Smallholder Adoption of Conservation Agriculture and GHG Reduction Potential in Mozambique and Lesotho

D.M. Lambert\textsuperscript{1}, W. McNair\textsuperscript{1}, D. O’dell\textsuperscript{1}, E. Bisangwa\textsuperscript{1}, T. Simone\textsuperscript{1}, N. Eash\textsuperscript{1}, M.D. Wilcox\textsuperscript{2}

F. Walker\textsuperscript{1}, M. Marake\textsuperscript{3}, C. Thierfelder\textsuperscript{4}

\textsuperscript{1}University of Tennessee Institute of Agriculture

\textsuperscript{2}Purdue University

\textsuperscript{3}National University of Lesotho

\textsuperscript{4}International Maize and Wheat Improvement Center, CIMMYT

\textsuperscript{3}Department of Soil Science

\textsuperscript{4}Harare, Zimbabwe

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The views expressed here are those of the authors.

ACKNOWLEDGEMENTS
Background

- *Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa*
- Lesotho and Mozambique
- Five year project
  - Identify optimal input management regimes for CA systems
  - Characterize C:N soil/cover crop interactions
  - C sequestration potential of CA systems
  - CA adoption, income, and maize marketing
  - Maize production, input use and CA adoption
Mozambique profile*

• Ag sector employs 90% of the population
• Average farm size: 2.4 ha
• 98% of production occurs on farms less than 5 ha
• 16% of labor for agricultural production is hired
• 11% of the farmland cultivated with tractors or animal traction
• Maize yields range between 0.4 and 1.3 Mt ha\(^{-1}\)
• 4% of farms use fertilizer
• When fertilizer used, typically under-applied at 3.2 kg ha\(^{-1}\).
• Estimated loss of 51 kg ha\(^{-1}\) yr\(^{-1}\) on tilled plots

*Mozambique Ministry of Agriculture, 2008
FARMING TO THE EDGE…

PRIVATE ACTIONS

LOCALIZED EXTERNALITIES

COMPETING FOR LIMITED RESOURCES…

SYSTEMATIC “MACRO” EROSION

SEASONAL WEATHERING & EROSION…
Two points of view (among many...)

Malthus

Boserup (Conditions of Agricultural Growth, 1965)
Conservation agriculture

Actions:

- Reduced, minimal, and no-till
- Residue management
- Intercropping and crop rotation

Expected Outcomes:

- Improve soil fertility
- Less yield variability
- Food security
- Surplus
- Moderate erosion
- Sequester carbon

Source: FAO
Demonstration plots

Tete, Manica, and Sofala Provinces, Mozambique 2008 – 2011

- Demonstration plots (CIMMYT/USAID, IFAD)
- Check, Basins, Jab planter
- Maize/cowpea rotations
- N = 638 farmers, 22 villages
- NPK/Urea (all plots)
- Herbicide on CA plots
Net returns: conventional tillage treatments and CA planting technologies, Mozambique, 2008 – 2011 (N = 631 farms)

<table>
<thead>
<tr>
<th>Net returns (USD ha(^{-1}))</th>
<th>Control</th>
<th>Basin</th>
<th>Jab planter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>104</td>
<td>148</td>
<td>195</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>452</td>
<td>478</td>
<td>499</td>
</tr>
<tr>
<td>CV</td>
<td>435</td>
<td>323</td>
<td>257</td>
</tr>
</tbody>
</table>

----H\(_0\): distributions not different*----

| Control | 0.07     | 0.12   |
|         | (0.0776) | (0.0002) |

*Kolmogorov-Smirnoff test; D-statistic (p-value)
Bowen’s Ratio Energy Balance and CO₂ flux: no-till/residue management and conventionally managed fields
No-tillage and tillage GHG profiles

CO₂ emissions

Lost

Sequestered

Cumulative carbon emission

Till: 2.31 kg ha⁻¹ day⁻¹
No-till: 2.22 kg ha⁻¹ day⁻¹

Trend difference: 
\( \Delta \text{diff}/\Delta t \approx 0.0071 \text{ Mt ha}^{-1} \text{ day}^{-1} \)
Mozambique Household Survey
March 16-31, 2012
Tete, Manica Provinces

10 enumerators from provinces; 2 females/8 males

Sample 10% of 5,265 households (HH)

8% M.O.E. (95% CI)

Stratified sampling of villages
Exposed/CA (204 HH)
Exposed/Non-CA (3,001 HH)
Unexposed (2,244 HH)

Systematic sampling
| Profile | | N |
|---|---|
| Distribution of groups: | | |
| Adopters | 27% | 153 |
| Abandoners | 3% | 15 |
| Conventional farmers | 70% | 383 |
| Aware of conservation agriculture | 44% | 553 |
| Participated in farmer groups before adoption | 58% | 149 |
| Years conservation agriculture practiced | 3.2 (0, 15) | 151 |
| Increased planting area, 2011-2012: | | |
| Conventional plots | 45% | 67 |
| Conservation agriculture plots | 55% | 82 |
| Plan to manage additional area under CA, 2013 | 95% | 148 |
Input use

