WORLD WATER WEEK
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Presentation

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Improving Small Scale Agriculture In A Changing Climate

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Increase In World Population (10^6)

Region	2008	2050	% Change
SSA	827	1761	+ 113
Middle East & NA	364	595	+ 63
Oceania	35	49	+ 41
World	6750	9191	+ 36
Latin America & The Caribbean	579	769	+ 33
North America	342	445	+ 30
Asia	3872	4909	+ 27
Europe	731	664	- 9

UN Dept. of Economic & Social Affairs (2006)

Estimates of Under-Nourished People (FAO, 2006)

Region	Population (10^6)	% of Total
India	212	24.8
Sub-Saharan Africa	206	24.1
Asia/Pacific	162	19.0
China	150	17.6
Latin America/Caribbean	52	6.1
Near East/North Africa	38	4.4
Transition Countries	9	1.1
Industrialized Countries	9	1.1
TOTAL	**854**	**100**
Developing Countries	**820**	**96.1**

Mean Crop Yield in India, Kenya and Developed Countries (FAO, 2005)

Crop	Yield (kg/ha)		
	Ethiopia	India	Developed Countries
Rice	1872	3284	6810
Wheat	1469	2601	3110
Maize	2006	1907	8340
Sorghum	1455	797	3910
Cowpea	730	332	1790
Chickpea	1026	814	7980

A Farmer in Nigeria

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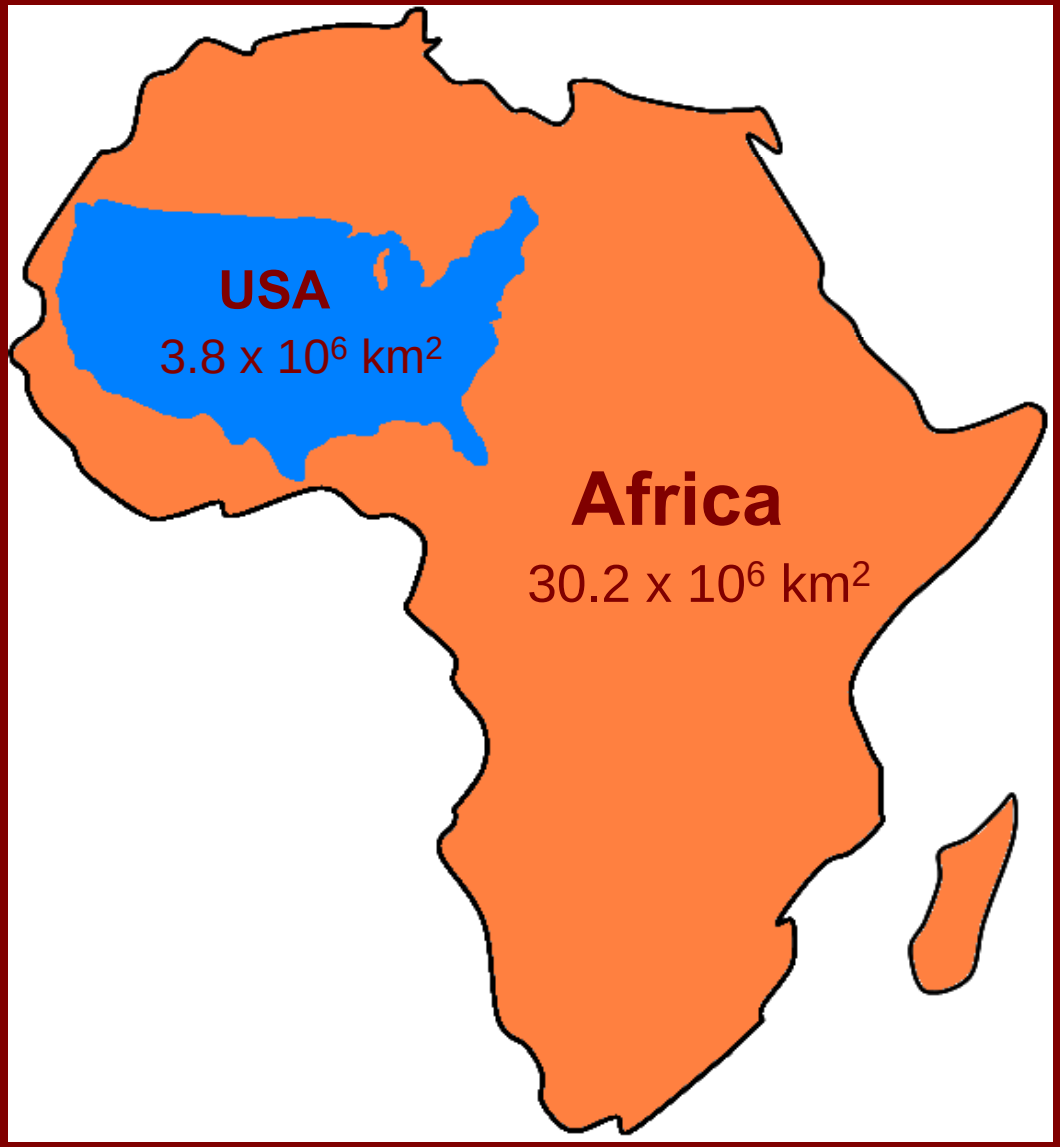
Bullock-Driven Ard in India

