Sustainable Intensification Innovations: ‘Discovery to Delivery Continuum is a Must for Impact at Scale’

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International Maize and Wheat Improvement Center
CIMMYT: International Maize and Wheat Improvement Center

- Mission: Wheat and maize science for improved livelihoods
- Part of Consultative Group on International Agricultural Research (CGIAR)
- Works in Asia, Africa and Latin America
- Impact on smallholder’s through partnerships
Agricultural practices of the past, which helped drive the Green Revolution, are not sustainable in the long run.

- Globally, high input driven food production has become increasingly unsustainable and now the question being asked is how much more growth can be achieved or even if present productivity levels can be maintained without collapse?
- Increased yields have not resulted in increased farmer incomes.
Efficiency and sustainability of farming depends on interactions
Transiting Towards Sustainability

Non-linear stages in technology/innovations

1. *Efficiency*- focuses on making better use of resources within existing system configurations

2. *Substitution*- focus on replacement of technologies, practices etc

3. *Redesign* centers on composition and structure of agro-ecosystem involving social and institutional dimensions *(Innovation Systems)*
The Innovation Process

- **Learn**: Integrate new knowledge
- **Scope**: Establish goals and objectives
- **Assess**: Evaluate effectiveness & impact
- **Plan**: Determine strategies & approaches
- **Observe**: Monitor progress
- **Implement**: Develop products, tasks, & activities

Flow:
- Learn → Scope
- Scope → Plan
- Plan → Implement
- Implement → Observe
- Observe → Learn

Activities:
- Re-develop
- Refine
- Continue
SIR4D: Innovation approach for Impact at Scale

- System focused
- Continuum of ‘strategic-applied research-capacity development-delivery’
- Participatory
- Innovation systems: Make your own recipes: there are no readily available recipes for SI/NRM
- Convergence and synergy with networks, and project, investments
- Consortium of active and complementing stakeholders with Farmer in center of it
Exploring windows of opportunity

- **Risks**
- **Challenges**
- **Opportunities**

- **Demographic**
- **Social**
- **Economic**
- **Market**

- **Current practices**
- **New practices**

- **Recombine**

- **Objectives**
- **Select**

- **Constraints**

- **Systems Based and Locally Adapted Solutions**
Management Factors Critical for Transitioning Towards Sustainability

<table>
<thead>
<tr>
<th>Factors</th>
<th>Energy/Cost</th>
<th>Adaptive capacity</th>
<th>GHG/GWP</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage-CE</td>
<td>20-25</td>
<td>*S</td>
<td>*S</td>
<td>*S</td>
</tr>
<tr>
<td>Biomass management</td>
<td>5-10</td>
<td>*S</td>
<td>*S</td>
<td>~</td>
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<tr>
<td>Water management</td>
<td>25-30</td>
<td>**S</td>
<td>**S</td>
<td>**S</td>
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<tr>
<td>Nutrient management</td>
<td>25-30</td>
<td>~</td>
<td>**S</td>
<td>**S</td>
</tr>
<tr>
<td>Others</td>
<td>5-20</td>
<td>~</td>
<td>~</td>
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</tr>
</tbody>
</table>
Conservation Agriculture (CA): Provide opportunities for transitioning towards sustainability

• 180 m ha globally
• Low adoption in Asia
## Innovative packaging for sustainable intensification portfolio (CA+ Diversification+ precision water & N)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Irrigation water use (mm ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice/Maize</td>
<td>Wheat</td>
</tr>
<tr>
<td>Conv RW system-Flood</td>
<td>7.04a</td>
<td>5.68b</td>
</tr>
<tr>
<td>CA- RW system-Flood</td>
<td>5.87b</td>
<td>6.47a</td>
</tr>
<tr>
<td>CA- RW system+ SSDI</td>
<td>6.30b</td>
<td>6.70a</td>
</tr>
<tr>
<td>CA- MW system- Flood</td>
<td>7.14a</td>
<td>6.51a</td>
</tr>
<tr>
<td>CA -MW system + SSDI</td>
<td>7.48a</td>
<td>6.59a</td>
</tr>
</tbody>
</table>