Herbicide

- CA: 6% Yes, 14% No
- Conv: 2% Yes, 36% No

Herbicide source from a project

- CA: 9% Yes, 11% No
- Conv: 2% Yes, 32% No

Fertilizer

- CA: 15% Yes, 19% No
- Conv: 11% Yes, 28% No

Fertilizer source from a project

- CA: 15% Yes, 18% No
- Conv: 11% Yes, 28% No

Local seed varieties

- CA: 5% Yes, 67% No
- Conv: 27% Yes, 37% No

Seed from a project

- CA: 15% Yes, 13% No
- Conv: 27% Yes, 37% No

Tete
Barue
Labor constraints, training, and credit

**Labor bottleneck: land preparation**

- Tete: CA 4%, Conv 16%
- Barue: CA 13%, Conv 38%

**Labor bottleneck: weeding**

- Tete: CA 4%, Conv 16%
- Barue: CA 20%, Conv 60%

**Labor bottleneck: planting**

- Tete: CA 3%, Conv 17%
- Barue: CA 1%, Conv 38%

**Hired labor**

- Tete: CA 5%, Conv 15%
- Barue: CA 19%, Conv 25%
Training, credit, and project support

Agricultural training
- CA Tete: 18% Yes, 2% No
- Conv Tete: 67% Yes, 13% No
- CA Barue: 34% Yes, 5% No
- Conv Barue: 52% Yes, 10% No

Loan
- CA Tete: 18% Yes, 2% No
- Conv Tete: 76% Yes, 4% No
- CA Barue: 28% Yes, 10% No
- Conv Barue: 51% Yes, 11% No

Inputs from project
- CA Tete: 18% Yes, 2% No
- Conv Tete: 55% Yes, 9% No
- CA Barue: 29% Yes, 38% No
- Conv Barue: 24% Yes, 29% No
Adoption patterns by practice: 3 or more consecutive years, 2008-2011

Barue
- No-till: 94% (n = 185)
- Residue mgt.: 75% (n = 185)
- Crop rotation: 67% (n = 185)

Tete
- No-till: 81% (n = 372)
- Residue mgt.: 55% (n = 372)
- Crop rotation: 75% (n = 372)
## Probability of continuous use (3 – 4 year period)

<table>
<thead>
<tr>
<th>Practice (dependent variables)*</th>
<th>Respondent attributes</th>
<th>Household characteristics</th>
<th>Farm management</th>
<th>Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>Household Head Age</td>
<td>Size</td>
<td>Herbicide use</td>
<td>Distance to market</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>Household Head Sex</td>
<td>% age 15-65</td>
<td>Fertilizer use</td>
<td>Labor shortages: land preparation</td>
</tr>
<tr>
<td>Residue management</td>
<td>Education</td>
<td>% staple produced</td>
<td>Seed variety</td>
<td>Labor shortages: weeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Farm size</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female primary vendor</td>
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<td></td>
<td>Livestock</td>
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<td></td>
<td></td>
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<td></td>
<td>HH net maize seller</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Distance to fields</td>
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<td>Ag. Training</td>
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<td></td>
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<td></td>
<td></td>
<td>Hired-in labor</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Barue</td>
</tr>
</tbody>
</table>

*Continuous practice for 3+ years, 2008 - 2011
No-till adoption: credit, herbicide/fertilizer use

Pr(Adopt no till, 2008-2011 = 1)
Female headed households

<table>
<thead>
<tr>
<th>Credit</th>
<th>Herbicide/Fertilizer Use</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>No loan</td>
<td>No herb</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>34%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>89%</td>
</tr>
</tbody>
</table>

Pr(Adopt no till, 2008-2011 = 1)
Male headed households

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<tbody>
<tr>
<td>No loan</td>
<td>No herb</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Herb</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>4%</td>
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<tr>
<td></td>
<td>Herb</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>No herb</td>
<td>11%</td>
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<td></td>
<td>Herb</td>
<td>40%</td>
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<td></td>
<td>No herb</td>
<td>27%</td>
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<td></td>
<td>Herb</td>
<td>67%</td>
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<td>Herb</td>
<td>34%</td>
</tr>
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<td>No herb</td>
<td>73%</td>
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Conservation agriculture adoption and hectares managed: Tete and Barue, Mozambique area survey

Farmer adoption

- New adopters
- Previous adopters
- 1.2 new adopters: 1 adopter

Hectares

- New area
- Previous area

1,135 ha (year 2039)

3,405 ha (year 2043)

1,753 ha (year 2054)

5,261 ha (year 2060)
Directions

• Additional C measurement collection
  – Plant growth stages
  – Cover crops (wheat, vetch, oats)

• Conservation agriculture technology and on production efficiency

• Adoption of CA technology, maize production, and participation in local maize markets

• Input use, maize production, and adoption of CA technology