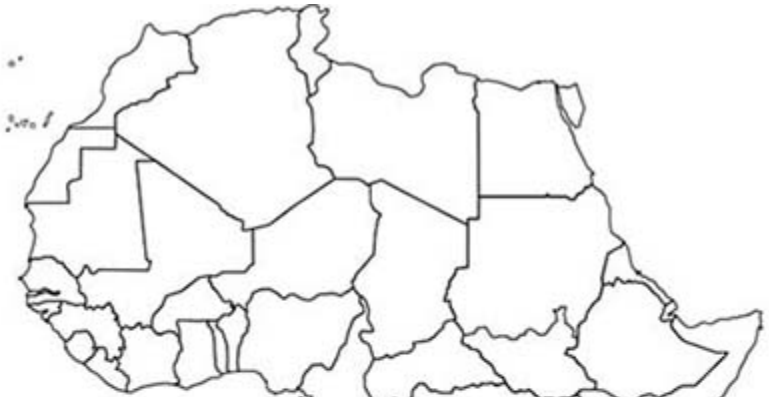
Modeling and mapping village futures

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

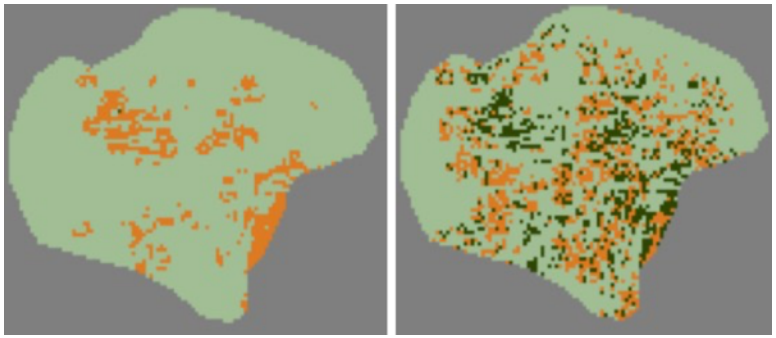
How can farmers make a living?

…in the place where they live

…while protecting the environment

3-stage process

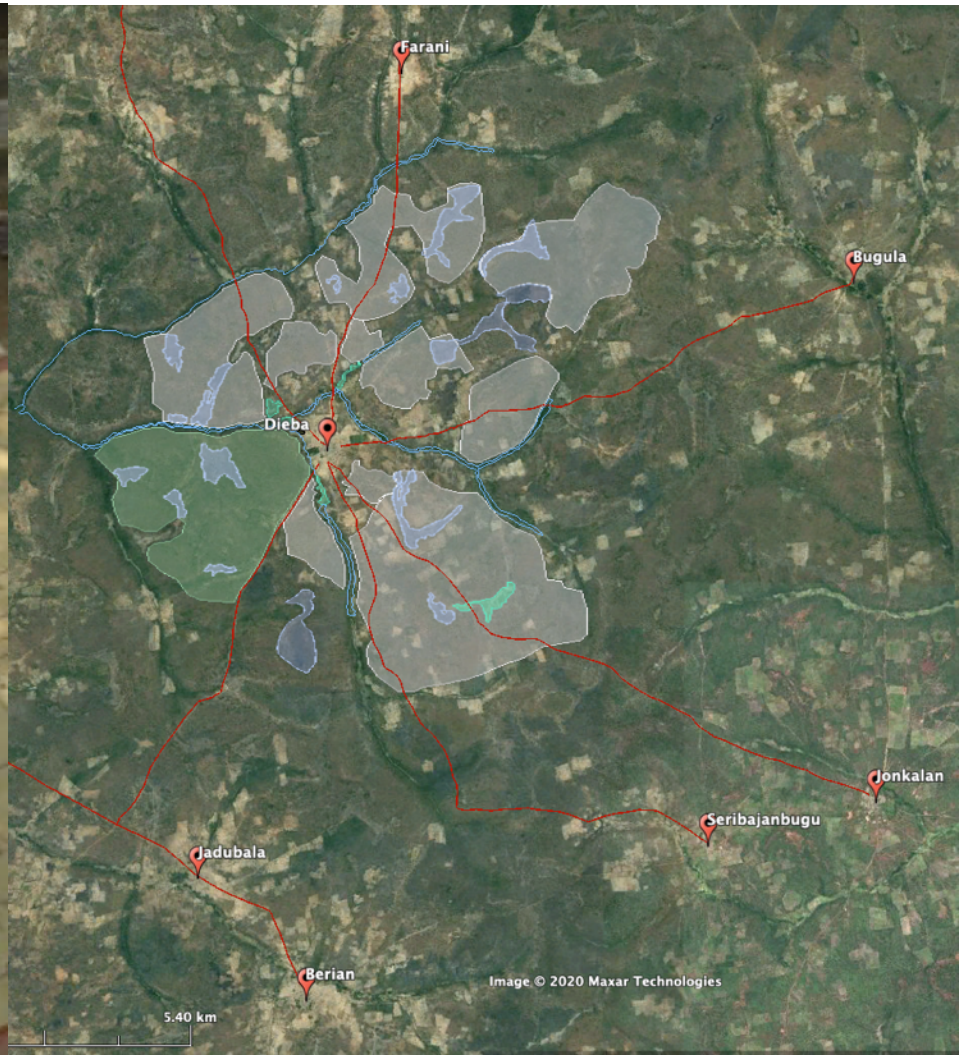
- Scenario development
  - Introductory meeting: Village histories
  - Demographic groups: looking to the future
- Land Use Game
  - Role-playing board game farmers can play
- MaliSENE Model
  - Agent-based model of land use change



