Integrated Resource Management for Efficient Food Production

Rattan Lal
Carbon Management and Sequestration Center
The Ohio State University
Columbus, OH 43210 USA
“Hello there folks. Do you know who or what I am? I am the geomembrane of the Earth. I am your protective filter, your buffer, your mediator of energy, water, and biogeochemical compounds. I am your sustainer of productive life, your ultimate sources of elements, and the habitat for most biota. I am the foundation that supports you, the cradle of your myths, and the dust from which you will return. I am a soil”.

Richard Arnold (2005)
Senior Soil Scientist
"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 out the life that could have been."

*Young and Crawford (2015)*
The answer lies in soils.

Soil Matters

Human Impact

Population
Energy use
Water use
Deforestation
CO₂ Emissions
Land Degradation
Desertification
GLOBAL FOOD INSECURITY
(FAO, 2015)

World's Hungry (10^6)

1050
1025
1000
975
950
925
900
875
850
800
795
0


Year

- Chronic undernourishment ~ 0.8 billion
- Micronutrient deficiency ~ 2 billion
- MDG of reducing undernourishment to 410 million by 2015 has not been met

- Latin American & the Caribbean 5.6
- Eastern Asia 19.8
- South-eastern Asia 7.7
- Sub-Saharan Africa 26.5
- Eastern Asia 19.8
- Latin American & the Caribbean 5.6
- Others 5.3

South America
Latin America & the Caribbean
Eastern Asia
South-eastern Asia
Sub-Saharan Africa
Others

2015
Global Food Demand in 21st Century

- Hunger-related death toll is 21,000/day (Poverty.com, 2015)

- Global food demand would double over the period 1990-2030, and increase by 70% between 2010 and 2050

- This would involve 3-4 times increase in the poorest countries

- In Africa and Asia, plant-derived food requirements may increase by a factor of 2.5 to 7 in some countries
**ANTHROPOGENIC EMISSIONS (Pg) BY CARBON CIVILIZATION**

I. Land use: 486
   (i) Prehistoric: 320
   (ii) 1750-2010: 166
   (iii) 2010-2030: 30

II. Fossil Fuel Combustion: 390
   (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.
### Population of Some Major Cities in Southeast Asia ($10^6$)

<table>
<thead>
<tr>
<th>Year</th>
<th>Bangkok</th>
<th>Calcutta</th>
<th>Ho Chi Minh</th>
<th>Rangoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>1.36</td>
<td>4.45</td>
<td>0.5</td>
<td>1.30</td>
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<tr>
<td>1975</td>
<td>3.84</td>
<td>7.89</td>
<td>2.0</td>
<td>2.16</td>
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<tr>
<td>2000</td>
<td>7.28</td>
<td>12.92</td>
<td>8.0</td>
<td>3.55</td>
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<tr>
<td>2015</td>
<td>10.14</td>
<td>17.25</td>
<td>-</td>
<td>4.86</td>
</tr>
</tbody>
</table>
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
- By 2015, 236 cities in the world will be ≥ 10 million people
- A city of 10 million requires 6000 tones of food/day
GLOBAL SOIL-RELATED CONSTRAINTS TO AGRONOMIC PRODUCTIVITY
SOIL C SEQUESTRATION

Subsistence farming, none or low off-farm input soil degradation

New equilibrium

Adoption of RMPs

Maximum Potential

Attainable Potential

Δt

Accelerated erosion

ΔX

ΔY

C Sink Capacity

Rate

NT

INM & NUE

Cover Crops

Biochar

Agroforestry

Desert. Control

Afforestation

Pasture Mgmt

H₂O harv., DSI

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

Lal, 2004

Time (Yrs)

Relative Soil C Pool

Lal, 2004
“Our tools are better than we are, and grow better faster than we do. They suffice to crack the atom, to command the tides. But they do not suffice for the oldest task in human history: to live on a piece of land without spoiling it.”

Aldo Leopold, 1938 University of Wisconsin Engineering and Conservation speech
1. Causes of Soil Degradation
2. Soil Stewardship & Human Suffering
3. Nutrient, Carbon, & Water Bank
4. Marginality Principle
5. Organic vs. Inorganic Nutrients
6. Soil Carbon & GHG Effect
7. Soil vs. Germplasm
8. Soil as Sink for Atmospheric CO₂
9. Engine of Economic Development
10. Traditional Knowledge & Modern Innovations

Sustainable Soil Management

- Mining C has the same effect on global warming whether it is put in the atmosphere or stored in the form of C2 in mineralized soil or in biomass.
- When people are poor, the soil is degraded. The land is overworked, financed, and managed to support the economy.
- When people are at higher risk of suffering, they pass on their sufferings to the land.
- Only by replacing what is taken can a soil be kept fertile, productive, and responsive to inputs.
- Plants cannot differentiate the nutrients supplied through inorganic fertilizers or organic amendments.
- Marginal soils cultivated with marginal inputs produce marginal yields and support marginal living.
- Recycling is a good strategy especially when there is something to recycle.
- Sustainable management of soils is the engine of economic development, political stability and transformation of rural communities in developing countries.
- Sustainable management of soil implies the use of modern innovations built upon the traditional knowledge.
- Those who refuse to use modern science to address urgent global issues must be prepared to endure more suffering.
THE ENGINE OF ECONOMIC DEVELOPMENT

WATER RESOURCES
- Quality
- Quantity

CLIMATE CHANGE
- Mitigation
- Adaptation
- Stabilization

RECARBONIZATION OF THE BIOSPHERE
(IMPROVING SOIL QUALITY)

BIODIVERSITY
- Above ground
- Below ground

FOOD SECURITY
- Quantity
- Quality
SOIL CARBON AND ECOSYSTEM SERVICES
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