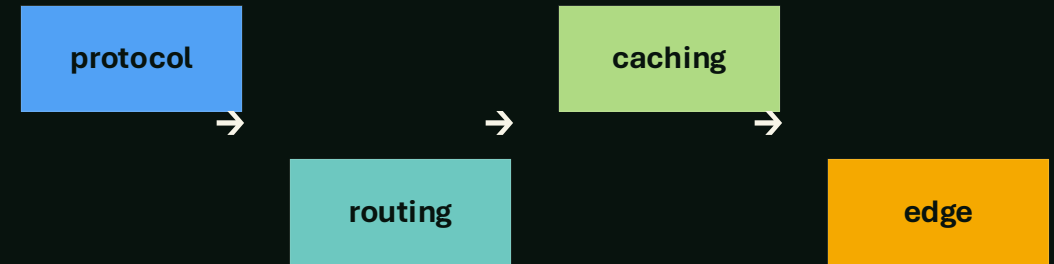


Reflections and insights from agent-based modelling for the biomass value chain



The internet didn't grow by adding more computers.

It grew through rules governing interactions between independent nodes.



Capacity ≠ movement

A network needs rules

Intermezzo

The actors are not trying to optimize the Dutch energy system as a whole; they are optimizing for their own needs and objectives. A battery owner optimizes their business case, an industrial consumer safeguards its production process, an energy supplier responds to market prices, a local grid operator tries to prevent congestion, a national grid operator maintains system balance, a producer focuses on marginal revenues, and an investor weighs risk against return, etc.



Don't copy the fossil fuel supply chain

Fossil fuels are a concentrated point source. Biomass is a distributed, living network of flows.



FOSSIL

point source → pipeline/tanker → refinery

- hoge energiedichtheid
- hoge koolstofconcentratie
- relatief homogeen
- goed lang op te slaan
- continu aanvoerbaar

Logica: schaal, standaardisatie, lineaire keten.



BIOMASSA

perceel → flows → hubs → biorefinery

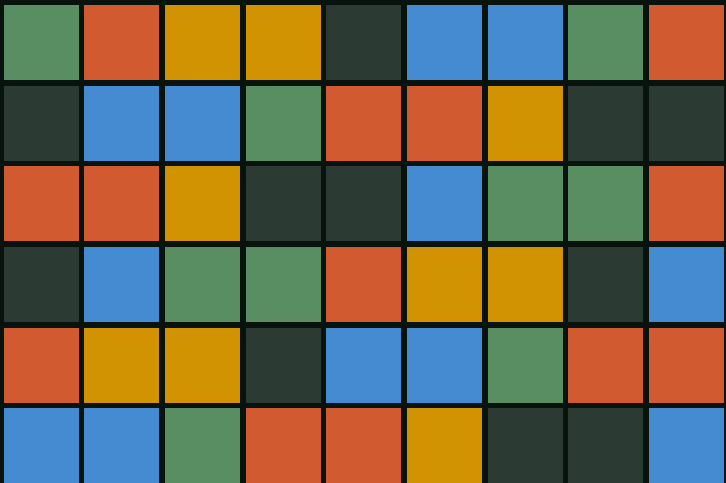
- lage bulkdichtheid
- vocht en variabele kwaliteit
- seizoensgebonden
- bodemfunctie en retourstromen
- eigenaren beslissen

Logica: lokale hubs, verdichting, routing, vertrouwen.

ICT-parallel: van mainframe naar edge, caching en protocollen tussen autonome nodes.

A hectare is more than a color on map.

A hectare is a node with flows, states and choices.



CONCEPTUAL MODEL

one dominant function



Main product	residu	soil
water	seeson	history

Reality is not 'A or B'