Defining scenarios

- How is the land around the village used now? How might that change?

Village landscape



Defining scenarios

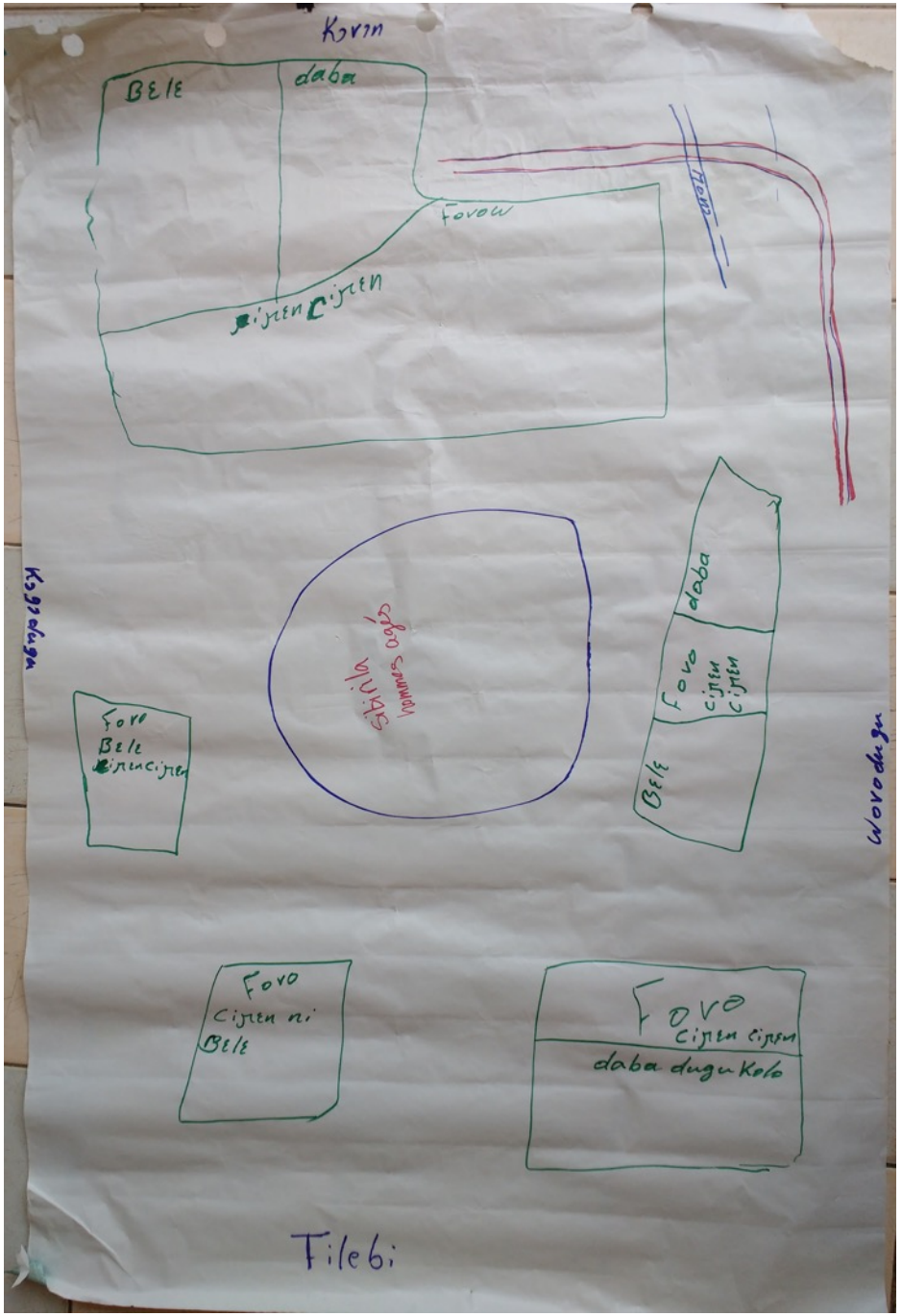
- How is the land around the village used now? How might that change?
- What will be different in 25 years? What will the village look like? What will people do?