Cereal Deficit In SSA

Year	Deficit (10^6 Mg)
2008	9
2025	35

Cooper et al. (2008)

Geographical Area of Africa



Countries In SSA That Suffered > 10 Times Drought Seasons (In 3 Yrs) Between 1970 and 2004

- An area 400-600 km wide stretching from Atlantic coast to Horn of Africa marked by 200 mm y^{-1} rainfall isocline

- High rainfall variability

Climate Change

- Projected climate change may exacerbate the problem of desertification, drought and soil degradation.
- It is essential to identify and implement coping (mitigation) and adaptive strategies.

Drought

It refers to a prolonged period during which the availability of fresh water supply is less than the demand, especially in arid and semi-arid regions.

Types of Drought

A. Climatic

1. Meteorological	When rainfall is deficient
2. Hydrological	When runoff in rivers declines

B. Non-Climatic

3. Edaphic	When infiltration rate of soil decreases
4. Agricultural	When available water is less than the need for agricultural use

Maingnet and De Silva (1998)

Other Soil Related Constraints In SSA

- Low AWC
- Poor quality soils
- Depleted of nutrients and SOC
- Extractive farming

Annual Nutrient Balance In Sub-Saharan Africa

- 26 kg N/ha
- 3 kg P/ha (-7 kg P_2O_5)
- 19 kg K/ha (-23 kg K_2O)

- 48 kg NPK/ha/yr

Drechsel et al. (2001)

Strategies of Coping with Climate Change

These options are “risk spreading”, and are designed to mitigate the negative impacts.

(a) Ex-ante risk management options

(b) In-season adjustment

(c) Ex-post management options

2. Increasing Yield Per Capita Land Area Needed

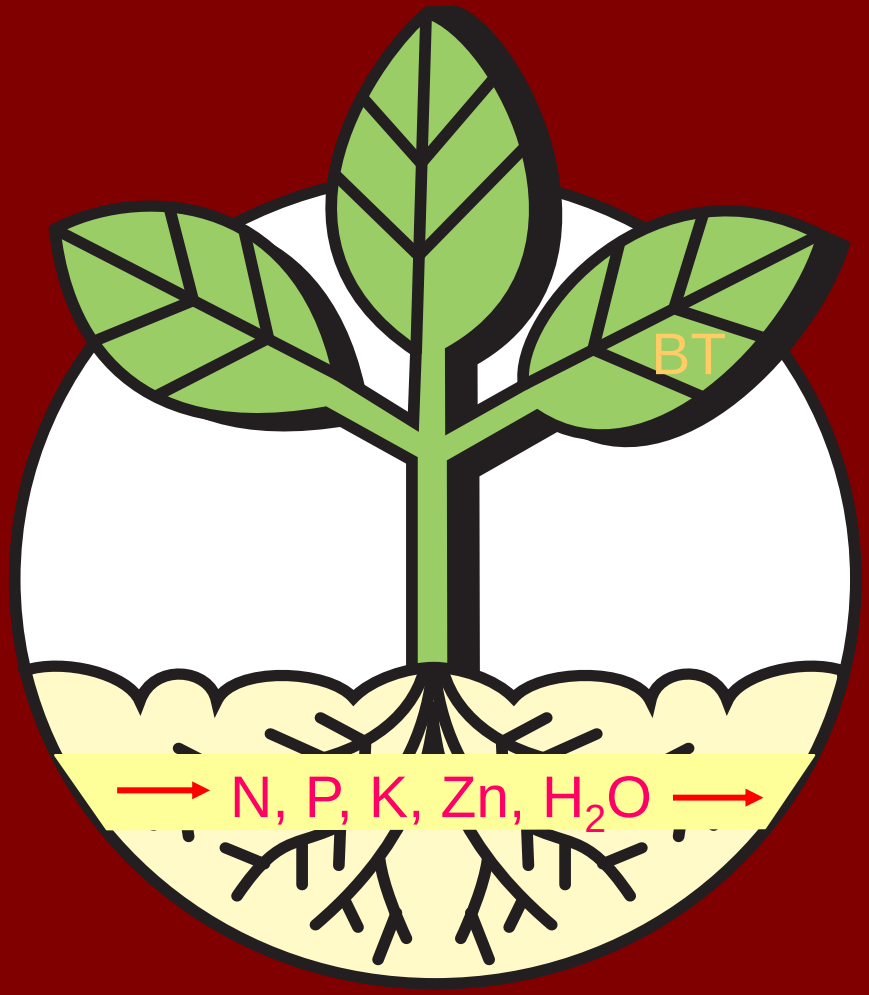
Farming system/input level	Ha/person
Shifting cultivation	2.65
Low traditional	1.20
Moderate traditional	0.60
Improved traditional	0.17
Moderate technological	0.11
High technological	0.08
Special technological	0.05 (5×10^9 ha)

