Malawi Soils are in great need to Restore Soil Health

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Soil Health Defined

- "The capacity of soil to function as a vital living system, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health." *Doran and Zeiss,2000*
- In my view soil health refers to a **specific** agricultural or natural system, such as maize farming as opposed to rice farming, or leaving the natural woodlands intact.
- Unhealthy soils, like unhealthy people can sufferer from various "sicknesses" or "constraints". Unhealthy soils can suffer from physical, chemical and/or biological constraints. Compare there two pieces of topsoils, both from a Brazilian Oxisol, photos taken one after another:

Healthy soil

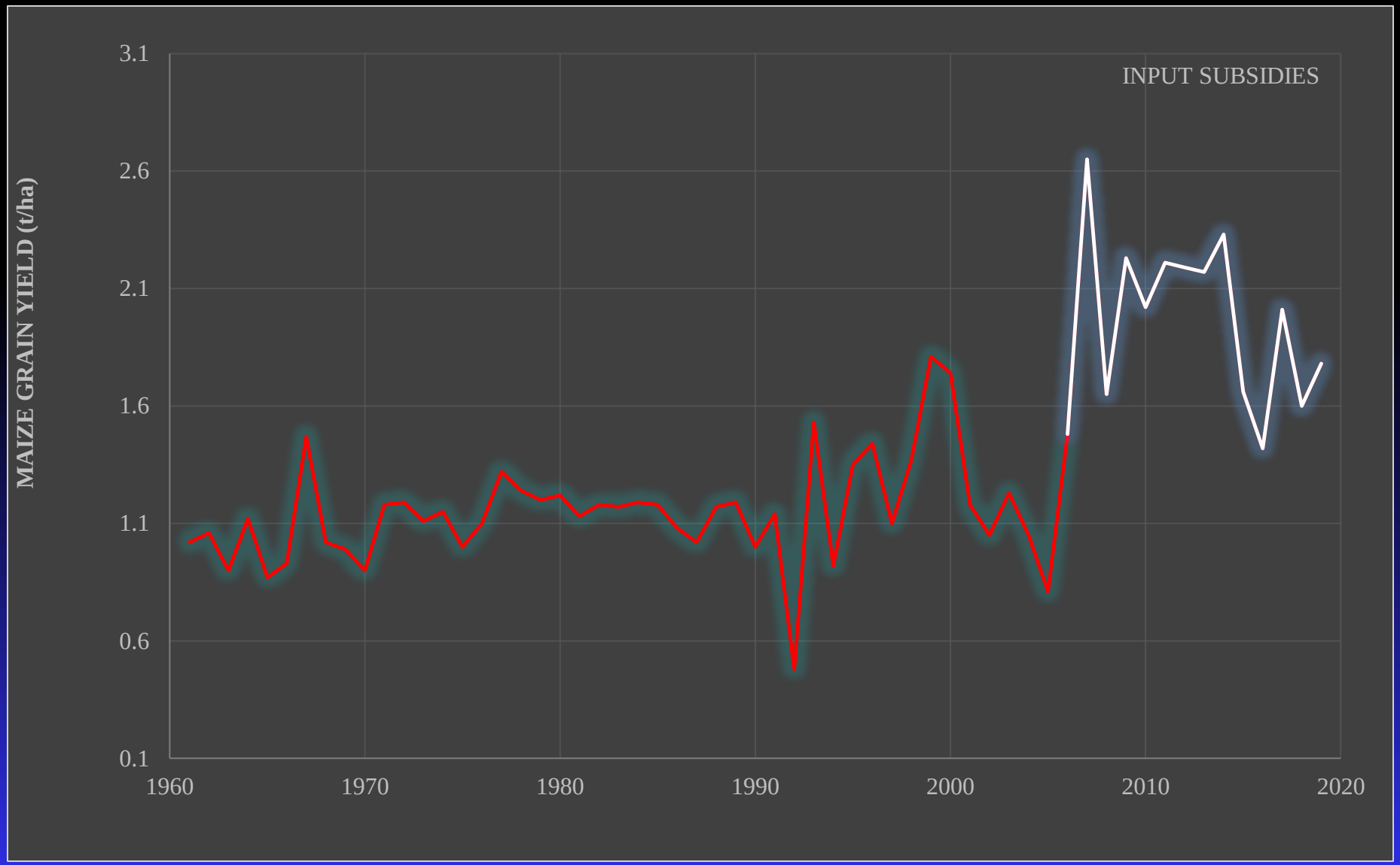
"Sick soil"

