Agent-based modelling and simulation for agricultural policy

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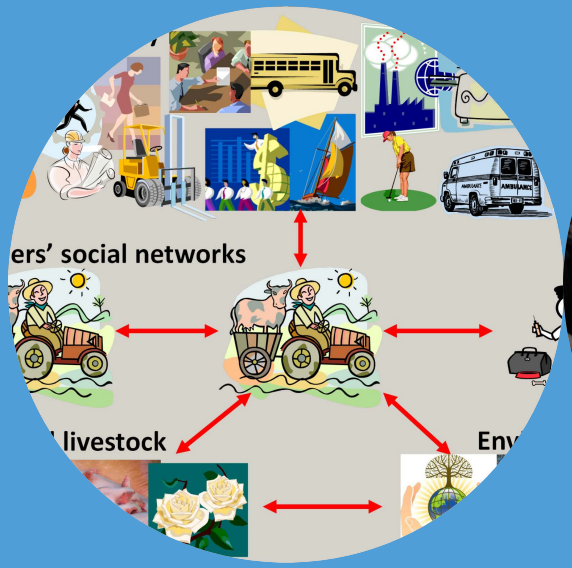
NATURAL RESOURCES AND AGRICULTURAL ECONOMICS

Ulaanbaatar, 10 October 2014, Tim Verwaart



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- Introduction to agent-based modeling and simulation
- Example 1: Water retention policy
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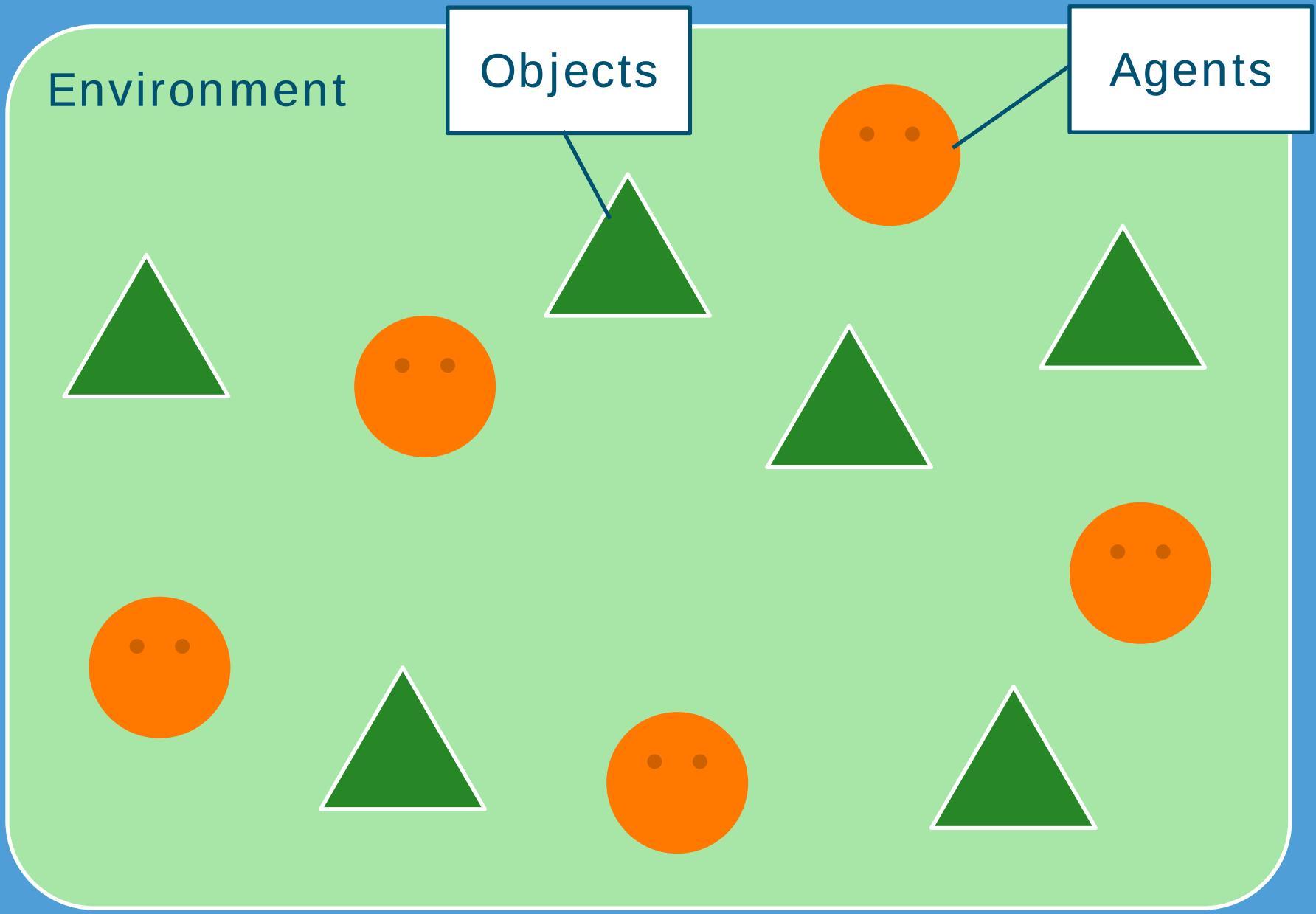
Agent-based simulation

