Linking Soil Health with Crop Health

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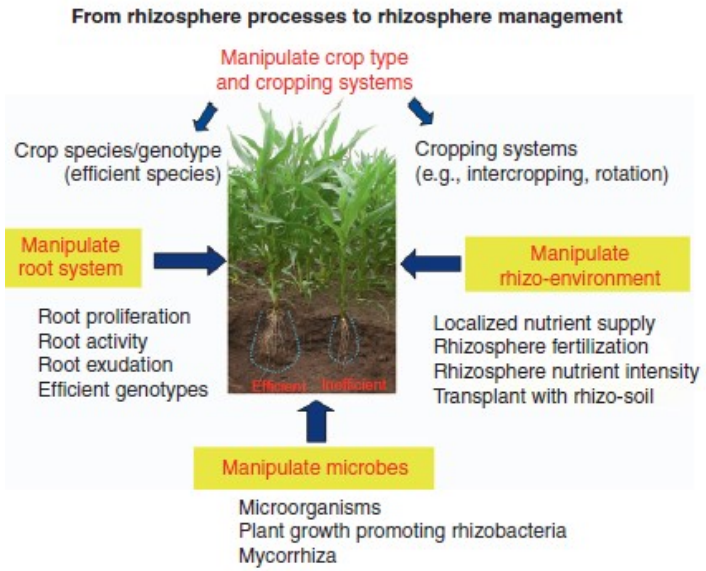
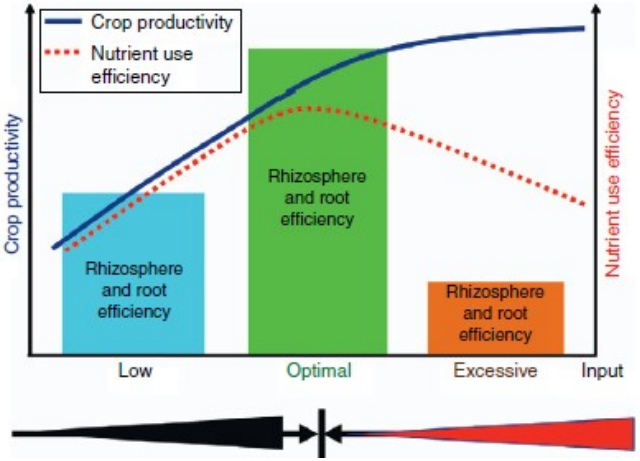
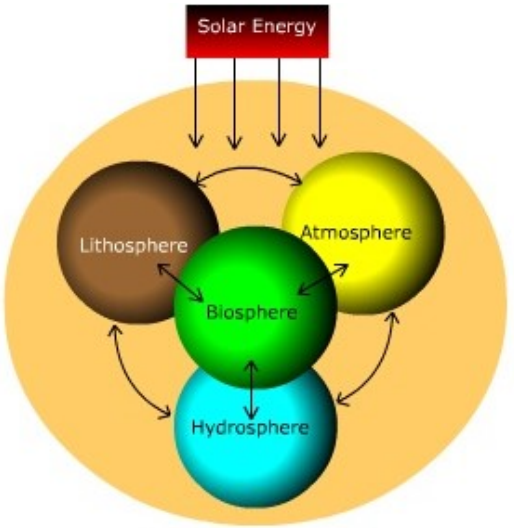
New Delhi





Soil (pedosphere) is a multifunctional resource and stands in dynamic interactions with the atmosphere, biosphere, hydrosphere and lithosphere as well as with the anthroposphere.

LAND RESOURCE: **Renewable?**



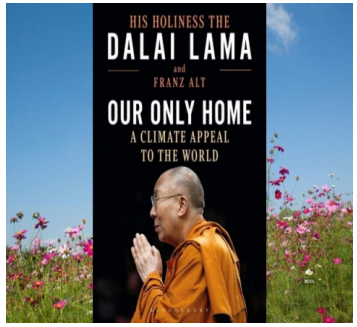
COLLAPSE OF HISTORIC CIVILIZATIONS

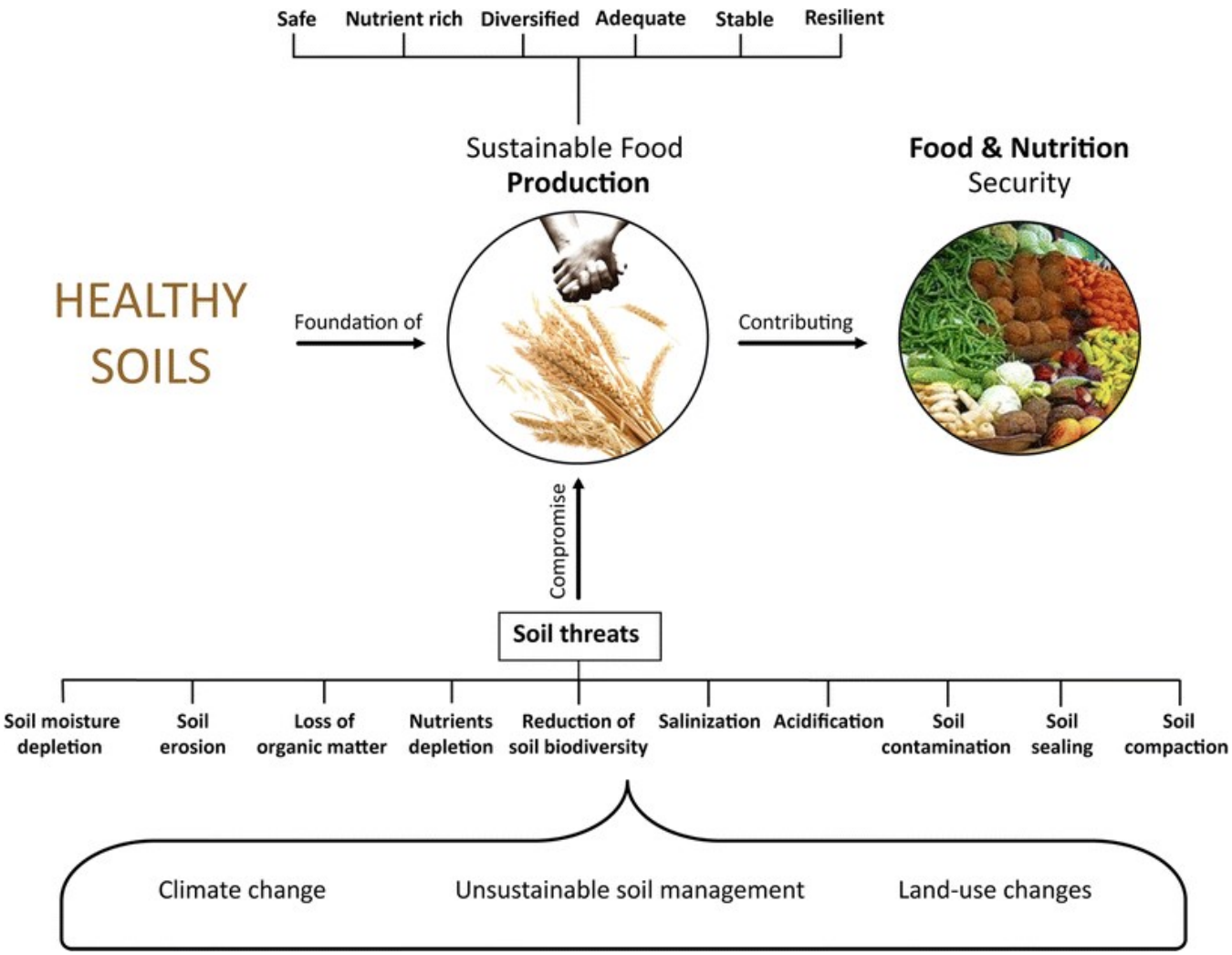
Civilization	Region	Era	Cause of Collapse
Sumerian	Mesopotamia	10,000 BCE	Salinization
Harappan	Indus Valley	2,000-2,000 BCE	Desiccation
Inca	Andean Region	750-900 CE	Soil Erosion
Maya	Central America	750-900 CE	Soil Erosion
Axum	Northern Ethiopia	100-600 CE	Ecological Degradation
Roman	Mediterranean	27BC – 395 AD	Exhaustion of soil