Agricultural changes mentioned

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

Defining Scenarios

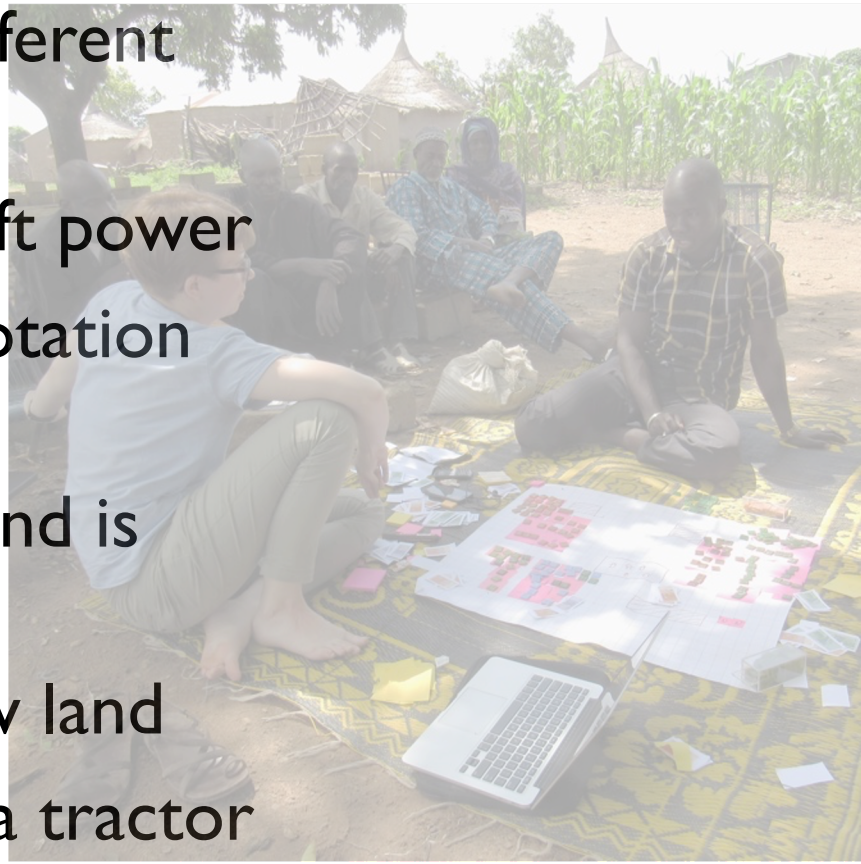
- Based on identified agricultural changes
  - Tractor subsidy program
  - More opportunity to plant cashew trees
- Population growth and migration included, but not varied



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

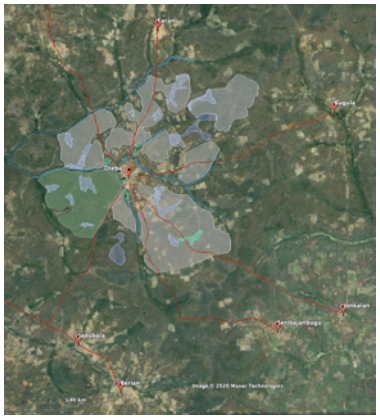
- Environment
  - Space (the game board)
- Step
  - Time increment (a turn)
- Resources
  - stuff (land, draft animals, crops...)
- Agents
  - stuff that can interact (players)
- Interactions
  - relationships among resources and agents (game rules, player decisions about what to plant where)

MaliSENE Agent-Based Model

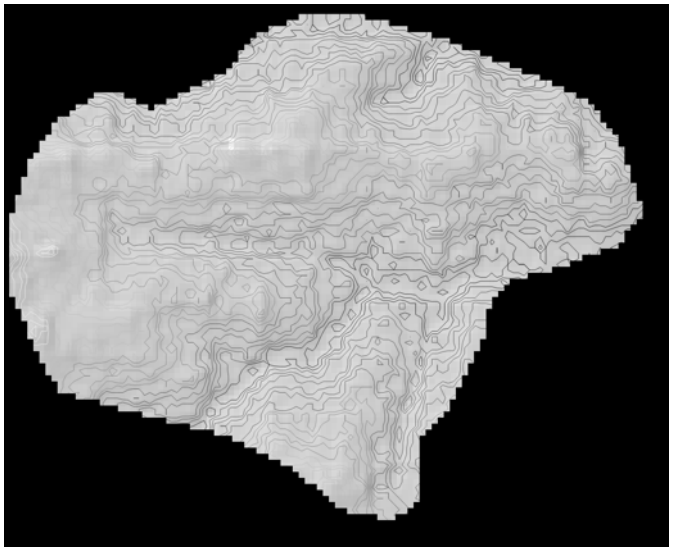
- Same concepts as the game
- The computer model lets us have a lot more agents and runs much faster
- But decisions determined by programming, not by real people

