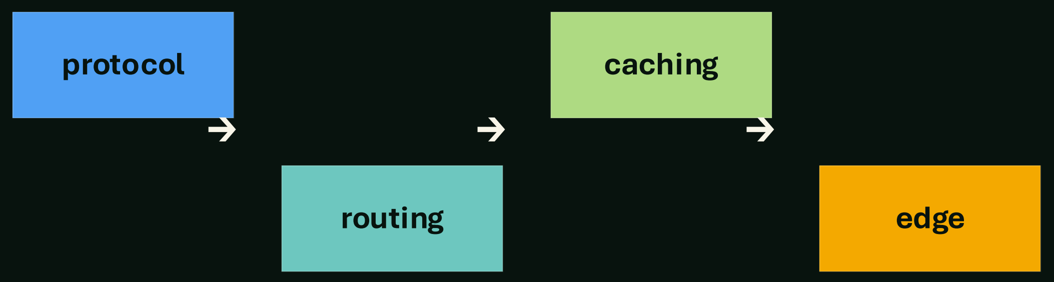
Reflections and insights from agent-based modelling for the biomass value chain

EEN ANALOGIE

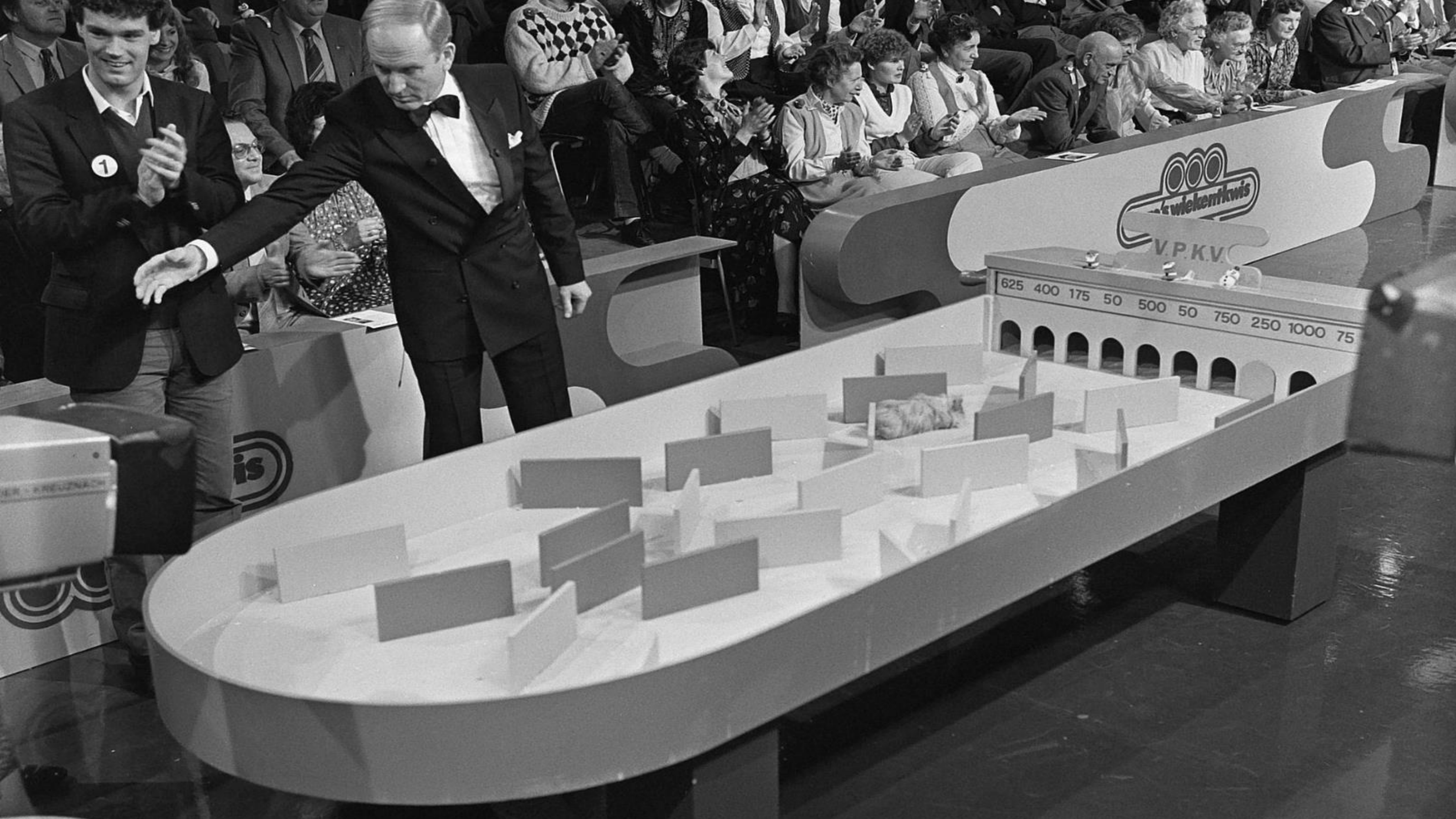
The internet didn’t grow by adding more computers.