- **Between 1870-1945, 17% land lost about 25 cm soil depth in Solapur, Maharashtra (Patel, 1998) now extended to about 35% area**

- **In 40-50 years total land abandoned in Pranmati hilly watershed, Uttarakhand(AgEE, 2004)**

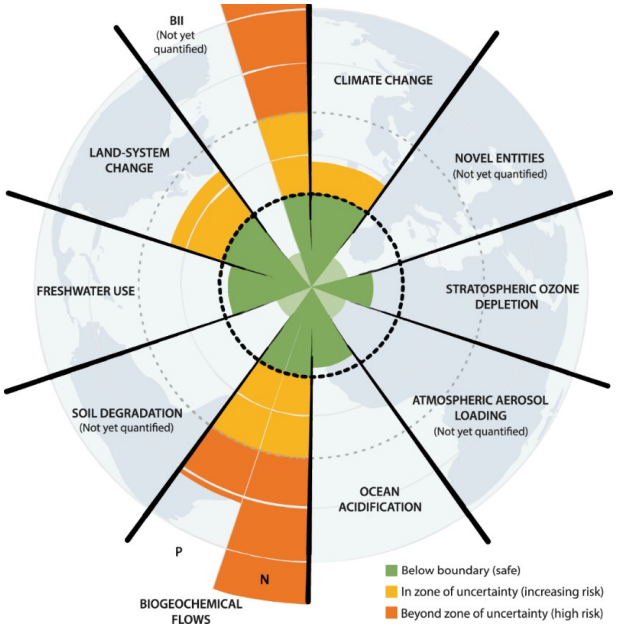
- **In NEHR similar results are found.**



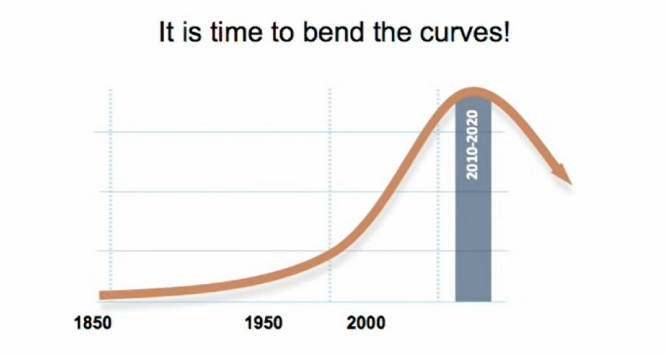

Safe
Nutrient rich
Diversified
Adequate
Stable
Resilient
Sustainable Food Production
Food & Nutrition Security
HEALTHY SOILS
Foundation of
Contributing
Compromise
Soil threats
Soil moisture depletion
Soil erosion
Loss of organic matter
Nutrients depletion
Reduction of soil biodiversity
Salinization
Acidification
Soil contamination
Soil sealing
Soil compaction
Climate change
Unsustainable soil management
Land-use changes

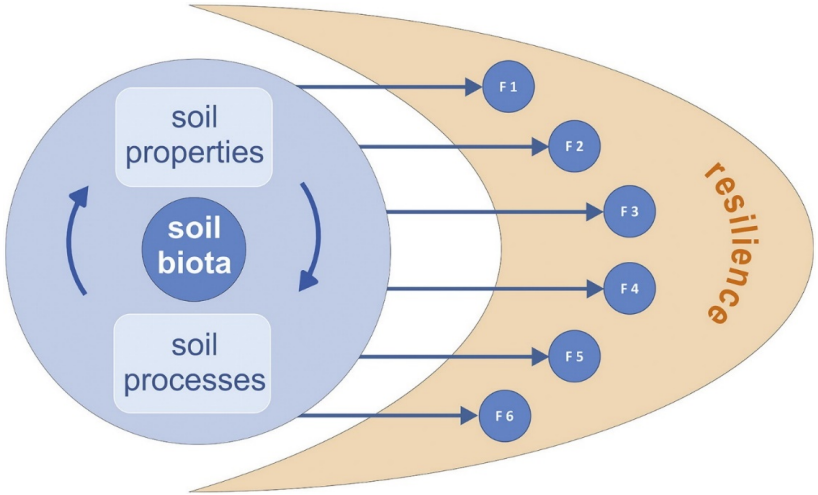
Global existential challenges

- **Food security**
- **Water security**
- **Energy security**
- **Climate change abatement**
- **Biodiversity protection**
- **Human health**

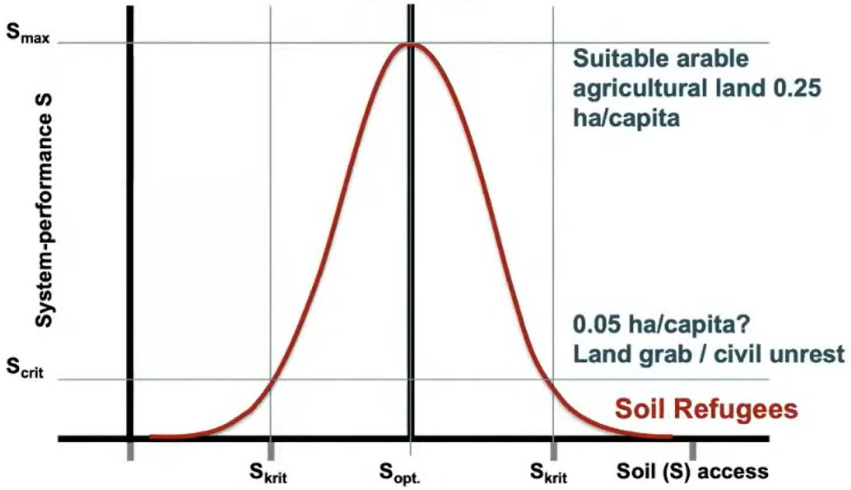


•Role of balanced nutrition……A deficiency in one **nutrient** cannot be **compensated by a surplus of any** of the others. So **one or few nutrient** alone cannot ensure the yield, and the **balance** between ...





EROSION AND PEAK/ENDANGERED/EXTINCT SOILS



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SUSTAINABILITY

Only 60 Years of Farming Left If Soil Degradation Continues

Generating three centimeters of top soil takes 1,000 years, and if current rates of degradation continue all of the world's top soil could be gone within 60 years, a senior UN official said

By Chris Arsenault (Thomson Reuters Foundation), Dec. 5, 2014

The causes include chemical-intensive farming, plowing or tilling, current livestock management, deforestation, and global warming. About 1/3 of the world's soil has already been degraded.

