

# Systems mapping

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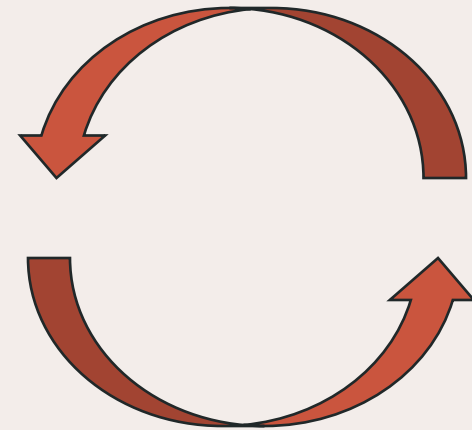
UNIVERSITY OF  
OXFORD

Human, environmental, physical, other  
geographers?

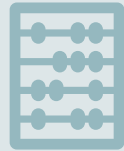
what



why



# What's a system?



“...a set of factors and/or actors (e.g. a behaviour, people, or organisations) that interact with one another.”



While the boundaries that delineate a system can be drawn in different ways, systems may be broadly categorised as simple, complicated, or complex.”

# Why use systems thinking?



Understand & explore complex systems



Identify key actors & behaviours



Map interactions & relationships



Collaborate with stakeholders for diverse insights



Use maps to find intervention points & unintended effects



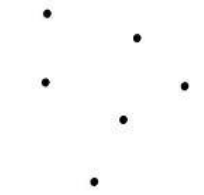
Develop models to simulate system behaviour & intervention impact



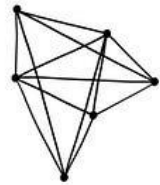
Build dynamic models with feedback loops & adaptive responses

Blake, C., Rigby, B. P., Armstrong-Moore, R., Barbrook-Johnson, P., Gilbert, N., Hassennezhad, M., Meier, P., Mitchell, K. R., Penn, A., Readman, B., Simpson, S. A., White, M., & Moore, L. (2024). *Participatory systems mapping for population health research, policy and practice: Guidance on method choice and design*. <https://doi.org/10.36399/gla.pubs.316563>