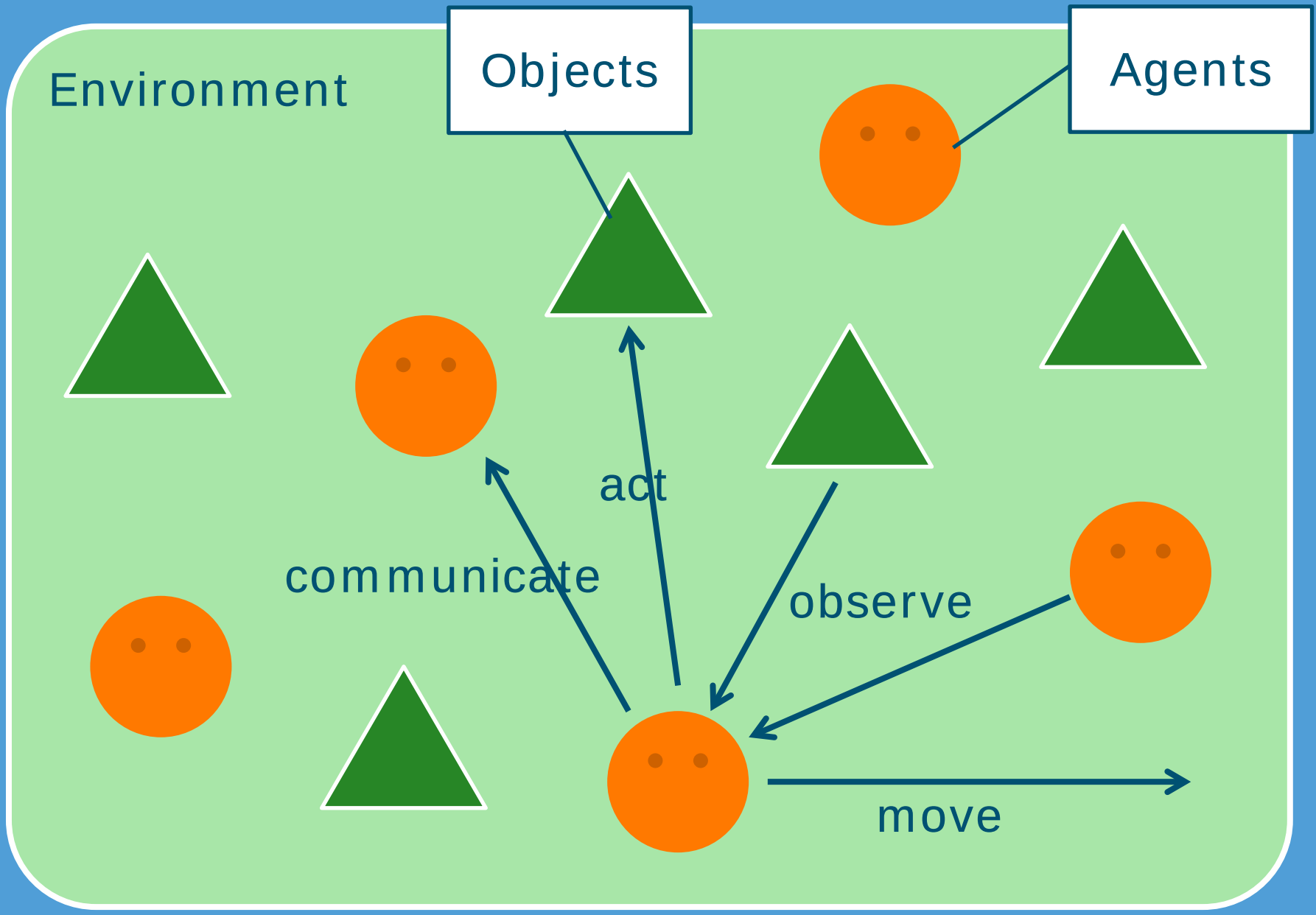
- A modelling paradigm in which
  - A population of individual actors
  - Is represented by a population of software agents
  - Situated in a simulated environment