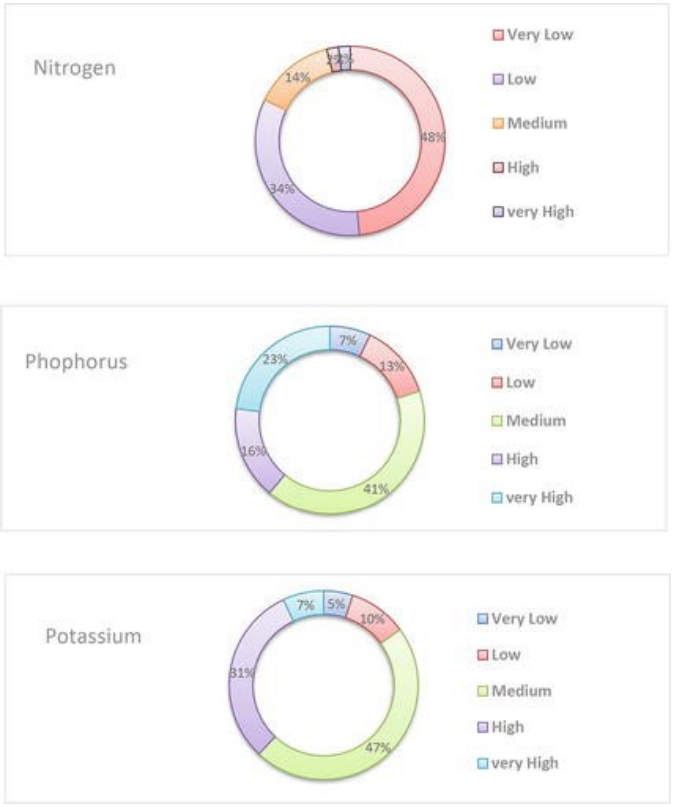
SUSTAINABLE SOIL MANAGEMENT

- Replace what is removed,
- Respond wisely to what is changed, and
- Predict what will happen from anthropogenic and natural perturbations

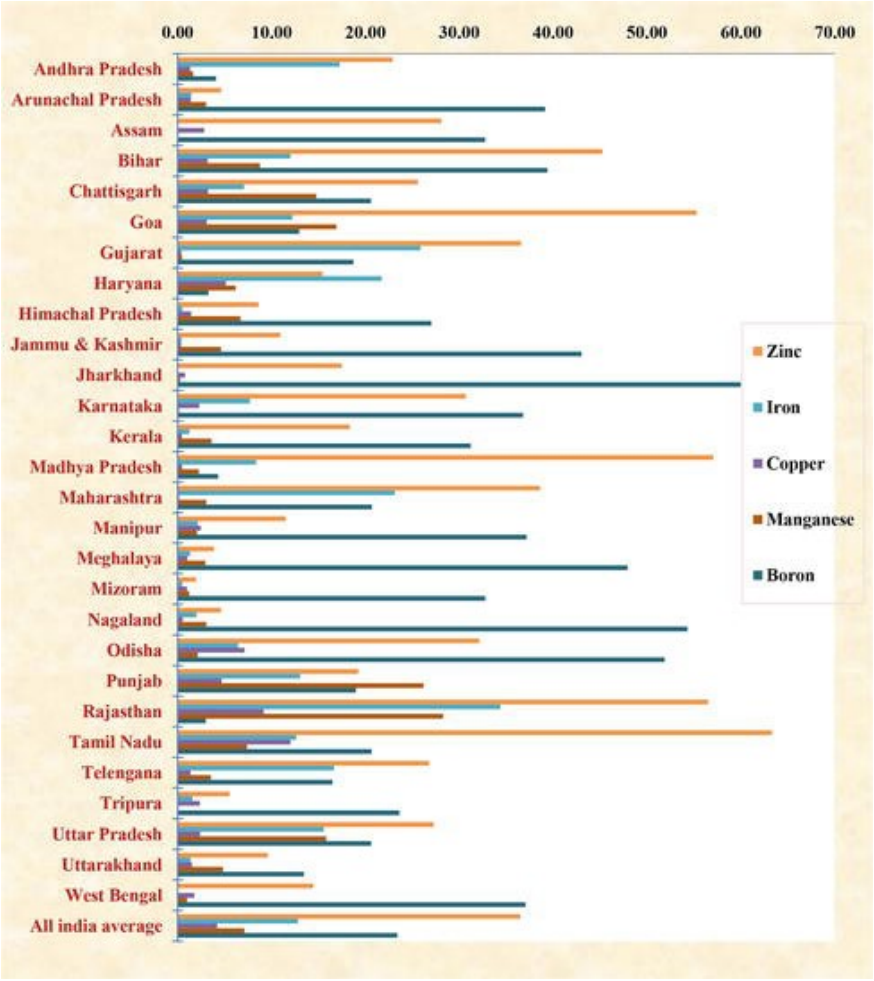
21ST CENTURY'S GREEN REVOLUTION

Rather than input-based (variety, fertilizers, irrigation), the GR of the 21st century must be:

(i) Soil-based	:	Soil resilience
(ii) Ecosystem-based	:	Eco-Efficiency
(iii) Knowledge-based	:	Science & Mgm-driven

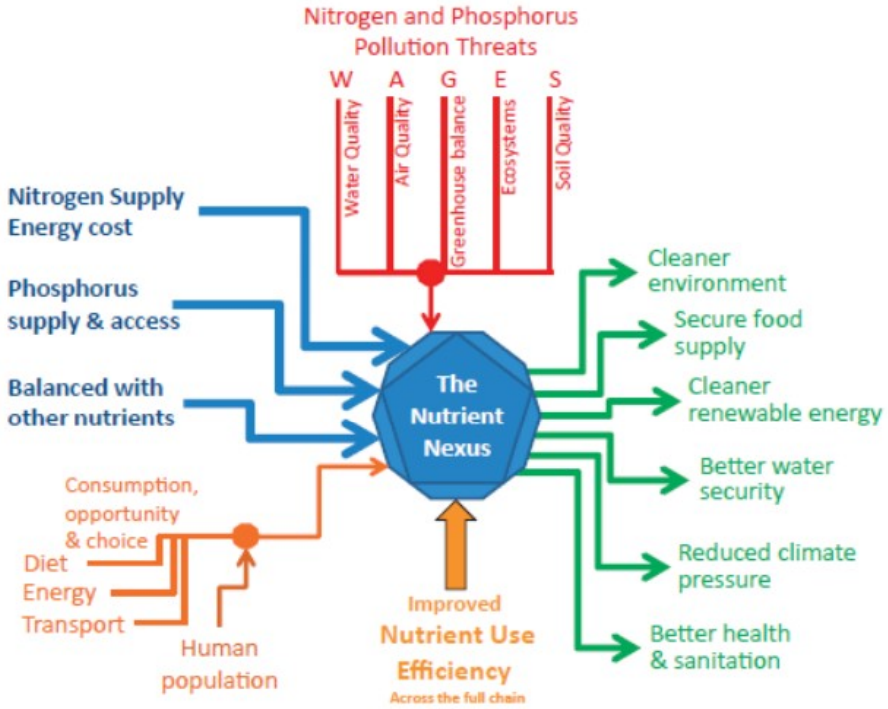


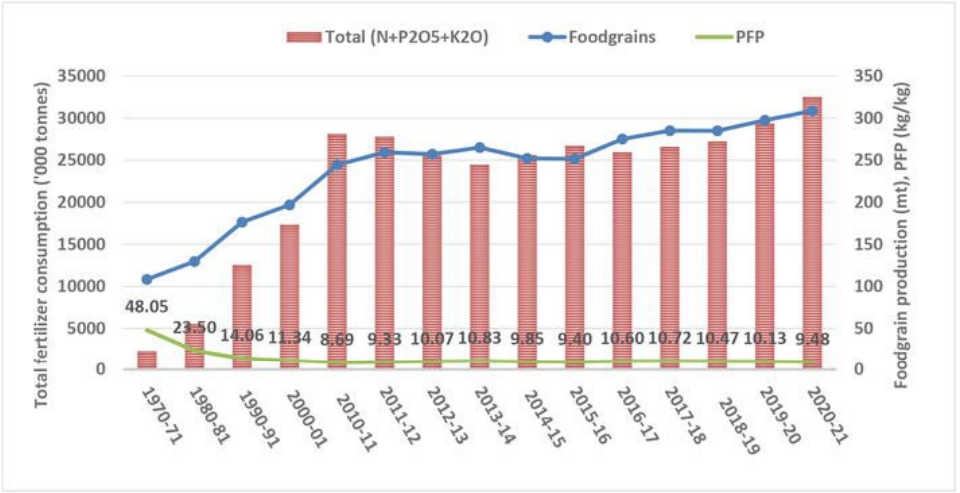
Primary nutrient deficiencies (%) in Indian soils.
(Source: https://www.soilhealth.dac.gov.in/NewHomePage/StateWiseNPKChart).