Malawi Soils are Inherently Good

Main soil constraints	Malawi 9.48 M has. %	SSA Africa %	Tropical America %
Low P (<10 ppm)	37	93	80 (est)
High erosion risk. Steep slopes	24	24	35
Acidity (Al toxicity)	9	26	43
Low K (<70 ppm)	2	56	47
Sandy topsoil	0.02	67	45
Calcareous (> pH 7.3)	0.13	2	1

Pachón and Sanchez, in preparation; iSDA,2021*, *Sanchez 2019

Malawi 60 years: MAIZE GRAIN YIELD (t/ha)



FAOSTAT Oct 20, 2021

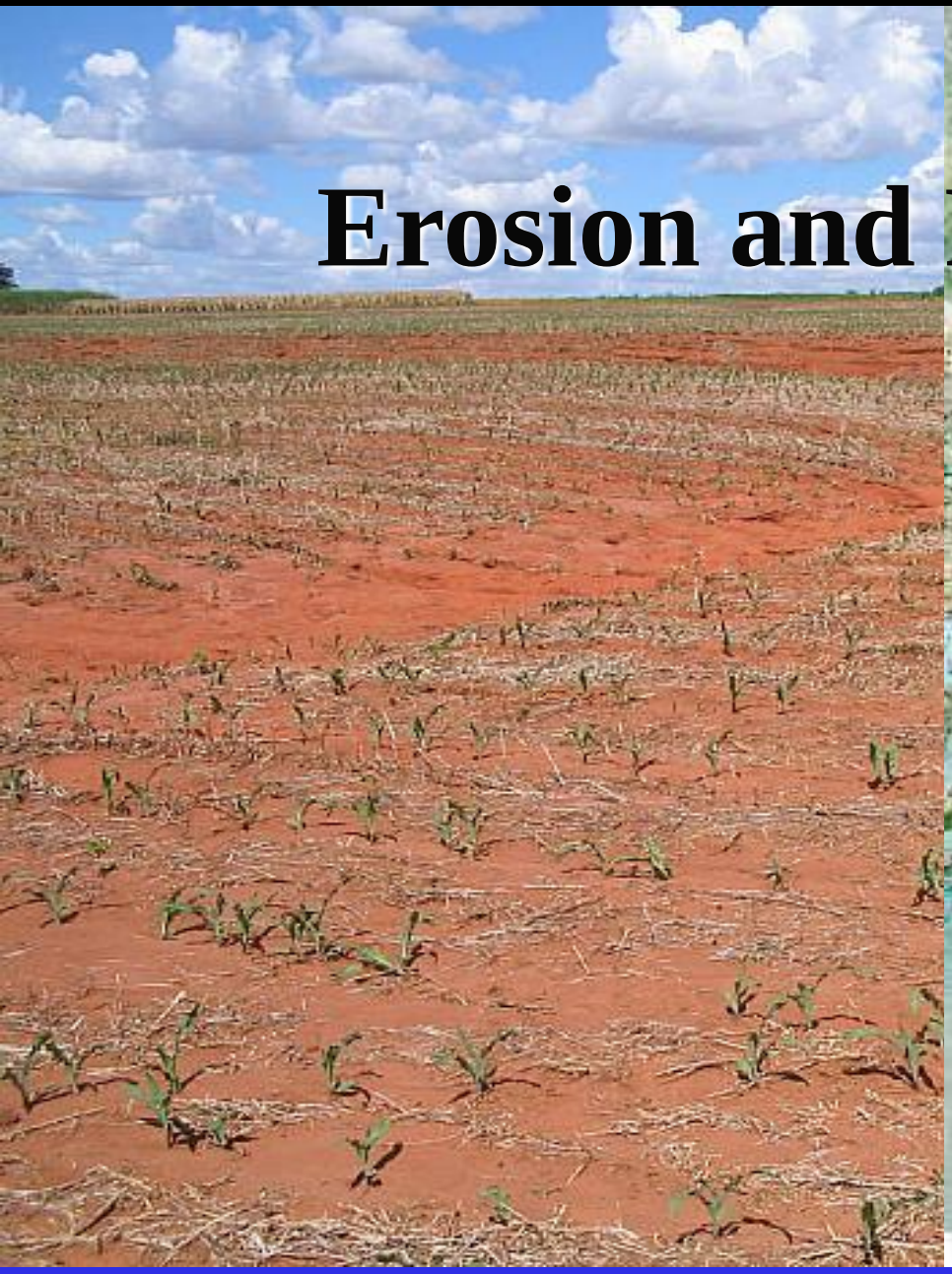
BUT, Most Malawi soils are now unhealthy because they have been depleted of nutrients

