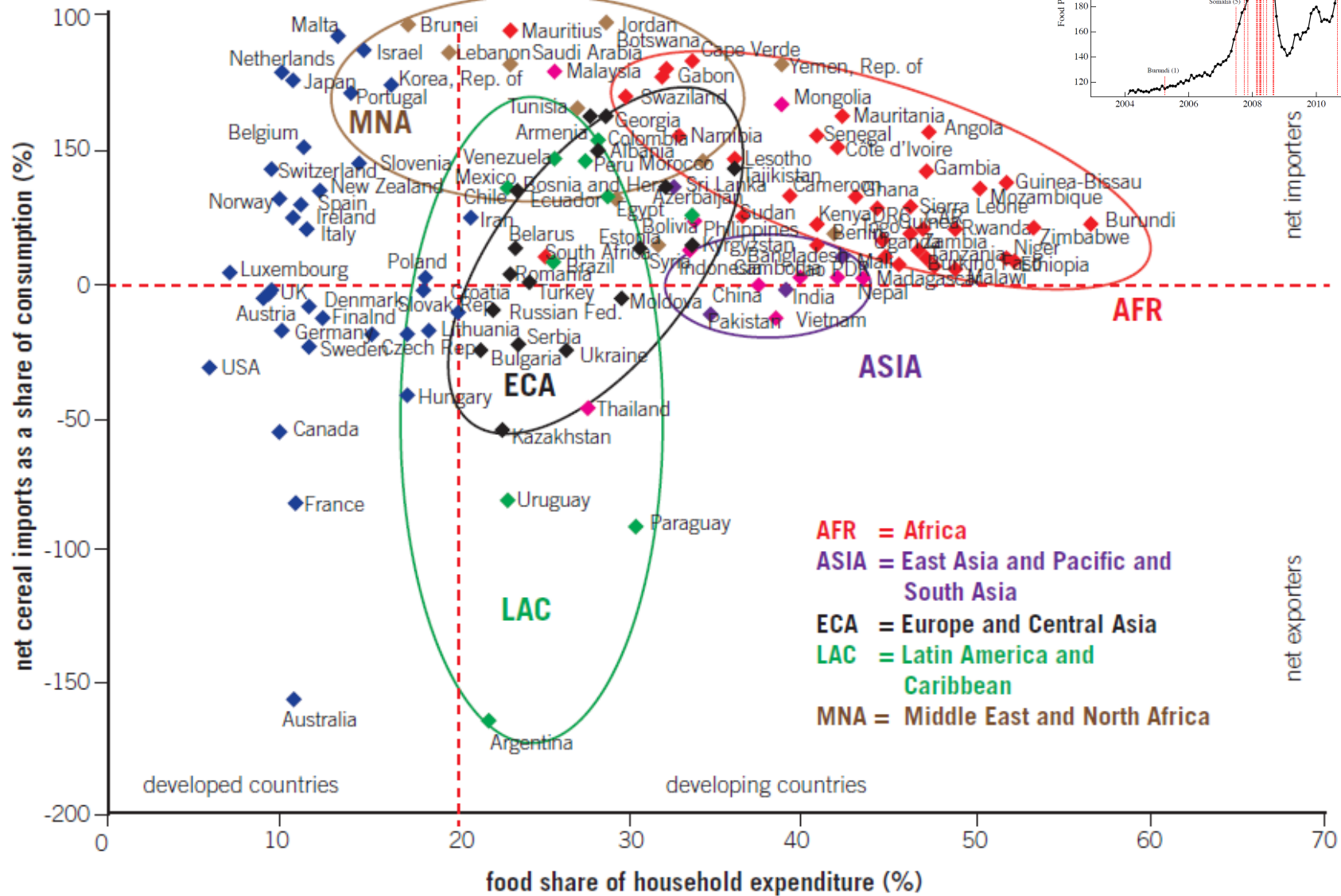


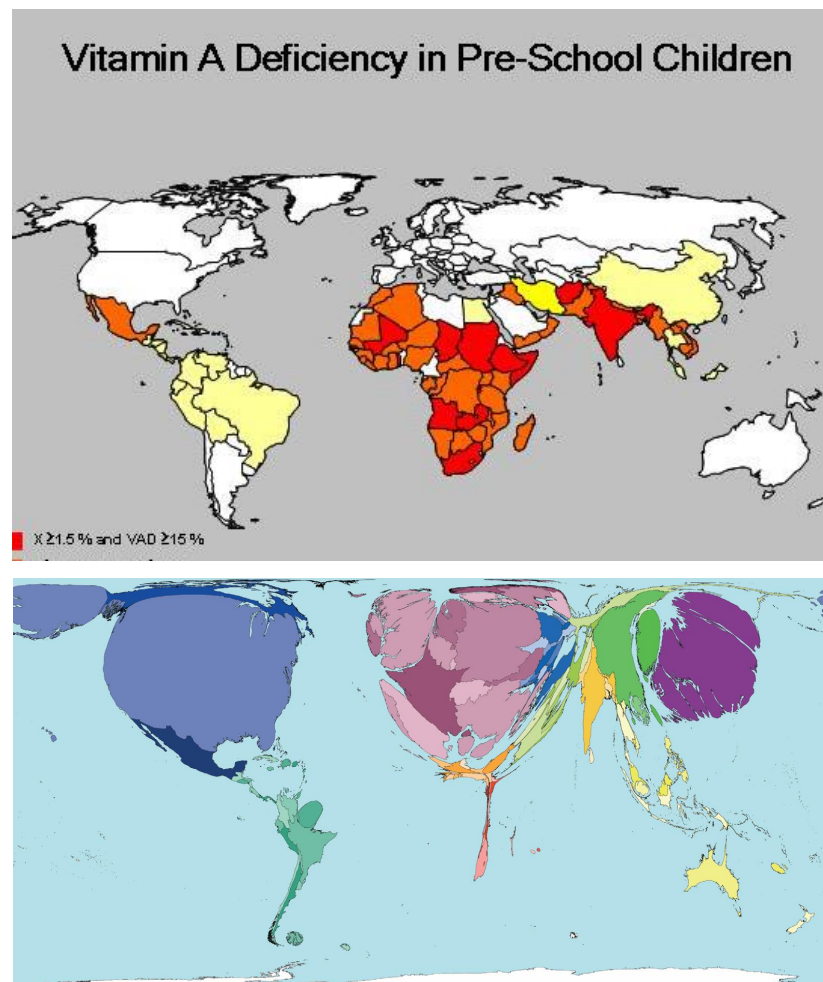
Figure 3. Countries' Vulnerability to Global Food Price Shocks



Source: World Bank (2011) Responding to Higher and More Volatile World Food Prices Development Committee Paper prepared by the Agriculture and Rural Development Department using data from FAOSTAT for net cereal imports as a share of consumption and the USDA for food share in household expenditures.

Micronutrient malnutrition is prevalent

- Vitamin A deficiency (VAD)
 - Night blindness, corneal scarring & blindness
 - Weakened immune system: VAD associated with
 - 20% of measles
 - 24% of diarrhea
 - 20% of malaria-related mortality in children;
 - 20% of maternal mortality
