



THE OHIO STATE UNIVERSITY

BEYOND DNC-2015

Rattan Lal

CHAIR INTERNATIONAL ADVISORY COMMITTEE UNU-FLORES

The Ohio State University

Columbus, OH 43210 USA

27.03.2015

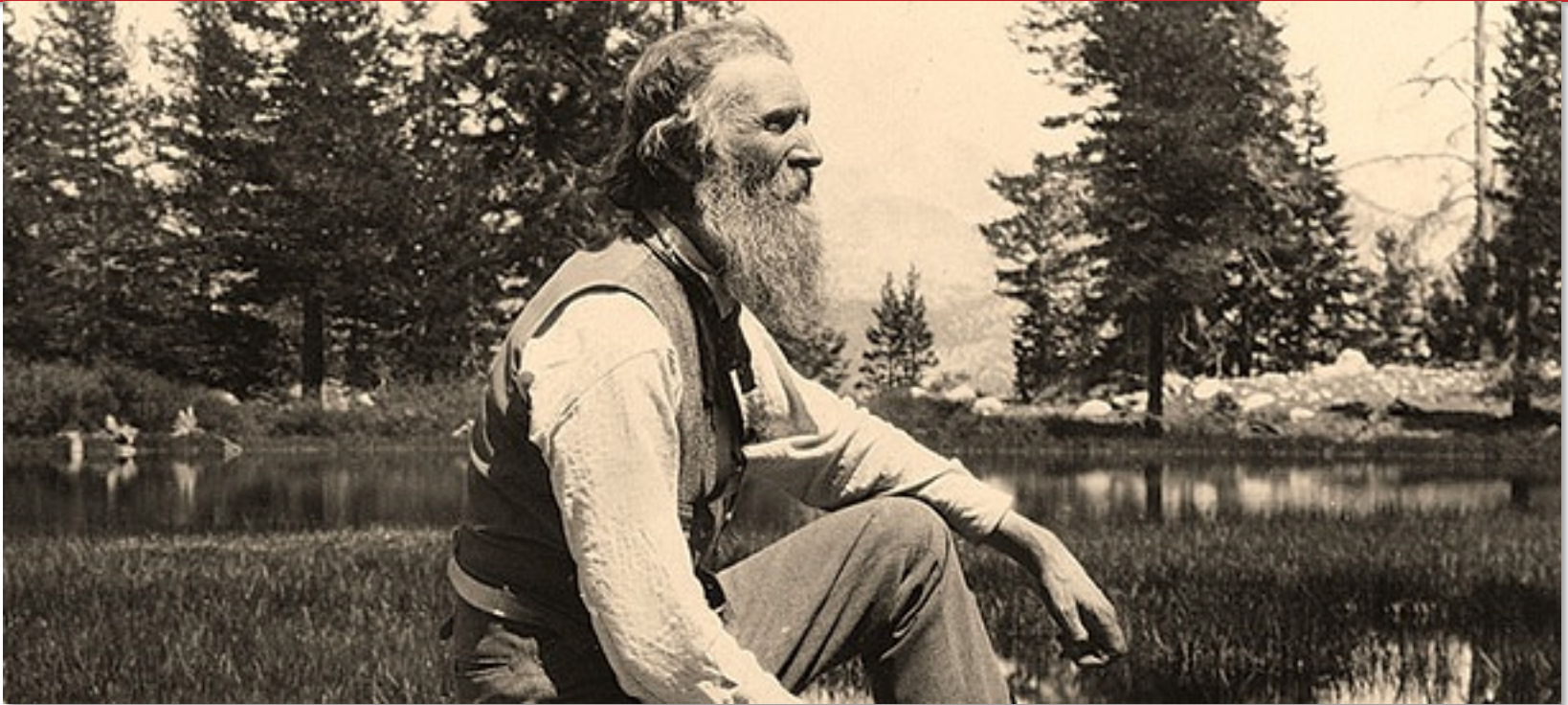


INTERNATIONAL YEAR OF SOILS 2015

The 68th UN General Assembly (A/RES/68/232) declared 2015 the “International Year of Soils”

The Objectives of IYS are:

- To create full awareness of civil society and decision makers about the fundamental roles of soils for human’s life
- To advance full recognition of the prominent contributions of soils to food security, climate change, adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development.
- To promote effective policies and actions for the sustainable management and protection of soil resources.



