Climate-smart soil protection and rehabilitation in India

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Outline

• Objectives of the CSS project
• CSS evaluation
  • Farm Typology
  • Climate Smartness Assessment (Kalkulator)
  • Biophysical assessment
  • Evaluation of Land Management Options (ELMO)
  • Attainable impact
• CSA prioritization framework
• Recommendations
Objective of the Climate Smart Soils Project

• Assessment of climate smartness of ongoing and potentially suitable alternative agricultural soil conservation practices, including:
  • analysis of farm-level cost-benefit and tradeoffs
  • evaluation of the overall CSA impact and scope
  • adoption and scaling potentials

• Design of a CSA prioritization process

“Agriculture has to be part of the solution to climate change.”
Climate smart agriculture

Triple-win goal – three pillars (FAO 2013):

1. Sustainably increasing agricultural productivity and incomes;
2. Adapting and building resilience to climate change;
3. Climate change mitigation: reducing greenhouse gases emissions, where possible.

"To ensure a food-secure future, farming must become climate resilient."
CIAT's approach to evaluate the climate smartness

Climate Smartness

Outcome Indicators

Adoption potential & Impact

- Identification of farm major farm types
- List of major management practices
- Expert assessment of practices
- Biophysical assessment
- Farm household modeling
- Evaluation of Land Management Options (ELMO)
- Cost-Benefit Analysis
- Attainable impact
- Attainable impact
CSA rapid assessment - methodology

- Stakeholder workshops
- Soil technology shortlist
- Case study farmer interviews
- Input data

Modelling CSA indicators for baselines and scenarios
Modelling of CSA indicators and trade-offs

Calories produced on farm/hectare
- Cash crops and meat not taken into account
- ‘Potential supply’ only

Soil nitrogen balances per farm/hectare
- Simplified, non-holistic indicators

GHG emissions from agriculture per farm/hectare
- Soil C stock changes not included
- IPCC tier 1/2 overestimating for SSA
Farming system types

Factors: intensification, production orientation, commercialization, agro-ecological potential and resource endowment

<table>
<thead>
<tr>
<th>District</th>
<th>Dryland farmer</th>
<th>Dryland diversified farmer</th>
<th>Rice farmer</th>
<th>Specialized irrigation farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmednagar</td>
<td>23</td>
<td>5</td>
<td>7</td>
<td>65</td>
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<tr>
<td>Dhule</td>
<td>50</td>
<td>5</td>
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<td>10</td>
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<td>Jalna</td>
<td>60</td>
<td>35</td>
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<td>5</td>
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<tr>
<td>Yavatmal</td>
<td>15</td>
<td>70</td>
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<td>15</td>
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<tr>
<td>Amaravati</td>
<td>10</td>
<td>75</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Overall project area</td>
<td>5</td>
<td>50</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

CASE STUDY FARMS SURVEYED

Legend
- Dryland diversified farmer
- Dryland farmer
- Rice farmer
- Specialized irrigation farmer
- Towns

Data source: [Source Name]
Shortlisted/tested soil technologies

- Composting, green manure, FYM
- Intercropping, crop rotation, rhizobium
- Reduced tillage and mulching
- System of rice intensification

Stakeholders listed most relevant soil protection and rehabilitation technologies

Picture: Stephanie Malyon, CIAT
Calories produced on farm

- Diversified dryland farmer
- Dryland farmer
- Rice farmer
- Specialized irrigation farmer

AME Days

- Chickpea
- Eggs
- Green gram
- Groundnut
- Horse bean
- Lentils
- Maize
- Mango
- Milk
- Millet
- Moth bean
- Onion
- Pigeon pea
- Rice
- Sorghum
- Soybean
- Vegetables
- Wheat
Nitrogen balance

- Diversified dryland farmer
- Dryland farmer
- Rice farmer
- Specialized irrigation farmer

kg N

Per Farm  Per ha
Soil erosion

Diversified dryland farmer
Dryland farmer
Rice farmer
Specialized irrigation farmer

Soil loss (t soil)

Per farm
Per ha

Soil loss (t soil)
Greenhouse gas emissions

- **Per farm**
  - Diversified dryland farmer
  - Dryland farmer
  - Rice farmer
  - Specialized irrigation farmer

- **Per ha**

Chains of gases:
- Enteric Fermentation
- Manure Management
- Soil emissions (N2O)
- Rice Production

Graph showing the comparison of greenhouse gas emissions in t CO2e/yr per farm and per ha for different farming methods.
Trade-offs: Productivity vs. N balance

![Diagram showing trade-offs between productivity and N balance](image)

- **Composting**
- **Intercropping/rotation + Rhizobia**
- **Reduced tillage + mulch**
- **SRI**