# TOOLS OF A SYSTEM THINKER



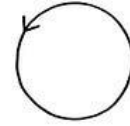
DISCONNECTION



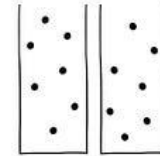
INTERCONNECTEDNESS



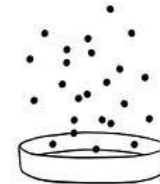
LINEAR



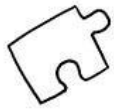
CIRCULAR



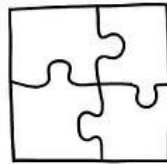
SILOS



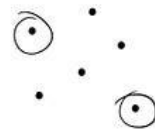
EMERGENCE



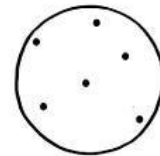
PARTS



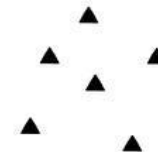
WHOLES



ANALYSIS



SYNTHESIS



ISOLATION

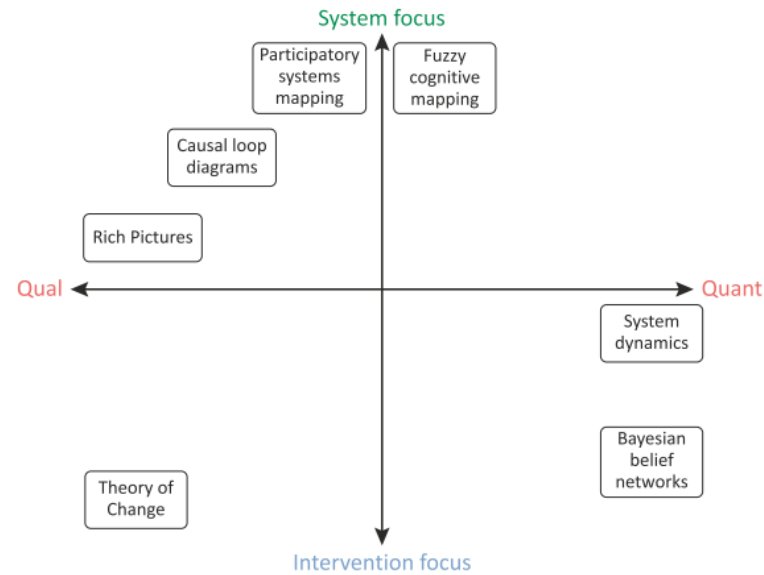


RELATIONSHIPS

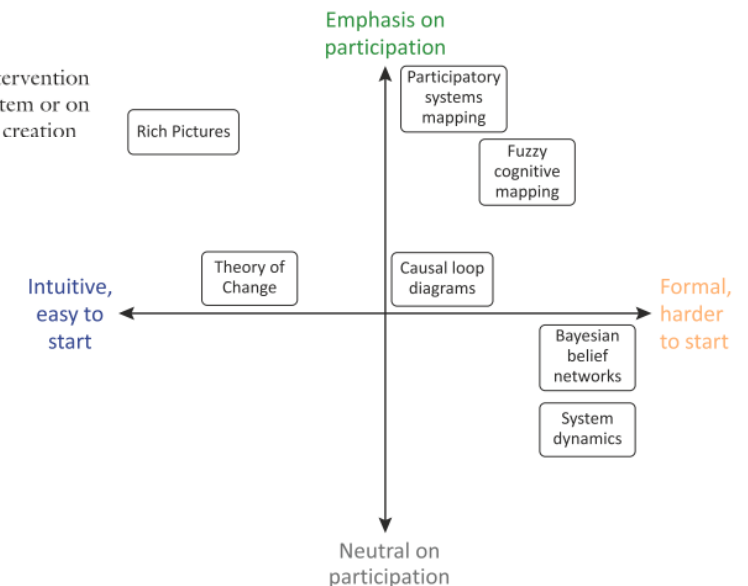


# Systems mapping methods

- Participatory systems mapping (high system focus, usually qualitative, highly participatory)
- Causal loop diagramming (med-high system focus, qualitative, can be participatory)
- System dynamics modeling (intervention and system focus, quantitative, tending towards neutral on participation but can be participatory)
- PSMs often lead to CLD development; CLD development is usually the first step to SD modelling

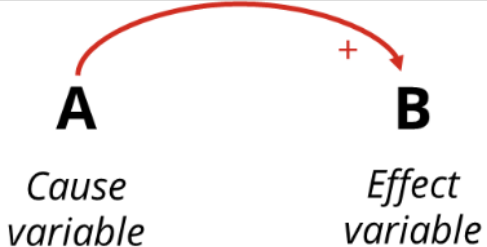

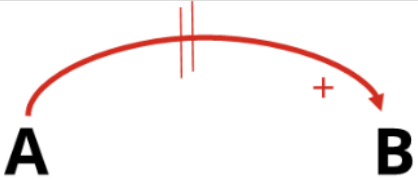


**Fig. 1.1** The methods in this book placed on a ‘system focus—intervention focus’ axis (i.e. does the method emphasise more focus on the whole system or on an intervention). and a ‘qualitative—quantitative’ axis. Source: authors’ creation



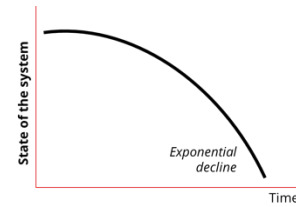
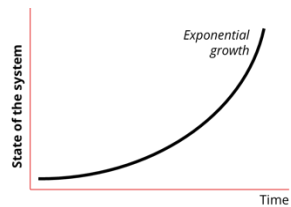
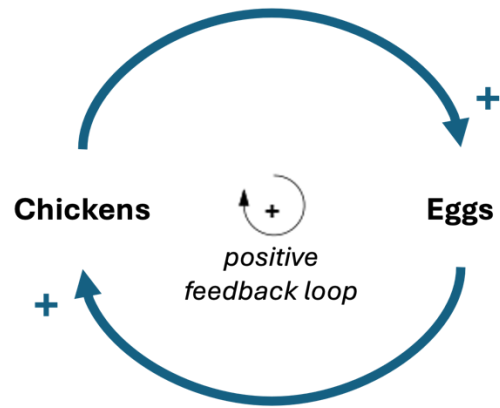
**Fig. 1.2** The methods in this book placed on an ‘emphasis on participation’ spectrum, and an ‘intuitive, easy to start—formal, harder to start’ spectrum. Source: authors’ creation

