Soils and Food Security

Soils: The Foundation of Life

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Soils are the foundation of food security
Cannot deal with food security alone. Must deal with other ecosystem services together.

Food Security

- When all people, at all times in a geographical area have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.
- 4 Dimensions:
  - *Availability*----the food is there
  - *Access*----produce it or purchase it
  - *Stability* over time
  - *Safe Utilization* by the human body

FAO 2005. The State of Food Insecurity in the World, 56p.

Soils and Tipping Points

- First Asian Green Revolution: rice on flooded soils: Zhejiang Province, China, 4200 BCE.
- 18th and19th Century Europe:
  - Jethro Tull´s invention of the moldboard plow
  - Justus von Liebig's recognition of plant nutrients, marking the start of modern agronomy.
- Haber-Bosch industrial ammonia synthesis (1913): mineral fertilizers.
- North American Green Revolution (1940's): hybrid maize, mineral fertilizers.
- Asian Green Revolution (1960-1990's). Fertilizer use accounted for 50% of yield increases
- Conservation agriculture, cover crops, precision farming (1960s on)
- Management of acid tropical soils (1970s on)
- African Green Revolution (2005 on)

Food vs Population Race Continues to be Won

Food production per capita (1961 = 100)	1971-1980	1981-1990	1991-2000	2011-2013
World	109	116	123	152
Tropical countries [All]	100	100	101	125
Tropical Southeast Asia	108	121	128	199
Tropical Latin America	102	104	109	122
Tropical South Asia	101	103	96	114
Tropical Africa	94	86	85	98

Per capita food production is currently 25% higher in poor countries than in the 1970s, but tropical South Asia and Africa are lagging behind

Calculated from FAOSTAT 2014

Food Insecurity in 2015

Region	Millions hungry	% hungry
Sub-Saharan Africa	220	28
India	195	25
China	134	17
Other Asia	183	19
Latin America	35	4
Rich Countries	15	2
World 2015 (pop. 7.2 billion)	795	11
World 1990 (pop 5.3 billion)	1011	19