It grew through rules governing interactions between independent nodes.



Capacity ≠ movement

A network needs rules



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Intermezzo

ENERGIE

Kolencentrales draaien in 2026 de hoogste productie in jaren

Sterke vraag uit België en hoge energieprijzen stimuleren de extra productie

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.

SYSTEEMARCHITECTUUR

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

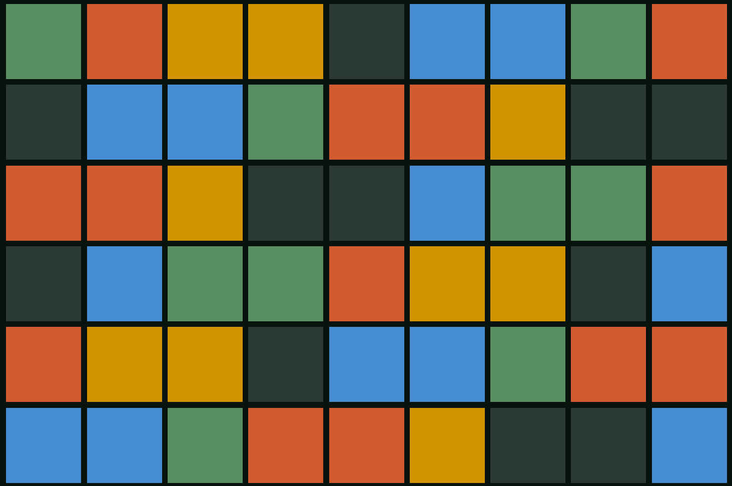
Logica: lokale hubs, verdichting, routing, vertrouwen.

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

LAND USE

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.

Avaliability 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

1 Theoretical

What grows or emerges as a residual flow?

→

2 Sustainable

What can be removed without damaging soil, nature, water or food?

→

3 Feasible

What can be collected, stored, densified and processed?

→

4 Mobilised

What do owners actually offer at a given price, contract and risk?

