Conservation Agriculture in South Asia: Pitfalls and Strategies for Scaling

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South Asia: The Region With Multiple Challenges

- Most populous region yet labour availability in farming is major challenge
- Natural resources are stressed
- A hot-spot for multiple climatic risks
Transitioning Towards Sustainability

Need three non-linear stages in technology development (Pretty et al., 2018)

(i) **Efficiency**-focuses on making better use of resources within existing system configurations

(ii) **Substitution**- focus on replacement of technologies, practices etc

(iii) **Redesign** centers on composition and structure of agro-ecosystem involving social and institutional dimensions
## 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</td>
<td>5-10</td>
<td>*S</td>
<td>*S</td>
<td>~</td>
</tr>
<tr>
<td>Water</td>
<td>25-30</td>
<td>**S</td>
<td>**S</td>
<td>**S</td>
</tr>
<tr>
<td>Nutrient</td>
<td>25-30</td>
<td>~</td>
<td>**S</td>
<td>**S</td>
</tr>
<tr>
<td>Others</td>
<td>5-20</td>
<td>~</td>
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<td>~</td>
</tr>
</tbody>
</table>
Conservation Agriculture (CA):
Provide opportunities for transitioning towards sustainability

Conservation Agriculture Basic Principles

Residue retention (no burning)  Zero tillage  Crop rotation
### Area of cropland under CA by continent – 2015/16

(source: FAO AquaStat: [www.fao/ag/ca/6c.html](http://www.fao/ag/ca/6c.html) & personal database)

<table>
<thead>
<tr>
<th>Continent</th>
<th>Area (Mill. ha)</th>
<th>Per cent of global total</th>
<th>Per cent of arable land of reporting countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>South America</td>
<td>69.9 (49.6)*</td>
<td>39.0 (40.9)#</td>
<td>63.2</td>
</tr>
<tr>
<td>North America</td>
<td>63.2 (40.0)</td>
<td>35.2 (58.0)</td>
<td>28.1</td>
</tr>
<tr>
<td>Australia &amp; NZ</td>
<td>22.7 (12.2)</td>
<td>12.7 (86.1)</td>
<td>45.5+</td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia &amp; Ukraine</td>
<td>13.2 (2.6)</td>
<td>7.4 (408)</td>
<td>3.8</td>
</tr>
<tr>
<td>Africa</td>
<td>5.2 (0.1)</td>
<td>2.9 (5000)</td>
<td>3.3</td>
</tr>
<tr>
<td>Europe</td>
<td>2.7 (0.5)</td>
<td>1.5 (447)</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>2.5 (1.6)</td>
<td>1.4 (56.3)</td>
<td>3.5</td>
</tr>
<tr>
<td>Global total</td>
<td>179.5 (107)*</td>
<td>100 (69.2)# ( )% change since 2008/09</td>
<td>12.5 (7.4)* %global cropland + includes non-cropland</td>
</tr>
</tbody>
</table>

~50% in developing regions, ~50% in industrialized regions

Source: Kassam et al (2018)
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)
Major pitfalls and strategies for scaling and adoption of CA

1. Philosophical perception
2. Research articulation & targeting
3. Development /infrastructure
4. Knowledge & capacity
5. Policy & investment priority related
1. Philosophical: myths based on perceptions

- Several myths around CA which are far away from their realities (Sharma, 2018) but largely responsible for restricting the scaling/ adoption of CA
  - *It's for large farmers and not for small*
  - *requires heavy machinery which is too costly and not available*
  - *results in soil compaction and formation of hard pan*
  - *results in low water infiltration, leading to waterlogging*
  - *requires breaking of the cycle after some years*
  - *increases weed infestations*
  - *requires more chemical fertilizers/nitrogen*
  - *increases insect and disease infestation*
  - *accumulate the crop residues and may make a heap over time*
  - *results in poor germinations and seedling emergence*
  - *competes with crop residues which are fed to animals*