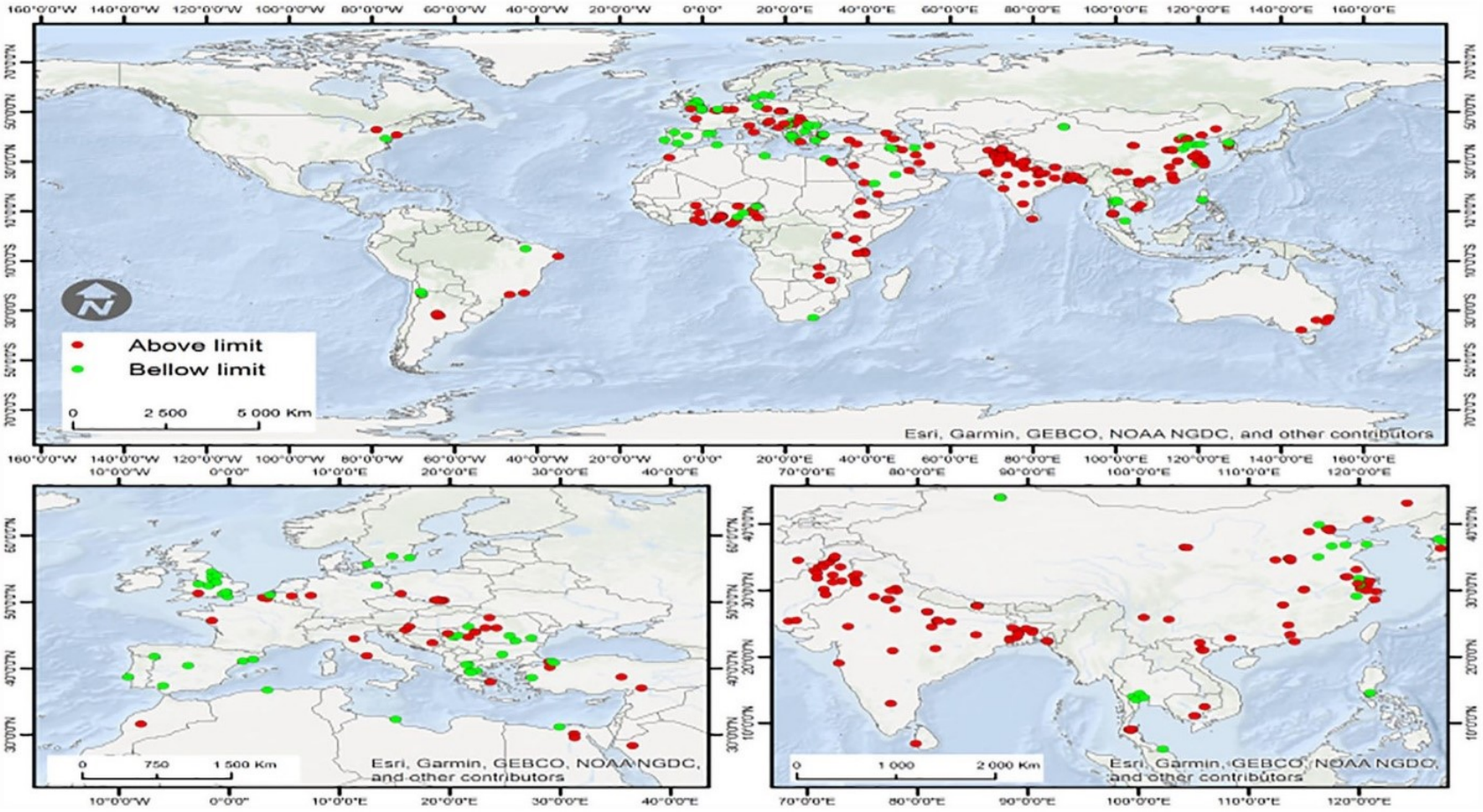
State-wise percent distribution of micronutrient deficiencies in India

Responsible plant nutrition management





A new global effort is needed to address "The Nutrient Nexus," where reduced nutrient losses and improved nutrient use efficiency across all sectors simultaneously provide the foundation for a greener economy to produce more food and energy while reducing environmental pollution (Drinkwater and Snapp, 2007; Gourley et al., 2012; Sutton et al., 2013).

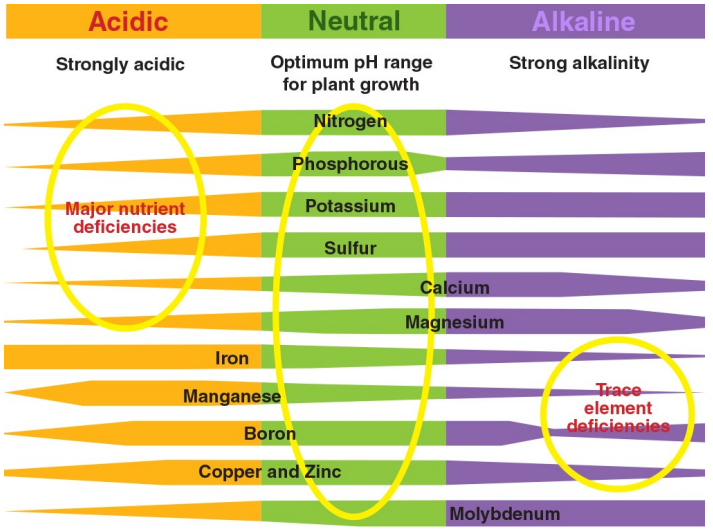


Soil and Human Health: Current Status and Future Needs
Eric C Brevik et al. (2020)

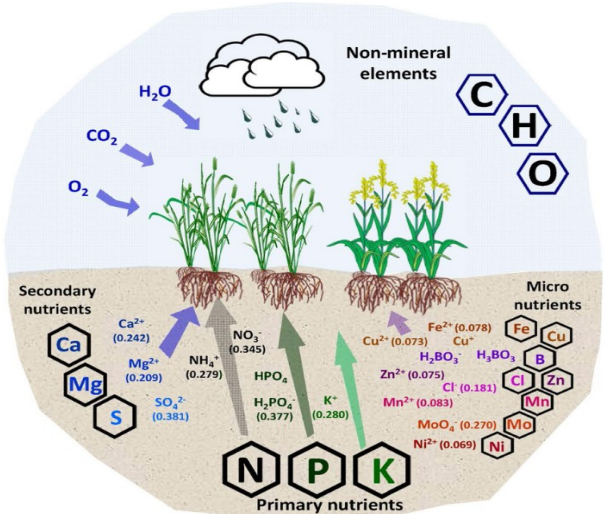
Studies in urban and peri-urban areas that investigated the concentration of heavy metals in fruits and vegetables. Red dots show sites where at least one chemical element had a concentration above the guidelines provided by FAO/WHO, the European Union, or national legislation. Green dots show sites where none of the chemical elements had a concentration above FAO/WHO, European Union, or national legislation levels. Source: FAO indicates Food and Agriculture Organization of the United Nations; WHO, World Health Organization

