Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management

Dr. Ch.Srinivasa Rao
ICAR-National Academy of Agriculture Research Management (ICAR-NAARM)
director@naarm.org.in; cherukumalli2011@gmail.com
Success Story of Indian Agriculture Sector & Food Security

1.3 Billions
1.7 Billion

More Food Production
@ Food Security
@ Nutrition Security
@ Livelihoods

@ 284 mt Food
@ 300 mt Fruits & Vegetables; 8.5 times Milk; 43 times Eggs; 13 times Fish

Sustainability
@ Water
@ Soil
@ Environment
@ Biodiversity
@ Forest
Sustainable Development Indicators in India: Constraints

- 7.5/1.30 billion
- Small Holder Farmers
- Rainfed Agriculture
- Food Security
- Livelihoods

- Declining land
- Declining water quality
- Declining soil quality
- Climate change and impacts

Hunger & Food Security
Sustainability of Food Systems in India with Soil Organic Carbon, Soil Health, Fertility under grassland and cropland as well as integrated systems, including water management

@ Technologies,  
@ Government Programs  
@ Implementation Process  
@ Innovative Models  
@ Impacts
Technology Implementation and Government Programs
Soil Organic Carbon (SOC) Sequestration

@ Soils of India & Tropical countries, SOC is very low: high temperatures & rain dependent Agri.

@ SOC to Climate Adaptation particularly for droughts

@ However, improving SOC in Tropical Semi-Arid and Arid Systems is a Challenge

@ Therefore, the cost per Unit Increase in SOC in Tropical Country like India is Much Higher than Temperate Countries.

@ Technology implementation in Small & Marginal Farmers in India & Others
Soil Health & Soil Organic Matter: Critical for Agri Sustainability

Partial factor productivity of NPK in finger millet in 30 years old long term experiment at Bangalore under rainfed conditions (1978-2007)

FYM 10t/ha=50-25-50 NPK; 10t FYM+50%NPK=75-50-62 NPK; 100% NPK=50-50-25

India

Advances in Agronomy (2013, 2015)
Promotion of Healthy Soils and Healthy Nation

- Healthy Nation
- Healthy Human Kind
- Healthy Food
- Healthy Crop / Fodder
- Healthy Soils
Some of the easily implementable carbon sequestration strategies at Village Level

- Horsegram incorporation
- Glyricidia
- Crop residue
- Intercropping with legumes
- Biogas linked with vermicomposting
- Community based Vermicomposting

India
### Recommended Management Practices for Carbon Sequestration

<table>
<thead>
<tr>
<th>Principle</th>
<th>Practices</th>
</tr>
</thead>
</table>
| Creating positive ecosystem carbon budget           | • Mulch farming  
• Conservation agriculture  
• Cover cropping  
• Agroforestry                                                                                                           |
| Reducing losses                                      | • Erosion control  
• Moderating mineralization by managing soil temperature, plant species and root:shoot ratio  
• Increasing humification by improving C:N, C:P and C:S ratio  
• Improving soil aggregation                                      |
| Deep transfer of carbon                             | • Plants with deep root system  
• Bioturbation (e.g., earthworm and termite activity)                                                                               |
| Protecting soil carbon                              | • Increasing aggregation  
• Decreasing soil disturbance  
• Enhancing recalcitrance of biomass C                                                                                         |

Enhanced Fertilizer Use Efficiency
Reduced Input Cost, Improved Profits & Environmental Services: Technologies and Govt. India Programs

- Precision Nutrient Application
- Nano Fertilizers
- Soil Health Card Mission
- Neem Coated Urea
- Variable Rate of Technology
- Placement of Nutrients
- Water-Nutrient Synergy
- Promotion of N Fixing Crops
- Organic Farming and
- INM

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Efficiency percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>30-50</td>
</tr>
<tr>
<td>P</td>
<td>10-20</td>
</tr>
<tr>
<td>K</td>
<td>&lt;80</td>
</tr>
<tr>
<td>S</td>
<td>8-12</td>
</tr>
<tr>
<td>Zn</td>
<td>2-5</td>
</tr>
<tr>
<td>Fe</td>
<td>1-2</td>
</tr>
<tr>
<td>Cu</td>
<td>1-2</td>
</tr>
<tr>
<td>Mn</td>
<td>1-2</td>
</tr>
</tbody>
</table>
Crop Residue to Biochar
For Carbon Sequestration, Drought Adaptation and Co-Benefits

Per each ton of crop residue provides Nitrogen 5.5 kg; Sulphur 1.2 kg; Phosphorus (~40%) 2.3 kg; Potash (~10%) 25.0 kg; Organic Carbon 400 kg.

