Sustainable Management of Agro-ecological Resources for Tribal Societies (SMARTS) in India & Nepal

Dr. C. Chan
Dr. T. Idol, Dr. C. Ray, Dr. P. Roul, BB Tamang, Dr. K. Pande, B. Paudel, A. Pradhan, J. Halbrendt

19th May 2014
Conservation Agriculture Production Systems (CAPS)

• CAPS concept developed by USAID Sustainable Agriculture and Natural Resource Management (SANREM) Feed the Future Innovation Lab program

• Based on principles of CA practices
  – Minimum soil disturbance
  – Continuous organic soil cover
  – Appropriate crop rotation
The overall goals are to improve:

- Crop yield
- System productivity
- Soil quality
- Probability of adoption
- Capacity building (among students, farmers, Institutions and NGOs)
- Social networking

Also to evaluate effects of CAPS on gender, & nutrition.
India
OBJECTIVES

• To evaluate short-term effects of CAPS on crop yields, system productivity, labor requirements and soil quality and,

• To provide recommendations to the decision makers to promote CAPS
The Study Area:
District of Kendujhar, Odisha, India

- Resource poor tribal people
- Predominantly smallholder, subsistence farmers with <2 ha land per household
- Rely on low input, rain-fed maize based cropping systems
On Station Trials
a) **1st season (June-October):**

4 Treatments, 3 replications and randomized block design

- $T_1$: Conventional tillage with sole maize,
- $T_2$: Conventional tillage with maize + cowpea,
- $T_3$: Minimum tillage with sole maize,
- $T_4$: Minimum tillage with maize + cowpea

• Improved varieties of maize and cowpea

b) **2nd season (November-January):**

Residual effect of 4 treatments (main plot) and direct effect of cover crop treatments (sub plot); split plot design.

- NCC: no cover crop (fallow)
- CC1: Mustard as a cover crop
- CC2: Horse gram as a cover crop
Results

- Treatments and year had no effect on maize yield but had an increasing trend in all except CT-M.
- Cowpea was an additional gain in intercropping plots.

Maize yield (kg ha\(^{-1}\)) by treatments and year
Effect on maize equivalent yield (MEY, kg ha\(^{-1}\))

- There was a significant effect of intercropping on MEY due to gain from cowpea and a better horsegram yield.
Soil

- No significant effect of treatments on many soil properties.
- Tillage had significant effect on water stable aggregates (WSA).
- CT had more significant impact on micro-aggregates while MT had significance on macro-aggregates (resistant to dispersion).

WSA by treatment (0-10) cm
Economics

- 27% of labor saving in minimum tillage over conventional tillage mainly due to reduction in no. of plowings.
- Minimum tillage along with intercropping had higher profitability of $403 ha\(^{-1}\) yr\(^{-1}\) where as conventional tillage with sole maize had less profitability of $311 ha\(^{-1}\) yr\(^{-1}\).
On farm trials
No. of participating farmers:

<table>
<thead>
<tr>
<th>Year\Village</th>
<th>Tentuli</th>
<th>Talachampei</th>
<th>Bayakumutia</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>26</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>30</td>
<td>26</td>
<td>20</td>
</tr>
</tbody>
</table>

- 4 treatments, randomized block design
- Improved varieties of maize and cowpea.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Season</th>
<th>Tillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (control)</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; season (June-October)</td>
<td>Mustard</td>
</tr>
<tr>
<td>T2</td>
<td>Maize + cowpea</td>
<td>Mustard</td>
</tr>
<tr>
<td>T3</td>
<td>Maize</td>
<td>Mustard</td>
</tr>
<tr>
<td>T4</td>
<td>Maize + cowpea</td>
<td>Mustard</td>
</tr>
</tbody>
</table>
On-farm (Rainy season)
On farm
(Post-rainy season)
Market View

Officials visit to on farm trials
Results

- Tillage and intercropping had no significant effect on maize yield.
- Intercropping had an significant effect on mustard yield.