Balanced nutrition in Indian context should address…

Ideal ratio of N:P:K= 4:2:1…WHY?
LTFE Recommendation
CHEMICALLY BALANCED SOIL : IDEAL pH
Critical limits and nutrient ratio(Ca:Mg)
Soil sustainability: redefine it
Soil services/disservices: net services
Not only from the perspective of plant nutrition but also….
Bio fortification vs agronomic fortification
Nutritional security and Human health: anemia, hypokalemia, deficiencies……..
Green credit

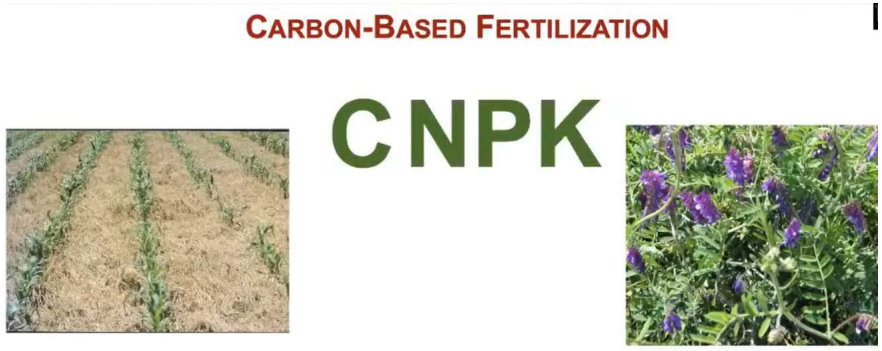


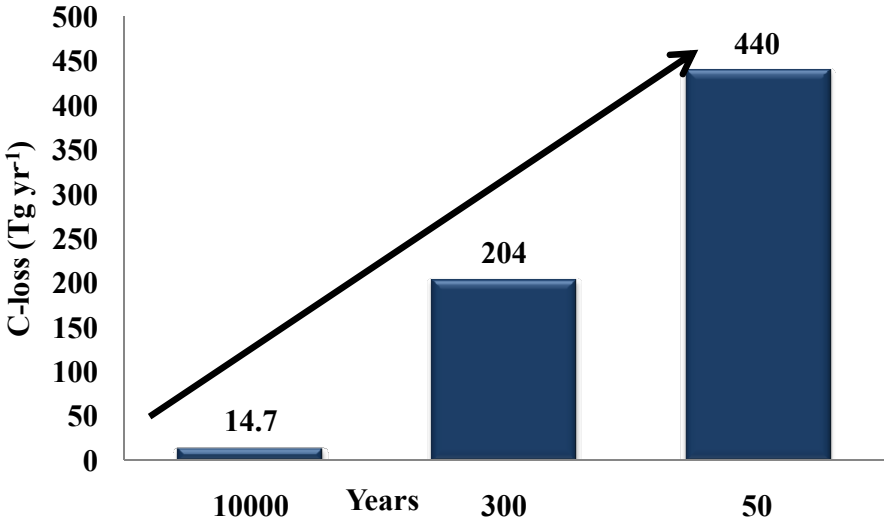
Soil pH and Nutrient Availability
(Source: Bluedale - http://www.bluedale.com.au)

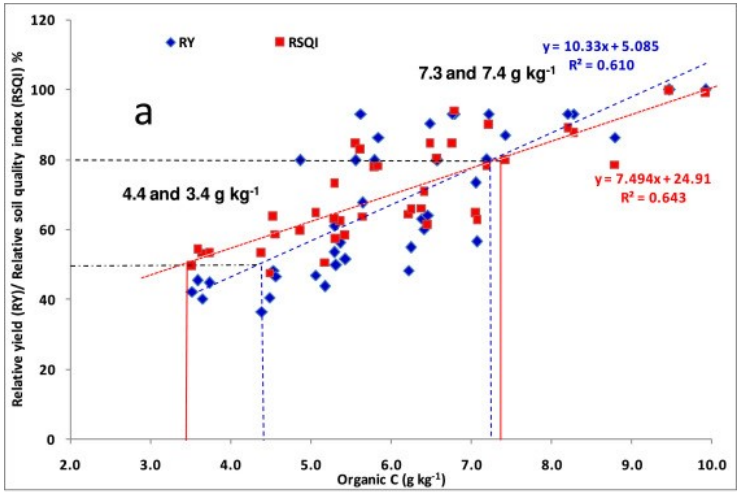


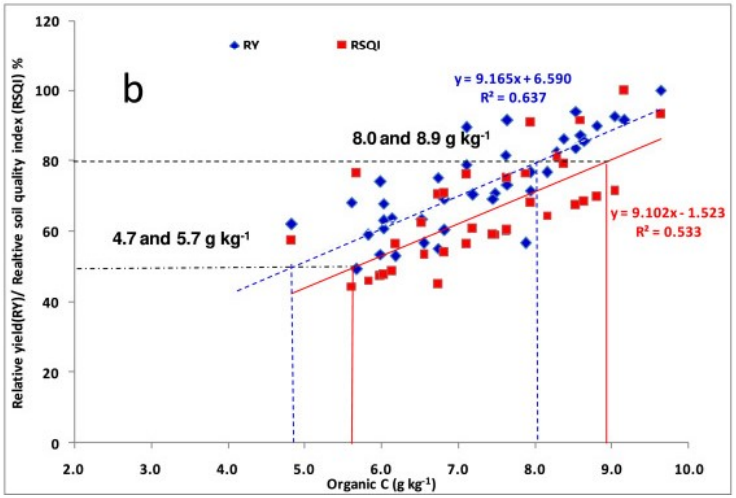
And when a new product/ <u>MINERAL</u> is explored then…

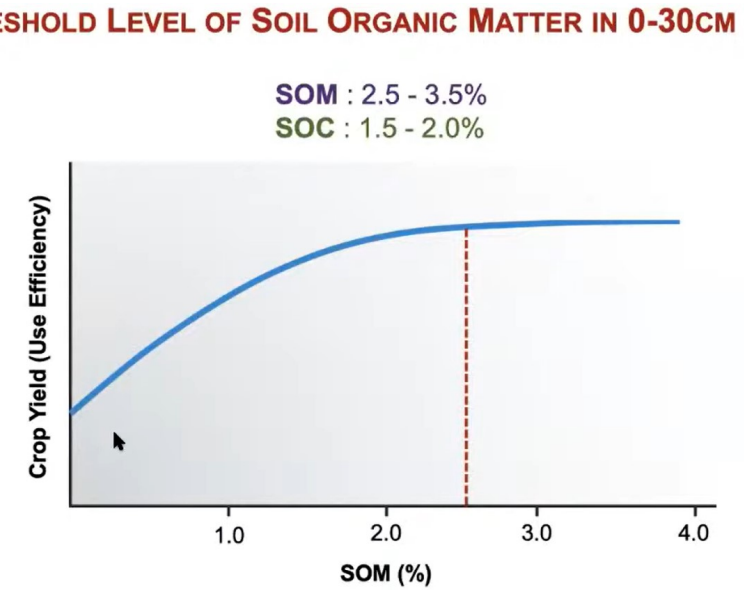
Balanced nutrition: NPK, CNPK and beyond…….