CURRENT MODEL VIEW

PIXEL

one dominant use

food or feed
or nature or biofuel

DESIRED MODEL VIEW

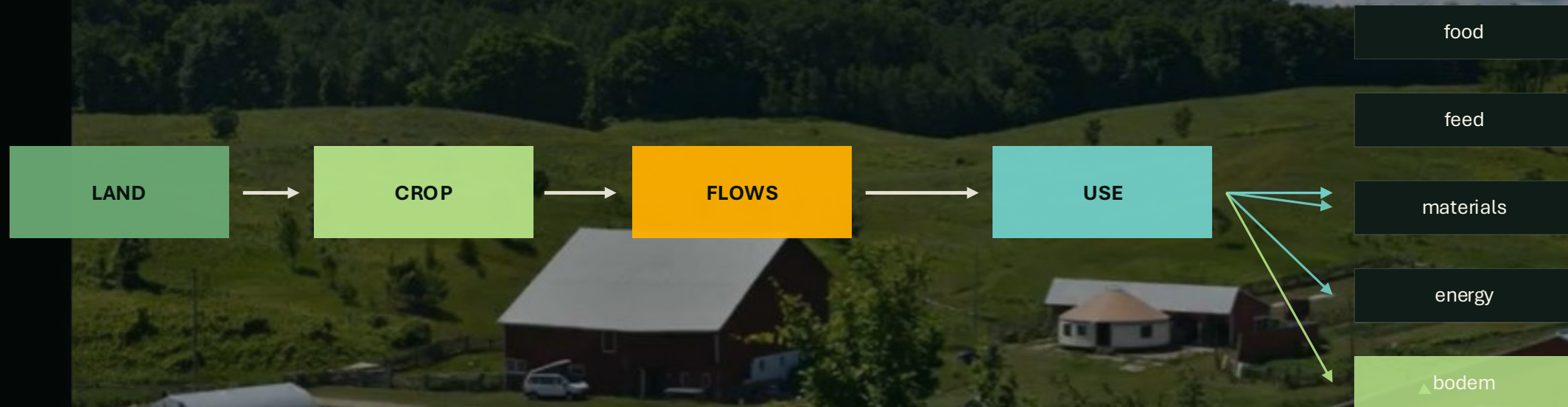
PLOT + FLOWS + STATE

main product · by-product · residue
soil function · water · biodiversity
season · history · future yield

**How can one location fulfil multiple functions simultaneously and over time?
How do we find space within space?**

Not : land → function

Better: land → flows → choices → retour.



Availability emerges along the way.

THEORETICAL
What grows?

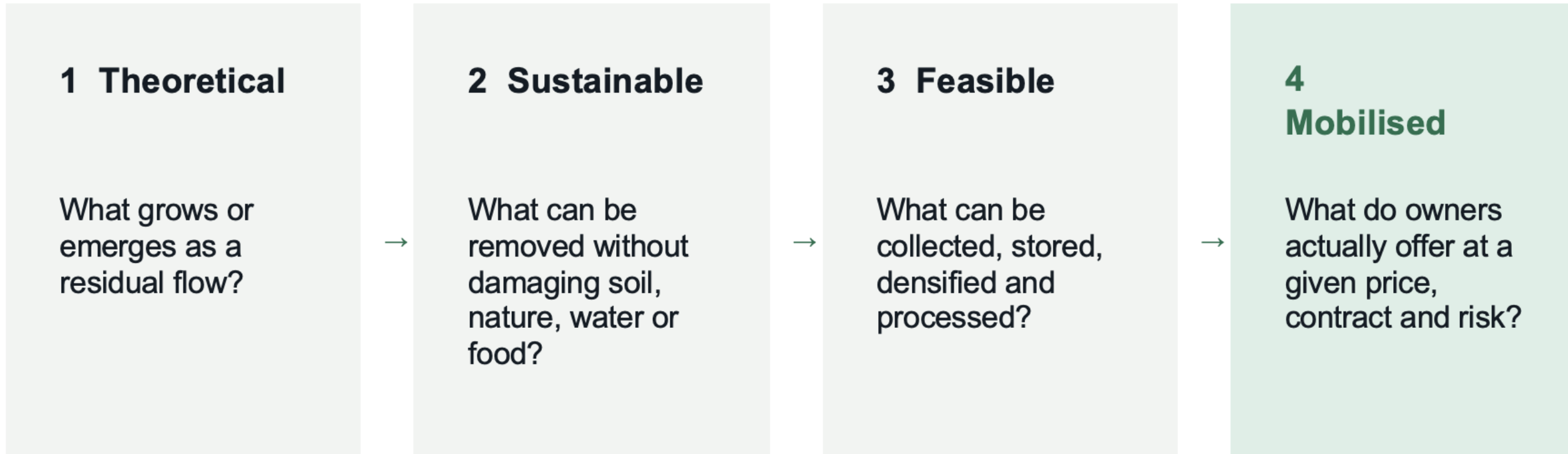
SUSTAINABLE
What can we use?