**“When we try to pick out anything by itself,
we find it hitched to everything else in the universe.”**

John Muir
(Naturalist, 1838-1914)



4 LAWS OF ECOLOGY

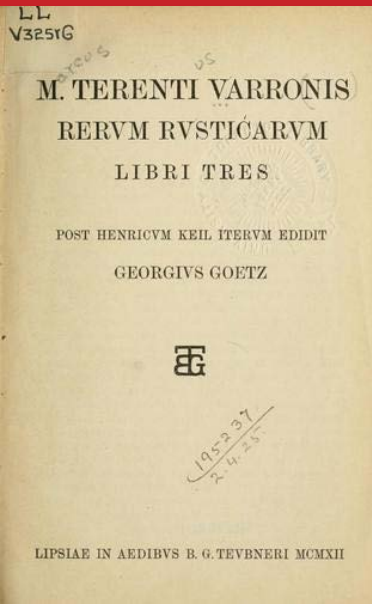
1. Everything is connected to everything else
2. Everything in nature must go somewhere
3. Mother nature knows best
4. There is no such thing as a free lunch

Barry Commoner, 1972



THE QUESTION-ANSWER DILEMMA

Answer to the question of soil-water-waste nexus has been changing with every generation since the dawn of human civilization.



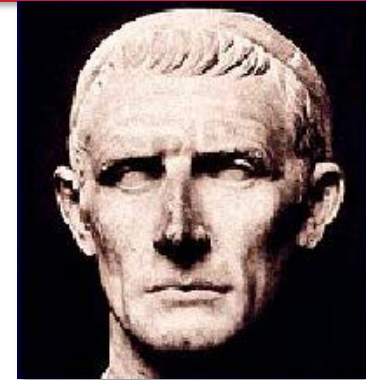
**Rerum
Rusticarum
Ribri III**

(Agricultural
topics in
3 books)

SUSTAINABLE AGRICULTURE

(116-27 BC)

Agricultura “est scientia,
quae sint in quoque agro
serenda ac facienda,
quo terra, (that the land)
maximos (the highest)
perpetetuo (in perpetuity)
reddat fructus” (yields)



**Marcus
Terentius
Varro**



KITAB-AL-FELAHA

Ibn-Al-Awan, a Moorish Philosopher wrote in the “Book on Agriculture” in the 12th century:

“The first step in the science of agriculture is the recognition of soils and of how to distinguish that which is of good quality and that which is of inferior quality. He who does not possess this knowledge lacks the first principles and deserves to be regarded as ignorant”.

(Vol. 1, p. 23)

“One must also take into consideration the depth of the soil, for it often happens that its surface layer may be black.”

(Vol. 1, p. 336)

Chankya 580 A.D. proposed similar concepts in his book “Artha Sastra”



NEXUS-BASED GLOBAL ISSUES

- Land-water-atmosphere-climate-nexus
- Societal response to climate change
- Natural resources and global security
- Sustainable intensification: producing more from less
- Urban ecosystems and recycling waste
 - Sky farming
 - Space agriculture



ECOSYSTEM SERVICES

- Goods and functions for nature conservancy
- Humans belong to nature (Chief Seattle)
- Therefore, what humans do must be profitable **to Nature!**



CLIMATE

“It refers to an aggregate of both average and extreme conditions

**“Climate is what you expect,
weather is what you get.”**

**Samuel Langhorne Clemens
(Mark Twain)**



SILVER LINING IN THE DARK CLOUD OF CLIMATE CHANGE

- The humanity can not afford to overlook any opportunities that may arise from changing climate, shifting species
- Ignoring any opportunities will be a serious over sight



SUSTAINABLE DEVELOPMENT GOALS

- Zero Net Land/Soil Degradation
- Zero net CO₂ and GHG emission
- Being the engine of sustainability, achieving SDGs necessitate that soils are the basis of economic/ecologic development.



ANTHROPOGENIC EMISSIONS (Pg) BY CARBON CIVILIZATION

I. Land use

- (i) Prehistoric : 320
- (ii) 1750-2010 : 136
- (iii) 2010-2030 : 30

II. Fossil Fuel combustion

- (i) 1750-2010 : 200
- (ii) 2010-2030 : 190

These emissions have and will affect the ecosystems from which we derive food, feed, fiber, fuel and shelter.



CLIMATE CHANGE AND THE HUMAN RESPONSE

- 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



Illustration by Lincoln Agnew, NYT 4/21/2013



CARBON PIE

Total C Pie = $(560\text{ppm}-400\text{ppm}) \cdot 4\text{Gt}/1 \text{ ppm} = 640 \text{ Gt}$

How do we divide the pie among nations?