Adapted from Buringh (1989)

Agricultural Intensification

Cultivating the best soils with the best management practices to produce the optimum sustainable yield and save marginal lands for nature conservancy

Agricultural Intensification



Delivering nutrients and water directly to roots of improved plants using nano-enhanced molecules

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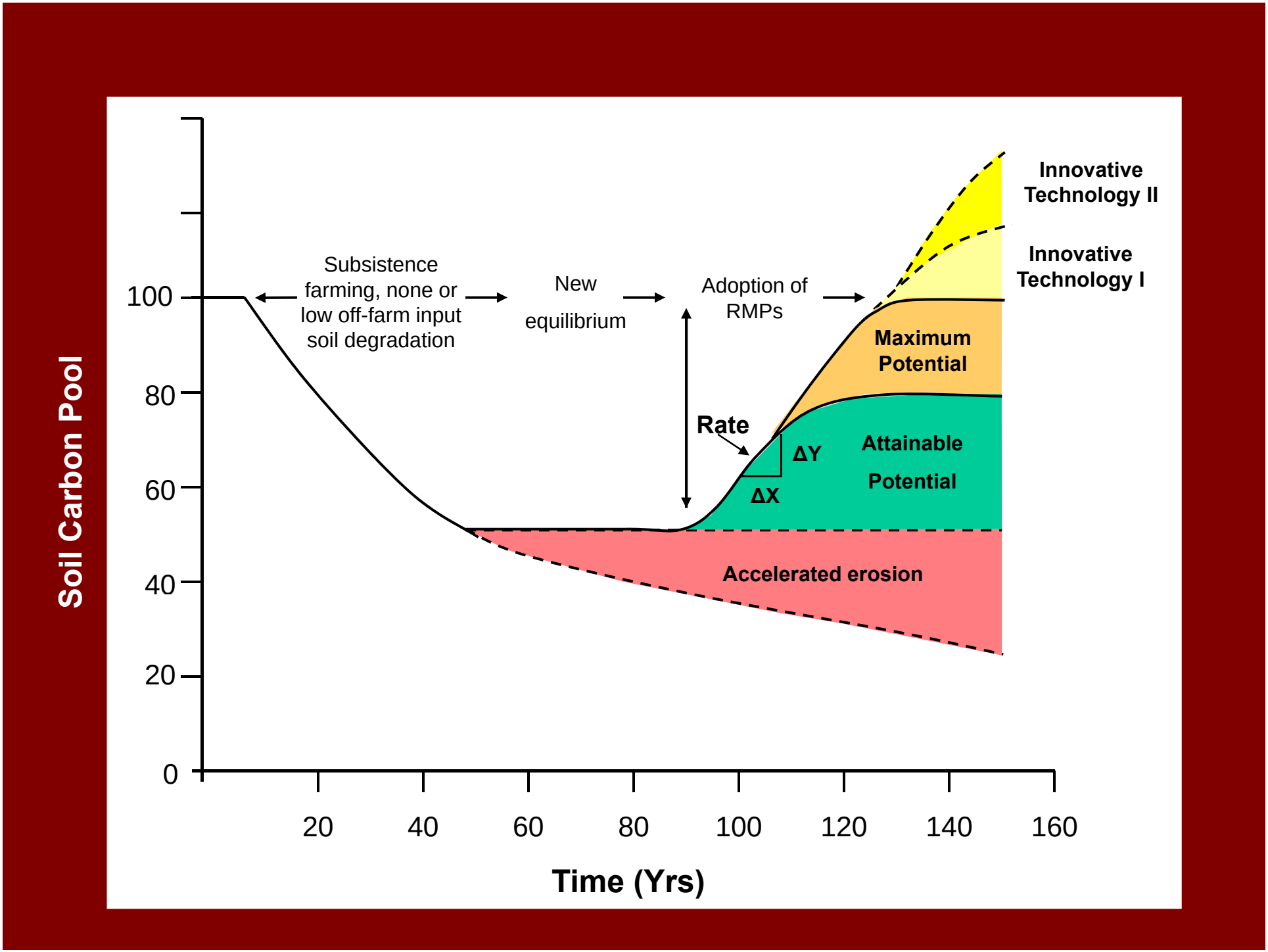