(□=diversified dryland farm, ∆=Dryland farm, ◊=Rice farm, □ with patterns=Specialized irrigation farm)
Trade-offs: Productivity vs. GHG emissions

- Composting
- Intercropping/rotation + Rhizobia
- Reduced tillage + mulch
- SRI

△GHG emissions (t CO2e/ha)

△Productivity (AME days/ha)

□=diversified dryland farm, Δ=Dryland farm, ◊=Rice farm, □ with patterns=Specialized irrigation farm
Biophysical monitoring and evaluation – green gram yields

Assessment of **agricultural performance** of *green gram* in response to various combinations of fertilizers and with or without seeds treated with rhizobia and P-solubilizing bacteria (= bio-fertilizer)

1. **Farmer practice**
   (9 kg P/ha as SSP)

2. **Chemical only**
   (25 kg N + 18 kg P/ha as Urea+DAP)

3. **50 % chemical + 1.5 t/ha vermi-compost**
   25 kg N + 11 kg P/ha)

4. **3 t/ha vermi-compost**
   (25 kg N + 5 kg P/ha)

5. **No fertilizer added**

### Green gram grain yields

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Green Gram Grain Yields (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fertilizer</td>
<td>Without: 600, With: 800</td>
</tr>
<tr>
<td>Farmer Practice</td>
<td>Without: 650, With: 850</td>
</tr>
<tr>
<td>Chemical fertilizer only</td>
<td>Without: 700, With: 900</td>
</tr>
<tr>
<td>50 % Chemical + 1.5 t/ha vermi-compost</td>
<td>Without: 750, With: 950</td>
</tr>
<tr>
<td>3 t/ha vermi-compost</td>
<td>Without: 800, With: 1000</td>
</tr>
<tr>
<td>No fertilizer added</td>
<td>Without: 850, With: 1050</td>
</tr>
</tbody>
</table>

*Source: WOTR & CIAT, unpublished*
Biophysical monitoring and evaluation – $N_2O$ emissions

Measurement and modeling of *nitrous oxide emissions*

![Graph showing biomass, green leaf area, and water stress index](image)

![Graph showing $N_2O$ emissions and precipitation](image)

Sum $N_2O$ emissions, 20 Jun - 11 Sep: 1.7 kg $N_2O-N/ha$
Evaluating Land Management Options (ELMO)

Participatory tool for assessing farmers’ land management (LM) decisions, preferences & trade-offs

1. Identify techniques & attributes to be discussed
2. Record respondent characteristics
3. Define LM techniques & baseline
4. Rank & Score LM costs & input requirements
5. Rank & Score LM benefits & desired outcomes
6. Rank LM advantages & positive attributes
7. Rank LM disadvantages & negative attributes
8. Rank and weight LM alternatives overall

Individual discussions with farmers
Relative importance of advantages & disadvantages of practices

Advantages
- Reduces risk
- Low upfront investment
- Diversifies income
- Multiple benefits
- Quick returns
- Drought protection
- Lasting impacts

Disadvantages
- Can’t see effect
- Too long to reap benefit/gain
- Brings pests & diseases
- Takes land out of production
- Too labour-intensive
- Too expensive

Too labour-intensive
- Bio-fertiliser
- Trees + bunds
- Compost
- Manure

Too expensive
- Bio-fertiliser
- Trees + bunds
- Compost
- Manure

Shows average scoring by farmers
Overall preference of practices

Shows percentage of respondents allocating different ranks to each land management practice.

Shows average weight attributed according to overall preference relative to other land management practices. Note that total exceeds 100%, because interviews cover different combinations of land management practices.
Farmer’s general perceptions and preferences

• **Technical knowhow** poses a major barrier to uptake as many farmers do not have the knowledge that is required to implement practices successfully, and lack the means to access this information.

• **Relative expense** is one of the major concerns when choosing between different practices.

• **Low upfront investment** needs is identified as an important advantage and sought-after characteristic.

• A critical concern is to **secure immediate benefits** in terms of higher crop yields, better food supplies and increased income.
Calculating “attainable impact” across the five districts

1. Number of farm households of each farm type
   ~ rural population / HH-size * farm type %

<table>
<thead>
<tr>
<th></th>
<th>Dryland diversified</th>
<th>Dryland</th>
<th>Rice</th>
<th>Specialized irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadnagar</td>
<td>5</td>
<td>23</td>
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<td>0</td>
<td>15</td>
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2. Adoption rates (% of the HHs likely to adopt the specific intervention) per farm type