Environment – quantified landscape

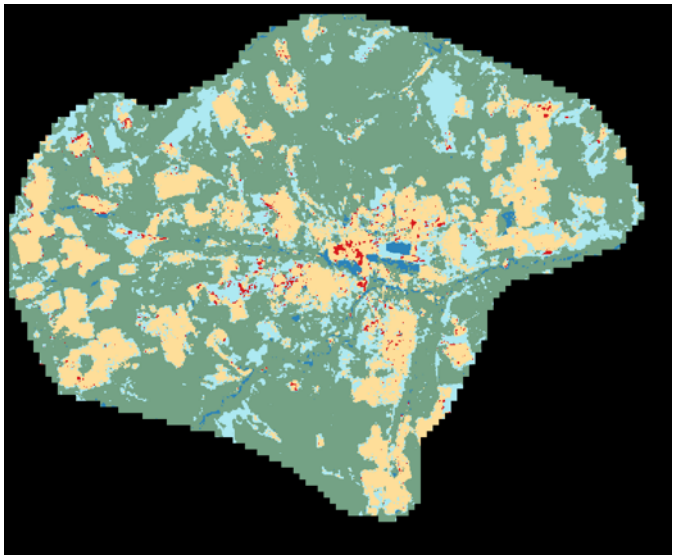
Community map



Elevation and slope



Landsat classification



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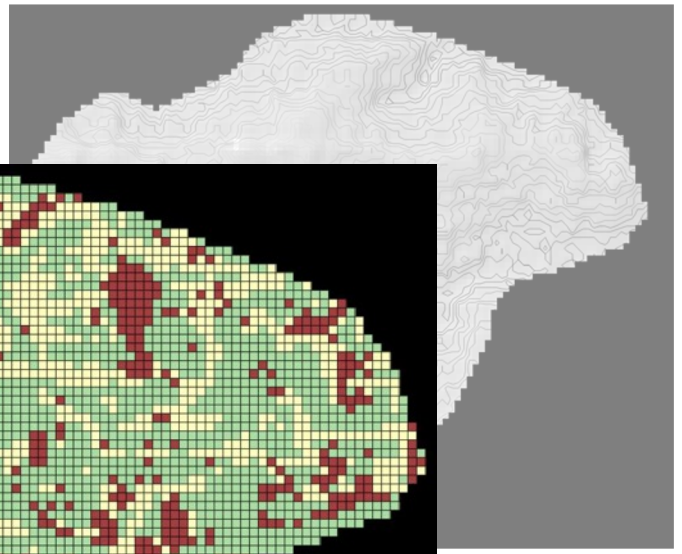
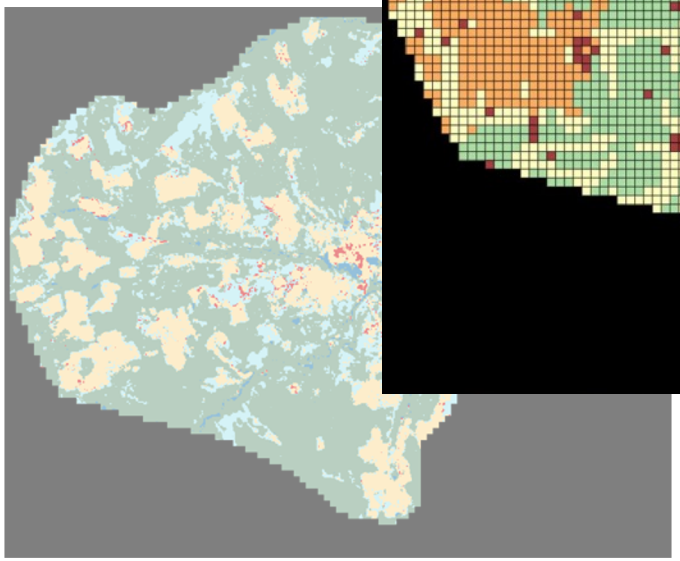
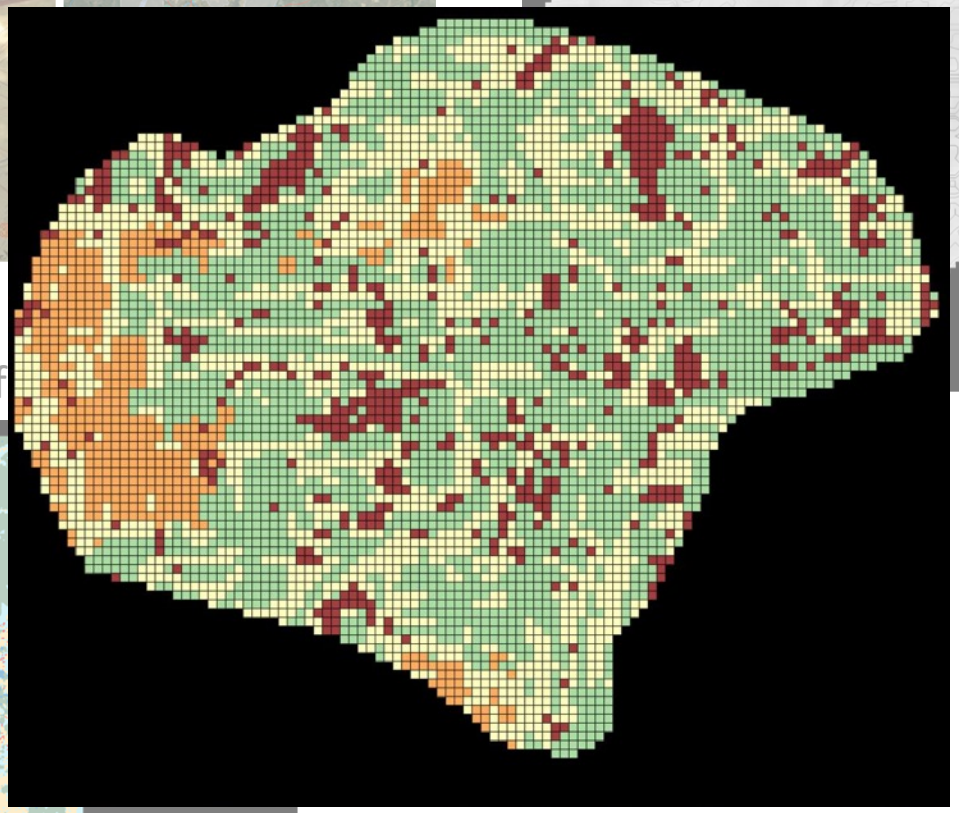