- Classically agriculture systems grew with dominance of seed systems, there is a philosophical issue of equating the ‘CA systems’ with ‘seed systems’, however the application of both are entirely different
2. Research Articulation & Targeting Related

- One size (doesn’t) fits all
- Arguments around CA *(per se)* works and doesn’t, rather than where and under what circumstance it works and where and under what circumstances it doesn’t?
- Science based recommendation domains of CA
- Classical definition of CA (simultaneous application of 3 interrelated principles) limits the adoption of CA under many situations as *either one cannot apply all principles or all are not needed simultaneously*
- Research questions - What challenges, at what time scale (short-, medium and long-term), what circumstances (Socio-economic), intended to address??
- What’s the ‘discovery to delivery pathway’?

- Revisit the scope of CA principles for Intensive (double/triple cropping) and irrigated systems of South Asia
- Locally adapted component technologies (seed variety, water, nutrient, weed, pest etc)
Eight Years of CA based Sustainable Intensification of Cereal Systems in NW India: Productivity, Profitability, Soil quality and Environmental footprints

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Productivity (Mg ha(^{-1}))</th>
<th>Irrigation water (mm ha(^{-1}))</th>
<th>Energy requirement (MJ ha(^{-1}))</th>
<th>Net return (USD ha(^{-1}))</th>
<th>Organic carbon (%)</th>
<th>Total GWP (t CO(_2) eq ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional RW</td>
<td>12.40</td>
<td>2557</td>
<td>75225</td>
<td>1361</td>
<td>0.45</td>
<td>6.3</td>
</tr>
<tr>
<td>CA based RW</td>
<td>13.17</td>
<td>1868</td>
<td>57833</td>
<td>1629</td>
<td>0.90</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>(6)</td>
<td>(-27)</td>
<td>(-23)</td>
<td>(20)</td>
<td>(100)</td>
<td>(-22)</td>
</tr>
<tr>
<td>CA based MW</td>
<td>14.09</td>
<td>738</td>
<td>39376</td>
<td>2122</td>
<td>0.84</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>(14)</td>
<td>(-71)</td>
<td>(-48)</td>
<td>(56)</td>
<td>(87)</td>
<td>(-29)</td>
</tr>
</tbody>
</table>

*In parenthesis= % change over conventional system

Source: ICAR-CSSRI-CIMMYT Collaborative Long-term Research platform
Meta analysis: performance (yield and income) of CA in different cropping systems and soil types

Jat et al (Forthcoming)
Meta-Analysis: Alternate Rice Production Systems

A global analysis of alternative tillage and crop establishment practices for economically and environmentally efficient rice production

Debashis Chakraborty, Jagdish Kumar Ladha, Dharamvir Singh Rana, Mangi Lal Jat, Mahesh Kumar Gathala, Sudhir Yadav, Adusumilli Narayana Rao, Mugadoli S. Ramesha & Anitha Raman

Profitable Alternatives to Crop Burning That Can Help Farmers and Reduce Air Pollution

Public cost, public and private benefits of managing residues with different Options

A
- Incorporate + Rotavate
- Incorporate + Plow
- Burn + Disc Harrow
- Bale + Disc Harrow
- Burn + Rotavate
- Bale + Rotavate
- Burn + Zero Till
- Bale + Zero Till
- Happy Seeder
- Happy Seeder + SMS

Subsidies (INR ha\(^{-1}\) year\(^{-1}\))

B
- Burn + Disc Harrow
- Burn + Rotavate
- Burn + Zero Till
- Incorporate + Plow
- Incorporate + Rotavate
- Bale + Disc Harrow
- Bale + Rotavate
- Bale + Zero Till
- Happy Seeder
- Happy Seeder + SMS

GHG Emissions (CO\(_2\)e kg ha\(^{-1}\) year\(^{-1}\))