 - South Asia and Africa have highest VAD prevalence
 - 157 million pre-school children
 - 30 million pregnant women



Dietary sources of micronutrients

➤ Vitamin A

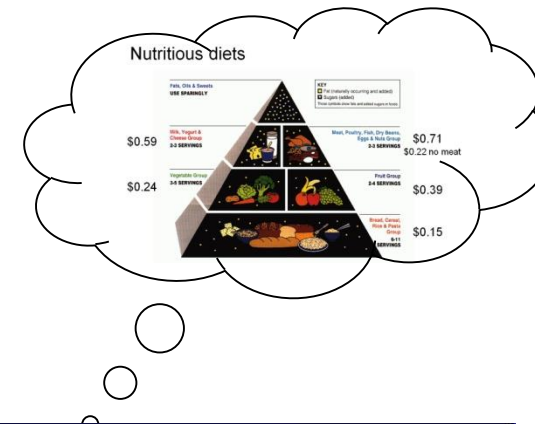
- Meat (esp. liver)
- Vegetables (carrot, sweet potato, spinach)

➤ Iron

- Red meat, fish, poultry
- Lentils, beans, leafy vegetables

➤ Zinc

- Oysters, animal proteins,
- Beans, nuts, whole grains



Biofortification of staple food crops

- Micronutrients available in staple foods
 - Sustainable, affordable
 - Accompanied by dietary/nutrition information
 - Complemented by supplementation and fortification
 - Acute malnutrition
- Equal or better agronomic performance of biofortified crops
 - Yield, disease resistance, drought tolerance...

