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Saving Oil by Managing Soil

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THE RESOURCES USED FOR AGRICULTURE

- 38% of the Earth's terrestrial surface is used for agriculture,
- 75% of agricultural land (3.73 Bha) is allocated to raising animals,
- 70% of the global freshwater withdrawals are used for irrigation,
- 30-35% of global greenhouse gas emissions are contributed by agriculture,

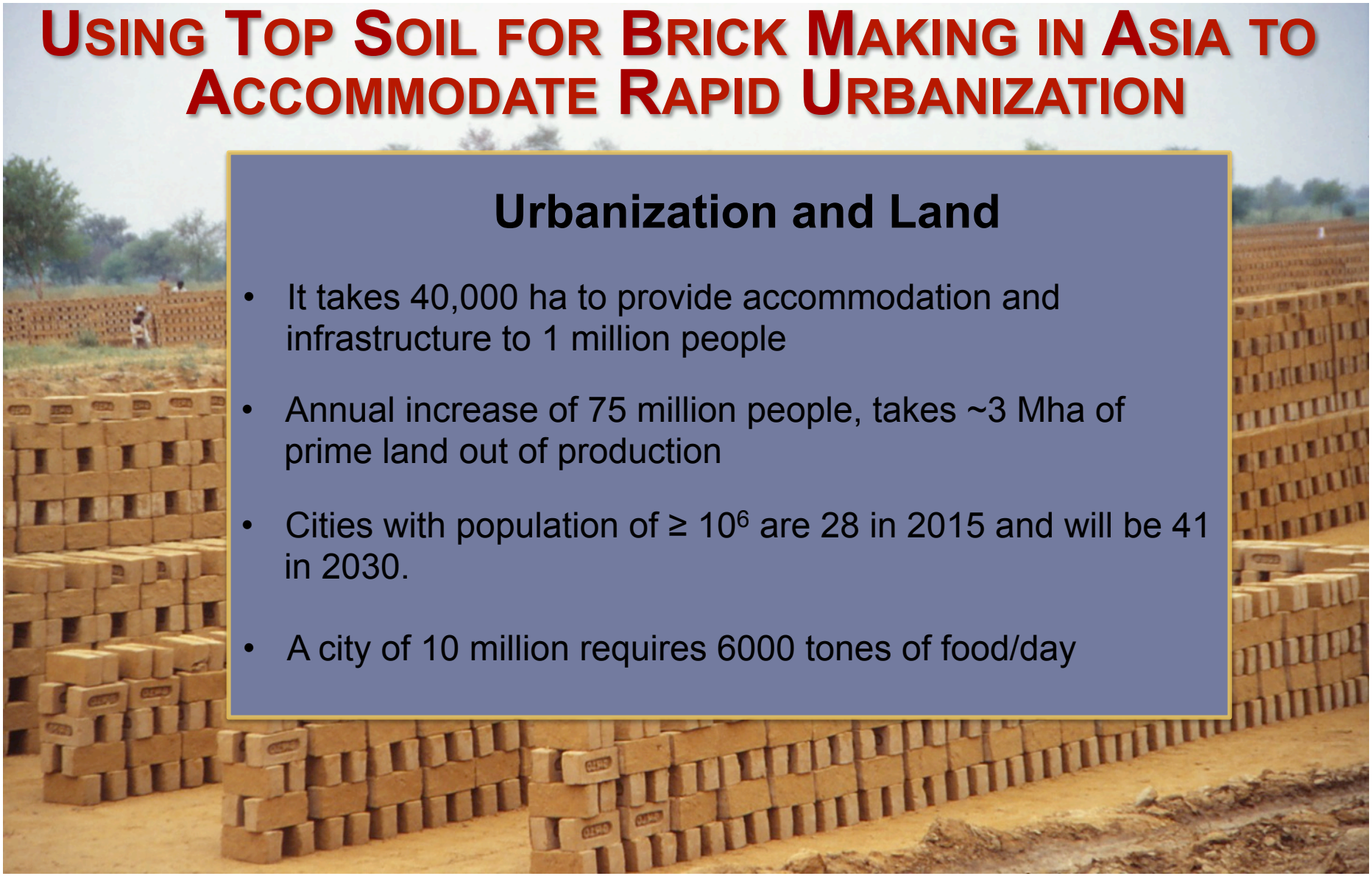
And yet 1 in 7 persons is food-insecure and 2-3 in 7 are malnourished.