Hunger MDG almost achieved

Calculated from FAO 2015

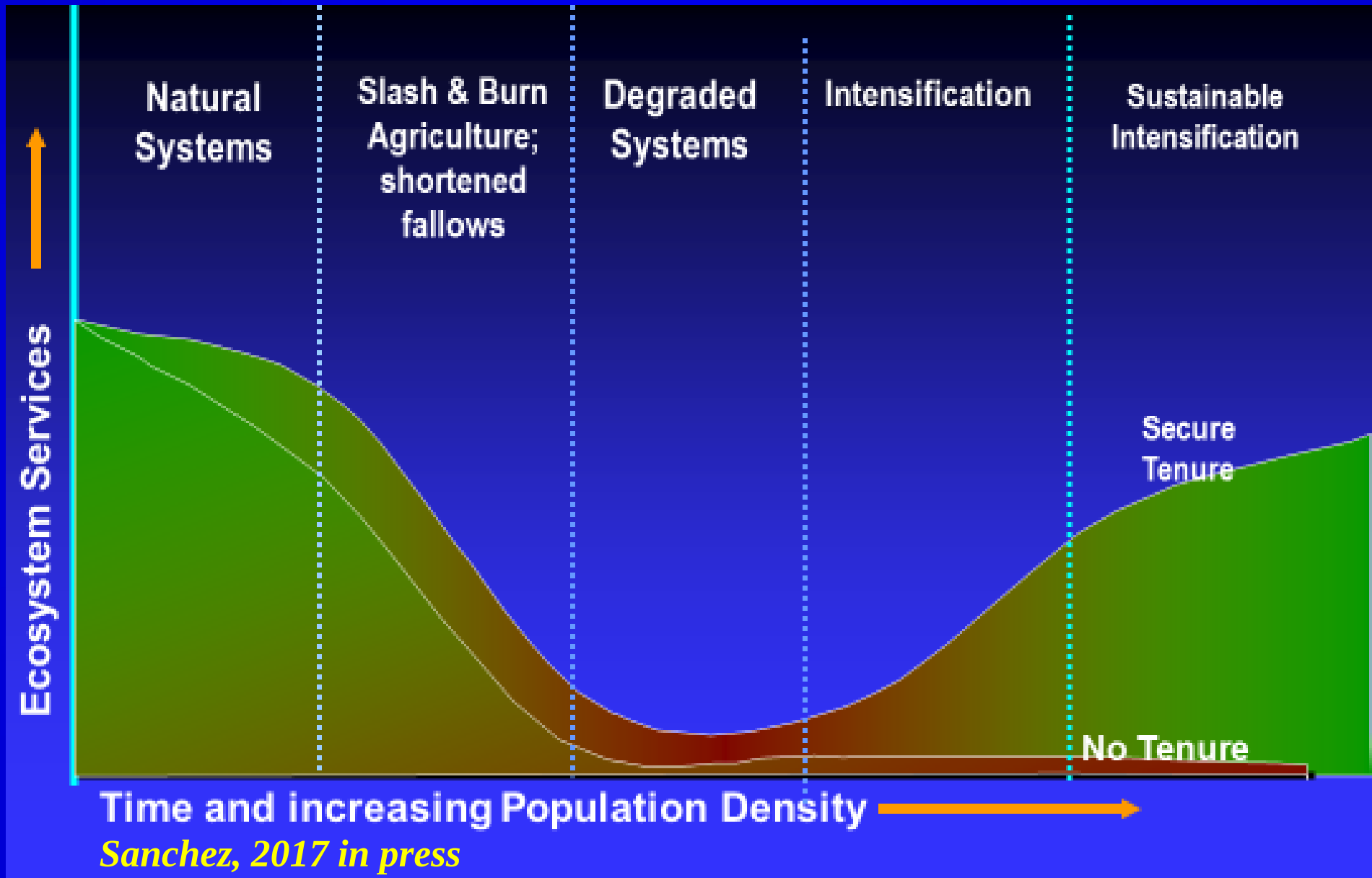
Key food security issues

- Nutrition security
- Sustainable intensification vs. extensification
- Tropical soil management
- Will Africa be able to feed itself?

1. Nutrition Security

- When food security not only refers to calories, but also to proteins, fats and micronutrients. *FAO 2015*
- Soil scientists consider B, Cl, Cu, Fe, Mn, Mo, Zn and others the essential micronutrients for plant growth.
- Human nutritionists consider the essential micronutrients to be I, Fe, Zn, vitamin A, folate, vitamin C, and vitamin B-12.
- "Hidden hunger" from micronutrient deficiencies affects more than 2 billion people worldwide (17% of the world population).
- Nutrition security is becoming the next big step. Many advocates including industry. *Report and Recommendations of DuPont Advisory Committee on Agricultural innovation. 2011 27p.*

2. The Path to Sustainable Intensification



Sanchez, 2017 in press

But Extensification is Accelerating

Land in Tropics	1961-1999 (38y)		1999-2013 (14y)	
	Change 10^6 ha	Rate 10^6 ha/y	Change 10^6 ha	Rate 10^6 ha/y
Agricultural land*	+197	+5.2%	+187	+14.4%
Forests & Woodlands	-203	-5.3%	-155	-11.9%

*Agricultural land = Arable land (short term crops) + permanent crops + permanent pastures