Best solution = healthy, balanced diet
Biofortification = temporary, 2nd best



Cross high proA x good drought tolerance...



BC1S1



BC1S2



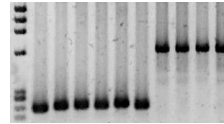
BC1S4



LCYE affects the ratio of carotenoids in the biosynthetic pathway

1. Alleles for *LCYE* identified by:

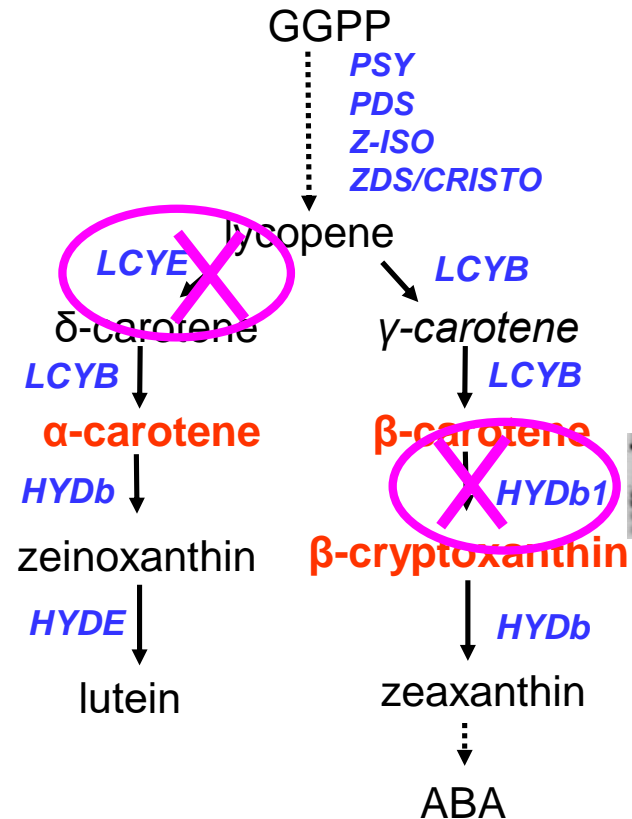
- Association mapping
- Linkage mapping
- Expression analysis
- Mutagenesis



Harjes et al., Science 2008

2. *HYDB1* has a large effect on BC

Yan et al., Nature Genetics 2010



Validation in 26 maize populations

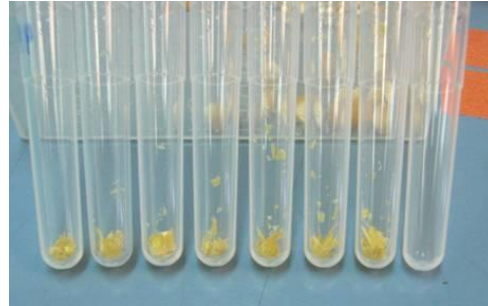
Genotype	ZEA	BC	ProA
LL_HH	7.6	7.7	8.4
LL_Hh	15.9	4.5	5.9
LL_hh	16.5	1.6	3.8
ll_HH	2.9	7.1	7.3
ll_Hh	11.0	2.8	4.2
ll_hh	14.9	1.6	3.2
Ll_HH	3.9	9.0	9.5
Ll_Hh	14.3	3.8	5.4
Ll_hh	18.6	2.0	3.9
LL--	13.33 ^A	4.60 ^A	6.03 ^A
Ll--	12.27 ^{A B}	4.93 ^A	6.27 ^A
ll--	9.60 ^B	3.83 ^A	4.90 ^B
--HH	4.80 ^A	7.93 ^A	8.40 ^A
--Hh	13.73 ^B	3.70 ^B	5.17 ^B
--hh	16.67 ^B	1.73 ^C	3.63 ^C

Means for nine interaction classes of LcyE (L) and CrtRB1 (H) in 6 maize populations

<1.5 times the ProA

2-3 times the ProA

Seed genotyping pre-planting



- Dry chipping using dog nail clippers
- ≈10,000 seeds genotyped pre-planting each season
- Discussing with private sector to establish automated seed chipping capacity





- ✓ 3 proVA hybrids released in Zambia – 2012
- ✓ 3 released in Zambia - 2015
- ✓ 2 released in Zimbabwe - 2015
- ✓ 4 released in Malawi - 2016



What happens to provitamins A during cooking?