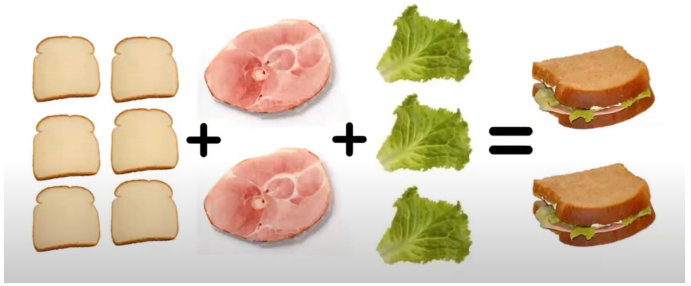












So what is limiting?

Critical limits (optimum and threshold) of oxidizable soil organic carbon (SOC) in Alfisols with rice-rice (a) and in Inceptisols with rice-potato-sesame (b) cropping systems (Source: Mandal, 2011).

Soil health indicators with its corresponding characteristics and values

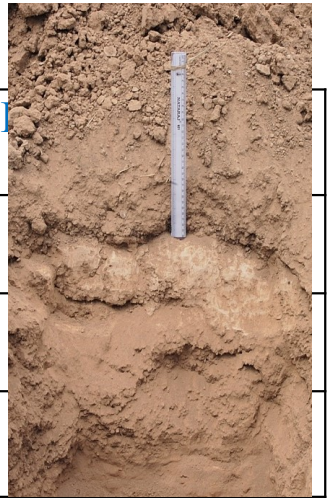
1. Soil structure

Established value	Characteristics	Estimated value
1	Loose, powdery soil without visible aggregates	
5	Few aggregates that break with little pressure	
10	Well formed aggregates difficult to break	

2. Soil compaction

Established value	Characteristics	Estimated value
1	Compacted soil, flag bends readily	
5	Thin compacted layer, some restriction to a penetrating wire	
10	No compaction, flag can penetrate all the way into the soil	

3. Soil depth



Established value	Characteristics
1	Exposed sub-soil (soil depth <25cm)
5	Moderately Shallow soil (25-50cm)
10	Deep soil with soil depth at least >50 cm

4. Status of residue

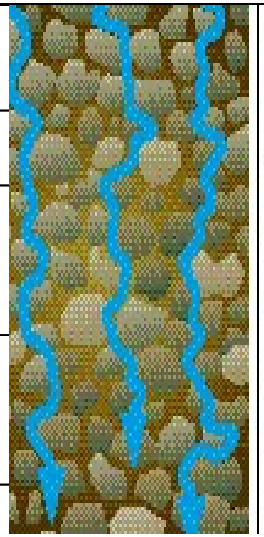
Established value	Characteristics	Estimated value
1	No visible sign of residue,soil colour appears pale or light	
5	Presence of decomposing residuesor mulch material, soil colour appears to be brownish	
10	Residue in various stages of decomposition, most residue well decomposed, soil colour appears to be dark or blackish	

5. Soil colour, odour and organic matter

Established value	Characteristics	
1	Pale, no presence of humus, no smell of decomposing residue or rotten residues	
5	Light brown, odourless, some presence of humus or little smell of rotten materials	
10	Dark brown or blackish appearance, fresh odour and abundant humus	

6.Soil water retention

Established value	Characteristics
1	Dry soil, does not hold water
5	Limited moisture level available for short time
10	Reasonable moisture level for a reasonable period of time



7.Soil cover

Established value	Characteristics
1	Bare soil fallow with sparse vegetation
5	Less than 50%soil covered by residue or live cover at least for 6 months
10	more than 50%soil covered by residue or live cover at least for 9 months

8. Erosion

Established value	Characteristics	
1	Severe erosion, presence of small gullies	
5	Evident but low erosion signs	
10	No visible signs of erosion	

9. Presence of invertebrates and insects

Established value	**Characteristics**	
1	**No signs of earthworms or insects presence or activity**	
5	**A few earthworm and arthropods present**	
10	**Abundant presence of invertebrates organisms**	

10. Microbiological activity

Established value	Characteristics	Estimated value
1	Very little effervescence after application of water peroxide	
5	Light to medium effervescence	
10	Abundant effervescence	

1.STEPS INVOLVED IN MAKING ENRICHMENT OF COMPOST

•Leaf litter from forest floor is collected during April- May and stored in a heap.

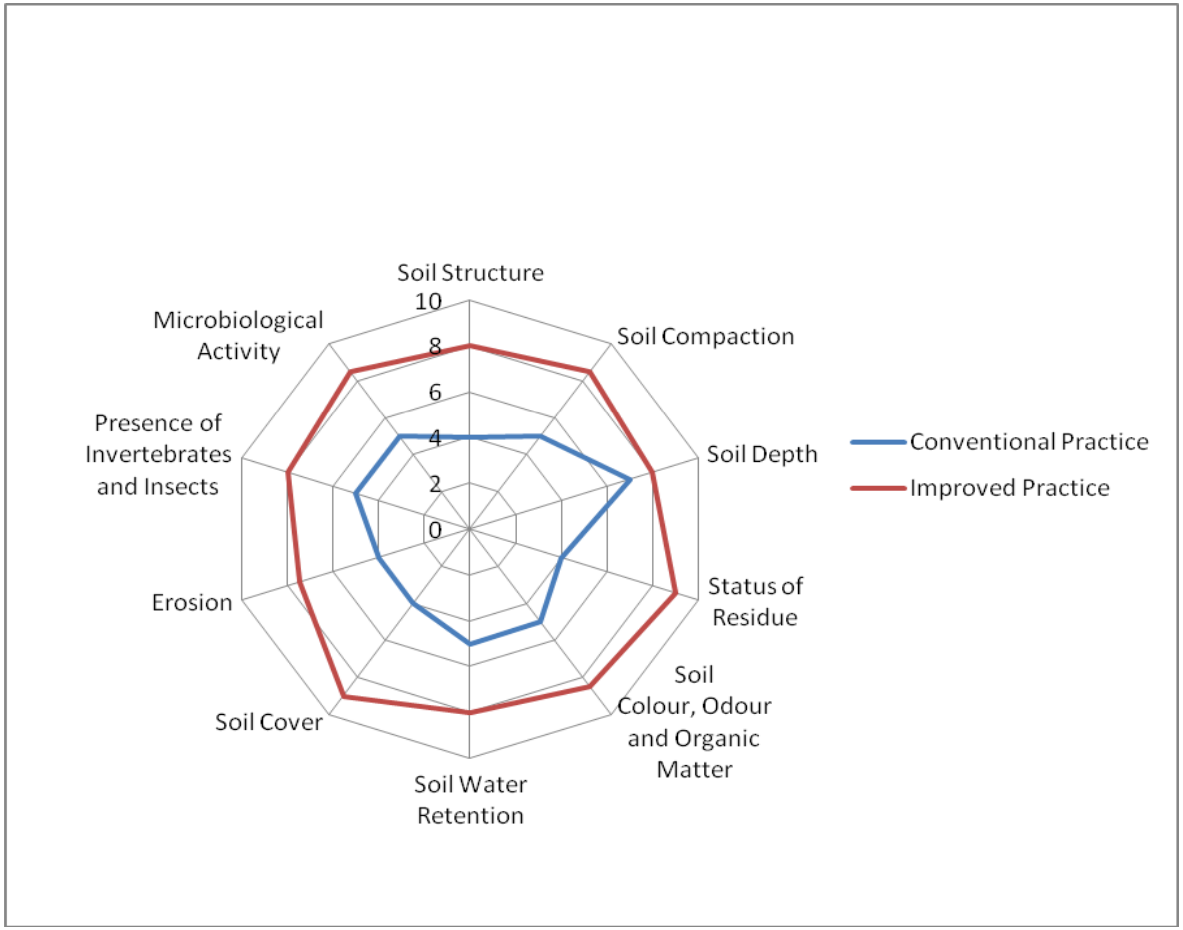
Collection of sal leaves from forest floor and its storage

The dried leaf litter is scattered in the floor of the cowsheds and used as bedding material.. The leaves acts as sponge and absorbs the dung and urine of the animals.