Jat et al forthcoming-[ICAR-CSSRI-CIMMYT Collaborative Research @ Karnal, Haryana, India]
## Innovations for Green solutions to address the food-energy-water (FEW) nexus in western IGP

<table>
<thead>
<tr>
<th>Scenario</th>
<th>System yield (rice eq) (t/ha)</th>
<th>System irrigation water use (cm)</th>
<th>WPi (kg grain m(^{-3}) water)</th>
<th>Net return, (Rs/ha/yr)</th>
<th>Energy use (kWh)</th>
<th>GHG (Kg CO(_2) eq. ha(^{-1}) year(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWCT-FP</td>
<td>11.79cd</td>
<td>208.61a</td>
<td>0.58e</td>
<td>128402</td>
<td>3995</td>
<td>3680</td>
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<tr>
<td>RWZT-FL</td>
<td>11.72d</td>
<td>193.22b</td>
<td>0.61e</td>
<td>135338</td>
<td>3702</td>
<td>3530</td>
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<tr>
<td><strong>RWZT-SSD</strong></td>
<td><strong>12.06c</strong></td>
<td><strong>109.98c</strong></td>
<td><strong>1.11d</strong></td>
<td><strong>143058</strong></td>
<td><strong>3551</strong></td>
<td>0</td>
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<tr>
<td>MWCT-FP</td>
<td>11.87cd</td>
<td>75.38d</td>
<td>1.60c</td>
<td>123305</td>
<td>1665</td>
<td>1655</td>
</tr>
<tr>
<td>MWPB-FU</td>
<td>12.43b</td>
<td>61.70e</td>
<td>2.03b</td>
<td>138324</td>
<td>1356</td>
<td>1348</td>
</tr>
<tr>
<td><strong>MWPB-SSD</strong></td>
<td><strong>12.93a</strong></td>
<td><strong>35.14f</strong></td>
<td><strong>3.70a</strong></td>
<td><strong>147612</strong></td>
<td><strong>1196</strong></td>
<td>0</td>
</tr>
</tbody>
</table>

Jat et al (2018): CIMMYT-BISA-PAU Collaborative Research @ Ludhiana, Punjab, India
Sub-surface drip fertigation with conservation agriculture in a rice-wheat system: A breakthrough for addressing water and nitrogen use efficiency

H.S. Sidhu\textsuperscript{a}, M.L. Jat\textsuperscript{b,a}, Yadvinder Singh\textsuperscript{c}, Ravneet Kaur Sidhu\textsuperscript{d}, Naveen Gupta\textsuperscript{a}, Parvinder Singh\textsuperscript{b}, Pankaj Singh\textsuperscript{a}, H.S. Jat\textsuperscript{b}, Bruno Gerard\textsuperscript{e}

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\textsuperscript{c} INSA Honorary Scientist, Department of Soils, Punjab Agricultural University, Ludhiana, India
\textsuperscript{d} Thapar University, Patiala, Punjab, India
\textsuperscript{e} International Maize and Wheat Improvement Centre (CIMMYT), El-Batan, Texcoco, Mexico
Innovations for Precision Nutrient Management in CA: Example from *Eastern IGP*

**Nutrient Expert for Hybrid Maize**

*Source: Jat et al (Forthcoming)*
Meta analysis: Multi-criteria performance of CA in major cereal based systems in South Asia

Yield & protein: 5, water: 10, Cost: 13, Income: 27

Jat et al (Forthcoming)
Key Elements for Scaling Innovations for Impact at Scale

- Translational Research – Farmers’ Participatory Knowledge Sharing and Capacity Development
- Regional Partnership
- Coordination and Convergence
- Greater Policy Support and Investments
The Hub Concept: A three-part system, based on an innovation model, for learning and experimentation supports the transformation of agriculture

Main points considered in design:

- Non-linear technological development process
- Collective generation of knowledge
- Technical and social innovation
- Involvement of different actors with different interests
- Reflects MasAgro model’s flexibility to adapt to the agro-ecological, social, and economic conditions of each region
- Takes into account scientific and empirical knowledge to create relevant solutions for real contexts where agricultural processes occur
Innovation hubs on Sustainable Intensification in South Asia

- Sustainable intensification of cropping systems can help reduce costs, increase incomes and make agriculture more sustainable for small farmers and the environment.