Soil Carbon Pool
100
80
60
40
20
0
20
40
60
80
100
120
140
160
Time (Yrs)
Subsistence farming, none or low off-farm input soil degradation
New equilibrium
Adoption of RMPs
Innovative Technology II
Innovative Technology I
Maximum Potential
Rate
ΔY
ΔX
Attainable Potential
Accelerated erosion

Estimate of Increase in Food Production in LDCs by Increasing SOC Pool by 1 Mg C ha^{-1} yr^{-1}

Crop	Area (Mha)	Production Increase (10^6 Mg yr^{-1})
Cereals	430	21.8 – 36.3
Legumes	68	2.0 – 3.2
Tubers	34	6.6 – 11.3
Total	532	30.4 – 50.8

Estimated Increase in Food Production in Africa by Increase in SOC Pool by 1 Mg C/ha/yr (Lal, 2006)

Type	Total Annual Increase (10^6 Mg/yr)
Grains	3.3 - 5.4
Roots and Tubers	3.0 - 6.2
Total	**6.3 - 11.6**

Issues of Soil Quality in Developed and Developing Countries

Developed countries	Developing countries
1. Optimizing crop yields per unit input 2. Minimizing input of chemicals and energy 3. Maximizing farm profit 4. Reducing risks of pollution/ eutrophication of surface and ground waters 5. Sustaining productivity on a long-term basis 6. Addressing issues of regional, national and global importance (e.g., global climate change)	1. Maximizing crop yields per unit area, time 2. Optimizing the use of off-farm input 3. Increasing household income 4. Ensuring adequate supply of water for human and animal consumption 5. Providing food for the family before the next harvest 6. Addressing concerns of the family

Ten Tenets of Soil and Water Management

Law #1
Causes of Soil Degradation

The biophysical process of soil degradation is driven by economic, social and political forces.