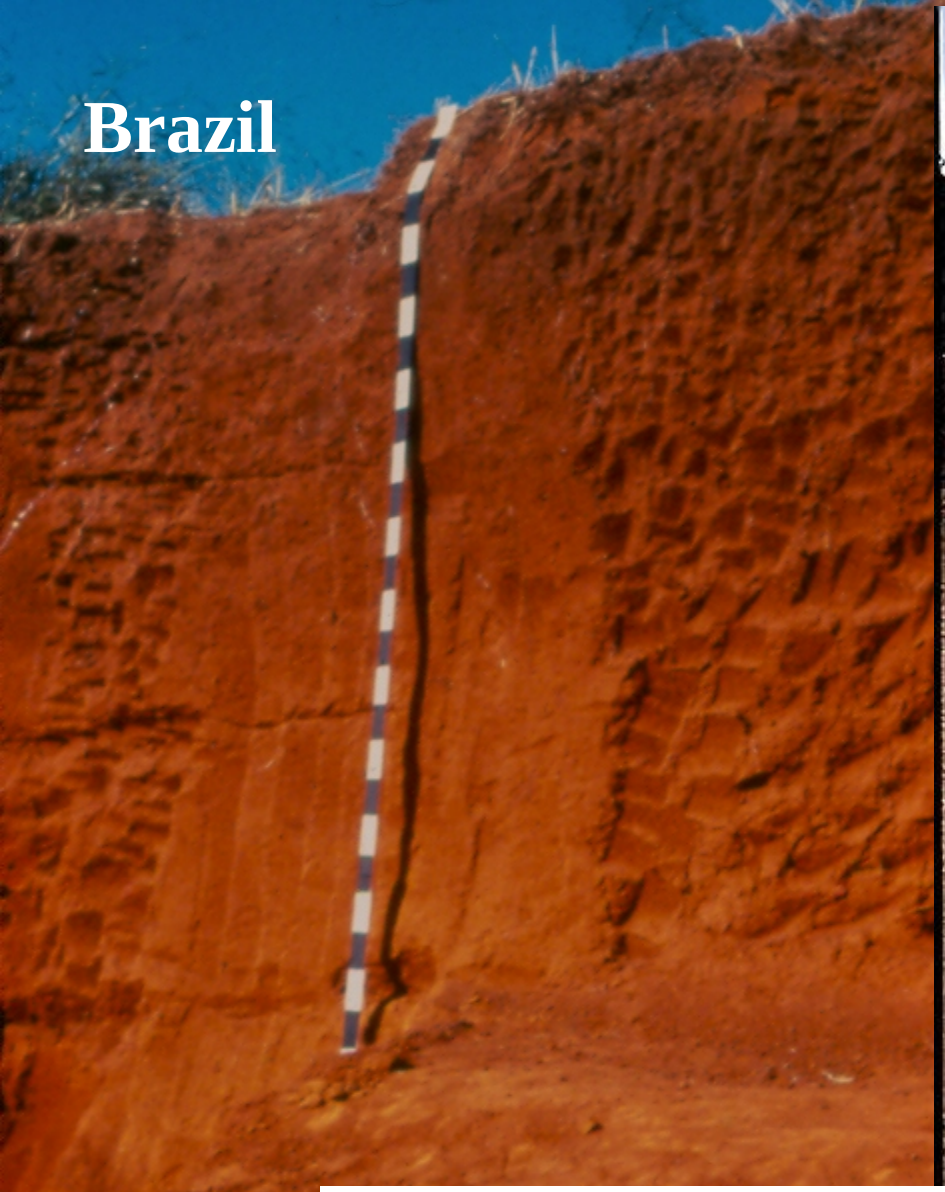
Virtually all in tropical Latin America and Africa; very little in tropical Asia and the temperate region