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

~~½ animal diet~~

→ no animal diet

~~½ waste~~

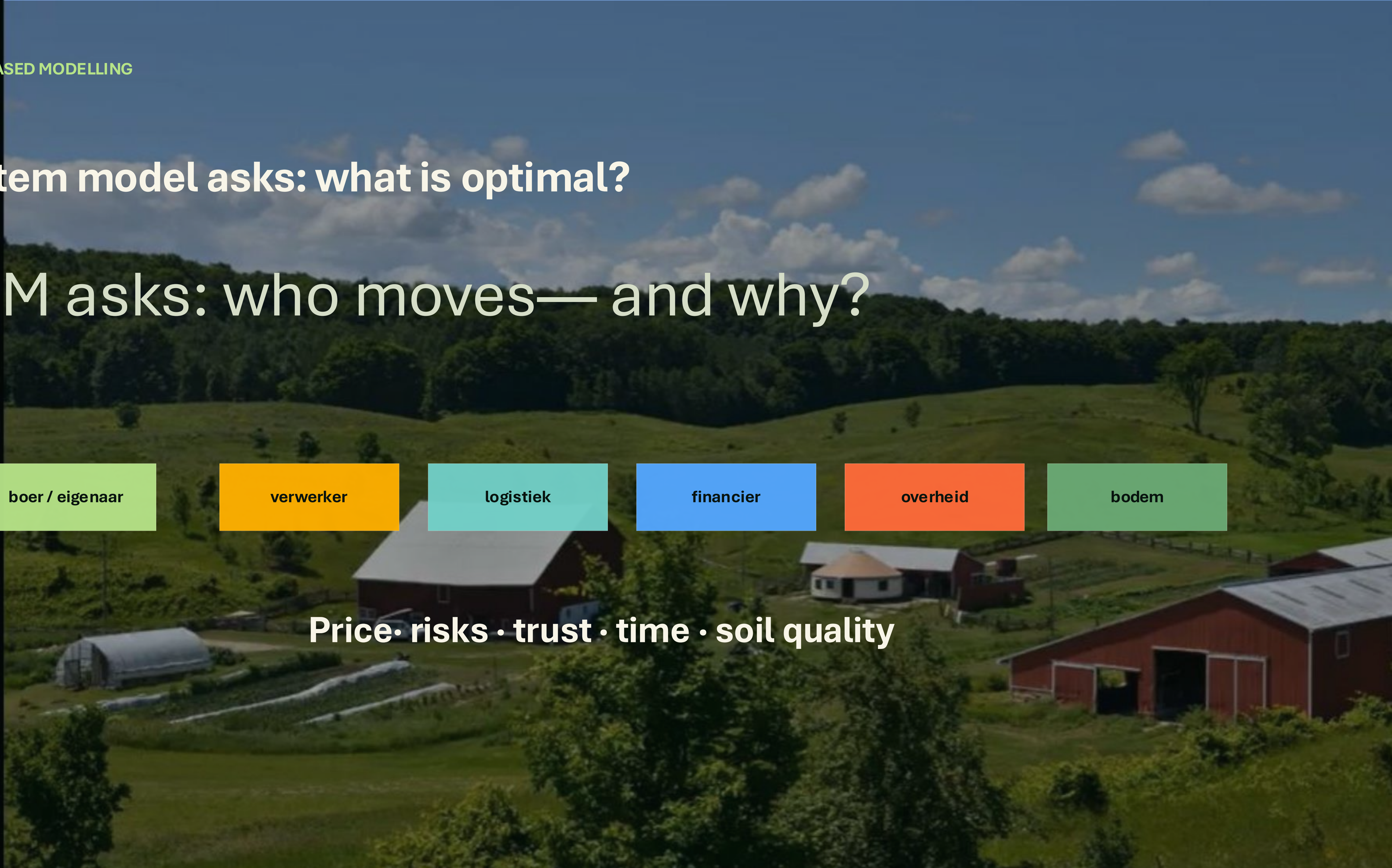
→ no waste

~~+ 82%~~

→ + ~280%

Possibility enough for ***11 billion people…***

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



AGENT-BASED MODELLING

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.

WAT ABM EERDER LIET ZIEN

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.

OPLOSSINGSRICHTING

Deep dive into the mud.

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

1	2	3	4
MODEL	**VELD**	**REGELS**	**ITERATIE**
hypothese	interviews	fricties	nieuw model

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

Drought makes hidden priorities visible

EVENT
Harvest and residue decline

SOIL
Greater need for organic matter

MARKET
Feed price rises

CONTRACT
Biofuel producer expects delivery

BEHAVIOUR
Who gets priority — and why?

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

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