Photo: H. De Groote



Photo: N. Palacios

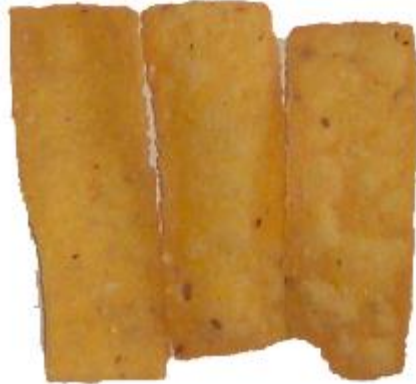
Effect of porridge preparation



Shanshan Li et al., 2007

25% loss of β -carotene

Effect of snack preparation



- 36% loss of provitamins A following nixtamalization and snack preparation by deep frying

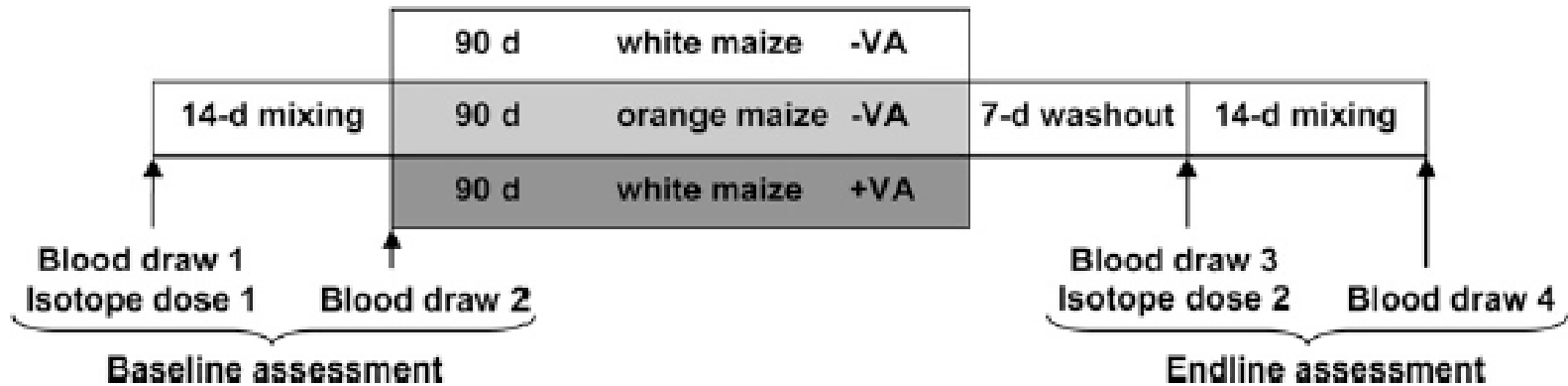


Lozano Alejo et al., 2006

40% loss of ProA during sweet tamal preparation



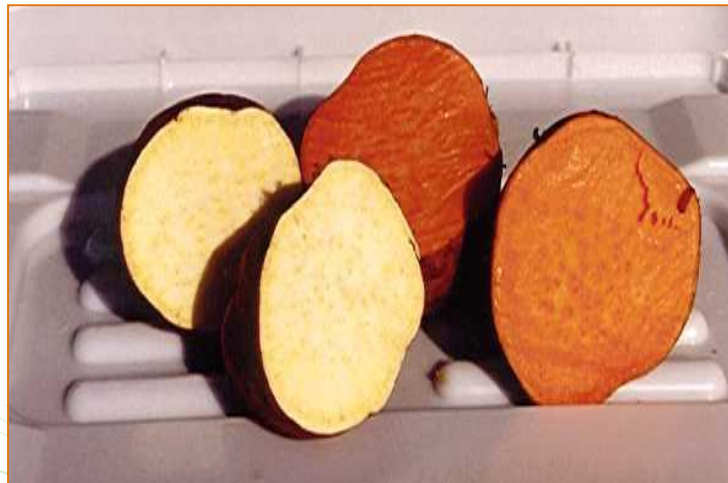
ORANGE MAIZE IS AS EFFICACIOUS AS A VA SUPPLEMENT



	VA-	Orange	VA+	P-value
Total body reserves retinol, μmol				
Baseline	686	685	723	0.35 (NS)
Endline	665b	806a	811a	0.004
Change	13b	84a	98a	0.003
Liver retinol concent. $\mu\text{mol/g}$				
Baseline	1.02	1.04	1.11	0.29 (NS)
Endline	0.96b	1.09a	1.17a	0.004
Change	-0.04b	0.06a	0.11a	0.0055

Will consumers and farmers consume/grow biofortified crops?