Higher profitability of minimum tillage with intercropping (9.69%) over conventional tillage with sole maize ($386 ha\(^{-1}\) yr\(^{-1}\)).
Stakeholder preference mapping
High preference for soil quality over profit and yield
Preference for CAPS 3 (maize + cowpea – MT) indicates perceived advantages of intercropping and minimum tillage.
Nutritional Security to tribal Farm families

Dioscorea Sp. plantation in backyards
Capacity building

- Training to 66 farmers (42 male and 24 female) on tillage, harvesting, post-harvest and crop residue management.
- 44 participants (26 male and 18 female) were exposed with tools of water stable aggregate, technology network, and fuzzy cognitive mapping.
- One District level workshop on maize-based conservation agriculture involving 80 participants (30 female, 50 male) *viz.* farmers and extension personnel was organized to deliver effect of maize-cowpea CAPS for sustainable tribal farming.
- 300 participants involving faculties & students, scientists, and Government of Odisha officials attended the workshop on conservation agriculture.
- 600 farmers from different districts of Odisha attended the farmer-scientist interaction section on "Soil health management through conservation agriculture".
- 1 student (PhD) from India in UH and 9 students (MS) in India
Focus group discussions
Networking

- Inclusion of SANREM FtF Innovation Lab in Cereals Systems Initiative for South Asia (CSISA) stakeholder consultation.

- a write up about SMARTS educational component will be featured on US India Education Foundation (USIEF) website.

- Kendujhar district department of agriculture and Agricultural Technology Management Agency (ATMA) approved a proposal to replicate minimum tillage and maize-cowpea intercropping in 500 ha of potential maize area.

- Mayurbhanj district has adopted in 1000ha with govt. funding.

- 3 leaflets (including 2 in local language) had been published.

- 7 abstracts and 16 presentations in different conferences, workshops and symposiums.
MEDIA COVERAGE

Bhubaneswar: A sustainable conservation agriculture system, being jointly implemented by Orissa University of Agriculture and Technology (OUAT) and University of Hawaii, the USA, has evoked encouraging response from farmers in Keonjhar where it is being piloted.

Hundreds of local farmers gathered at a camp held at Tenthali in Swabhumi block of Keonjhar district on Thursday to highlight the usefulness of conservation agriculture production system (CAPS) farming practices under the project – Sustainable Management of Agro-ecological Resources for Tribal Societies (SMARTS). OUAT had launched the project in June to improve soil health and hence productivity. The project focused on maize-based cropping systems involving legumes and mustard and horse gram as cover crops with residue management. Twenty households were involved in the process of on-farm validation of selected CAPS.

During the camp, local farmers were informed about the harvesting and post-harvest management process of mustard grown as cover crop after maize by agro scientists. The farmers provided the crops which boosted their experience with the experts.

Training camp for farmers in Keonjhar: A one-day training camp for farmers was organized in Tenthali village of Banspal block in Keonjhar district to highlight the usefulness of conservation agriculture production system (CAPS) in the tribal pockets of the district. The camp was organized as part of the sustainable management of agro ecological resources project, a collaborative research of OUAT and University of Hawaii (USA) for improving the farm income of tribal farmers with maintenance of soil health. The project emphasizes on maize-based cropping system involving vegetable cowpea as intercrop in rainy season followed by mustard under residual soil in post-rainy season.
Workshop

Inauguration of CAPS leaflet

Presentations
Threats

Earthen check dams

Farmer groups to protect crops from elephant

High runoff

Elephant invade

Elephant watch tower
Challenges

- Cowpea damage due to closer spacing in case of on farm trials.
- Early season drought during maize sowing.
- Only cover cropping is not acceptable to farmers.
- Cover crop (Mustard) crop was badly affected by Cyclone ‘Phailin’
- Farmers have no preference for Crop residue recycling