Law #2
Soil Stewardship and Human Suffering

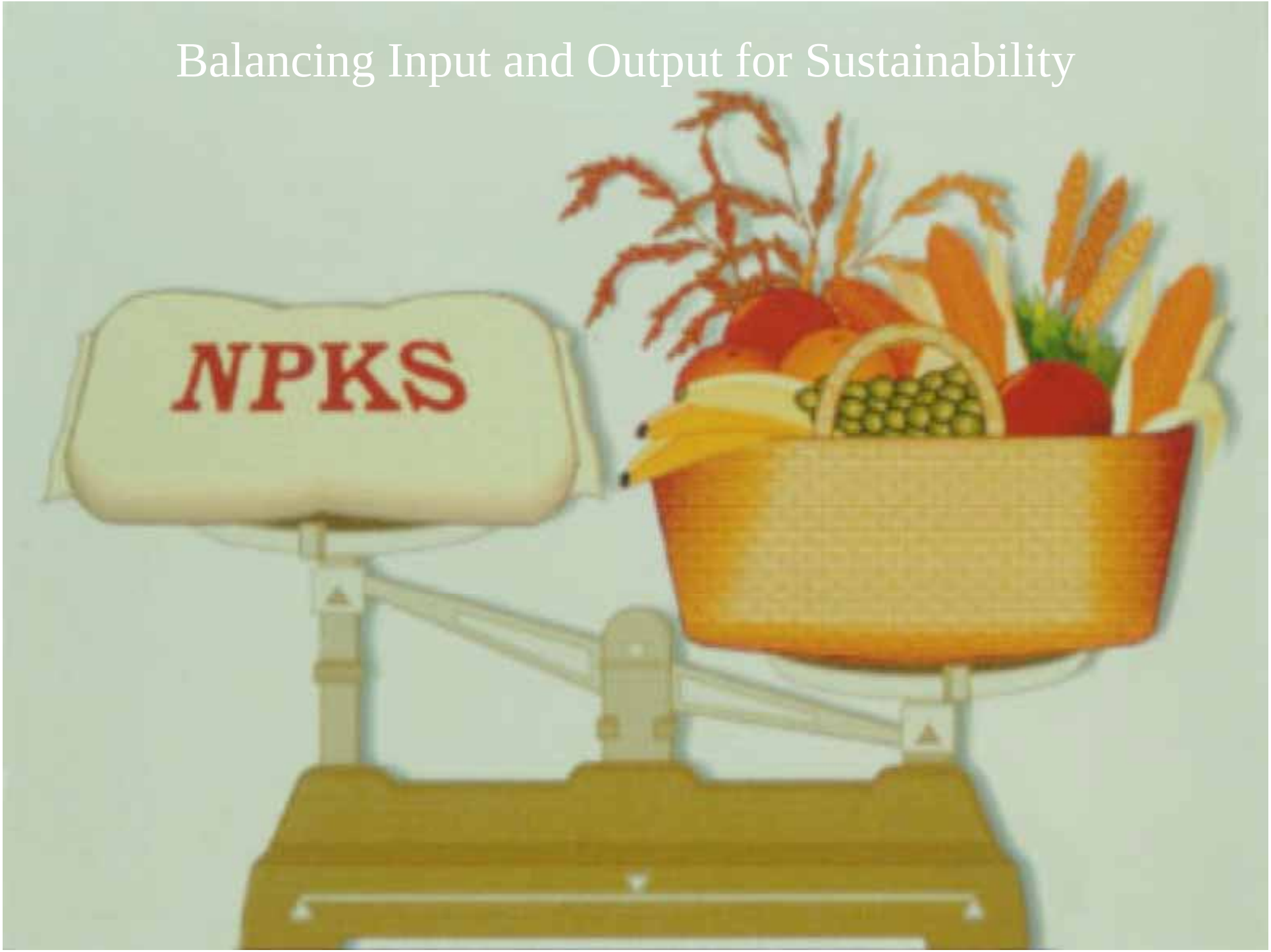
When people are poverty stricken, desperate and starving, they pass on their sufferings to the land.