STATE-OF-THE-WORLD

Dynamics per Minute

Death from hunger	: 15.6
Deforestation	: 24.7 ha
Fresh water withdrawal	: $8.4 \times 10^6 m^3$
Energy consumption	: 1.05 PJ
New motor vehicles	: 160
Urban encroachment	: 5.7 ha
Soil degradation	: 9.5 ha
CO_2 – C emissions	: 20 Gg

USING TOP SOIL FOR BRICK MAKING IN ASIA TO ACCOMMODATE RAPID URBANIZATION



Urbanization and Land

- It takes 40,000 ha to provide accommodation and infrastructure to 1 million people
- Annual increase of 75 million people, takes ~3 Mha of prime land out of production
- Cities with population of $\geq 10^6$ are 28 in 2015 and will be 41 in 2030.
- A city of 10 million requires 6000 tones of food/day

SOIL: THE ESSENCE OF LIFE

"Hello there folks. Do you know who
geomembrane of the Earth. I am yo
your mediator of energy, water
am your sustainer of pr
elements, and the ha
supports you, t
you will re

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ndation that
dust from which

- Soil matters
- It is the answer to important global issues
- Food production must be soil-centric
- Soil management is essential to saving energy

Richard Arnold (2005)
Senior Soil Scientist

MEETING FOOD DEMAND BY 2050

The world produces enough food to feed 10 billion people . Thus, food and nutritional security must be achieved by:

- **Reducing** waste (30-50%),
- **Increasing** access to food by addressing poverty, inequality, wars and political instability,
- **Improving** distribution,
- **Increasing** use of plant-based diet,
- **Accepting** personal responsibility of not taking things for granted, and
- **Increasing** agronomic productivity from existing land, restoring degraded lands ,and converting some agricultural land for nature conservancy without any conversion of natural land to agroecosystems.

THE LIVING SOIL

Soil is an organic-carbon mediated realm in which solid, liquid, gas and biology all interact from a scale of nanometer to landscape.

The weight of live organisms in arable land is 5 t/ha

THE DIRT

"Dirt has no currency in western society, and has little impact on politicians. It comes under the journalist "MEGO" category… My Eyes Glaze Over.

Bar a few impressive dust storms, we care little of our soil. We do not relate what we eat in our home, buy in out supermarkets, or drink from our Starbucks to the soil. And yet, without soil, we become thirsty, hungry, and we die. Without soil, we become Mars, with no water, no atmosphere, and only relics of life, with at best distant stargazers trying to figure our the life that could have been."

Young and Crawford (2015)

CLIMATE CHANGE AND HUMAN RESPONSE

Illustration by Lincoln Agnew, NYT 4/21/2013

- Humans have not had to deal with such a drastic climate change since 10-12 millennia ago
- Now the humans, with population of 7.2 billion and projected to be 10 billion, have to deal with it and increasingly so in the future
- Yet, there is no consensus as in Rio +20

GLOBAL SOIL ORGANIC CARBON POOL 0-30cm DEPTH

Total Pool = 684-724 (704) Gt *.... Batjes (1996)*

0.4% Increase/yr = 2.8 Gt C/yr

OFF-SETTING OIL BY SOIL C SEQUESTRATION

CARBON COST OF PLOWING

TILLAGE	kg C E/ha
Moldboard plowing	15.2
Chiseling	7.9
Heavy Disking	8.3
Standard Disking	5.8
Sub-soiling	11.3
Cultivation	4.0
Rotary hoeing	2.0