- Emerged in the 1990
  - Enabled by advances in computer science and
  - Advances in computer technology (capacity)


Environment
Objects
Agents

Agents' capabilities

- Observe the environment
- Awareness of other agents
- Make deliberate decisions
  - Reactive
  - Pro-active (goal-driven)
- Exchange information with other agents
- Move around in the environment
- Act upon objects in the environment

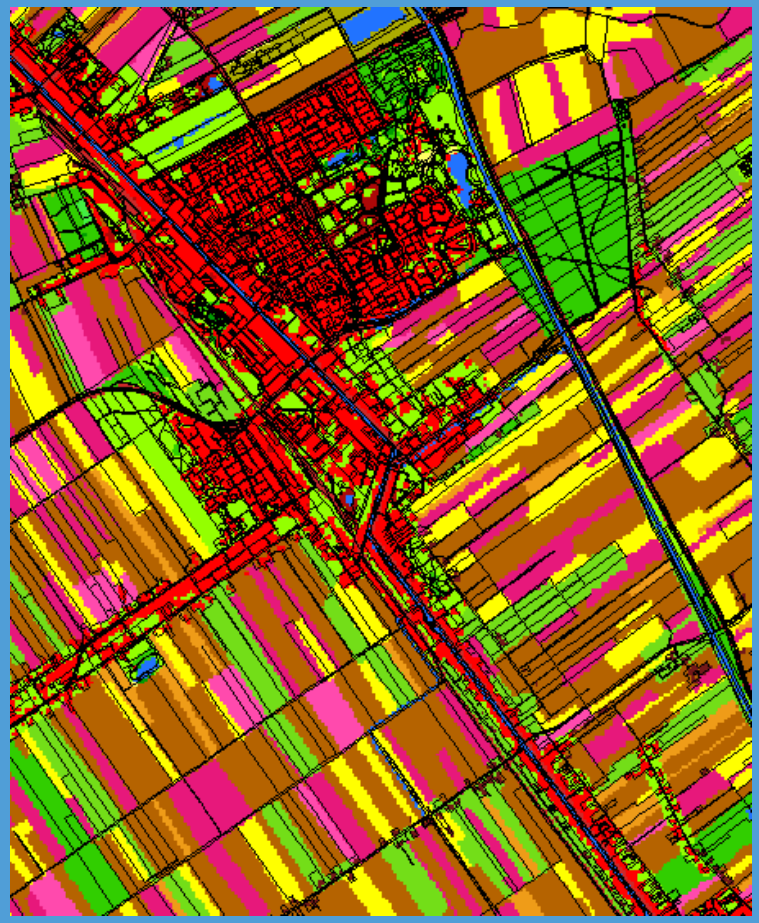

Environment
Objects
Agents
act
communicate
observe
move

Decision making in software agents

- May be simple or complex
- May be rational (optimizing) or heuristic
- May be deterministic or stochastic
- May be diverse:
    - Different agent types,
        - e.g. farmers and consumers
    - Different decision making algorithms and criteria
    - Different characteristics,
        - e.g. wealth, preferences