640 Gt

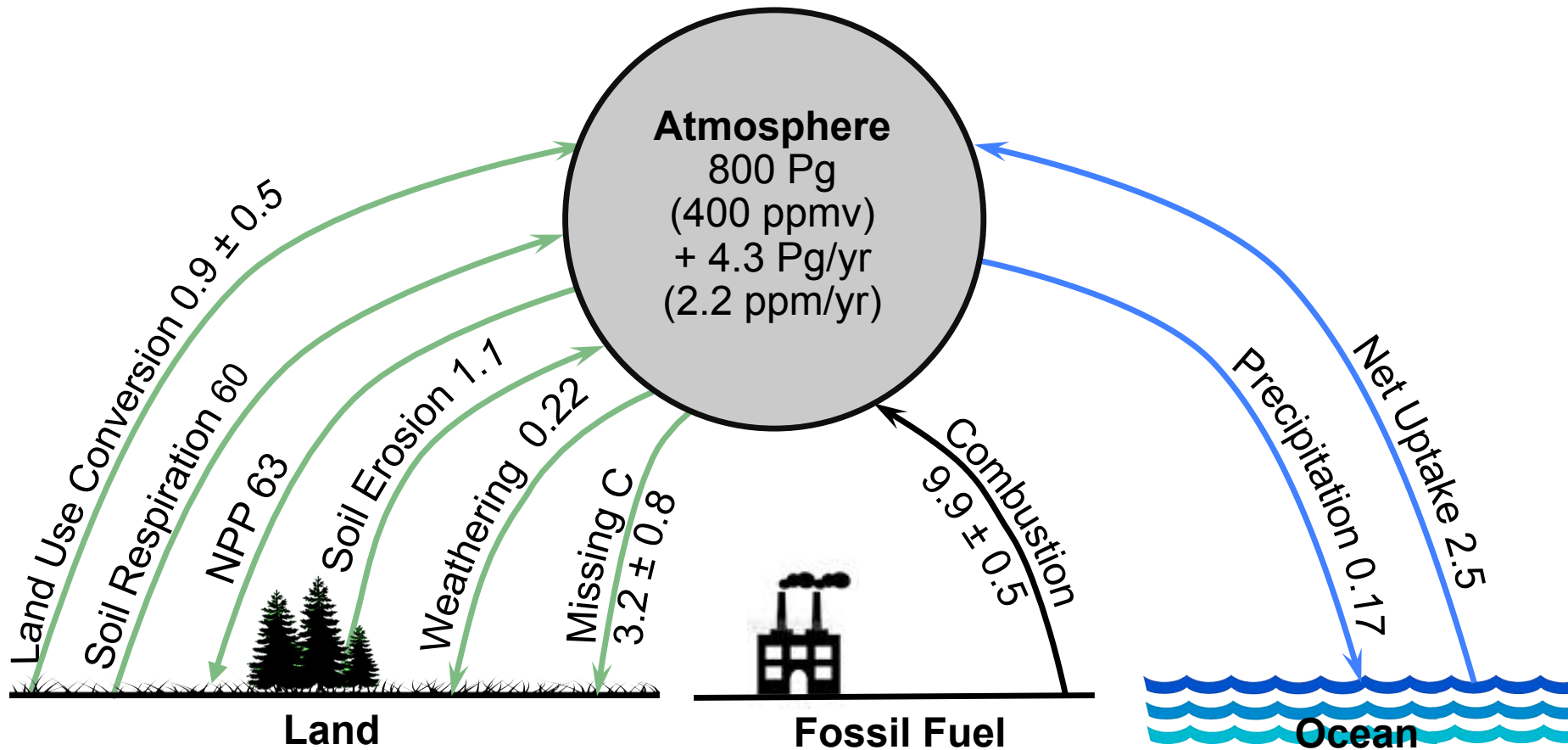


BIOFUELS?

(1 Billion ton cellulosic feedstock)



THE TERRESTRIAL AND OCEANIC PROCESSES IMPACTING ATMOSPHERIC CHEMISTRY





CAN SOIL C SEQUESTRATION MITIGATE CLIMATE CHANGE?

- No, C sink capacity of soils of agro-ecosystems is finite (~ 1 PgC/yr for 50-100 years).
- But, it has numerous co-benefits and is the more cost-effective option.
- Restoring soil quality, of which SOC pool is the important determinant, is essential to human wellbeing and nature conservancy.