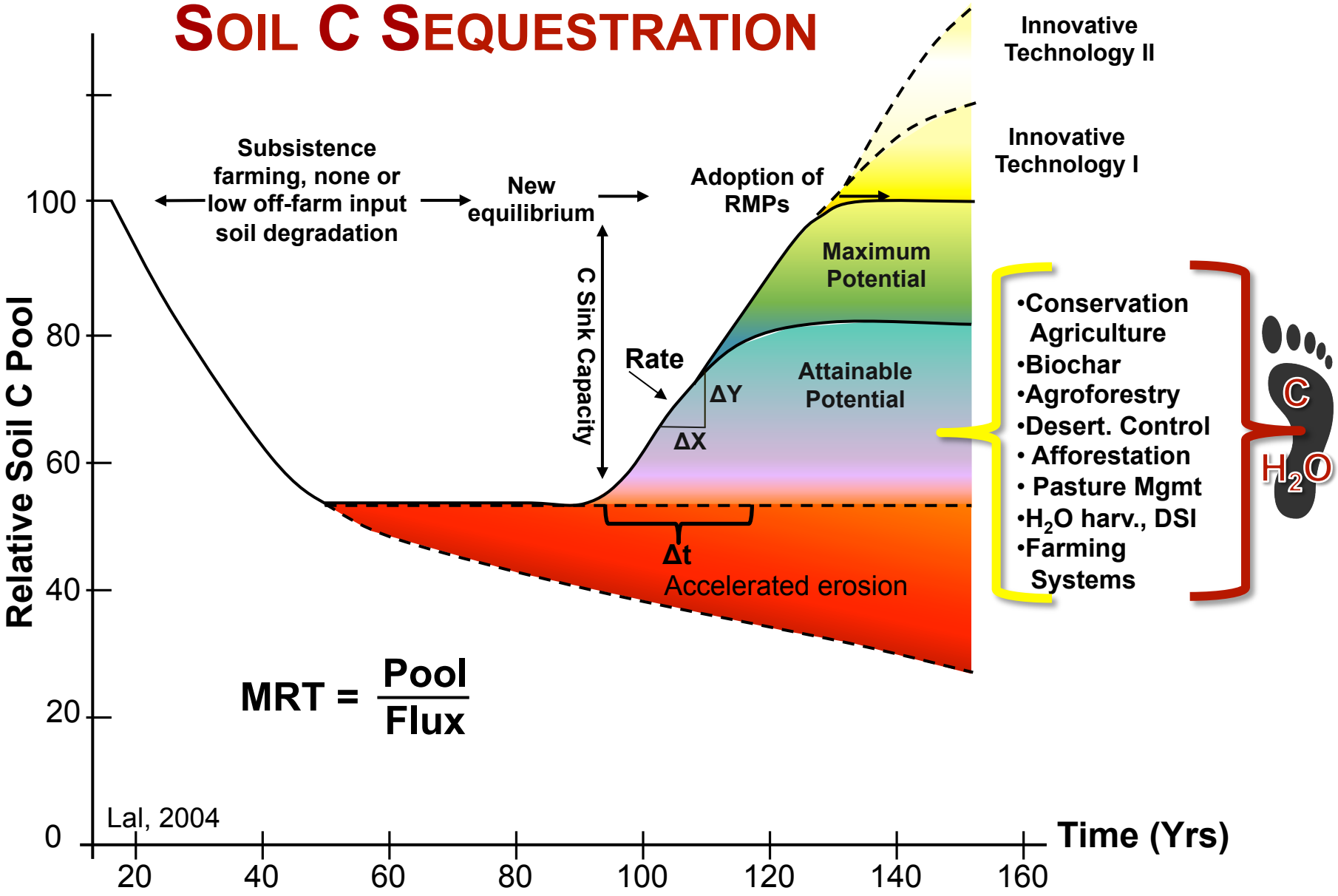
CARBON COST OF FERTILIZERS &PESTICIDES (LAL, 2004)

Input	Equivalent Carbon Emission (Kg C Kg^{-1})
(i) Nitrogen fertilizer	0.9 - 1.8
(ii) Phosphorous	0.1 - 0.3
(iii) Potassium	0.1 - 0.2
(iv) Herbicides	1.7 - 12.6
(v) Insecticides	1.2 - 8.1
(vi) Fungicides	1.2 - 8.0

CARBON COST OF HERBICIDES (LAL, 2004)