Source: Team analysis based on CSISA data
Co-innovations with farmers at research-stations
Multi-Stakeholder On-Farm Participatory Research-cum-Innovation Platform
Farmer led innovation platforms

- KVKs (Adaptation)
- Agri Universities (Students)
- ICAR Institutes (Research)
- State Deptt of Agri NODAL AGENCY
- Farmer Commission (Policy support)
- CIMMYT/CGIAR ARIs
- CA/SI adopters
- CA/SI Services
- New Farmer societies (CA/SI) (Innovation & Adaptation)
- CSA P adopters
- CSA P modules farmers
- Farmer cooperatives (CA/SI/CSA participatory innovation platform- Service windows, stakeholder meets, travelling seminars, field days)
- Private Sector (Input-output, services)
- Media awareness
Science of Scaling for Impact

Targeting with Clarity of Objectives

Ecosystem Services

Original farm configuration

Farm profitability

Legend:
- Housing
- Intensive grassland
- Extensive grassland
- Maize
- Wheat
- Woodland
Tradeoffs of Policy Targeting in Isolation

Rice harvesting dates

- **Before and after ground water act**
  - (2003-2008)
  - (2009-2017)

Active fires in Punjab and Haryana

*Nature Sustainability (June 2019) https://doi.org/10.1038/s41893-019-0304-4*
Multi-Criteria Assessment for Performance of innovations: Large number of farmers participatory trials on CA/SI in Eastern Gangetic Plains

Maize in rotation with rice and other crops with CA is evolving a potential diversification alternative in eastern IGP

Source: Sustainable and Resilient Farming Systems Intensification (SRFSI) project. Partnership: India- ICAR-RCER Patna, UBKV-Coochbehar, BAU-Sabour, DoA-WB, JEEViKA-Bihar; Bangladesh-BARI, BMWRI, BARC, DAE, RDRS; Nepal-NARC, DoA-Nepal, IDE-Nepal. CGIAR-CIMMYT, IRRI, IFPRI, IWMI. Australian- CSIRO, University of Queensland, Curtin,
Meta analysis: performance (yield and income) of CA in different cropping systems and soil types

Jat et al (Forthcoming)
Profitable Alternatives to Crop Burning That Can Help Farmers and Reduce Air Pollution

<table>
<thead>
<tr>
<th>Method</th>
<th>Farmer Profit (INR ha(^{-1}) year(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy Seeder</td>
<td></td>
</tr>
<tr>
<td>Happy Seeder + SMS</td>
<td></td>
</tr>
<tr>
<td>Bale + Zero Till</td>
<td></td>
</tr>
<tr>
<td>Burn + Zero Till</td>
<td></td>
</tr>
<tr>
<td>Bale + Rotavate</td>
<td></td>
</tr>
<tr>
<td>Burn + Rotavate</td>
<td></td>
</tr>
<tr>
<td>Bale + Disc Harrow</td>
<td></td>
</tr>
<tr>
<td>Burn + Disc Harrow</td>
<td></td>
</tr>
<tr>
<td>Incorporate + Rotavate</td>
<td></td>
</tr>
<tr>
<td>Incorporate + Plow</td>
<td></td>
</tr>
</tbody>
</table>

Also compared for Public and private costs and benefits:
- Subsidies
- Water withdrawals
- GHG emissions
- Particulate matter

Business models of SMEs as a mechanism for scaling climate smart technologies: The case of Punjab, India

A.E. Groot a, *, J.S. Bolt a, H.S. Jat b, M.L. Jat c, M. Kumar c, T. Agarwal c, V. Blok d

a Climate Change Group, Wageningen Environmental Research, Wageningen University & Research, Droevendaalsesteeg 3, 6708 PB the Netherlands
b ICAR-Central Soil Salinity Research Institute (CSSR), Karnal, Haryana, India
c Researcher International Maize and Wheat Improvement Centre (CIMMYT), NASC Complex, New Delhi, India
d Management Studies Group, Wageningen University, Wageningen University & Research, the Netherlands
The Power of Technology + Enabling Policy
No-till Example from Punjab, India