C
- Burn + Disc Harrow
- Burn + Rotavate
- Burn + Zero Till
- Incorporate + Plow
- Incorporate + Rotavate
- Bale + Disc Harrow
- Bale + Rotavate
- Bale + Zero Till
- Happy Seeder
- Happy Seeder + SMS

Particulates (kg ha\(^{-1}\) year\(^{-1}\))

D
- Burn + Disc Harrow
- Burn + Rotavate
- Burn + Zero Till
- Bale + Disc Harrow
- Bale + Rotavate
- Bale + Zero Till
- Incorporate + Plow
- Incorporate + Rotavate
- Happy Seeder
- Happy Seeder + SMS

Water Withdrawals (m\(^3\) ha\(^{-1}\) year\(^{-1}\))

Shyamsundar, Springer, Tallis, Polasky, Skiba, Jat et al, Science - Under process
No-till Example from Punjab

- 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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No strict imposing ban</th>
<th>Imposing ban without investment</th>
<th>Imposing ban with investment</th>
</tr>
</thead>
</table>

The Power of Technology + Enabling Policy
3. Development/infrastructure related

- CA based machinery needs are entirely different from that of intensive tillage based machinery
  - Supply uncertainty and price issues
- Local CA machinery manufacturing, after sale services and availability of spare parts (SPARES and REPAIRS) are lacking in most parts of the region except that of in parts of north-west India
- Private sector investment in CA machinery manufacturing infrastructure in most parts of the region are lacking
  - Market uncertainty challenges

- Scaling of CA for impact at scale needs infrastructure development on manufacturing of CA machinery through establishment of sub-regional, state level manufacturing hubs for supply of locally adapted and demand driven machinery
4. Knowledge, Capacity & Skill related

- Large knowledge, capacity and skill gap on CA
- Application of CA principles are very site-specific; capacity and skills of stakeholders is critical for successful implementation of CA
- The agronomic management practices for CA still revolves around conventional tillage based systems.
- CA in course curriculum in universities?
- With some exceptions, there are no any practical training course on CA to develop the skills of the range of stakeholders
- No tracking mechanism

- There is a need for reorientation of capacity and skill development programs.
- Developing/strengthening knowledge networks on CA are critical for cross learning and confidence building for scaling.
5. Policy & Investment Priority Related

- Foresight for investments
- Return over investments (RoI) in terms of private as well as public benefits
- The investments on agriculture considering short-term goals and quick-fixes are many a times counter-productive and delimits the scaling of CA
- Investments on more innovative, futuristic and sustainable agriculture technologies such as CA and linking with country commitments such as Sustainable Development Goals (SDGs).
- Subsidy v/s incentives for efficiency
Adapting to Climatic Risks: Direct Seeded Rice

Vaishali, Bihar (2015) - Drought Year
Sustainable intensification in Rainfed systems: Example from Karnataka
Wheat Beats the Heat with CA
No-till Wheat Under Extreme Climate Risks: (Excess Rains at Wheat Grain Filling in 2014-15)
CA in Maize Systems: Adapting to Climate Risks (200+ mm in 3 days in end of June 2017) in Haryana, India

Source: Jat et al (2018)
January 2019: Ludhiana, India
Cost-effective opportunities for climate change mitigation in Indian Agriculture: NRM/CA systems on lead

- Technical Mitigation potential = 85.5 MtCO$_2$e/year
- 40 MtCO$_2$e/year is related to NRM specially CA, nutrient, water mgt
- 80% of mitigation potential achieved via cost saving options

The Future of Food, Farming and Farmer

The CA Cycle

- Reduced chemical load
- Improved soil health
- Reduced weather risks
- Lower GHGs emission
- Energy saving
- Save water
- Efficiency
- Resilience

Returns

Conceptualized by ML Jat
The Theory of Change (ToC) for ‘Transitioning Towards CA Mediated Sustainability’

- Long-term process research- Science Evidence
- Participatory on-farm validation and refinement: backward and foreword integration
- Multi-disciplinary (CA 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
Thank you for your interest!

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