Advantages of agent-based simulation

- Allows for diversity of agents
  - E.g., use census data to parameterise the agent population
- Simulate effects of interactions,
  - E.g., collaboration and competition
- Allows for realistic environment
  - E.g., use actual data to represent land plots in the environment



Agricultural research and policy application

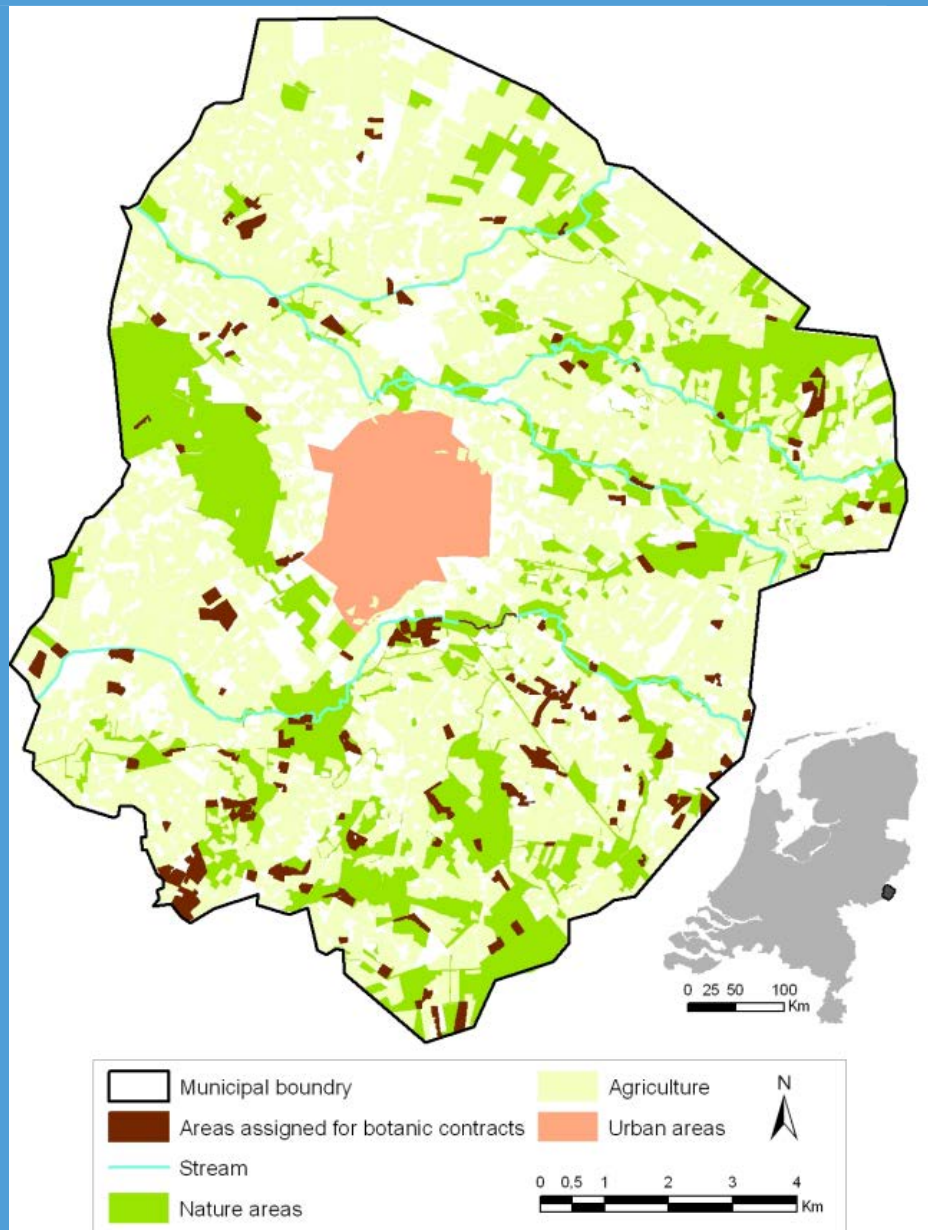
- Common pool problems
- Land markets
- Land use planning
- Food supply chain configuration
- Natural resources management
- Water management
- Epidemiology