# Causal loop diagrams

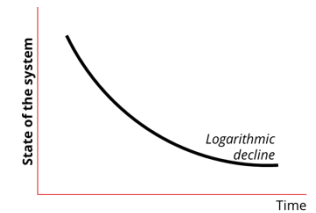
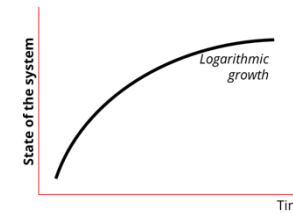
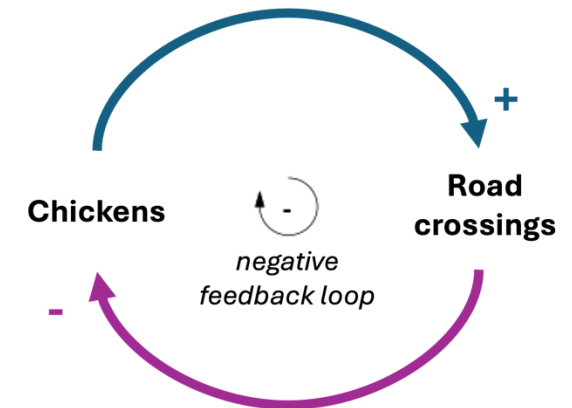
<p><b>positive relationship:</b> change in A changes B in the same direction</p>	<p><b>negative relationship:</b> change in A changes B in the opposite direction</p>	<p><b>delayed relationship:</b> change in A changes B in the same direction but with some time delay</p>
 <p>A Cause variable → B Effect variable</p>	 <p>A → B</p>	 <p>A → B</p>