Actions

- On station experiment to find out optimum spacing options
- Change of cowpea variety
- Re-sowing and gap filling to maintain the plant population.
- Dual purpose (Economic yield + Cover crop) mustard was suggested
- On-farm threshing of mustard for residue recycling
Crop Residue Handling

Polythene sheet for on field mustard threshing
Development impacts

- Technologies being tested have potential for increasing profitability of the tribal farmers
- CAPS research started by OUAT is sole government owned institute for formal agriculture training
- Tools to bridge the gap in understanding about CAPS among the stakeholders
- Gradual adoption of CAPS technologies both at local farmers and district administrative level
CA Adoption in other areas of Kendujhar

Adoption in another district Mayurbhanj
CAPS Presentation before state level officials
Nepal
Nepal: study sites

Thumka village - Gorkha
Hyakrang village - Dhading
Kholagaun village - Tanahun

Research sites

25 farmers’ fields from 3 villages
Situation analysis

• **Problems of poverty and food insecurity**
  + 90% hill districts are in food shortage

• **Push for Intensification**
  + high food demand (about 2% pop. growth)
  + limited arable land (per capital 0.09 ha)
  + low crop yields (≈ half of world average)

• **High land degradation and challenges for sustainability**
  + intensification
  + sloping land
  + no conservation practices

• **Climate change**
  ➢ increased climatic variations, increased challenges
OBJECTIVES

• To evaluate short-term effects of CAPS on crop yields, system productivity, labor requirements, soil quality, gender and nutrition.

• To provide recommendations to the decision makers to promote CAPS
On-farm evaluation

1. Selection of CAPS through focus groups
   ✗ Two tillage type: strip tillage (ST) & full tillage (FT)
   ✗ Two crop rotation \{summer-post rainy season\}
   CAPS1: FT maize-legume
   CAPS2: FT maize-millet+legume
   CAPS3: ST maize-millet+legume

   Legume crop for CAPS:
   2011- cowpea; 2012 & 2013 – black gram

2. Traditional system: FT maize-millet
Other studies

- Gender impacts of CAPS using gender survey
- Information network of CAPS using Social Network analysis
- Farmers preference for CAPS using Analytical Hierarchy Process (2 times)
- Mental mapping of farmers using cognitive survey
- Economic modeling study to estimate the impacts
Crop yields significantly different by CAPS

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Maize (ton/ha)</th>
<th>Millet (ton/ha)</th>
<th>Black gram (ton/ha)</th>
<th>Cowpea (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (Y)</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Village (V)</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CAPS (T)</td>
<td>**</td>
<td>***</td>
<td>***</td>
<td>**</td>
</tr>
<tr>
<td>Y x T</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>V x T</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Y x V</td>
<td>***</td>
<td>***</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Field (village)</td>
<td>**</td>
<td>**</td>
<td>*</td>
<td>**</td>
</tr>
</tbody>
</table>

***, **, * indicate the factor were significant at P<0.001, P<0.01, P<0.05; NS indicate factor was not significant at p<0.05
Higher maize yield in CAPS

Maize yield from CAPS1 was higher than traditional system and CAPS3 over three years

Average maize yield from CAPS treatments, 2011-2013
Lower millet production in CAPS

Millet production in traditional system was higher than CAPS2 & CAPS3 b/c of sole cropping

Average millet yield from CAPS treatments 2011-2013

Yield (ton/ha)

2011 2012 2013
Higher legume production in CAPS

Black gram and cowpea yields in -
• CAPS1 was higher than CAPS2 and CAPS3 because of sole cropping

Average yield of cowpea and blackgram in CAPS treatments, 2011-2013

- Year and crop
- Yield (ton/ha)
- 2011 (CP)
- 2012 (BG)
- 2013 (BG)
- CAPS1
- CAPS2
- CAPS3
System productivity significantly different by CAPS