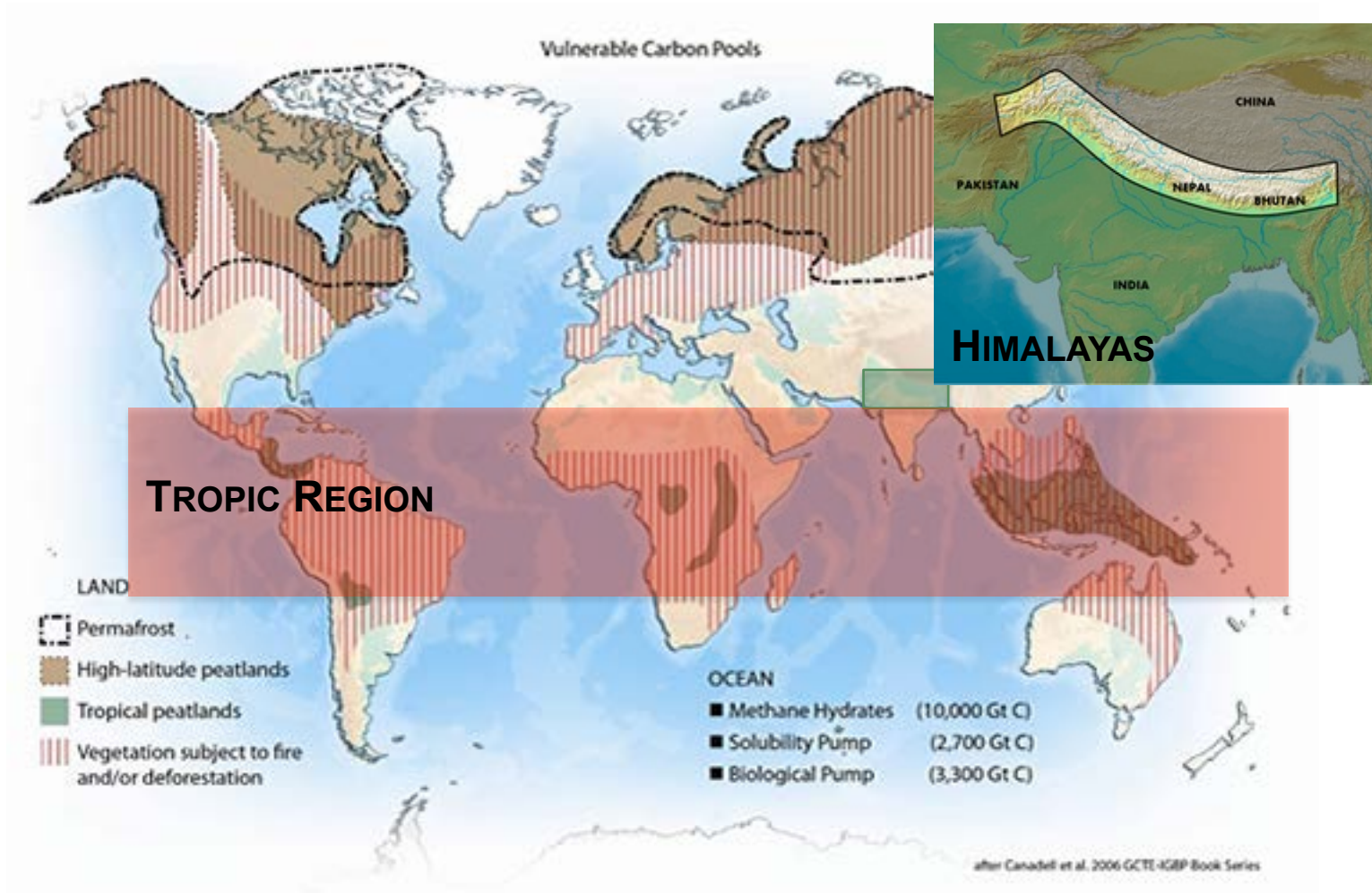
CAPACITY OF SOIL CARBON SINK

- Total SOC pool to 2-m depth = 2400 Pg
- Increasing SOC pool by 1% = 24 Pg
- 1 Pg = 0.47 ppm