Law #3

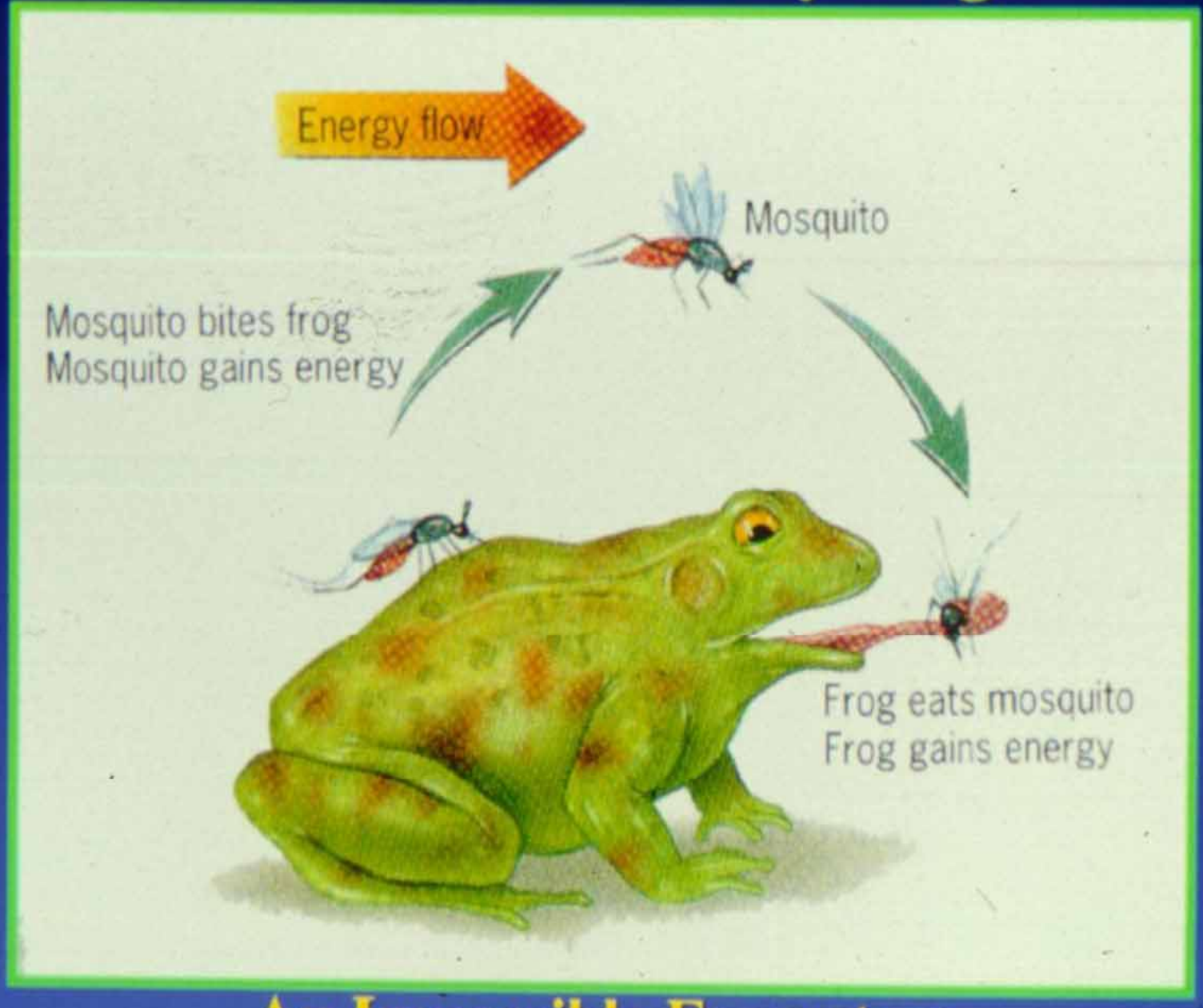
Nutrient, Carbon and Water Bank

It is not possible to take more out of a soil than what is put in it without degrading its quality.

Balancing Input and Output for Sustainability



The Ultimate Recycling



An Impossible Ecosystem

Law #4
Marginality Principle

Marginal soils cultivated with marginal inputs produce marginal yields and support marginal living.

Law #5
Organic Versus Inorganic Source of Nutrients

Plants cannot differentiate the nutrients supplied through inorganic fertilizers or organic amendments.

Law #6
Soil Carbon and Greenhouse Effect

Mining C has the same effect on global warming whether it is through mineralization of soil organic matter and extractive farming or burning fossil fuels or draining peat soils.

Law #7
Soil Versus Germplasm

Even the elite varieties cannot extract water and nutrients from any soil where they do not exist.