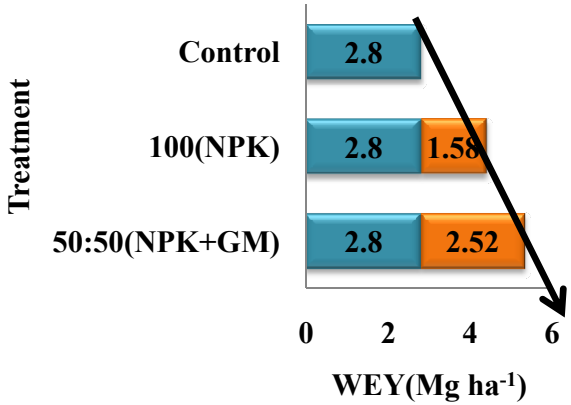
The soaked leaves is removed after 2-3 days and transferred to a pit. Wherever biogas plant is installed, the cowdung slurru is diverted to a storage tank containing sal leaves(pit).

Soaking of biogas slurry in dried sal leaves in a pit for compost making

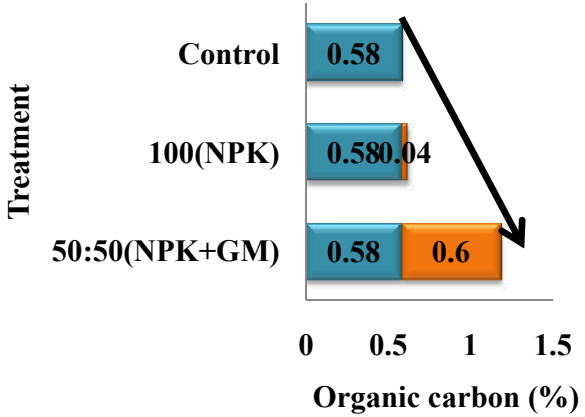
Amoeba diagram for relative assessment



Practices to limit soil erosion in slopping crop lands

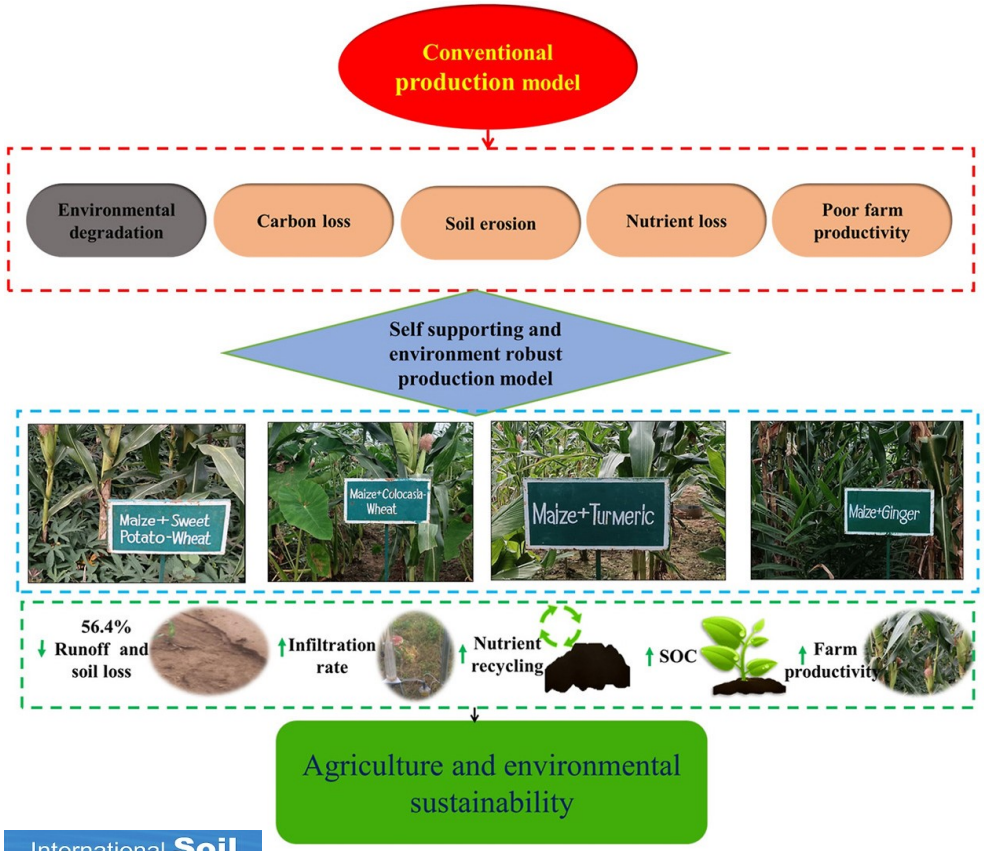


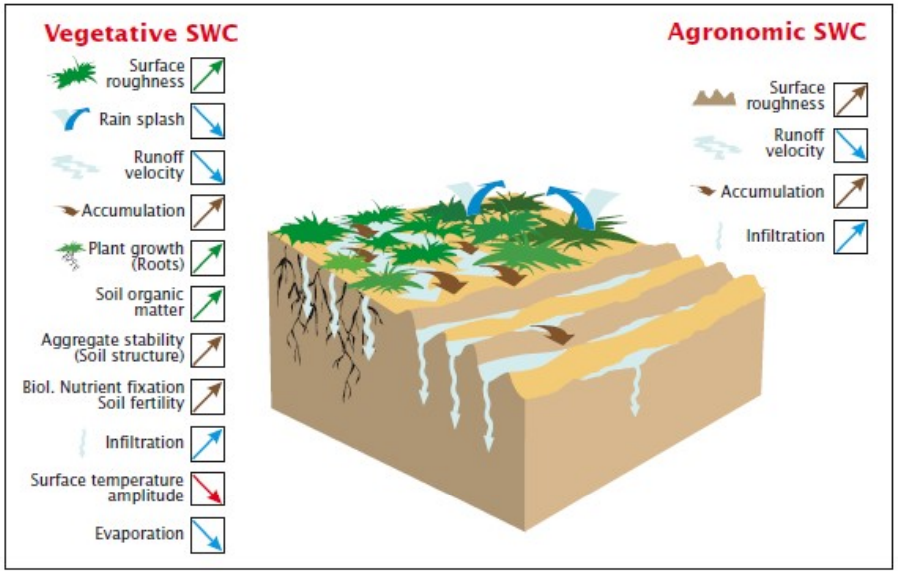
7 year Agronomic experiment at IISWC
SOURCE: Singh et al, 2017.