C sink capacity for every 1% increment \approx 11 ppm

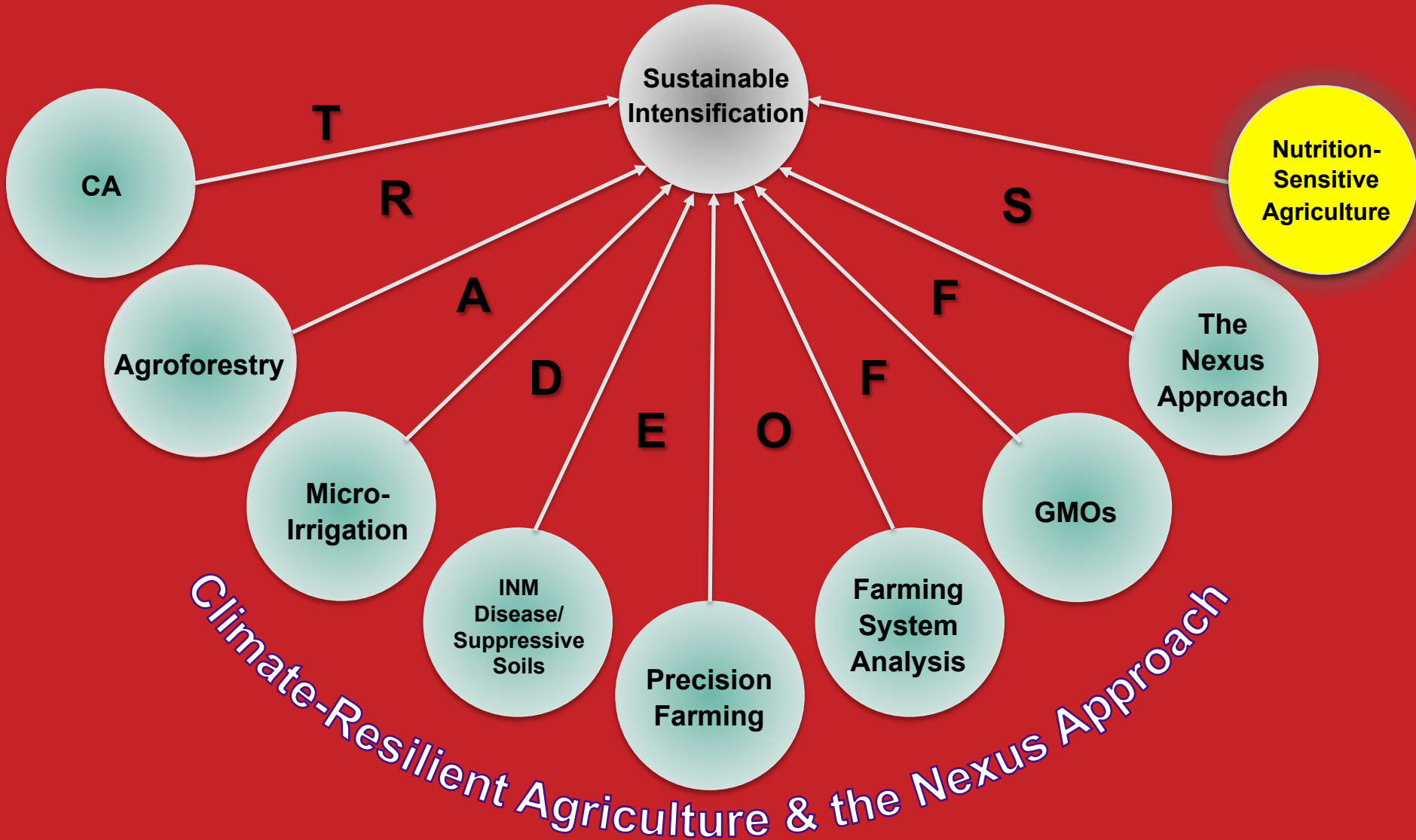


VULNERABLE CARBON POOLS





NO PANACEA NOR A SILVER BULLET





NUTRIENTS REQUIRED TO CONVERT BIOMASS INTO HUMUS

Crop Residues



Biochemical Transformations



+ (N, P, S etc.)

Humus



Elemental Ratio	Cereal Residues	Humus
C:N	100	12
C:P	200	50
C:S	500	70



TRADING NUTRIENTS FOR CARBON

Sequestration of 10,000 kg of biomass C as humus
requires additional nutrients:

- 833 kg N
 - 200 kg P
 - 143 kg S
- } 28,000 kg of C in residues
62,000 kg of residues (oven dry)