- ProA sweet potatoes are orange; consumers prefer white
- ProA maize is orange; consumers prefer white
- Will farmers choose to grow orange maize varieties?
- Will seed companies market the new orange varieties?



Demand Creation

Training program for extension workers and nutrition promoters



Nutrition Promoters teaching mothers with children < 5 years



A.M. Ball HarvestPlus, Uganda



Raising awareness; creating demand



A. M. Ball

Market strategies



H+ stakeholder consultation, Zambia

Madson Chisi, Zambia Agric. Res. Inst.

- Technology should be neutral or labor reducing (cooking, processing, etc.)



Photo: Hugo De Groot



Photo: Sherry Tanumihardjo

Marx Mbunji, SeedCo

- Crop needs to be high yielding; don't focus on those "micro" things...



Will consumers buy & consume biofortified maize?

Mr. M. Ililonga, Zambia Consumer Association

- Consumers are very sensitive about cost (should be affordable); cost of staple food is of concern to people



Will consumers accept orange maize?

- By 2015, one of the orange maize hybrids had gained >1% market share, enabling >100,000 farmers to grow Provitamin A maize.
- Four maize milling companies expressed interest in buying orange maize grain and introducing orange maize flour in retail shops
- The number of farmers adopting Provitamin A orange maize is projected to grow to over half a million in four years.
- The tribal leader from Eastern Province became the first adopter and largest grower of orange maize in Zambia. His influence resulted in Eastern Province taking the lead in biofortified maize production.

Eliab Simpungwe (2015), HarvestPlus, Zambia



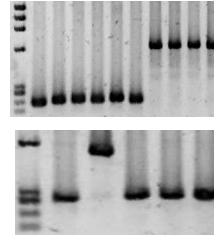


Multi-disciplinary approaches



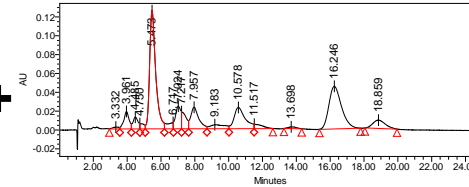
Plant breeding

+



Molecular biology

+



Plant biochemistry

+



Agronomy

+



Education & marketing

+



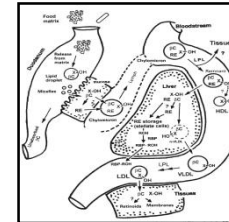
Farmer participation

+



Socio-economics

+

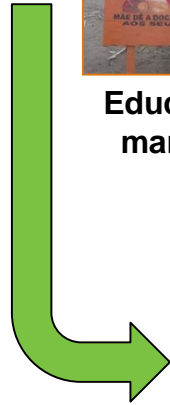


Nutrition

+



Food technology

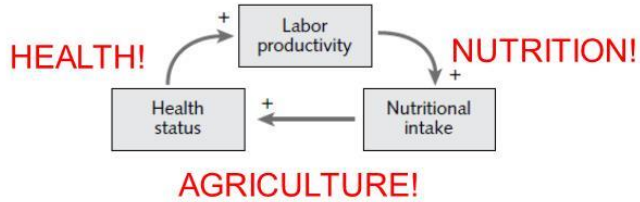


Healthy children

**You can make a difference!
...in your profession of
choice!**

~~POVERTY~~

POVERTY IS NOT AN ACCIDENT, LIKE SLAVERY AND APARTHEID, IT IS MAN-MADE AND CAN BE REMOVED BY THE ACTIONS OF HUMAN BEINGS.



“Play your card, and play it hard!”*

You are the good news!



“Where are the leaders who have the necessary scientific competence, the vision, the common sense, the social consciousness, the qualities of leadership, and the persistent determination to convert the potential benefits into real benefits for humankind in general and for the hungry in particular?”

...there are not enough of them

...we must... develop them in our educational systems...



* Watch this video! <https://www.youtube.com/watch?v=FRwo01maYqY>