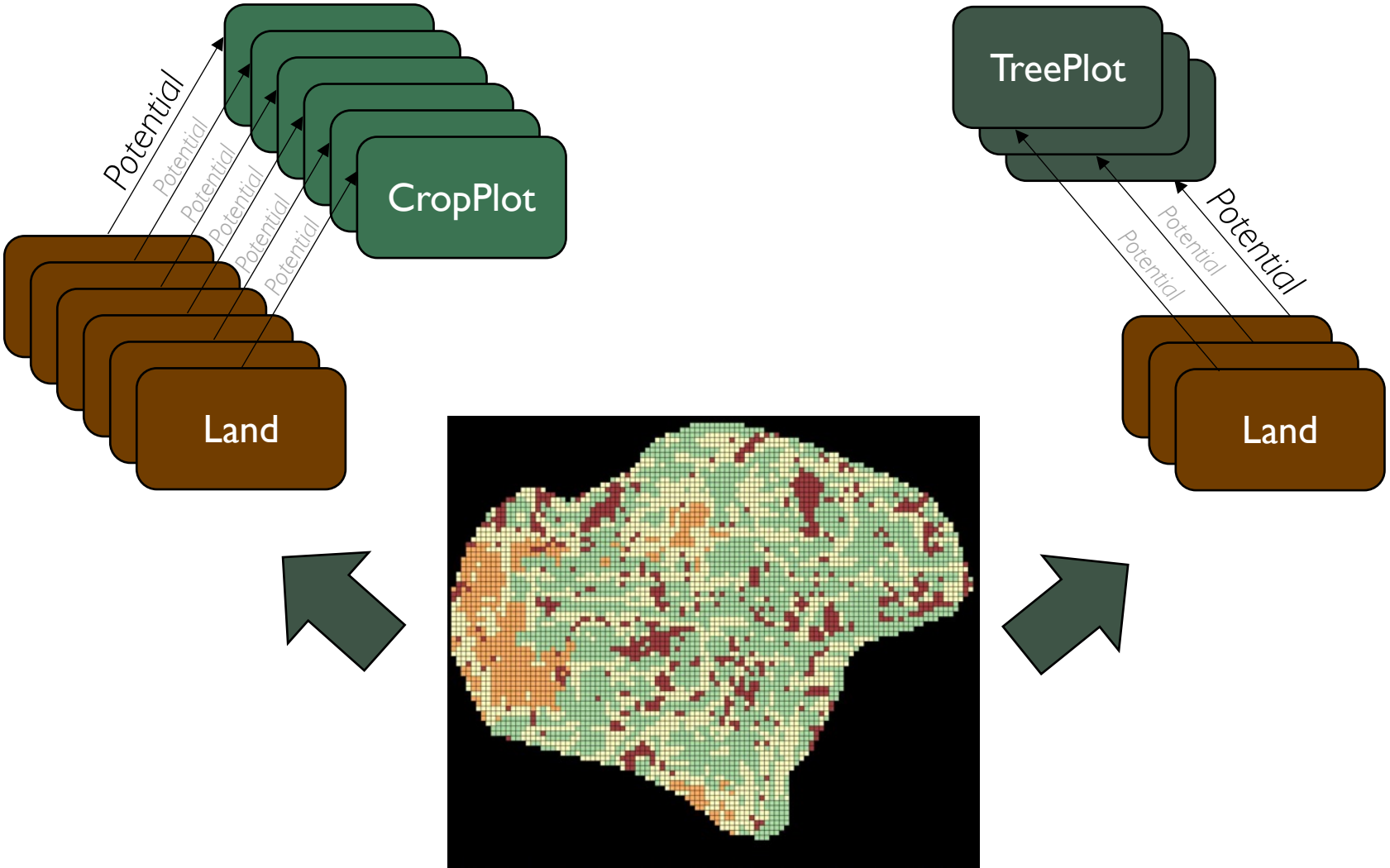
Landsat classif





Model “board”