These ingredients will produce + 17,241 kg of humus

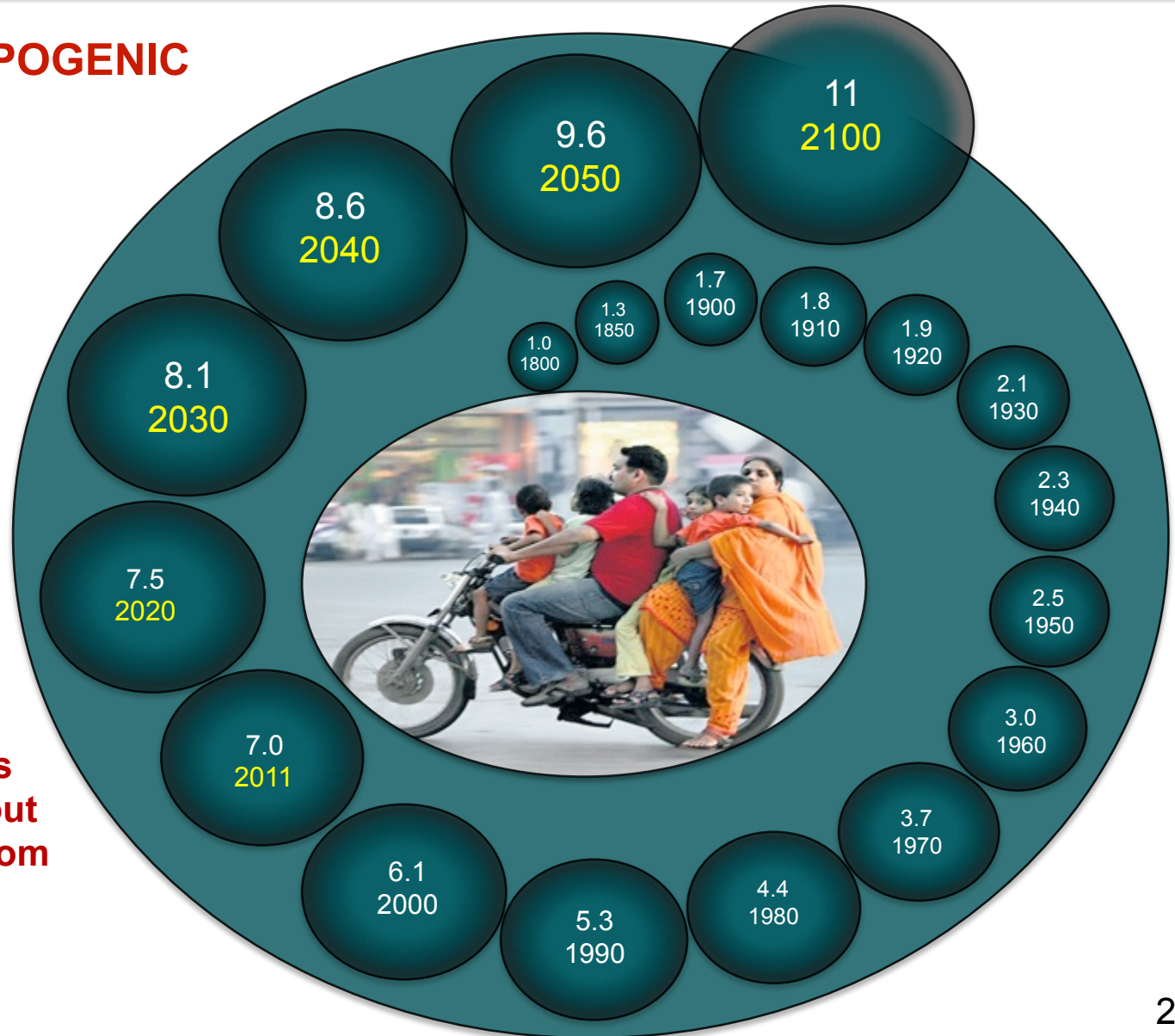


THE ANTHROPOGENIC DRIVER

I = P x A x T

- P = Population
- A = Affluence
- T = Technology

Over the last 10,000 years, the number of humans has increased about a thousand-fold from 2- 20 million to 7.3 billion.





IMPORTANCE OF URBAN AGRICULTURE

City	Population (10 ⁶)		Growth Factor
	1950	2025	
New Delhi	1.4	28.6	20.4
Calcutta	4.5	20.1	4.5
Bombay	2.9	25.8	8.9
Pune	0.6	6.6	11.0
Hyderabad	1.1	8.9	8.1
Bangalore	0.7	9.5	13.6
Madras	1.5	9.6	6.4
% of population living in cities of > 1 million	3.1	15.6	5.0

(Adapted from Kazmin, 2011)



URBANIZATION AND FOOD

- 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
- By 2015, 236 cities in the world will be \geq 10 million people
- A city of 10 million requires 6000 tones of food/day





THE VERTICAL FARMS IN URBAN CENTERS

Farming inside tall buildings within the cityscape:

- Year round produce,
- No losses due to extreme weather,
- Low fossil fuel consumption of harvest, transport and refrigeration,
- Low use of pesticides/herbicides,
- Less water use,
- Safe crops without contamination, and
- Low wastage

No Soil Degradation

Returning land back to nature



Troughs of bok choy stack up vertically at the 30-foot urban farm in Singapore. The veggies rotate along the A-frame to ensure they receive even light.

<http://www.npr.org/blogs/thesalt/2012/11/06/164428031/sky-high-vegetables-vertical-farming-sprouts-in-singapore>



URBAN AGRICULTURE

(by 2050 80% people will live in cities)

Singapore

- Converting roof tops into gardens (rooftop greenhouses)
- Planting and harvesting crops in empty lots
- Abandoned city space (contaminated soils)
- Indoor farming using grey water
- Vertical farms

New York City



THE WATER-SOIL-WASTE NEXUS AND GLOBAL SECURITY





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.**



POVERTY ENVIRONMENT NEXUS

- “Love and business and family and religion and art and patriotism are nothing but shadows of words when a man is starving.”