   ~ ELCMO: “weight” of composting; others not deemed of interest

<table>
<thead>
<tr>
<th></th>
<th>Composting</th>
<th>Reduced tillage and mulch</th>
<th>Intercropping/rotation and rhizobia</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversified dryland farmers</td>
<td>24</td>
<td>10</td>
<td>10</td>
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<tr>
<td>Dryland farmers</td>
<td>33</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Rice farmers</td>
<td>19</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Specialized irrigation farmers</td>
<td>24</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Calculating “attainable impact” across the five districts

3. Number of adopting farms x estimated impact per farm

<table>
<thead>
<tr>
<th></th>
<th>Composting</th>
<th>I/R &amp; Rhizobia</th>
<th>Reduced T&amp;M</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diversified dryland farmers</strong></td>
<td>373.48M</td>
<td>236.72M</td>
<td>174.42M</td>
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<tr>
<td><strong>Dryland farmers</strong></td>
<td>168.3M</td>
<td>147.32M</td>
<td>93.2M</td>
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<tr>
<td><strong>Rice farmers</strong></td>
<td>74.91M</td>
<td>N/A</td>
<td>67.59M</td>
<td>16.77M</td>
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<tr>
<td><strong>Specialized irrigation farmers</strong></td>
<td>32.91M</td>
<td>32.28M</td>
<td>68.35M</td>
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</table>

At 20% adoption rate:

> 1 billion total AME increase
Importance of expected adoption rates

<table>
<thead>
<tr>
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<th>SRI</th>
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<tbody>
<tr>
<td>Diversified dryland</td>
<td>444.62M</td>
<td>118.36M</td>
<td>87.21M</td>
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<tr>
<td>farmers</td>
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<tr>
<td>Dryland farmers</td>
<td>26.33M</td>
<td>7.05M</td>
<td>4.03M</td>
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<tr>
<td>Rice farmers</td>
<td>71.34M</td>
<td>N/A</td>
<td>33.84M</td>
<td>9.68M</td>
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<tr>
<td>Specialized irrigation farmers</td>
<td>82.99M</td>
<td>16.19M</td>
<td>38.18M</td>
<td>N/A</td>
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</tbody>
</table>

At “ELMO informed” adoption rates:
< 1 billion total AME increase
# Trade-offs with GHG emissions

## AME

<table>
<thead>
<tr>
<th>Farmer Type</th>
<th>Composting</th>
<th>I/R &amp; Rhizobia</th>
<th>Reduced T&amp;M</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversified dryland farmers</td>
<td>144.42M</td>
<td>113.30M</td>
<td>57.22M</td>
<td>N/A</td>
</tr>
<tr>
<td>Dryland farmers</td>
<td>20.34M</td>
<td>7.41M</td>
<td>4.01M</td>
<td>N/A</td>
</tr>
<tr>
<td>Rice farmers</td>
<td>91.32M</td>
<td>N/A</td>
<td>9.04M</td>
<td></td>
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<tr>
<td>Specialized irrigation farmers</td>
<td>60.59M</td>
<td>30.93M</td>
<td>15.06M</td>
<td>N/A</td>
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</tbody>
</table>

## GHG emissions

<table>
<thead>
<tr>
<th>Farmer Type</th>
<th>Composting</th>
<th>I/R &amp; Rhizobia</th>
<th>Reduced T&amp;M</th>
<th>SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversified dryland farmers</td>
<td>2.04M</td>
<td>0.20M</td>
<td>0.23M</td>
<td>N/A</td>
</tr>
<tr>
<td>Dryland farmers</td>
<td>0.9LM</td>
<td>0.00M</td>
<td>0.00M</td>
<td>N/A</td>
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<tr>
<td>Rice farmers</td>
<td>0.25M</td>
<td>0.01M</td>
<td>0.00M</td>
<td></td>
</tr>
<tr>
<td>Specialized irrigation farmers</td>
<td>0.15M</td>
<td>0.00M</td>
<td>0.00M</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Recommendations

• Multi-tools approach to evaluating the climate-smartness of interventions

• Impacts did not only vary by technology, but also farming system. Targeting is key, and rapid quantifications can help to prioritize

• Biophysical data and understanding farmers’ economic perceptions and preferences both valuable and complementary
Thank you!
CSA prioritization framework

1. Scoping
   - Delineate Geographic Area
   - Identify Farm Types
   - Agree on Key Indicators
   - List Practices to Consider:
     - WOCAT Database
     - CSA Compendium
     - Expert Assessment

2. Long List
   - Expert Scoring of Long List of Practices

3. Short List
   - Farm & Household Modeling
   - Biophysical Assessment
   - Cost-Benefit Analysis
   - Evaluation of Land Management Options

4. Portfolio
   - Project Design & Implementation at Scale

Stakeholder Consultation & Workshops