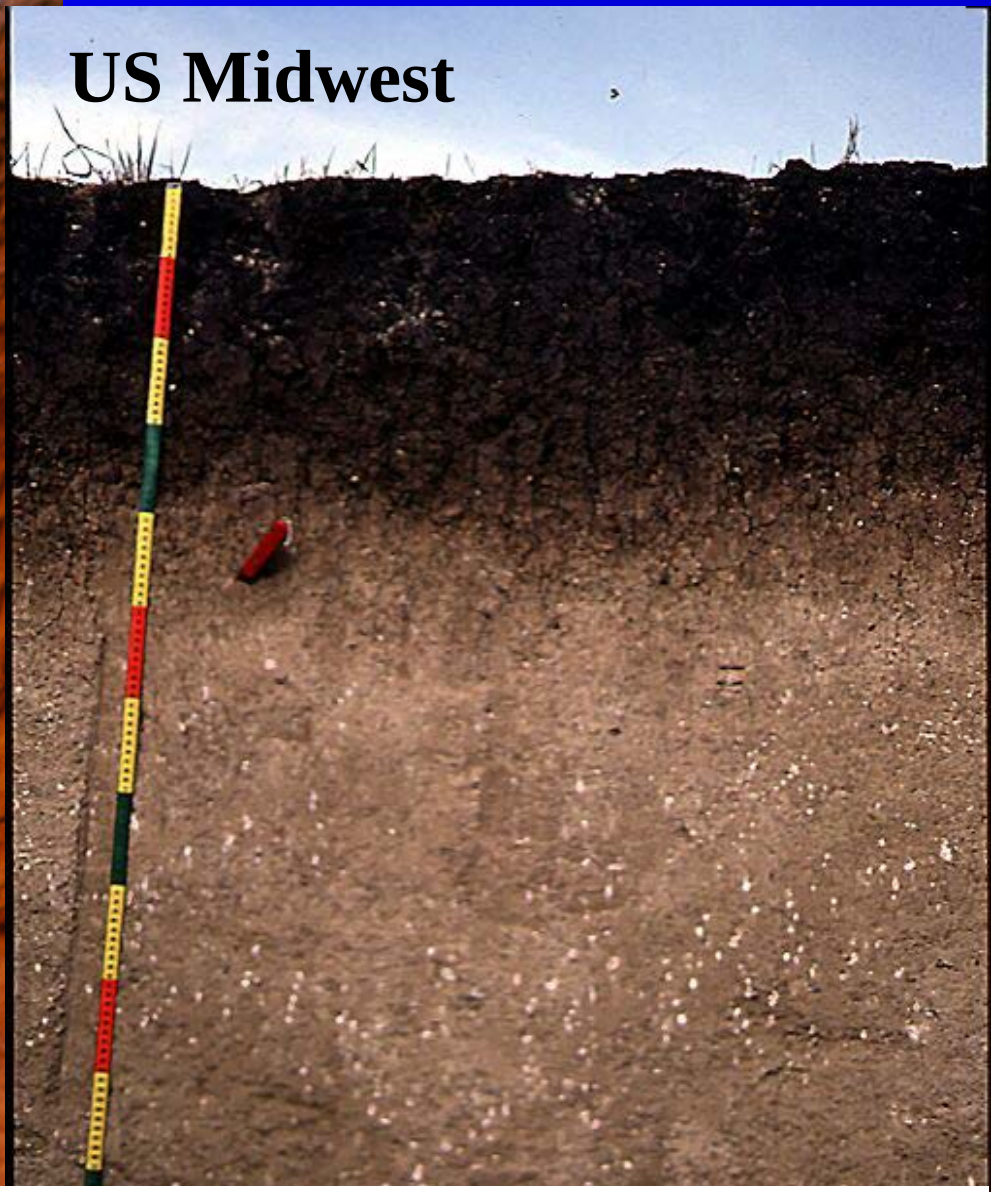
Tradeoffs with biodiversity and carbon

Calculated from data in FAOSTAT 2001, 2002, 2015

3. Tropical Soil Management

- Up to the 1970s tropical soils were considered unique: red, acid, infertile, low in organic matter and when cleared they would turn irreversibly into laterite bricks
- Useless for agriculture
- “Green Hell, Red Desert”





Similar Soil Organic Matter Contents
Similar Soybean Yields
Safety net of nitrate, preventing stream pollution in tropics

Covering the Topsoil and Mining Nutrients and Water from the Subsoil

The Outcome: Cereal yields (2005)	(tons/ha)	(bu/acre)
Sub-Saharan Africa	1	16
Latin America	3	48
South & East Asia	3	48
China	5	80
North America, Europe, Japan	10	160

Sanchez 2015. Nature Plants 1: 1-3.