Example 1: Water retention policy

- Due to climate change, increased variations in wet and dry periods are expected in Dutch regions
- Authorities anticipate by planning policy measures to increase the buffering capacity
- Dairy farmers in wet areas are offered contracts to provide land for water retention and nature conservation
- Two policy scenario's are tested For cost-efficiency:
    - Fixed subsidy per ha
    - Subsidy dependent on adjacency to natural areas and other farmers providing land for buffering

Spatially explicit simulation

- Agricultural census data on individual farms and livestock
- Land register data to identify individual land plots and land use
- Soil quality maps and groundwater maps to estimate value of land for agricultural production
- Different scenario's for world market milk price
- Time step size: 1 year



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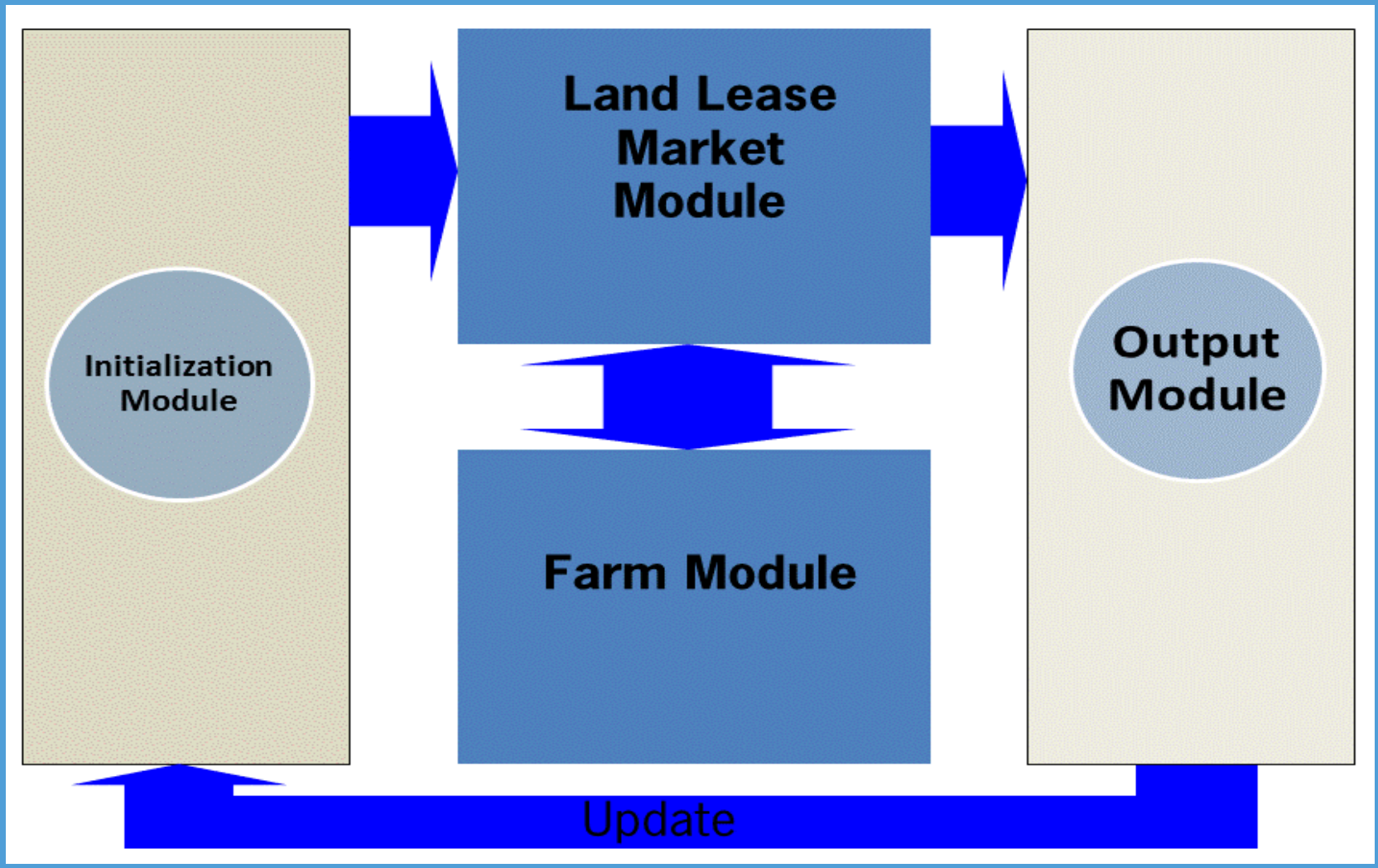
Structure of the simulation