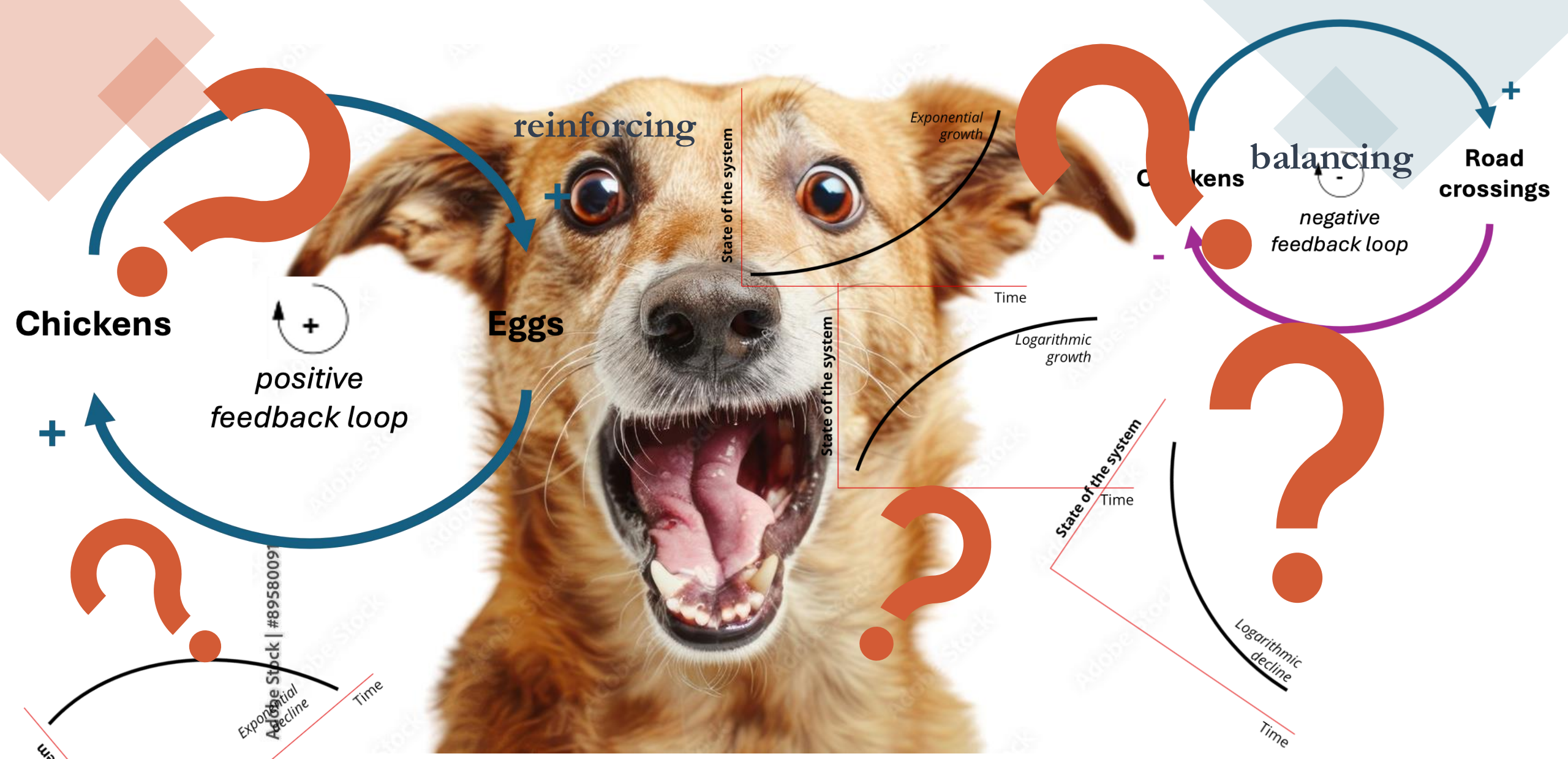
# Feedbacks

reinforcing



balancing



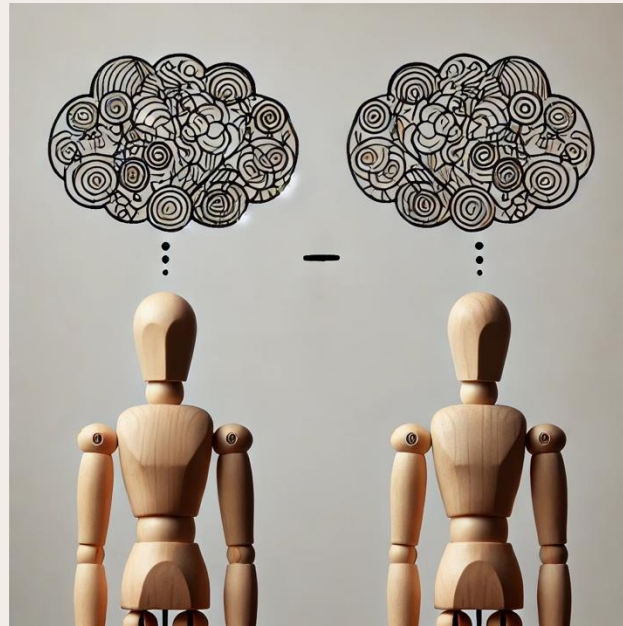


Why did the chicken cross the road???

Getting started

# Participatory systems mapping and mental models

What they tell us...



... and what they don't.