FEASIBLE
What is physically usable?

MOBILISED
What is offered by agents?

**The first three filters are often included in (system optimization) studies.
The fourth filter is found in the real world.**

Between potential and supply there are four filters



Availability is not a fixed model input — it emerges from ecology, technology, economics and behaviour.

~~Realistic world?~~ → “Ideal” world



~~50% yield gap~~
→ zero yield gap



~~1/2 animal diet~~
→ no animal diet



~~1/2 waste~~
→ no waste

Possibility enough
for **11 billion**
people...

~~+ 82%~~
→ + ~280%

Prof. Verena Seufert calculations based on:
Cassidy et al. (2013) ERL
Foley et al. (2011), Nature
Mueller et al. (2012), Nature

System model asks: what is optimal?

ABM asks: who moves— and why?

boer / eigenaar

verwerker

logistiek

financier

overheid

bodem

Price · risks · trust · time · soil quality

Existing models give direction — but simplify the choice

SYSTEM OPTIMISATION

Searches for the best configuration of supply, transport, infrastructure and conversion technology under given assumptions.

What is system-optimal?

AGENT-BASED MODELLING

Studies how farmers, processors, logistics providers, technology companies and governments actually respond — to each other and to changing circumstances.

Does that optimum actually materialise?

Both perspectives are needed.

Model says GO. Agents (sometimes) say NO.

Vfour groundbreaking ABM studies:

1971

Schelling

macro-patronen uit lokale voorkeuren

1996

Sugarscape

markten en ongelijkheid bottom-up laten ontstaan

2004–06

EpiSims

interventies testen op echte mobiliteitsnetwerken

2003–07

Land-use ABM

pixels koppelen aan beslissende landeigenaren

Lesson: the system optimum does not automatically emerge from individually rational behaviour.

Deep dive into the mud.

Data sprints as fieldwork to observe and understand (unwritten) rules of behaviour.

1

MODEL

hypothese



2

VELD

interviews



3

REGELS

fricties



4

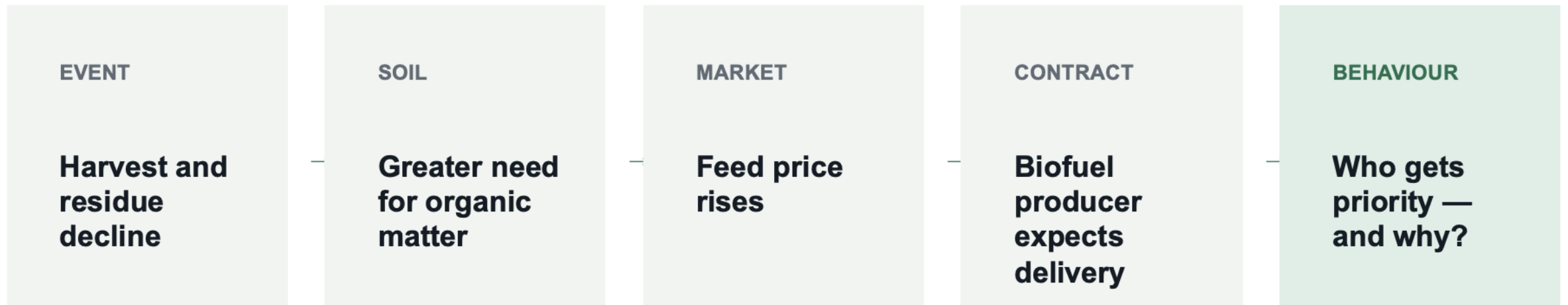
ITERATIE

nieuw model

open data + GIS + expert knowledge + initial model rules + validation

Ontario, Canada

Drought makes hidden priorities visible



ABM question: when does the chain break, when does it adapt and who carries the consequences?

Four challenges determine whether the model becomes usable

1 Multiple use

One hectare is not a single variable: multiple functions, flows, seasons and owners must be modelled simultaneously.

2 Intertemporality

A choice made today affects tomorrow's soil, yields, contracts, and options.

3 Shocks and ownership

Drought, harvesting, policy, energy prices and contract terms change supply and priorities.

4 Scale and architecture

Central, local or modular processing? Scale advantage competes with transport, storage and flexibility.

Modelling does not only require the average situation, but also choices when yield, space or scale constrains.