500 million tones of crop residue is available in India, comes 200 million tons of organic carbon.

Convert it Biochar or Energy Source?

Technology support and Scale of Implementation Needs
Government Programs for Soil Health and Organic Carbon Improvement in Indian Soils

1) Promotion of Soil Health Card Mission with Organic Carbon Emphasis
2) Crop Residue Recycling (Climate Adaptation)
3) Mulch cum Manuring of Organic Residues for Climate Adaptation and Improved Soil Organic Matter (Climate Adaptation)
4) Tank Silt Recycling (Bring Back the Eroded Top Soil)
5) Promotion of Legume Cover Crops (Climate Adaptation)
6) Intercrops with Legumes.
7) Conservation Agriculture Systems (Area Increasing)
8) Agro Forestry Systems (Area is Increasing)
9) Integrated Nutrient Management (Area Increasing)
10) Agri Horticulture Systems (Area Increasing)
11) Water Saving Rice Systems (Area Increasing)
12) Direct Seeded Rice (Area Increasing)
India to Improve Water Use Efficiency

- Irrigation uses 83% of water, diversion of water to agriculture expected to reduce (72% by 2025)

- Efficiency Water Use Systems

- Efficient Crops and Cultivars

- Water Saving Rice

1) Prime Minister Krishi Sinchai Yojana (Prime Minister Agriculture Irrigation Plan) for Improving Water Use Efficiency (More Crop Per Drop of Water; Micro-Irrigation Systems)

2) National Mission on Water

3) Rain Water Conservation and Utilization through Farm Ponds
Water Sensitive-Agri. Education in India

THIRSTY INDIA

Water Available for Every Indian

In 1947 60,00,000 Liters
In 2015 18,00,000 Liters
In 2025 13,40,000 Liters

India
Community Participation is the Key for Rain Water Conservation and Recharging
@ Loss a kilogram of wheat and rice would mean wasting 1,500 and 3,500 litres of water respectively that goes into their production.

@ Globally, almost 250km³ of water and 1.4 billion hectares of land are devoted to producing food that is lost or wasted.

@ According to Food and Agriculture Organization (FAO), every year around 1.7 billion tonnes, or almost one third of food produced for human consumption, are lost or wasted.

@ The associated economic, environmental and social costs of this loss are around $1 trillion, $700 billion and $900 billion per year respectively.

@ Carbon value of this 1.7 billion t food= 0.55 billion tonnes in the world.
Agro-Forestry and Forestry, Cover Crops, Wind Breaks besides Enhanced CO$_2$ Fixation

Climate Adaptation

@ National Agro-forestry Policy
@ Green-India Mission
Integrated Farming System for Climate Resilient Agriculture and Food Production Systems

National Mission for Sustainable Agriculture

Year 2008

Year 2011

India
Critical Role of Technology Packaging in Rainfed Drylands (Soil-Water-Crops)

**Technology**
- In-situ moisture conservation
- Land treatments
- Farm ponds
- Drought tolerant cultivar
- Soil test based nutrients

**Institutions**
- VCRMC
- Seed bank
- Custom hiring of farm machines
- Water groups

**Adaptation/Mitigation**
- Adaptation to Droughts: Resilient
- Household food and livelihoods: Enhanced
- Village carbon balance: +
- Co-Benefits of Mitigation

Srinivasarao et al., Adv in Agronomy (2016)
Technology Targeting

@ Which technology to Where

@ Creation of institutions such as community Seed Banks, farmer producer organisations/farmer producer companies, custom hiring centres for farm machinery and equipment, cooperative credit societies, etc.
Research, Technology and Policy Implementation Synergy: for Better Implementation of Carbon Positive Programs in India
India to Offer

Knowledge and Implementation for SOC, Improved Nutrient and Water Use Efficiency Models under South-South Cooperation and to Developing Countries