### ANOVA

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Maize Yield Equivalent (maize ton/ha)</th>
<th>Annual Revenue ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (Y)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Village (V)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CAPS (T)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Y x T</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>V x T</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Y x V</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Field (village)</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

***, **, * indicate the factor were significant at P<0.001, P<0.01, P<0.05; NS indicate factor was not significant at p<0.05
Higher MYE from CAPS

- CAPS1 and CAPS2 was higher than traditional system
- CAPS3 was not different from all other treatments

CAPS with ST system did not produce significant yield advantage

Average MYE produced from treatments of on-farm trial, 2011-2013
CAPS increased annual revenue

- CAPS1 & CAPS2 was higher than traditional system
  - higher price of legumes

- CAPS3 was comparable to traditional system
Labor requirement significantly different by CAPS

Factors in ANOVA (Randomized block design)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Total labor requirement (human.days/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year (Y)</td>
<td>***</td>
</tr>
<tr>
<td>Village (V)</td>
<td>**</td>
</tr>
<tr>
<td>CAPS (T)</td>
<td>***</td>
</tr>
<tr>
<td>Y x T</td>
<td>**</td>
</tr>
<tr>
<td>V x T</td>
<td>***</td>
</tr>
<tr>
<td>Y x V</td>
<td>NS</td>
</tr>
<tr>
<td>Field (village)</td>
<td>**</td>
</tr>
</tbody>
</table>

***, **, * indicate the factor were significant at P<0.001, P<0.01, P<0.05; NS indicate factor was not significant at p<0.05
Lower labor required for CAPS1, while higher labor required for CAPS2 & CAPS3.

CAPS1 required lower labors than all other treatments because of low labor need for legumes.

CAPS2 & CAPS3 required higher labor than traditional system and CAPS1.
CAPS improve soil quality?

- SQI= f (BD, K, N, OM, pH) determined by PCA analysis
  1=best, 0=worst
- Soil Quality Index not different by CAPS
- SQI significantly increased from 2012 to 2013 for all CAPS but not for traditional system
Summary from on-farm trials

✓ FT Maize-legume: highest returns & lowest labor req.
✓ FT Maize-millet+legume: higher return & higher labor
✓ ST Maize-millet+legume:
  ▪ Lower return & higher labor than maize-legume
  ▪ Still better than traditional system
✓ Returns from ST was comparable to FT, but labor requirements was lower (under maize-millet+legume)
✓ For soil quality, all CAPS seems better than traditional system, though need more time to conclude
Gender Studies

Studies were conducted to:

• Determine the gender-based division of labor and time allocation for agricultural activities
• Measure expected shifts in labor from CAPS were also determined
• Determine gendered preferences for CAPS treatments
• Assess gender inclusion in agricultural decision-making
• Women spend 21.4% of their time on agriculture, while men spend 20.2% of time on agriculture.
Shifts in Division of Labor Resulting from CAPS

- T2 to T3 (legume intercrop w/ full till) resulted in the greatest labor increases for women
- T1 to T4 (legume intercrop w/ strip till) resulted in the least change to the division of labor
- Land preparation, sowing, and harvesting were the overall drivers for increased labor
• For both men and women, labor savings (+ values) are expected during land preparation, fertilization, and weeding for maize and legumes
• Labor increases (- values) are expected during harvest
• In general, women experience greater labor savings, as well as greater increases in labor over the course of the cropping season
Both men and women placed high priority on yield, however men placed the 2nd priority on soil quality and women placed the 2nd priority on profit.

The preferred CAPS treatments for men and women, T2 & T3, both use full tillage and legume cultivation, meeting the simultaneous goals of yield, profit, and soil quality.
Gender-based Agricultural Decision-Making

- While the majority of agricultural decision-making is conducted equally (60.5% men, 46.2% women), a large proportion of women reported only “some” (28.2%) or “no control” (23.1%) over on-farm decision-making.