... O’Henry (1907)

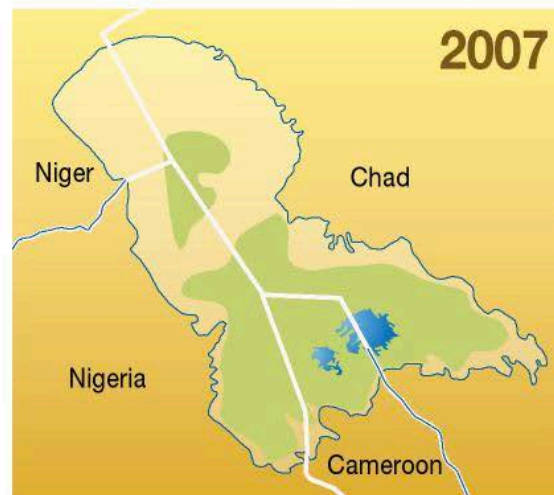
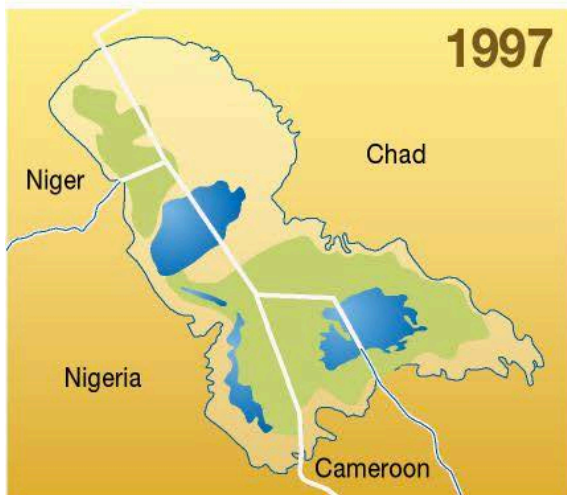
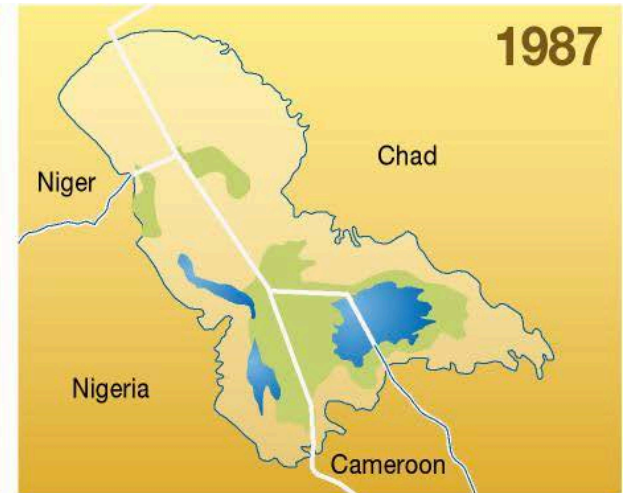
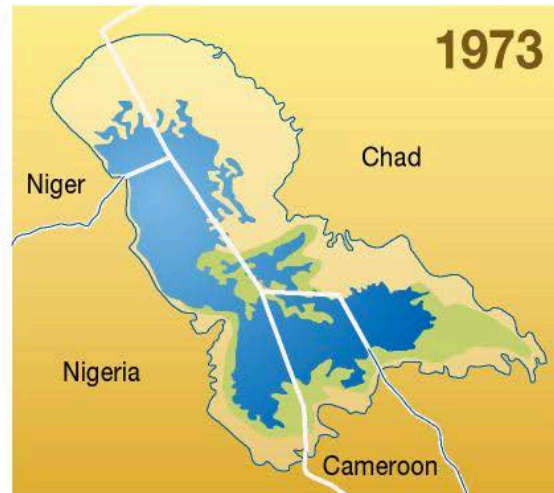
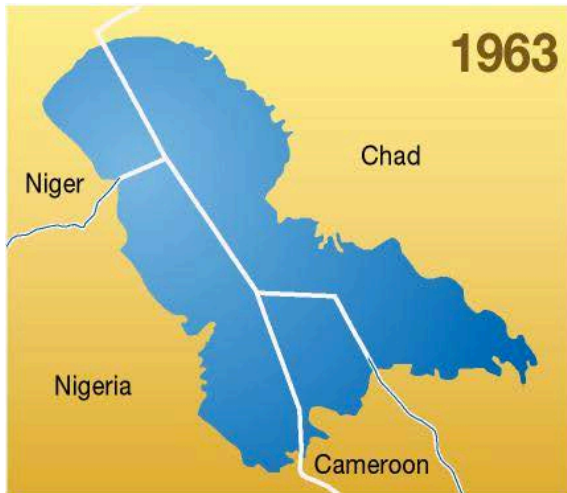
- There are not many troubles in the world more alarming than those caused by the fire in the pit of an empty stomach.