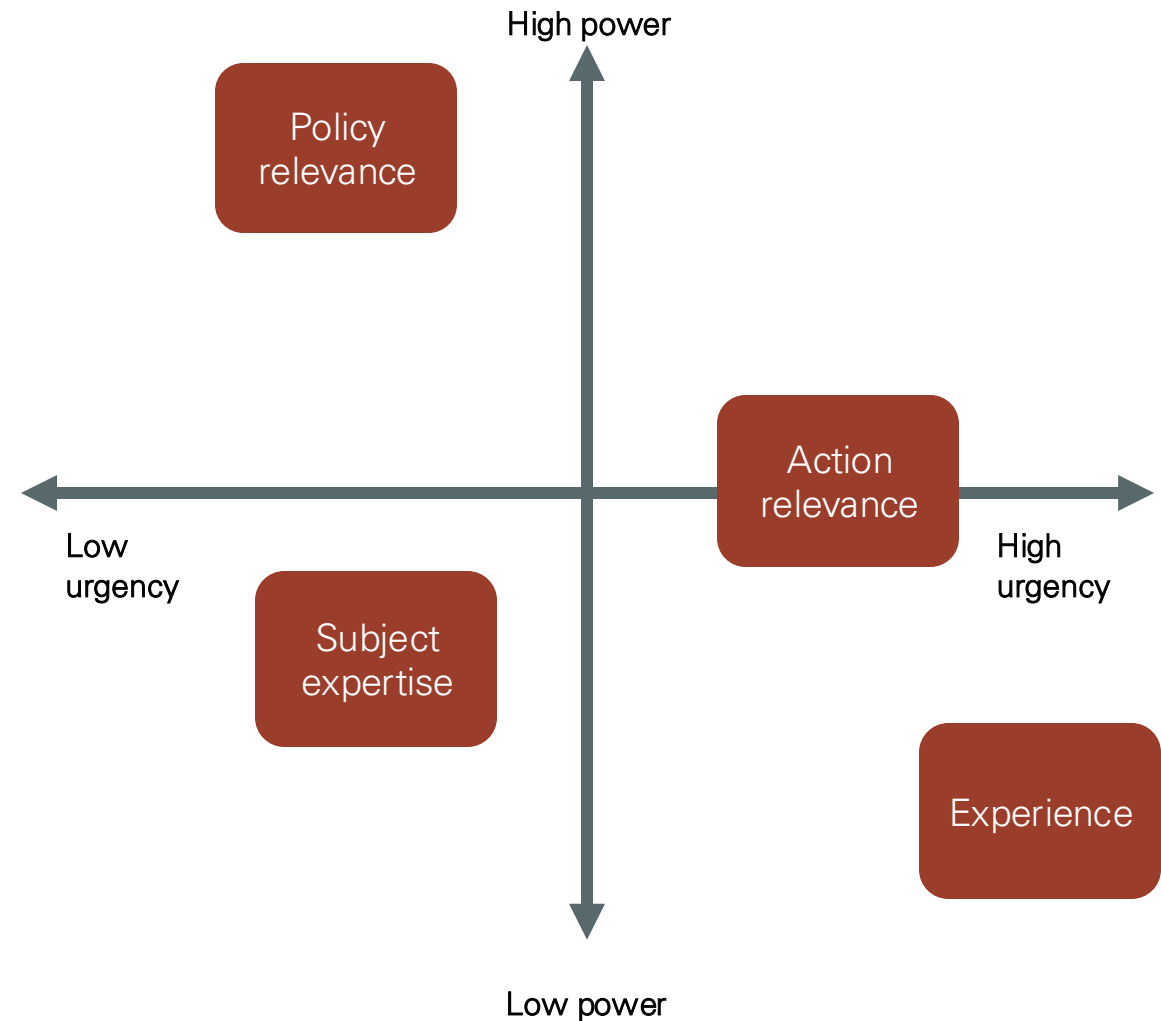
# Before the workshop

- Select a focal problem (and potentially focal factors)
- Gather knowledge/ stakeholders

# Diverse stakeholder management

Stakeholder types:

1. Policy and action relevance<sup>1</sup>
  - Decision-making power
  - Need for change
  - Interest in change
2. Subject expertise and experience<sup>2</sup>
  - Professional
  - Personal (consumers and end users, community members, personal experience)



de Gooyert, V., Rouwette, E., van Kranenburg, H., & Freeman, E. (2017). Reviewing the role of stakeholders in Operational Research: A stakeholder theory perspective. In *European Journal of Operational Research* (Vol. 262, Issue 2, pp. 402–410). Elsevier B.V. <https://doi.org/10.1016/j.ejor.2017.03.079>

Lee, G. Y., Hickie, I. B., Occhipinti, J. A., Song, Y. J. C., Skinner, A., Camacho, S., Lawson, K., Hilber, A. M., & Freebairn, L. (2022). Presenting a comprehensive multi-scale evaluation framework for participatory modelling programs: A scoping review. In *PLoS ONE* (Vol. 17, Issue 4 April). Public Library of Science. <https://doi.org/10.1371/journal.pone.0266125>

Deutsch, A. R., Frerichs, L., Perry, M., & Jalali, M. S. (2024). Participatory modeling for high complexity, multi-system issues: challenges and recommendations for balancing qualitative understanding and quantitative questions. *System Dynamics Review*. <https://doi.org/10.1002/sdr.1765>

# Planning your session(s)

## 1. Objective

- To maximise participation and minimize participant burden: several short duration (90 min) small group or individual qualitative diagramming sessions (PSMs)

## 2. Focus of each session

- to understand the system through specific viewpoints (e.g. personal experience, or mental models around acceptance)

## 3. Number of sessions determined by

- Synthesis of system maps produced, to understand information gaps
- Reaching saturation (model completion), when sessions became repetitive

# Concept map



## What it is:

Your hypothesis or understanding from the literature



## What it's useful for:

Do experts in the field agree with this conceptualization?

Encouraging discussion and deliberation over the state and structure of a nebulous system

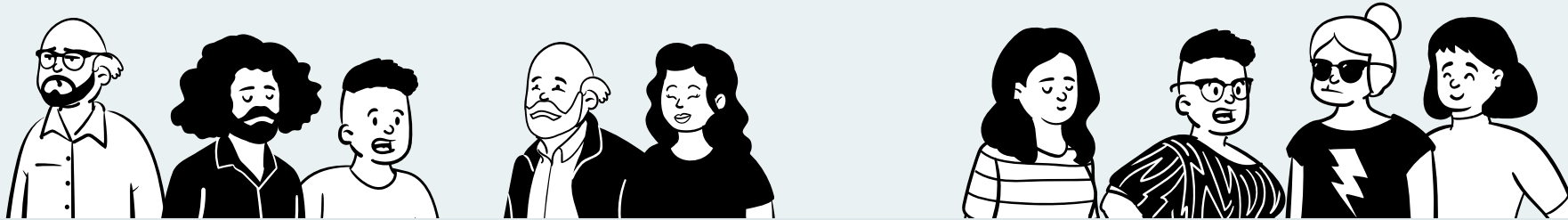
How they see the state of the system shifting over time. For which it's useful to have a common understanding of what the state of the system is now



## What it's NOT:

An 'accurate' representation of reality (whatever you may conceive this to be)

# Adapting this to different stakeholder groups and types



Individuals – you might want to build the concept map together (through a semi structured interview format)