Partial NUTRIENT BALANCE	Nitrogen N	Phosphorus P	Potassium K	Sulfur S
Pre subsidy 1990-2005: Average grain yields of 1.14 t/ha	kg nutrient/hectare/year			
Input: average of 14 kgs/ as 1/2 urea, ½ as "NPK" (calculated from data by Solomon Mkumba)	**4.8**	**0.7**	**0**	**0.3**
Output: removed by all grain + stover that was taken out (calculated)	**33.4**	**3.0**	**25.7**	**2.0**
Net partial nutrient **balance**	**-28.6**	**-2.3**	**-25.7**	**-1.7**

Partial because doesn't include leaching, runoff and erosion losses, which can be large.
Low nutrient use efficiency

Bare soil guarantees runoff and erosion at the start of the rains

Erosion and Runoff Stars



But the natural system keeps the soil covered

But the 2 subsidy programs is beginning to balance the nutrient budget

NUTRIENT BALANCE	Nitrogen N	Phosphorus P	Potassium K	Sulfur S
Subsidy period 2006-2019. Average grain yield 2 t/ha	**kg nutrient/hectare/year**			
Inputs: ave. of 50 kg of 23%N, 21% P_2O_5 , 0% K and 4% S (calculated)	**34.5**	**4.5**	**0**	**2.5**
Output: removed by grain + stover taken out (calculated)	**38.7**	**5.3**	**46.8**	**3.5**
Net partial nutrient balance	**-4.2**	**-0.8**	**-46.8**	**-1.0**

Pretty close except for K!