Model structure



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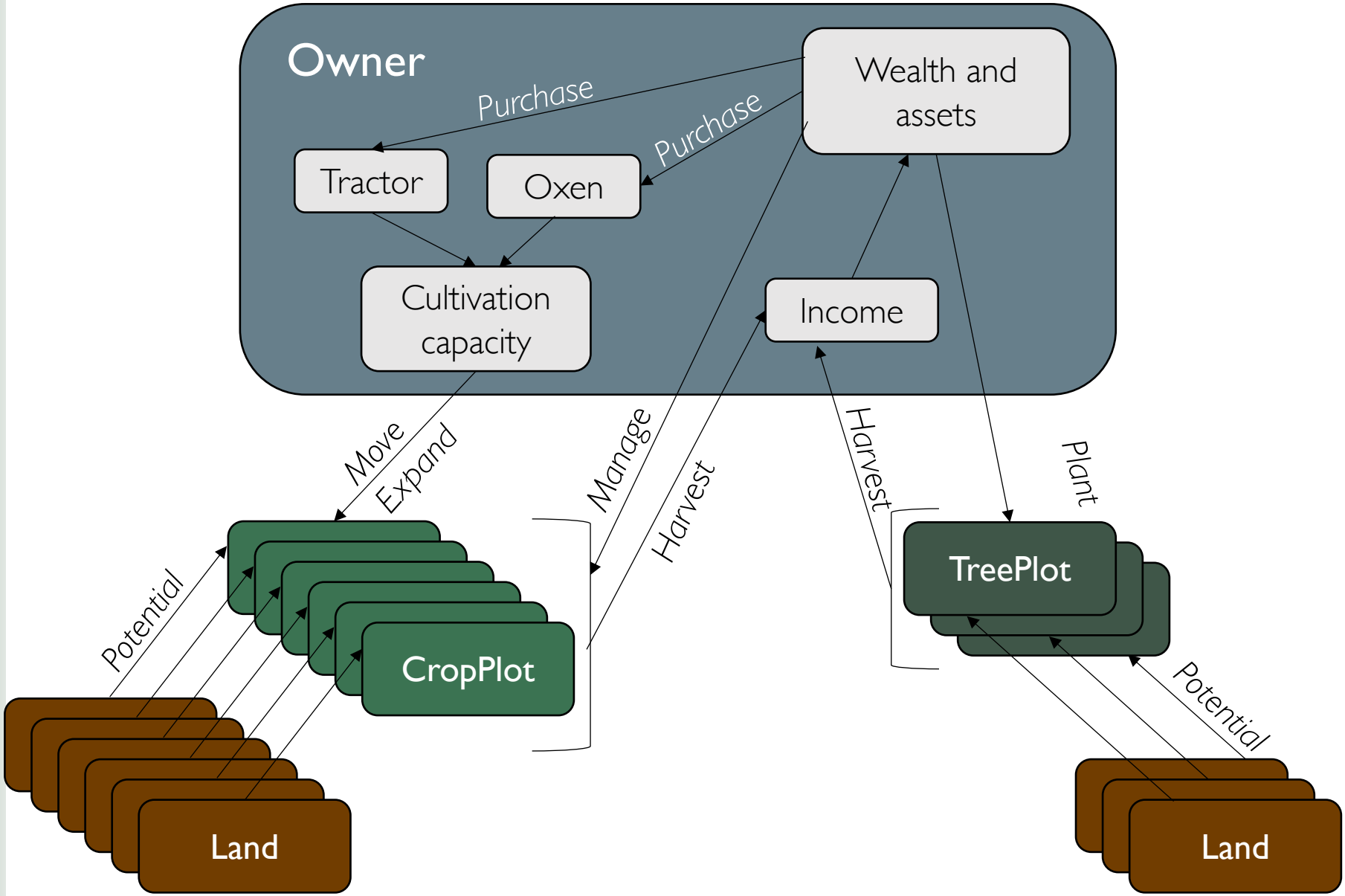


Scenarios tested

- 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

Income in year 20

	Annual income per person (US$, average)		
Tree planting preference:	Low	Medium	High
Tractor types:			
None	**170**	**826**	**1632**
Subsidized	**170**	**814**	**1484**
Unsubsidized	**170**	**819**	**1589**
Rental	**406**	**1278**	**2458**