Simulation result

- Fixed compensatory payments are preferable to obtain a maximal area for water retention.
- When policy makers target contributions to the spatial habitat network, differentiated payments give more value for money.

Schouten, M.A.H.; Polman, N.B.P.; Westerhof, E.J.G.M.; Opdam, P.F.M. (2012) Evaluating agri-environmental schemes using a spatially explicit agent-based modelling approach. OECD Workshop on Evaluation of Agri-environmental Policies, 20-22 June 2012, Braunschweig, Germany

M. Schouten, T. Verwaart, W. Heijman (2014) Comparing two sensitivity analysis approaches: Experiments with a spatially explicit rural agent-based model. Environmental Modelling & Software 54: 196-224

Example 2: Supply chain strategy

- Dutch pig farmers are under pressure of low prices and environmental regulations that incur increased cost
- The pork sector seeks a way out by offering organically grown products for which consumers are willing to pay a better price
- However, demand for organically grown pork grows only slowly; organic farmers face an even higher cost level and when too many farmers invest in organic production, many of them go bankrupt
- This simulation compares supply chain scenarios for extending the market for organic pork

The model – diversity of actors

- WTP is determined by sustainability preference, norm sensitivity, opinion dynamics and budget

- Optimize turnover given demand for sustainability; may form long term contracts

- Deliver either certified or noncertified batches; invest in certification depending on demand, capital and risk aversion

- NGO broadcasts sustainability information with a certain strength and tenor

The model - typology

Consumers

- Conservative
- Caring
- Balanced
- Engaged
- Openminded

(Hessing-Couvret ea 2002)

Producers

- Traditional
- Economical
- Balanced
- Professional
- Openminded

(De Lauwere 2002)

Differ in

openness
budget/capital
norm sensitivity

risk aversion

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Scenarios

Baseline

No coordination; only regular and organic meat products

Differen-tiation

10 brands, differ in sustainability level

Example: The Netherlands)