Biomass matters.

Now we need to discover why it does not move —

- Why are the agents not moving?
- Where is the space within space?

**Which agent must act differently tomorrow —
and what does that agent need to move?**

Belangrijke ABM-studies

APA-stijl referenties voor de historische lijn.

Schelling, T. C. (1971). Dynamic models of segregation. *The Journal of Mathematical Sociology*, 1(2), 143–186. <https://doi.org/10.1080/0022250X.1971.9989794>

Epstein, J. M., & Axtell, R. (1996). *Growing artificial societies: Social science from the bottom up*. Brookings Institution Press & MIT Press.

Eubank, S., Guclu, H., Kumar, V. S. A., Marathe, M. V., Srinivasan, A., Toroczkai, Z., & Wang, N. (2004). Modelling disease outbreaks in realistic urban social networks. *Nature*, 429, 180–184. <https://doi.org/10.1038/nature02541>

Ferguson, N. M., Cummings, D. A. T., Fraser, C., Cajka, J. C., Cooley, P. C., & Burke, D. S. (2006). Strategies for mitigating an influenza pandemic. *Nature*, 442, 448–452. <https://doi.org/10.1038/nature04795>

Parker, D. C., Manson, S. M., Janssen, M. A., Hoffmann, M. J., & Deadman, P. (2003). Multi-agent systems for the simulation of land-use and land-cover change: A review. *Annals of the Association of American Geographers*, 93(2), 314–337. <https://doi.org/10.1111/1467-8306.9302004>

Matthews, R. B., Gilbert, N. G., Roach, A., Polhill, J. G., & Gotts, N. M. (2007). Agent-based land-use models: A review of applications. *Landscape Ecology*, 22, 1447–1459. <https://doi.org/10.1007/s10980-007-9135-1>

Referenties bij de presentatie

•

GLOBIOM documentation. (n.d.). Introduction to the Global Biosphere Management Model. IIASA. https://globiom.org/introduction.html	Concawe, Utrecht University, & TNO. (2025). Sustainable biofeedstock supply chains for advanced biofuels in Europe towards 2050.
IIASA. (n.d.). Global Biosphere Management Model (GLOBIOM). https://iiasa.ac.at/models-tools-data/globiom	Oak Ridge National Laboratory. (2025). Mapping and synthesis of international biomass supply assessment.
West, T. A. P. (n.d.). Introduction to land system science [Course notes]. Vrije Universiteit Amsterdam.	Elbersen, B., & Broeze, J. (2022). Identifying and implementing circular applications of agri-residues. Wageningen University & Research.
International Energy Agency. (2018). The future of petrochemicals: Towards more sustainable plastics and fertilisers. IEA.	Yazan, D. M., et al. (2018). Cooperation in manure-based biogas production networks: An agent-based modeling approach. Applied Energy. https://doi.org/10.1016/j.apenergy.2017.12.074
U.S. Department of Energy, Bioenergy Technologies Office. (n.d.). Feedstock logistics for bioenergy.	Jack, M. W. (2009). Scaling laws and technology development strategies for biorefineries and bioenergy plants. Bioresource Technology. https://doi.org/10.1016/j.biortech.2009.06.109
Kellerman, A. (1989). Agricultural location theory 1: Basic models. Environment and Planning A, 21(10), 1381-1396. https://doi.org/10.1068/a211381	Psathas, P., et al. (2022). Optimizing the design of a biomass-to-biofuels supply chain network using a decentralized processing approach. Energies. https://doi.org/10.3390/en15145001
PBL. (2020). Beschikbaarheid en toepassingsmogelijkheden van duurzame biomassa.	Leiner, B. M., Cerf, V. G., Clark, D. D., Kahn, R. E., Kleinrock, L., Lynch, D. C., Postel, J., Roberts, L. G., & Wolff, S. (2009). A brief history of the Internet. ACM SIGCOMM Computer Communication Review, 39(5), 22-31. https://doi.org/10.1145/1629607.1629613
CE Delft. (2020). Bio-Scope: Toepassingen en beschikbaarheid van duurzame biomassa.	Mommen, M. (2026). Biomassa beweegt niet vanzelf: Discussiepresentatie en concept voor datasprints [Werkdocument].
Panoutsou, C., & Maniatis, K. (2021). Sustainable biomass availability in the EU to 2050.	