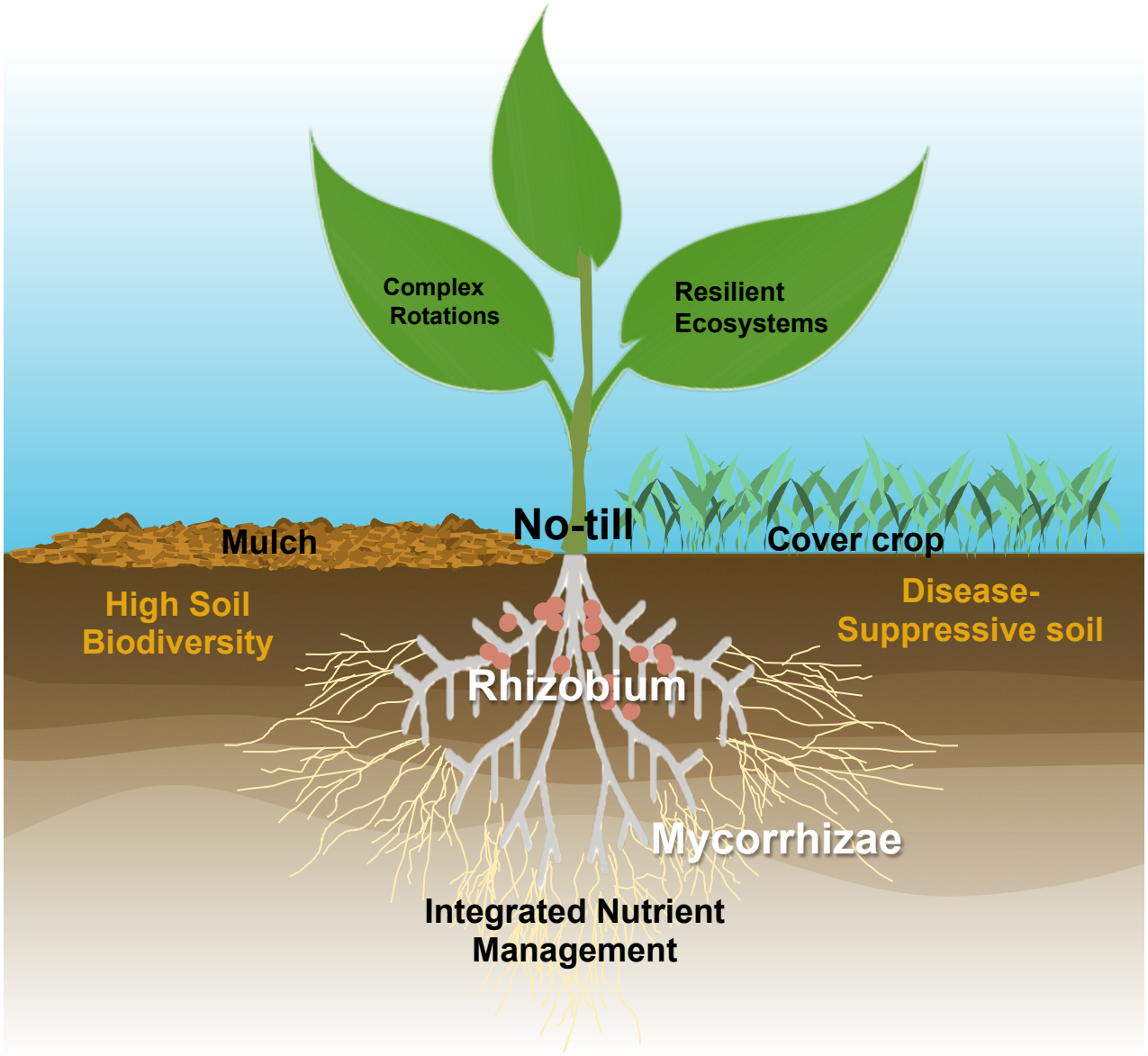
HERBICIDE	kg C E/kg a:i
Atrazine	3.8
Dicamba	5.9
Glyphosate	9.1
Paraquat	9.2