But not enough yield from the added nutrients

Low Agronomic Use efficiency

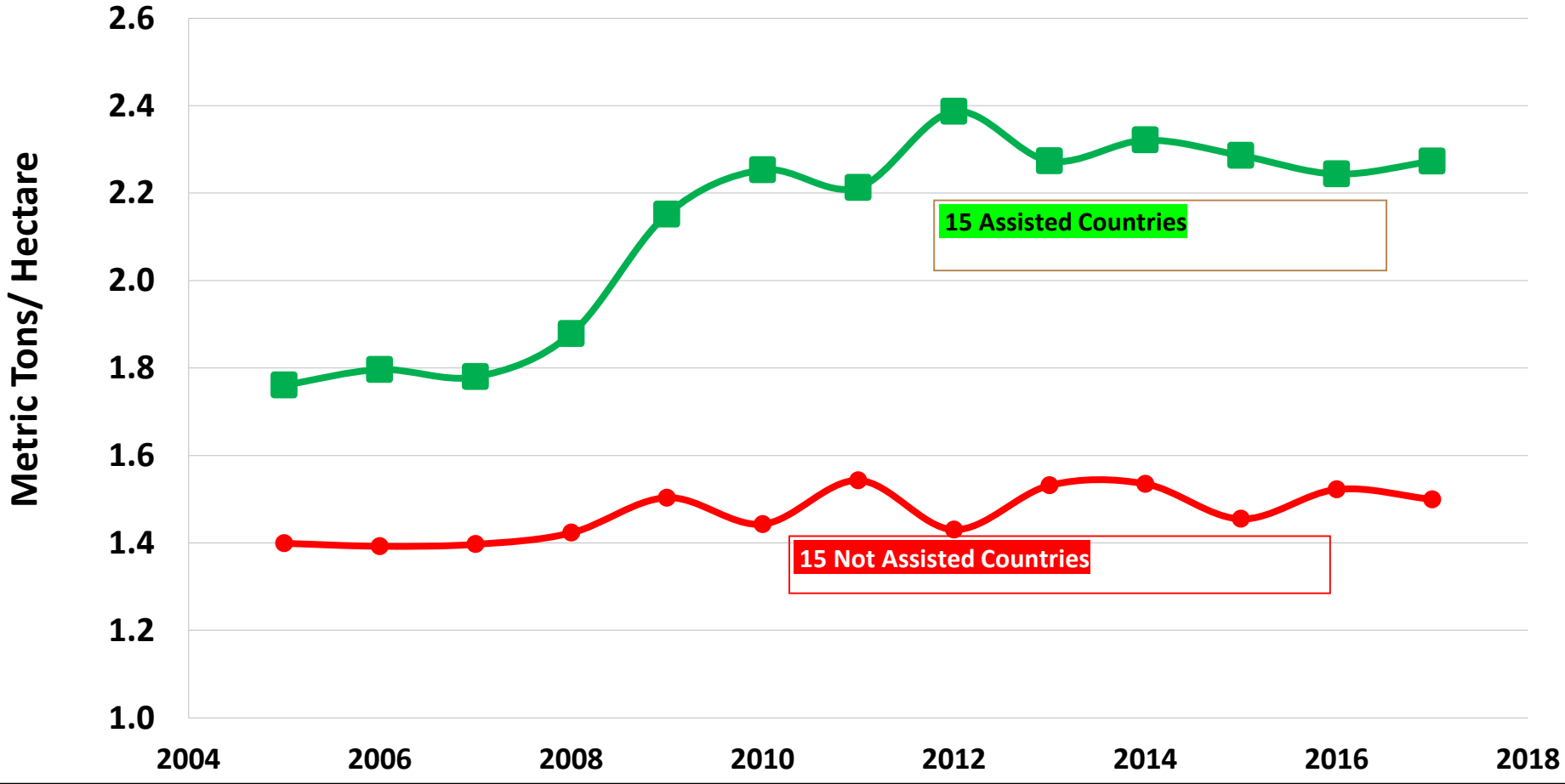
AE_N = kg grain from fertilizers-kg grain from control / Kg N fertilizer				
14 Malawi subsidy program	**32** Full ISFM	**37** Global cereal average	**57** US maize mean in 2000	

Sanchez 2019

How do you get back to a heathy soil status?

- Add mineral fertilizers correctly (4Rs) plus organics.
- Plant on time your best maize hybrids and best varieties of grain legumes and other crops. Practice good agronomy, spacing, contours.
- Keep the soil covered, to continue preventing runoff and erosion.
- Produce additional biomass in the soil to rebuild Soil Organic Carbon (SOC).
- More positive macrofauna and microbes.
- SOC increase is essential to rebuild physical , chemical, and biological soil components.