- “When people are poverty stricken, desperate and hungry, they pass on their sufferings to the land.”

... Lal (2008)



LAKE CHAD



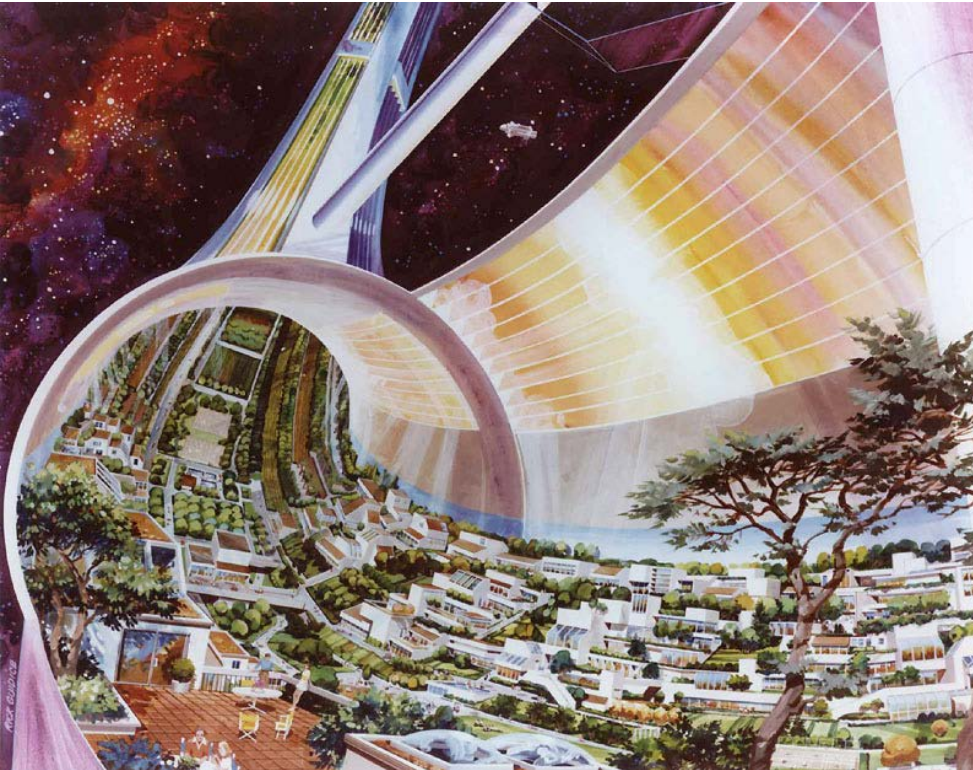
Water (blue square)
Former shoreline (yellow square with white border)
Vegetation (green square)

This collection of maps has been sourced from a series of satellite images provided by NASA Goddard Space Flight Center:
<http://www.gsfc.nasa.gov/gsf/earth/enviro/lakechad/chad.htm>

PHILIPPE REKACEWICZ
FÉVRIER 2008



SPACE AGRICULTURE



It is soil-based for:

- Decomposing organic wastes
- Sequestering CO₂
- Filtering H₂O



SPACE FARMING



Plant physiologist Ray Wheeler checks onions being grown using hydroponic techniques. The other plants are Bibb lettuce (left) and radishes (right). Credit: NASA/KSC



Arabidopsis plants appear purple under red and green light produced by light-emitting diodes. Scientists are studying plant growth under various light conditions. Credit: NASA/KSC



THE SOIL LESS SOLUTION

Scarcity of arable land, projected climate change, water scarcity, growing urban and total population, necessitate soil scientists and agronomists to look beyond the traditional farming from soil-based operations to highly efficient greenhouse or vertical farms involving aquaculture, aquaponics, hydroponics, aeroponics, aerofarms and other soil-less cultures.

- This approach would be useful to water-scarce countries with little arable land (e.g., Middle East)
- This would minimize the problem of land grab
- Reduce the issue of the so called soil refugees.



THE PATH FORWARD

Rather than a silver bullet or a panacea, we must look for multiple paths. We cannot afford to be myopic and locked into a specific strategy.

**We need some revolutionary approaches
Including in education at all levels**





NEED FOR ACTION

- This is the time to demonstrate impacts of the nexus approach in addressing global issues at some benchmark locations.
- There is an urgent need to translate knowledge and goodwill into action



SOIL: THE GLOBAL ICON

Soil is Life and Life is Soil



Enhance Global Awareness