Law #8
Soil As Sink For Atmospheric CO2

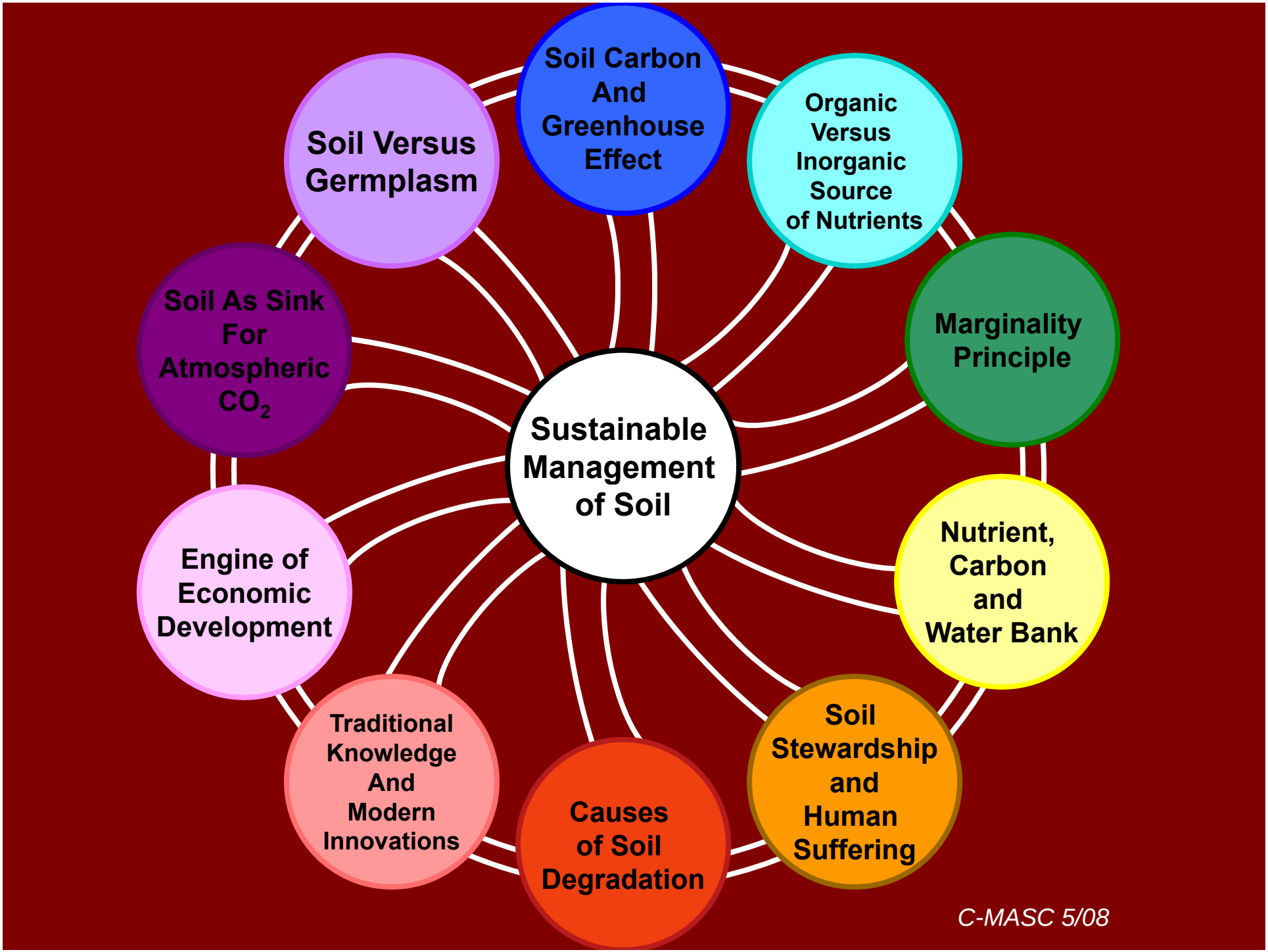
World soils can be a major sink for atmospheric CO_2 and CH_4 through conversion to a restorative land use adoption of recommended management practices. The C sink capacity of the pedosphere (~ 1 Pg C/yr) also has numerous ancillary benefits. It is essential to advancing global food security.

Law #9
Engine of Economic Development

Sustainable management of soils is the engine of economic development, political stability and transformation of rural communities in developing countries.

Law #10
Traditional Knowledge and Modern Innovations

- It is not an “either or” scenario.
- Modern science must synthesize the traditional knowledge.
- Those who refuse to use modern science to address urgent global issues must be prepared to endure more suffering.


Soil Carbon And Greenhouse Effect
Organic Versus Inorganic Source of Nutrients
Soil Versus Germplasm
Soil As Sink For Atmospheric CO_2
Marginality Principle
Sustainable Management of Soil
Engine of Economic Development
Nutrient, Carbon and Water Bank
Traditional Knowledge And Modern Innovations
Causes of Soil Degradation
Soil Stewardship and Human Suffering
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Mother of the Necessity: The Soil

If soil and water resources are not restored or judiciously managed:

- **Crops will fail even if rains do not**
- **Hunger will perpetuate even with emphasis on biotech and GM crops**
- **Civil strife and political instability will plague the world even with sermons and mantras on human rights and democratic ideals, and**
- **Humanity will suffer even with great scientific strides**

Soil and Survival

"Upon this handful of soil our survival depends. Husband it and it will grow our food, our fuel, and our shelter and surround us with beauty. Abuse it and the soil will collapse and die, taking humanity with it."

From Vedas

Sanskrit Scripture 1500 BC