4. Will Africa be Able to Feed Itself?

There is a link between unhealthy soils and unhealthy people

PA Sanchez, MS Swaminathan. 2005. The Lancet 365: 442–44

The Poverty Trap: Poor soils result in low yields and low household capital. Low household capital prevents investments in soil nutrients, which is a primary constraint on soil productivity.

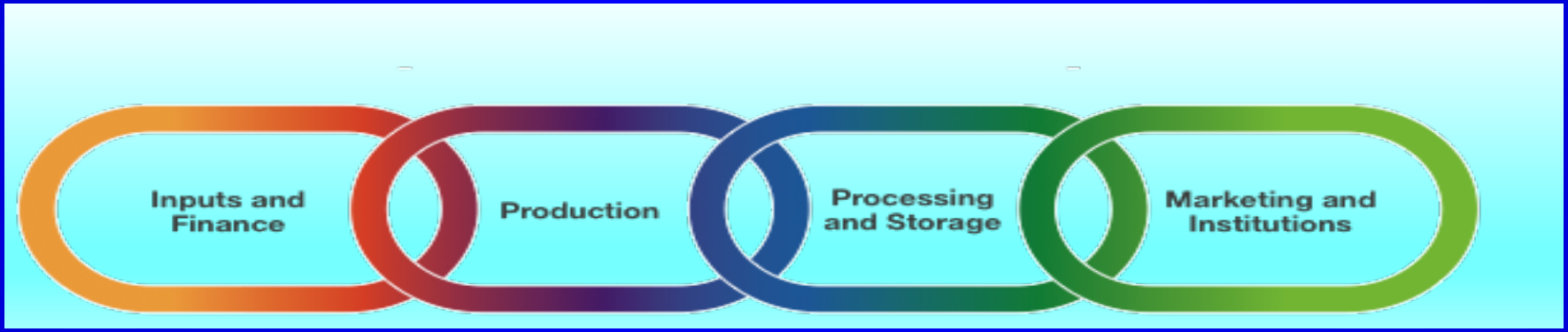
CB Barrett, LEM Bevis. 2015. Nature Geoscience 8: 907-912.

Why 1 ton/ ha?

There is a Major Biophysical Reason and a Major Economic Reason

1. **Soil fertility depletion is extreme in smallholder farms in Africa; the key entry point is not improved varieties or water but replenishing soil nutrients. Known this for decades*.**