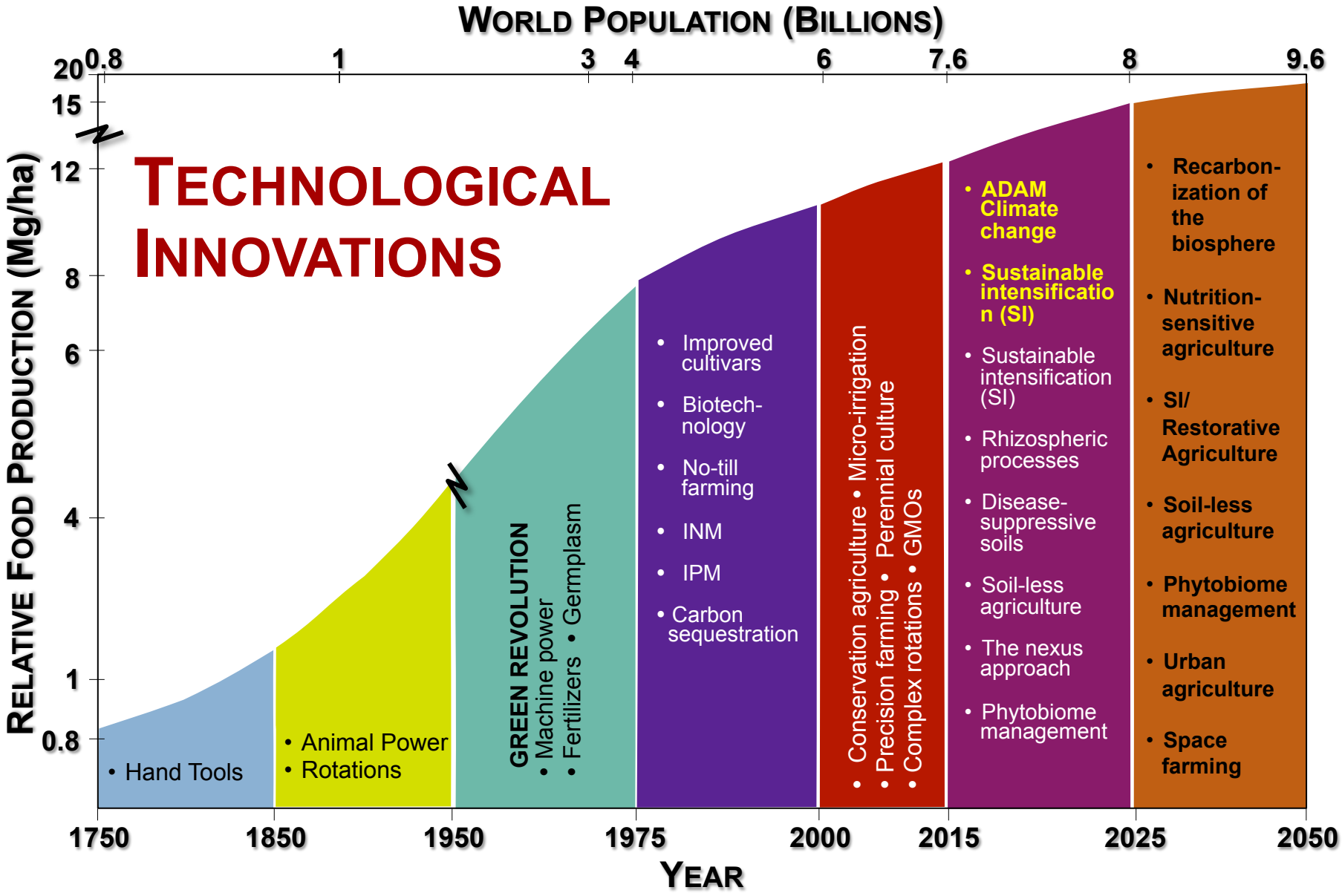
SOIL C SEQUESTRATION



$$MRT = \frac{Pool}{Flux}$$

Conservation Agriculture System




WORLD POPULATION (BILLIONS)
0.8
1
3
4
6
7.6
8
9.6
RELATIVE FOOD PRODUCTION (Mg/ha)
20
15
12
8
6
4
1
0.8
TECHNOLOGICAL INNOVATIONS
• Hand Tools
• Animal Power
• Rotations
GREEN REVOLUTION
• Machine power
• Fertilizers • Germplasm
• Improved cultivars
• Biotech-nology
• No-till farming
• INM
• IPM
• Carbon sequestration
• Conservation agriculture • Micro-irrigation
• Precision farming • Perennial culture
• Complex rotations • GMOs
• ADAM Climate change
• Sustainable intensification (SI)
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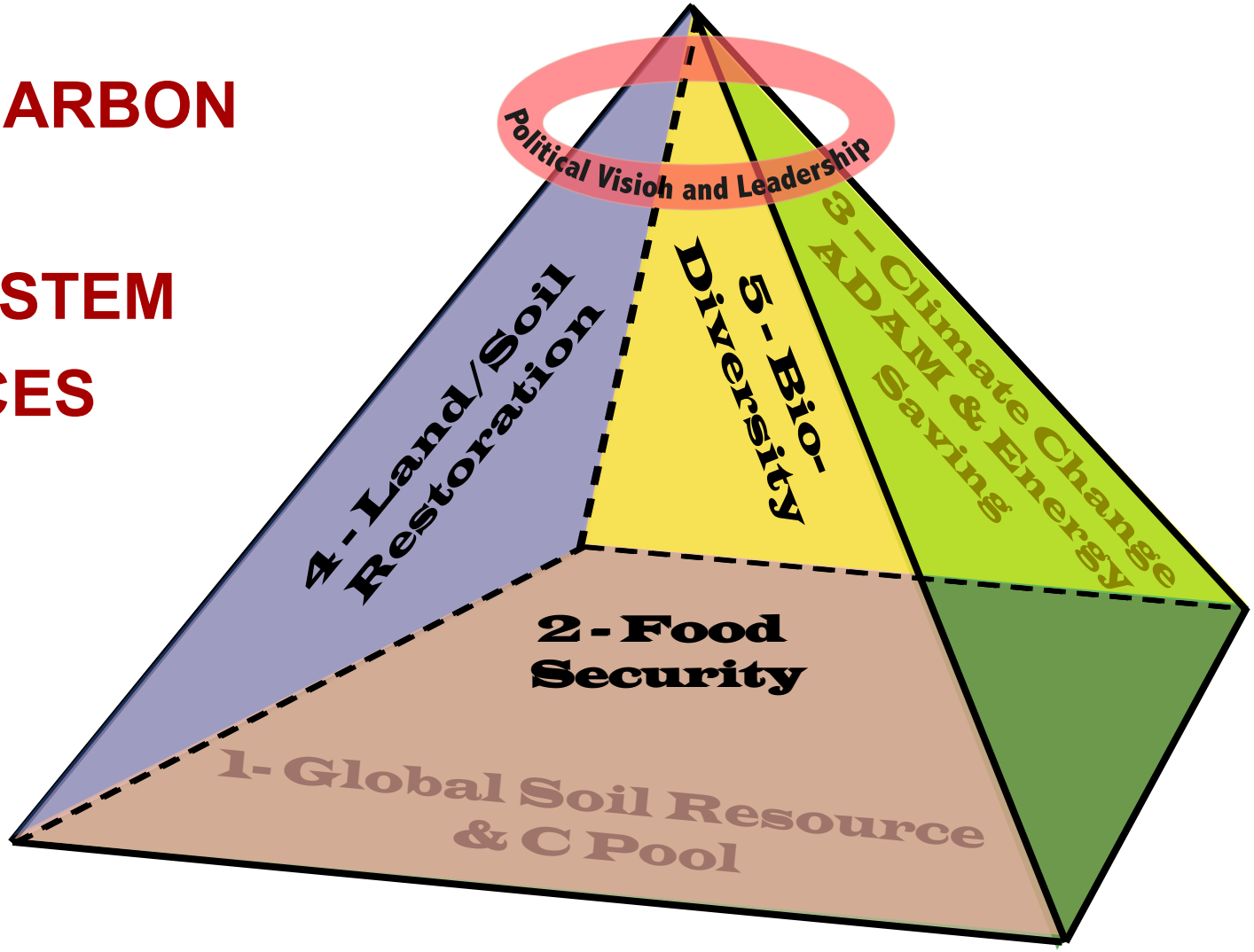
• Rhizospheric processes
• Disease-suppressive soils
• Soil-less agriculture
• The nexus approach
• Phytobiome management
• Recarbon-ization of the biosphere
• Nutrition-sensitive agriculture
• SI/ Restorative Agriculture
• Soil-less agriculture
• Phytobiome management
• Urban agriculture
• Space farming
1750
1850
1950
1975
2000
2015
2025
2050
YEAR

SOIL CARBON AND ECOSYSTEM SERVICES



MANKIND AND THE ENVIRONMENT

"Mankind is on the horns of a dilemma.

For whether we like it or not, our collective way of life has become unsustainable and we need to do something about it – and soon.

The choices we have already made about the way we lead our lives have been slowly eating away at the very support system that enables us to live and breathe.

This cannot, and should not, go on.

We need to make some tough decisions, we need to make them now and we need to act on them as one, with total and undivided commitment – today and in the future.

Faced with facts we cannot argue against, we need to consider our priorities and accept that we have to make certain sacrifices; we need to start putting 'life' ahead of 'lifestyle'."

IMO, World Maritime Day (2009)

SOIL STEWARDSHIP

Soil stewardship and care must be embedded in every fruit and vegetable eaten, in each grain ground into the bread consumed, in every cup of water used, in every breath of air inhaled, and in every scenic landscape cherished.

SOIL: THE GLOBAL ICON