Groups (workshop) - often with pre-defined focal factors or concept maps

# During the workshop

- Pick a focal factor
- Brainstorm factors
- Consolidate factors
- Connecting factors and checking (iterate and prompt)
- Collect extra info (node/link characteristics)



<https://openpolicy.blog.gov.uk/2022/01/24/tools-for-climate-policy-2-systems-mapping/>

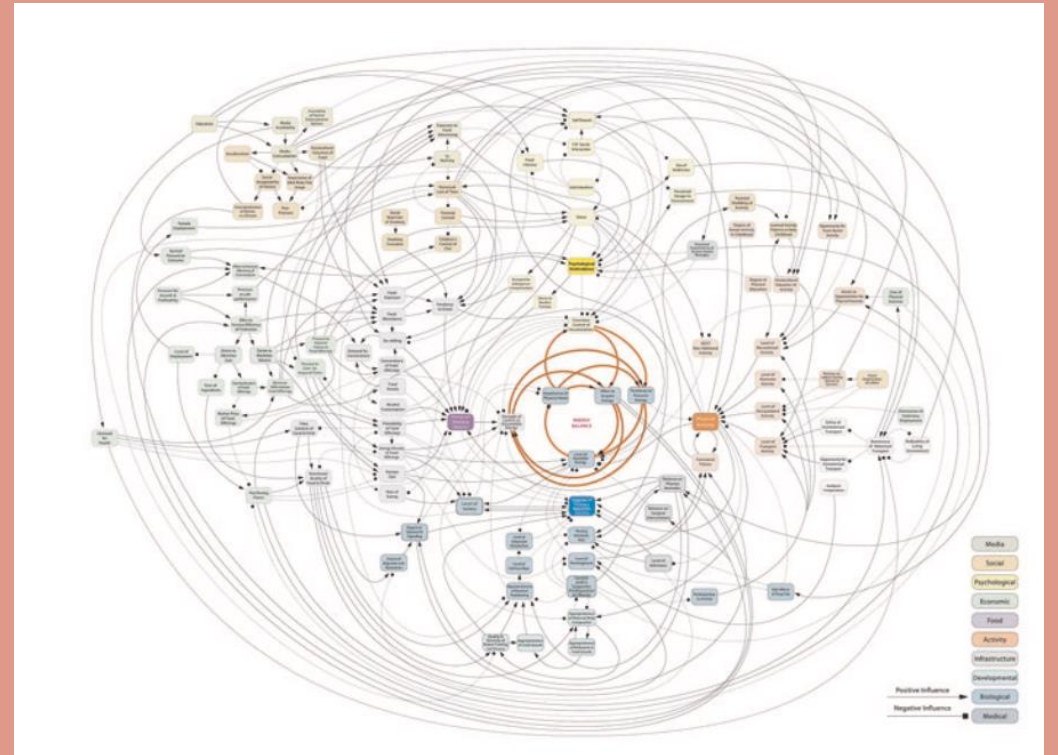
# Types of moderators in group model building

Depending on group size, you either need all or some of these. Roles can be merged based on expertise and size of group and session

Facilitator/ knowledge elicitor	<ul style="list-style-type: none"><li>• Does most of the speaking and prompting, active role</li></ul>
Notetaker/recorder	<ul style="list-style-type: none"><li>• Records key insights (especially those not recorded by participants on maps), passive role</li></ul>
Process coach	<ul style="list-style-type: none"><li>• Focuses on group dynamics, not content, and supports the facilitator, especially in large groups.</li></ul>
Recorder	<ul style="list-style-type: none"><li>• Documents key discussions and visuals to help reconstruct the group's thinking and must understand modelling.</li></ul>
Gatekeeper	<ul style="list-style-type: none"><li>• Connects the client group and modeling team, ensures the right people are involved, and influences the process.</li></ul>

# After the workshop

- Digitise map
- Verification
- Analysis/modelling



Barbrook-Johnson, P., & Penn, A. S. (2022). Systems Mapping How to build and use causal models of systems. <https://gum.co/systemdiagrams>