Cereal (maize and rice) yields have taken off in SSA countries receiving international support for improved seed systems and mineral fertilizers at the national scale, compared with SSA countries that have not received such assistance, where yields remain stagnant. (DeVries, 2019)



Produce biomass in the soil to rebuild SOC

- Crop diversification
- Intercropping
- Double cropping using grain legumes
- Need N fixed by legumes to increase SOC

Use of Legumes and Biological N fixation (BNF)

When grain legumes are intercropped with a cereal, there is no immediate benefit to the cereal crop because there is little decomposition of the roots from growing legumes. Improved soil fertility comes in the next cereal crop. This is when legumes can decrease N fertilizer needs

Grain legumes for nutrition, cash, soil fertility

Brazil stands alone, not only the tropics as probably the world leader in using BNF.

Based on sound science, Brazil uses very little nitrogen fertilizer (10 kg N/ha) in relation to its overall cropland area. (52 million has in 2016).

It devotes 34 million hectares to soybean production, with a national average yield of 3t/ha. It uses essentially no N fertilizer on soybeans.

About 3.8 million tons of N was fixed by improved strains of *Bradyrhizobium* in *soybeans*, worth about 4 bn 2007 US dollars in N fertilizer equivalent every year.

Maize-Grain legume rotations and intercropping keep the soil covered throughout the rainy season

But what about the dry season (May Nov.)? Several options

HOW to do cover soil in the dry season?

- Use deep rooted plants to capture water and nutrients from the entire subsoil and keep a vegetative ground cover over the topsoil for the rest of the dry season

Exploit the entire soil profile!!

Through deep rooting

Captures water and leached nutrients, recycling them back to the top.

Keeping the soil surface covered decreases soil evaporation, saving water.

Also, ground cover reduces compaction, and weeds

Constant soil cover

Can we do both? cover the topsoil and use the subsoil as deep as roots penetrate?

YES!

- **Improved leguminous fallows (Sesbania, Tephrosia, Crotalaria, Pigeon pea, etc.**
- **Deep rooting *Brachiaria ruzisensis* grass**

Leguminous Tree Fallows: Long term research experience in Malawi

Improved Fallows also Provide Fuelwood, Help Preserve Woodland Biodiversity, and Decrease Women Labor

0.3 has. of fallows supplies fuelwood for a family to cook for 1 year

Long term experiment in Makoka

A treasure trove for additional data acquisition

Using subsoil Water and Nutrients: Deep C sequestration

Grazed, *Brachiaria ruzizensis* pasture

Oxisol, Baldim, MG, Brazil

Cattle: 5 months without rains


Brachiaria ruziziensis: Why is it so good?
Brazilan farmers plant it as a cover crop

Systems adaptation

The introduction of *Brachiaria* into maize systems in the Brazilian Cerrados adds 2-3 months to a 6-7 month growing season

Adaptation to DR Congo

Maize and Brachiaria intercropping

Brachiaria monocropping

Early stages (1.5 to 2 months after planting)

By Bernard Vanlauwe

Medium stages (2.5 to 3.5 months after planting)

Maize and Brachiaria intercropping

Brachiaria monocropping

How do you do all this?

- Consult the farmers first and often – how to keep the soil covered on their farm?
- Transform AIP into a Soil Heath Program including high yielding varieties and hybrids, small, medium and large farms (ex tobacco), cellphone us.
- Grow nutrient dense foods (grain legumes, tree nuts, unsaturated oils, milk, chickens, eggs, red meat for weaned babies. Less cereals, root crops, saturated oils, sugar.
- Extension, extension, extension!

Malawi—The First African Green Revolution
September 2005

From the outside looking in

- Malawi has done what no other SSA country has.
- THE LITTLE ENGINE THAT COULD!!
- I know Malawians don't like to brag, but its time to do so!

Recommendations

- **Modify AIP to focus on restoring soil health. Bumper year coming.**
- **Use part of AIP budget to:**
  - **Maximum use of grain legumes.**
  - **Keep soil covered the year around.**
  - **Use deep subsoil as far as deep roots go**
  - **Rethink improved fallows, maybe around cropped fields**
  - **Try *Brachiaria ruziziensis* and other ones repatriated to Africa. Can be done quickly like in DRC.**
  - **Focus on growing nutrient dense foods.**
  - **Make extension highly exciting.**

Thanks to

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