- Given that women take on a larger proportion of CAPS labor, there is a disconnect between those making decisions and those affected by those decisions (i.e. increased labor).
Cognitive Modeling Study

• Cognitive modeling was used to determine differences in researcher and farmer perceptions of the agricultural system.

• The models were used to predict perceptions of conservation agriculture practices and their perceived outcomes.
Cognitive Modeling: Perception Gaps

- **Red boxes** indicate factors of the farm system where perceptions differed from the other study groups in regards to minimum tillage (out of 20 total factors).
- **Hyakrang and Khola Gaun** showed the most differences from the Researcher group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Soil Nutrients</th>
<th>Soil Moisture</th>
<th>Soil Quality</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khola Gaun</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hyakrang</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thumka</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researchers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Variations in soil structure, texture, and composition can in part contribute to differing perceptions of the relative importance of soil within the system.
- This can lead to differences in adaptive management strategies and decision-making over time.
Impact on nutrition and health

• Study was undertaken in the Chepang communities of Nepal
  – Household with children (6 to 60 months) or women-divided in 3 categories
    1. Change in agriculture practice (project intervention)
    2. Got some training and input supplies
    3. NO intervention from this project
  – Selected households were interviewed using structured questionnaires for
    • agriculture practices, health, nutrition and sanitation related knowledge, attitude and practices.
Impact on nutrition and health

• Results shows that:
  – Food consumption behavior of women, children and households did not differ significantly among different types of households.
  – Nutritional status of children based on weight/height was significantly related with the agricultural diversity and the production of legumes.
  – Total Household income, Land holding and Household dietary diversity were significantly related with the body mass index of women.
Impact on nutrition and health

• It can be concluded that:
  – Project intervention increased agricultural production, including legumes
    • Majority of produce were sold than consuming
      – Positive contribution to household income
      – Less impact on nutritional status
  – Various indicators evaluated in this study were not found significantly different among different types of households.
    • mixed farming system using legume as a crop had some positive impacts on some nutritional-health indicators of children.
Farmers preference and incentives for adoption of CAPS

- enhancing crop yields is the most important factor, while labor saving is the least important
- farmers have low preference for strip tillage based CAPS, because of knowledge gap
- profitability of all CAPS are better than traditional system
- farmers’ production constraints do not hinder the adoption of CAPS.
Training & capacity building

- farmers from 101 households in 3 villages have taken multiple trainings (CAPS, IPM, soil and water management, etc.)
- about 20 farmers got exchange visits to research stations
- 2 visits for extension personnel to demonstration plots
- 5 research methods trainings to home country students and professionals
- 4 capacity building visits to host country Co-PIs and professionals
- 3 MS students (all graduated) & 1 Ph D student (expected to graduate by April 2015) from host country;
- students supported to participate in scientific conferences such as F-CASA, IFAMA, HumTech
- a conference titled ‘Frontiers of Conservation Agriculture in South Asia and Beyond (F-CASA)’ on 26-27 March 2013 in Kathmandu, Nepal (23 papers & 12 posters)
- a book is forthcoming
Development impacts

• The adoption of maize-legume system is already started (even before the project). However, the integration of millet+legume intercrop expected to improve the food security of Chepang people.

• Not much adoption of intercropping and strip tillage. However, farmers have appreciated millet+legume more than strip tillage system.

• Farmers groups in the adjoining areas of the project sites and other project sites of LI-BIRD and partner organizations are interested in receiving training on CAPS practices.

• Opportunity to use CAPS as technology for climate change adaptation is being explored by tying up the results with other LI-BIRD projects in 8 more districts.
Ongoing works

• Continuation of the on-farm trials for 4\textsuperscript{th} year
• We have started to implement two potential CAPS on larger (whole terrace) scale:
  -- ST maize-millet
  -- ST maize-millet+legume

The implementation of these CAPS will be done by using local plough on the entire terrace.
Thank you !!