- Primary data from 46 villages in 6 districts of Punjab (January 2019)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2016-17</th>
<th>2017-18</th>
<th>2018-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZT drill</td>
<td>1289</td>
<td>1291</td>
<td>1294</td>
</tr>
<tr>
<td>Happy Seeder</td>
<td>8</td>
<td>64</td>
<td>247</td>
</tr>
<tr>
<td>Area under ZT</td>
<td>845</td>
<td>7500</td>
<td>28372</td>
</tr>
<tr>
<td>Scenario</td>
<td>No strict imposing ban</td>
<td>Imposing ban without investment</td>
<td>Imposing ban with investment</td>
</tr>
</tbody>
</table>
Impact at scale- Happy Seeder

Punjab agriculture secretary: Direct sowing in 17 per cent of wheat area

800000 ha in Punjab & Haryana in 2018-19

- Long term investment for science evidence
- Policy support & investment
- Private sector capacity & business models
- Human capital
- Public and private benefits
Laser Assisted Precision Land Leveling: A Silent Water Revolution With Impact at Scale Through Science and Participatory innovations approaches

- Introduced through partnerships between CGIAR and NARS through eco-regional program, The Rice-Wheat Consortium (RWC)
- Best example of impact at scale in NRM with large private investments (~US$ 500 million) with public and private benefits

- Introduced in India during 2000-01 (RWC/CIMMYT-IRRI, ICAR/NARS)
- Adoption: ~6 million ha in India
- Direct employment generation: 350 person days/unit/yr

- At current level (40000 units) employment generation: 14 million person days/yr
- Indirect employment: manufacturing, transport, services

- Electricity saving for irrigation
- Water saving in RW system (5 mha, 18 ha-cm ha-1 yr-1) = 10 km3 yr-1

- Yield gains in RW system (5 mha, 0.5 t ha-1 yr-1) > 2 mt yr-1
- Other benefits- GHG mitigation, savings in subsidy bill etc

Source: Jat et al, 2006; 2009a,b; 2011; 2015; Aryal et al, 2015, 2018
Enabling environment for rural micro-entrepreneurship through business models: Example from smallholder systems of Eastern India

Farmers’ Club
2013 = 3
2016 = 23

- Input suppliers (seed, agrochemical, fert.) and manufacturer
- NABARD and Credit agencies
- Value chain and small scale processing units for Dal meels

R & D Institutions
- Technical backstopping and convergence
- Capacity building

Single window services
- Participatory Research
- Rural employment
- Seed supply
CLIMATE SMART VILLAGE (CSV) PROGRAM
“A community based holistic approach for empowering farm families for building resilience against climatic risks”
Building the capacity: Advanced Course on CA@CIMMYT India

Advanced Course – Asia & North Africa

CONSERVATION AGRICULTURE:
Gateway for Sustainable Intensification of Smallholder Systems

10th Batch
Commencing from 7th November 2019

Dates
November 7-22, 2019

Venue
CIMMYT-BISA
Ludhiana/Karnal India

Second International Training Course on Conservation Agriculture and Scale Appropriate Mechanization for West Africa

Second Batch
Commencing 27th March, 2019

Dates
March 27, 2019 - April 10, 2019

Venue
BISA-CIMMYT
Ludhiana (Punjab), India

Duration
15 Days
Advanced Course on CA/SI@CIMMYT India

• **NRM:** Agronomy, Soil Science
• **Agril Engineering:** Farm Machinery & Power Engineering, Soil Water Engineering
• **Crop Sciences:** Plant Physiology, Plant Breeding
• **Social Sciences:** Agricultural Extension, Agricultural Economics, Agricultural Statistics, Agri-Business Management
‘Transitioning Towards Sustainability’

- Long-term process research- Science Evidence
- Participatory on-farm validation and refinement: backward and foreword integration
- Multi-disciplinary (CA/SI is Agriculture and not just Agronomy & Engineering) and multi-stakeholder (farmer centric) approach
- Science evidence backed policy informing
- Science of scaling: Business models and social inclusivity
- Capacity (Confidence) development
- ‘Discovery to Delivery Continuum’
Thank you for your interest!

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