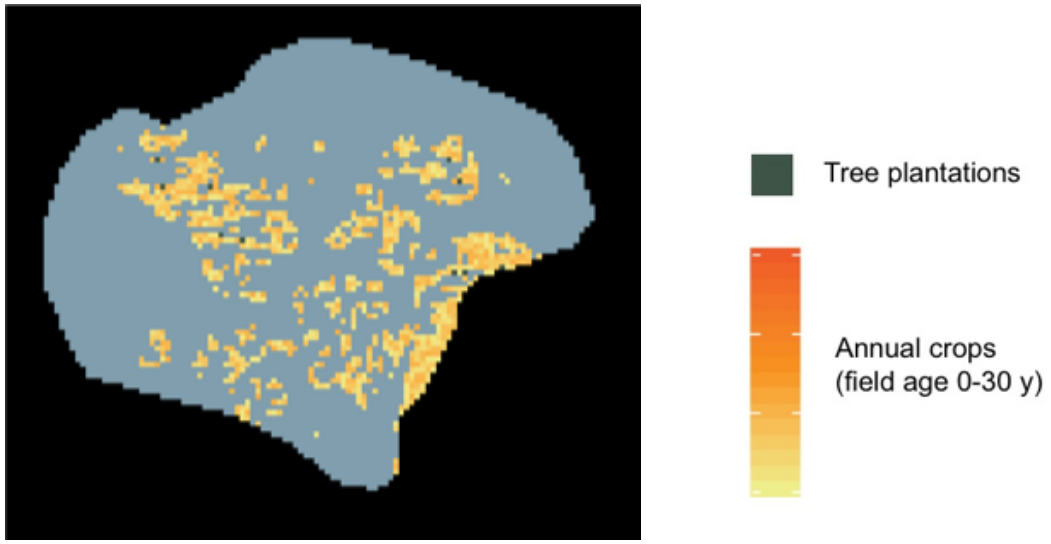
Initial value: US$ 190 per person

In low tree preference scenarios no agent could afford a tractor

Inequality in year 20

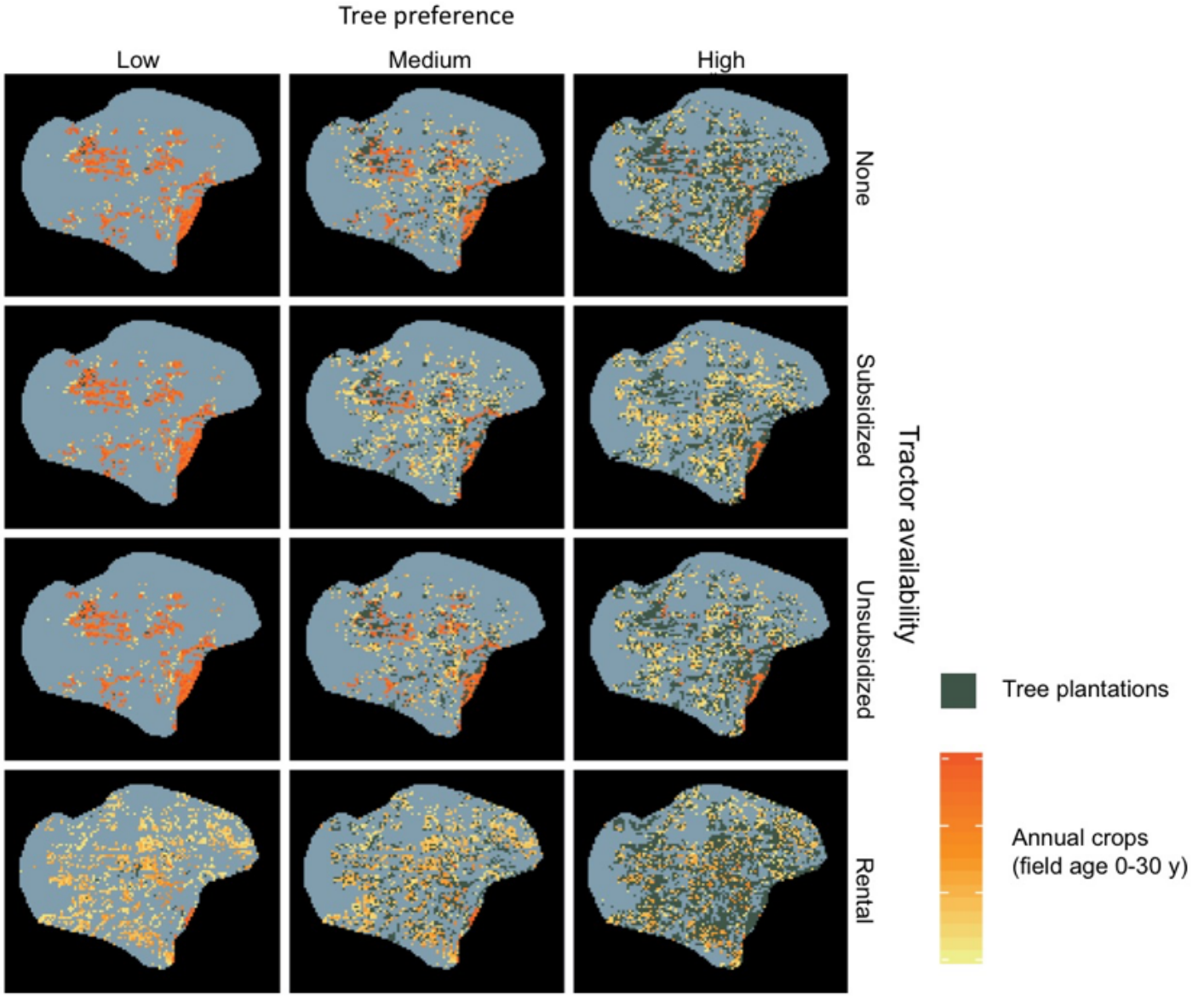
- Income:
  - Initial GINI coefficient 0.614
  - Final GINI coefficients generally lower
    - Lowest final:
      - High tree planting/subsidized tractors - 0.483
    - Highest final:
      - No trees/tractors: 0.670
- Land
  - Initial GINI coefficient 0.411
  - Little change between initial and final values