Total citation = 212

Practices to limit soil erosion in slopping crop lands





International Soil and Water Conservation Research

Yadav,D., Singh, D., Subhash Babu , Madhu, M., Singh, D.V., **Mandal, D**., Chandra Rathore, A.C., Sharma, V.K., Singha, V., Kumawat A., Yadav, D.K., , Yadav, R.K., K umar, S. **2023**. Intensified cropping reduces soil erosion and improves rainfall partitioning and soil properties in the marginal land of the Indian Himalayas, **International Soil and Water Conservation Research**. https://doi.org/10.1016/j.iswcr.2023.10.002

Production Phosphate Rich Organic Manure (PROM) for rural employment

Conventional inorganic phosphorus fertilizer

- Low P use efficiency due to rapid soil fixation
- Depends on finite rock phosphate reserves
- High cost with low nutrient recovery
- Impair long-term soil health

Increase cost of production and environmental footprint

Phosphorus rich organic manure


Creates rural employment opportunities


Adds value to farm and animal wastes

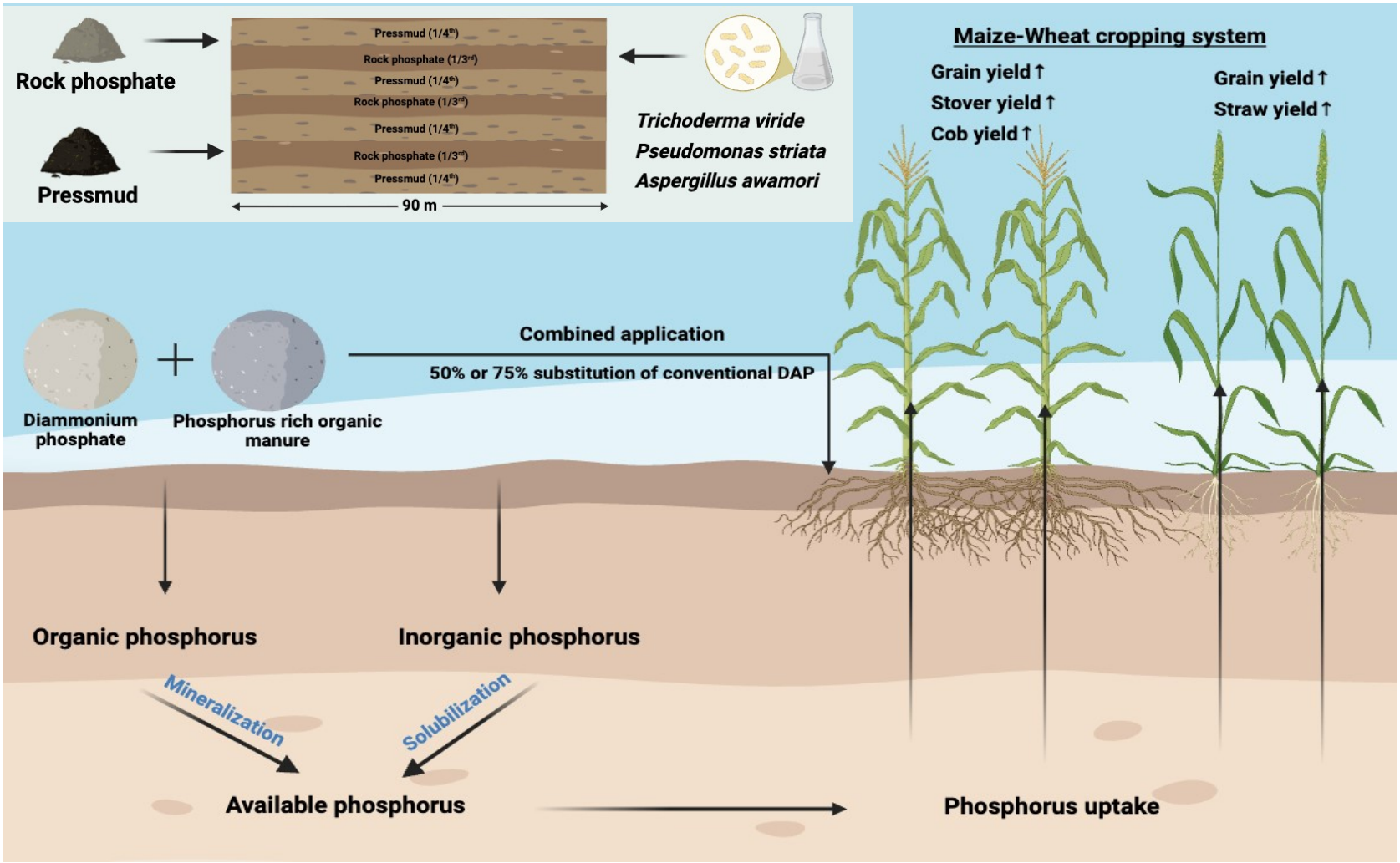

Provides a low-cost locally made P source


Improved crop yield

- **In India, Phosphate Rich Organic Manure (PROM) market was valued at $203.2 million in 2020 and is projected to reach $419.6 million by 2030.**
- **Simple and low-investment technology suitable for rural areas.**
- **Promotes eco-friendly and sustainable rural development.**

- ✓ Production of organic fertilizer like PROM in group or cluster of small and marginal farmers (< 2 ha land holding) may get input cost (Rs. 15000/-) under PKVY scheme
- ✓ Production of PROM may be a suitable enterprise for rural employment

Role of PROM as cost effective phosphorus fertilizer



Soil Health Benefits

- ✓ PROM found to substitute 50-75% of DAP in maize- wheat system
- ✓ Reducing P fertilizer cost by Rs. 1000/- ha^{-1}
- ✓ Improve P use efficiency by 10-15%
- ✓ Utilization native (reserve pool of soil P) P

Agroforestry Success-stories in boulder-and stony riverbed lands of Doon Valley region

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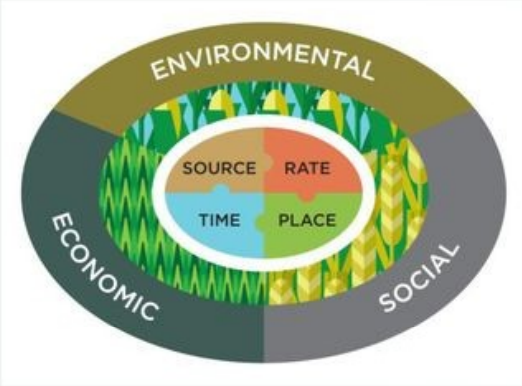
Fertilizer Best Management Practices: 4Rs



Right fertilizer Source, at the Right Rate, at the Right time and in the Right Place

4R Plus

ifa INTERNATIONAL FERTILIZER ASSOCIATION

Conservation practices include: Cover crops; No-till; Strip-till; Grass waterways; Drainage water management etc

- **The critical level of C input requirements for maintaining SOC at the antecedent level**
- **1.1 to 3.5 Mg C/ha/y**
- **Differs among soil type and production systems.**

TRADITIONAL BIOFUEL FROM ANIMAL MANURE

More plant nutrients are burnt in dung as household fuel than chemical fertilizers used/yr in India.

Conclusions

- Light house and living laboratories: Better connect innovation, practitioners and scientists
- C-input management
- Rice fallow management: adopting diverse cropping systems
- Land sharing and land sparing: Restoring wetlands, CPRs, and marginal and degraded lands

Implementation of policies:

-pro-nature

-pro-soil

-pro-land managers

Strong relationships between soil health and food security calls for strategic and immediate actions especially at the local level to reverse soil degradation

Soil sustainability –

Degraded soil – keep it in rest to rejuvenate; effective soil management policies and measures

Productive soil – managed it with BSMP, allowing no degradation;

Degrading soil – correcting – a) allowing rest (naturally), b) rest with medicine, and b) cultivating with medicines (normal)

There is much larger challenge than was faced by Norman Borlaug, M.S. Swaminathanand other Green Revolutionaries.