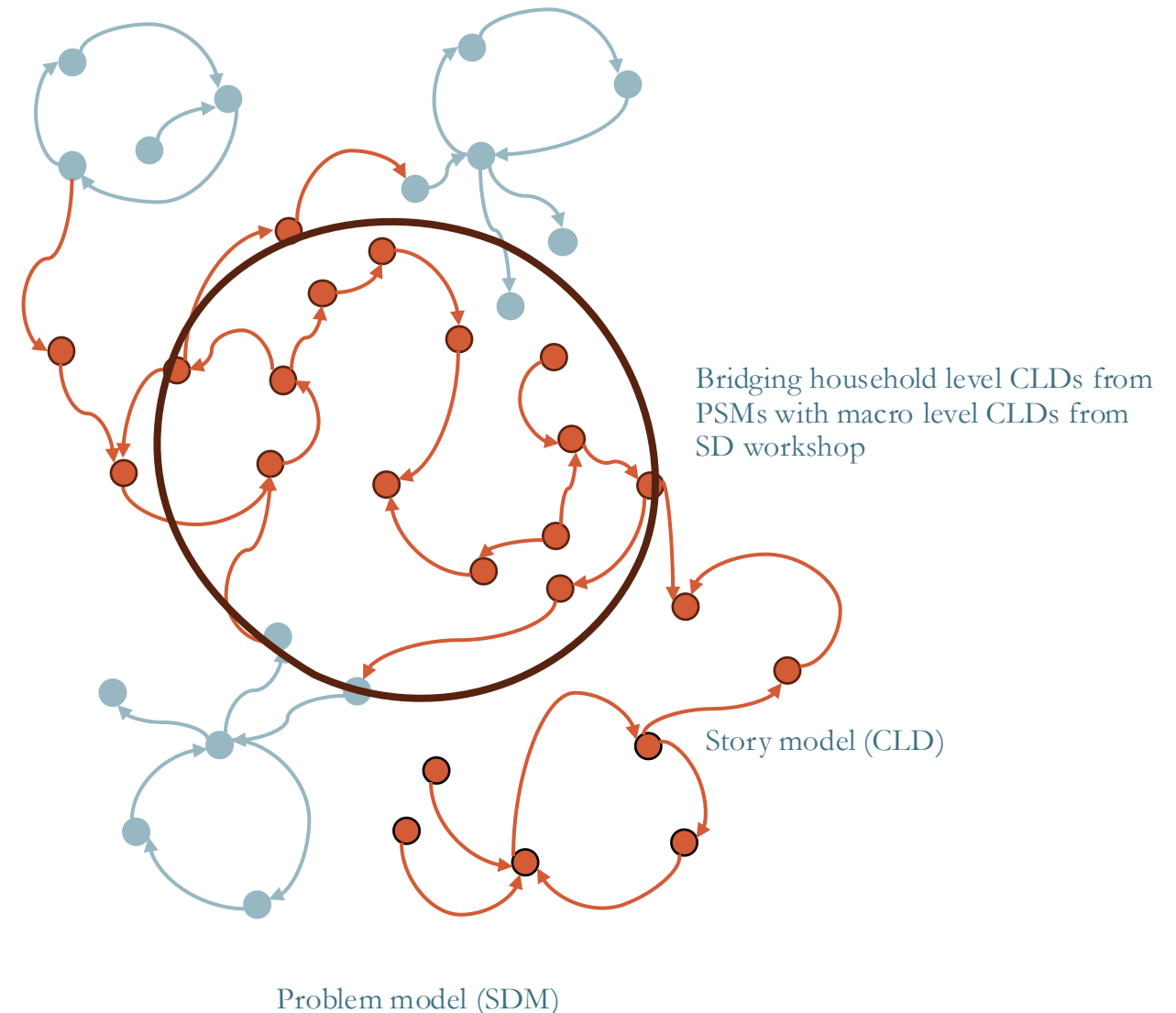
# 'Problem' models within a 'story' model

1. Develop two levels of model (Duetsch et al 2024)
  - a. Story model (CLDs representing the system). Useful for refining problem models.
  - b. Problem models (smaller SD structures representing specific problems). Used for policy testing.

→ Build CLD of whole system and SDM of relevant structures within for quantitative policy testing

“...in developing dynamic hypotheses, we needed to consider the best way to quantitatively model variables at multiple levels of granularity and as existing within different areas of the system”

- Potential leverage points can be examined using story model (zoomed out CLD that contains the SDM) to also examine which critical variables are connected to these leverage points.



