Modeling and mapping village futures

Mary Ollenburger
mary.ollenburger@umces.edu
Bougouni District, Mali

- Good climate for agriculture
- Low population density
  - about 25 people per sq. km.
- Most people are farmers
  - They self-identify as farmers
  - Usually have add’l income source
    - e.g. small shops, gold mining, temporary migration
- Incomes hard to estimate but typically near $1.90/day PPP (‘’extreme poverty’’)
Research Question

How can farmers make a living?
…in the place where they live
…while protecting the environment
3-stage process

- Scenario development
  - Introductory meeting: Village histories
  - Demographic groups: looking to the future

- Land Use Game
  - Role-playing board game farmers can play

- MaliSENE Model
  - Agent-based model of land use change
Defining scenarios

- How is the land around the village used now? How might that change?
Village landscape
Defining scenarios

• How is the land around the village used now? How might that change?
• What will be different in 25 years? What will the village look like? What will people do?
Agricultural changes mentioned

• Mechanization
  • allow farmers to cultivate more land
• Tree crops
  • cashew, mango
• Reduced reliance on cotton
Defining Scenarios

• Based on identified agricultural changes
  • Tractor subsidy program
  • More opportunity to plant cashew trees

• Population growth and migration included, but not varied
The Land Use Game
The Land Use Game

• Five farmers (players) with different starting asset levels
• Land cultivated limited by draft power
• Each turn is one three-year rotation (cotton-maize-groundnut)
• Productivity declines unless land is fallowed
• Trees can be planted on fallow land
• Wealthiest farmer purchases a tractor in turn 2
How do people play?

• Fallowing
  • after 6 years productivity declined
  • planted trees, continued growing food crops for first 3 years
  • farmers discussed the best strategy and all followed the same one

• Tractor owners rented out at or near cost

• Slight expansion in food crop land
• Larger increase in tree crop land
• Land distribution became more equal
• Investments made in livestock despite lack of return (savings)
What do we learn?

• Cultivation of staple crops continued even when less profitable than tree crops
  • risk-aversion, lack of trust in markets
• Land can fill up!
  • current abundance makes this hard to imagine
• Is it important to ‘reserve’ land for livestock?
• Are these game boards plausible?
  • In Sibirila: yes—people already plant cashew
  • In Dieba: no—some people will plant trees but not as many as in the game
Agent-based models

- Environment
  - Space (the game board)
- Step
  - Time increment (a turn)
- Resources
  - stuff (land, draft animals, crops...)
- Agents
  - stuff that can interact (players)
- Interactions
  - relationships among resources and agents (game rules, player decisions about what to plant where)
MaliSENE Agent-Based Model

• Same concepts as the game
• The computer model lets us have a lot more agents and runs much faster
• But decisions determined by programming, not by real people
Environment – quantified landscape

Community map

Elevation and slope

Landsat classification
Environment – quantified landscape

Community map

Elevation and slope

Landsat classification

Model “board”
Model structure
Model structure

Owner

- Tractor
- Oxen

Cultivation capacity

Purchase

Wealth and assets

Purchase

Income

Move
Expand

Manage
Harvest

CropPlot

TreePlot

Land

Potential
Scenarios tested

• Tree planting preference:
  • Low (0.03), Medium (0.3), High (0.8)

• Tractor availability:
  • For purchase:
    • Not available (infinite price)
    • Subsidized (half price)
    • Unsubsidized (full price)
  • For rental only

• Factorial combinations -> 12 scenarios
Indicators used

- Income – household and village level
- Inequality within village
  - income and land
- Village-scale land use change
- Field ages and land use distributions
  - increased field ages or decreasing land suitability in cropped areas may indicate land degradation
### Annual income per person (US$, average)

<table>
<thead>
<tr>
<th>Tree planting preference:</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor types:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>170</td>
<td>826</td>
<td>1632</td>
</tr>
<tr>
<td>Subsidized</td>
<td>170</td>
<td>814</td>
<td>1484</td>
</tr>
<tr>
<td>Unsubsidized</td>
<td>170</td>
<td>819</td>
<td>1589</td>
</tr>
<tr>
<td>Rental</td>
<td>406</td>
<td>1278</td>
<td>2458</td>
</tr>
</tbody>
</table>

Initial value: US$ 190 per person

In low tree preference scenarios no agent could afford a tractor
Inequality in year 20

- Income:
  - Initial GINI coefficient 0.614
  - Final GINI coefficients generally lower
    - Lowest final:
      - High tree planting/subsidized tractors - 0.483
    - Highest final:
      - No trees/tractors: 0.670

- Land
  - Initial GINI coefficient 0.411
  - Little change between initial and final values
Land use distribution – year 0
Land use distribution – year 20

Ref – year 0
Land use change

- Baseline (no tractors, low tree preference) shows little change
- Annual crop areas similar in all tree preferences
- Minimal effect of tractor subsidy
Land suitability and field ages

• Land suitability
  • Expansion onto unsuitable land beginning around 40% of area cropped

• Increase in field age
  • Lower field ages in high tree planting scenarios – trees provide incentive for falling
  • Increase in field age often accompanied by higher input use, reducing degradation
Improving livelihoods

• Mechanization and new crops have the potential to dramatically change farmers livelihoods
• High-value, low labor crops, with low initial investment costs, provide widespread benefits
• Improving access to credit is more effective than subsidization
Sustainable extensification?

• Some land expansion is inevitable
• Perennial tree crops may mitigate impact of expansion while broadly improving incomes
• Mechanization improves incomes, but leads to expansion of area in annual crops
Thank You

Ken Giller, Katrien Descheemaeker, Todd Crane
ICRISAT Mali
AMEDD Mali
Institut d’Economie Rurale
FENABE Bougouni
The McKnight Foundation
USAID-AfricaRISING
Farmers in Sibirila, Dieba, Flola, Madina, Sorona, Banco, and Kodialan