Land use distribution – year 0



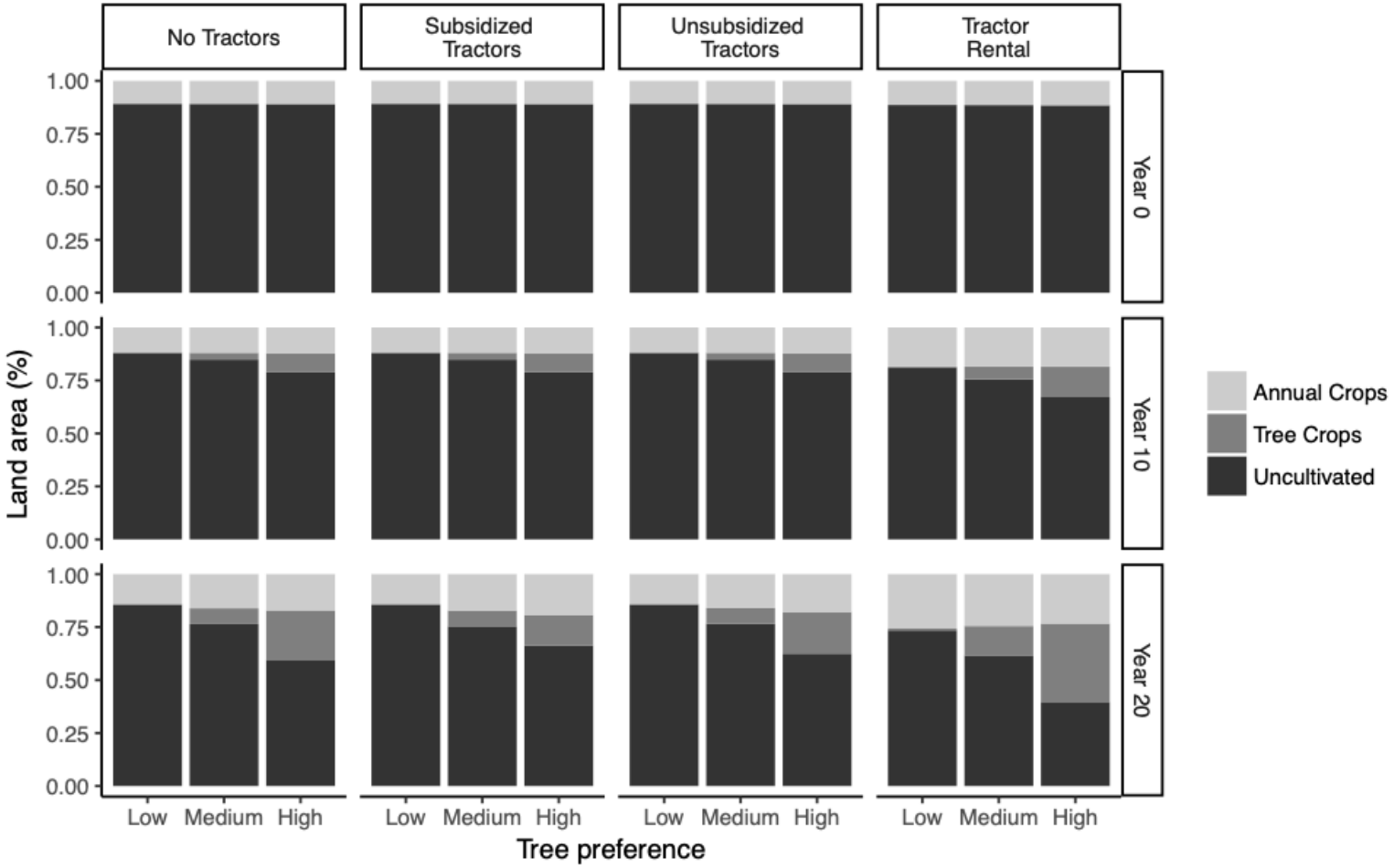
Land use distribution – year 20

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 fallowing
  - 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

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