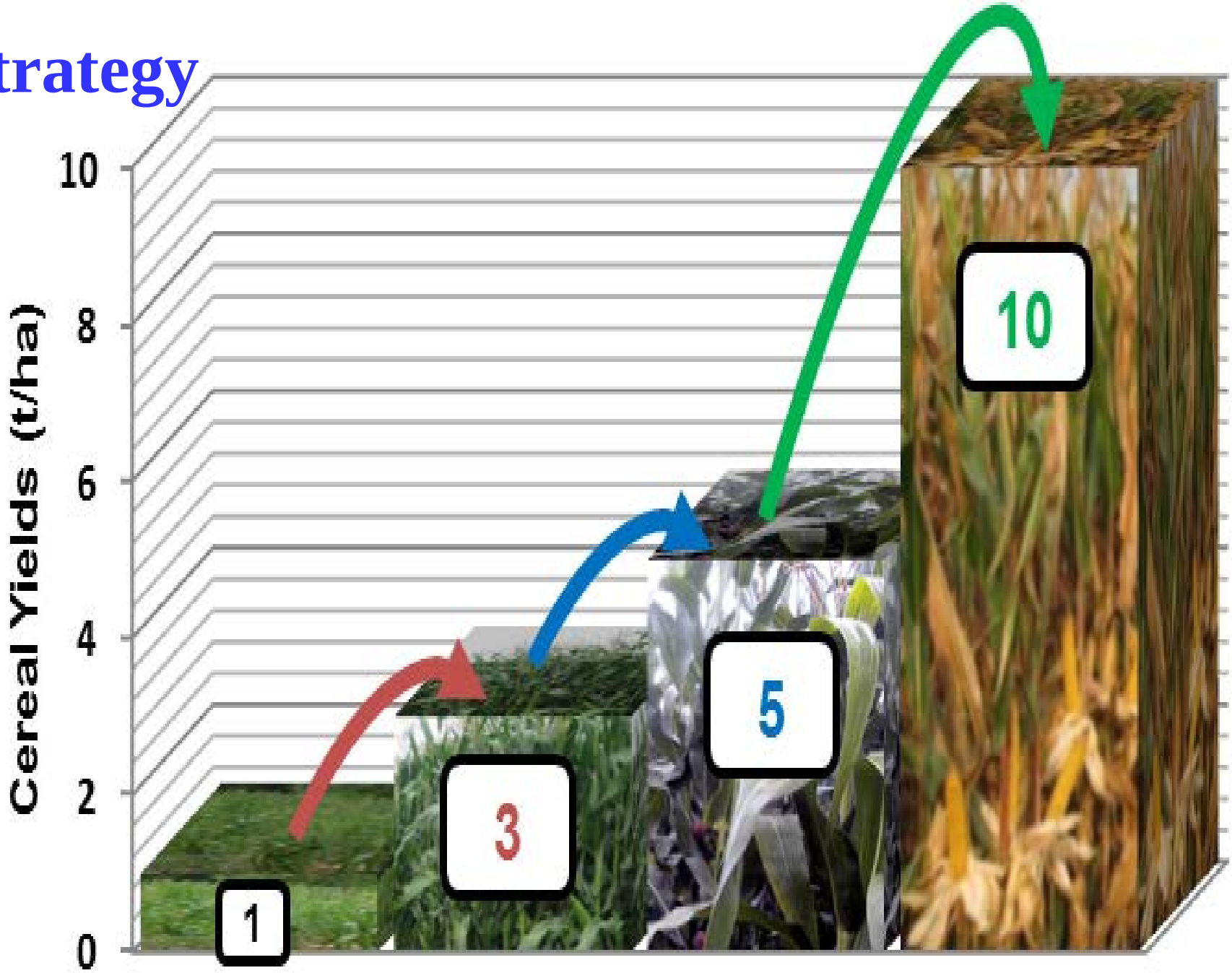
2. **A broken or nonexistent value chain:**



Sanchez 2017 in press

**See new study by Folberth et al, 2013. Agricultural Systems 119: 22-34.*

Strategy



Sanchez 2015. Nature Plants 1: 1-3

From 1 to 3 tons/ha

Maize yields have increased from 1 to 1.75 t/ha from 2005-2015

- A major political decision. Malawi 10 yr ave: from 0.8 to 1.9 t/ha.
- Best fertilizer recommendations and best available seeds.
- Positive results in the media.
- Agrodealer development.
- Market and infrastructure improvements
- Banking sector beginning to lend to smallholders.
- Crop insurance schemes developing
- Awareness of nutritional security
- Awareness of adapting to climate change

From 3 to 5 tons/ha

- Needs technology, stronger political commitment and enabling policies, particularly in infrastructure.
- Need rapid soil analysis and fertilizer blending plants.
- Use more organic inputs.
- Use the best hybrid seeds or GMO´s. Its up to countries.
- Soil erosion control by policies emphasizing continuous soil cover.
- An effective extension system, preferably private.
- Effective value chain.
- Nutritional security is part of it.
- Climate change adaptation.
- It took China 20 years (1979-1999) to go from 3 to 5 tons/ha.

From 5 to 10 tons/ha

- Agronomically possible. Plenty of evidence.
- Needs a fully functioning value chain.
- Needs peace, political and economic stability.
- Government enabled, private sector led.
- Mechanization. Larger farms or cooperatives grow the cereals and other basic food crops.
- Small farms grow nutrient-dense high value crops, livestock and fish.
- Government no longer managing poverty, but managing growth.