Green Track

1 brand with 10-99% of organic meat given WTP of consumers

Example: soy market

Market platform

Builds on Differentiation , with supply forecasts to producers

Example: horticulture

Producers' organisation

Contracts between brand and producer with fixed premium. Long term contracts

Example: German poultry

Results - Comparing scenarios

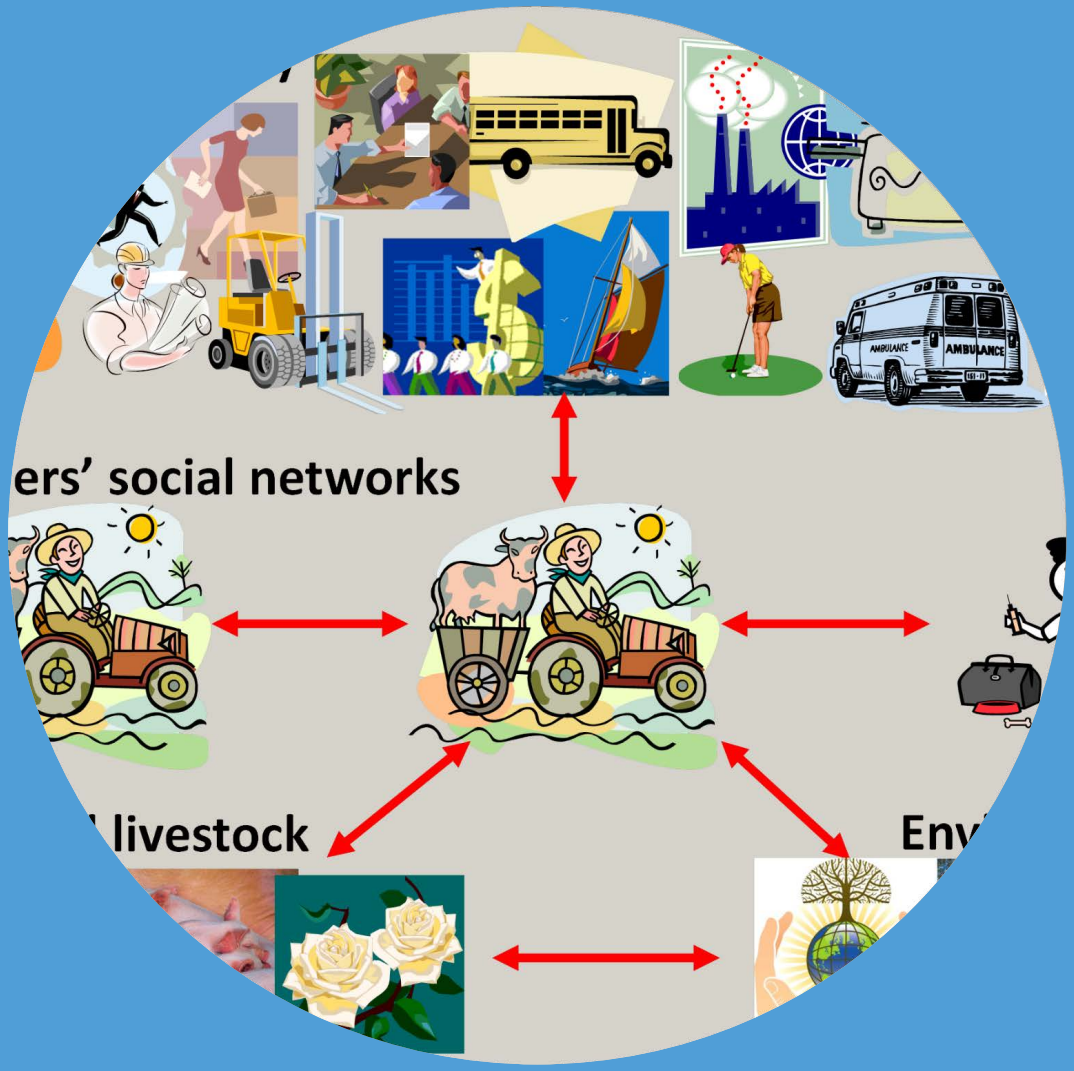
Scenario	Sustain-ability	Consumer uptake	Producer defaults	Average revenue
Baseline	3-4	Elite	Highest	Low
Differen-tiation	2	Broad	High	Moderate
Green Track	3-4	Elite	High	Moderate
Market platform	1	Broad	Low	High
Producers' organisation	5	Elite	none	Highest

E. van den Broek, T. Verwaart (2014) Evaluating Scenarios for Upgrading Sustainability of the Meat Supply Chain. In: F. Amblard et al. (eds.) Advances in Artificial Economics. Heidelberg: Springer

Conclusion

- Agent-based modelling and simulation is a useful addition to the toolbox for research and policy support
- It can be based on actual micro data, with diversity of actors, situated in a realistic environment, on a time scale ranging from seconds to years
- It helps to explore potential behaviours of complex social-ecological and sociotechnical systems under a diversity of scenario's and interventions
- It can be applied to test hypotheses about the internal mechanisms and decision making that drive system behaviour

If you did never apply agent-based methods: try it!



Introduction:

Nigel Gilbert (2008) Agent-based models. SAGE Publications, San Francisco

Software: NetLogo.
http://ccl.northwestern.edu/netlogo/