## Clarifying research problems, model boundaries, and levels of granularity (system v problem model)

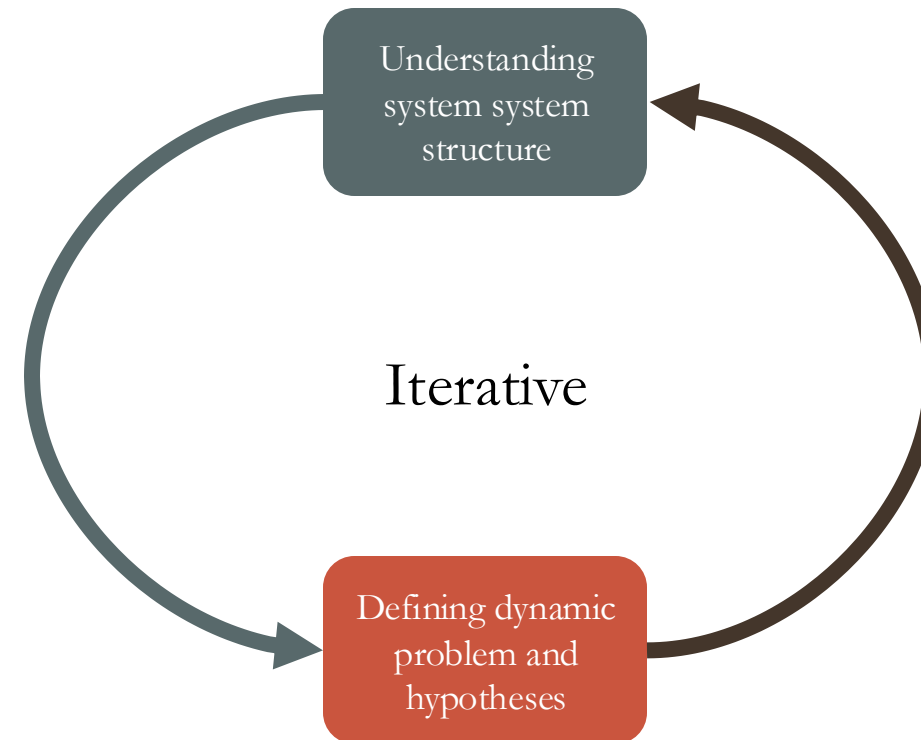
1. Iterative process towards comprehensive and complete model<sup>1</sup> but unclear how to determine when completeness is reached<sup>2</sup>
2. System models vs problem models: the latter is considered best practice<sup>3</sup> but sometimes stakeholders want to see the system.
3. Level of aggregation (macro to micro) and connecting key leverage variables across systems
4. Managing uncertainty v maintaining parsimony

1 Martinez-Moyano and Richardson 2013

2 Ryan et al 2021

3. Sterman 2000

## Developing testable quantitative SD models



# Exercise



Divide yourselves into four groups.



Come up with a research question/conceptual map



For 30 min each, take turns being facilitators and workshop participants.

## Sharing experiences

1. How did you find the experience?
2. What did you find challenging about it?
3. What are your thoughts on this method?

# I have a CLD, now what?

- Use CLD for **negotiation, deliberation, or problem-solving**
- Bridge **contrasting stakeholder viewpoints**
- Understand **system state, intervention points, and future challenges**
- Extend to **system dynamics model** for quantification

Does every  
problem require a  
systems approach?



Shutterstock

# Get in touch!

[poornima.kumar@eci.ox.ac.uk](mailto:poornima.kumar@eci.ox.ac.uk)

# Resources

## Basics and overview

- Barbrook-Johnson, P., & Penn, A. S. (2022). *Systems Mapping: How to build and use causal models of systems* (1st ed.). Palgrave Macmillan. <https://gum.co/systemdiagrams>
- Sterman, J. D. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. Irwin/McGraw-Hill.
- Penn, A., & Barbrook-Johnson, P. (2022). How to design a Participatory Systems Mapping process. <https://www.cecan.ac.uk/sites/default/files/2019-03/PSM%20Workshop%20method.pdf>
- Wolstenholme, E. F. (2003). Towards the definition and use of a core set of archetypal structures in system dynamics. *System Dynamics Review*, 19(1), 7–26. <https://doi.org/10.1002/sdr.259>

## Bridging quantitative-qualitative methods and system scales

- Naugle, A., Langarudi, S., & Clancy, T. (2024). What is (quantitative) system dynamics modeling? Defining characteristics and the opportunities they create. *System Dynamics Review*, 40(2). <https://doi.org/10.1002/sdr.1762>
- Deutsch, A. R., Frerichs, L., Perry, M., & Jalali, M. S. (2024). Participatory modeling for high complexity, multi-system issues: challenges and recommendations for balancing qualitative understanding and quantitative questions. *System Dynamics Review*. <https://doi.org/10.1002/sdr.1765>

## Software

PSM (to digitise maps, or conduct virtual workshops)

- Kumu
- Miro

**Quantitative system dynamics modelling** (also support causal loop diagramming)

- Vensim
- Powersim
- Stella Architect (ISEE systems) – paid

[https://eprints.ncrm.ac.uk/id/eprint/4206/1/Sys\\_Mapping\\_NCRM\\_BATH\\_2018\\_for\\_sharing.pdf#page=8.00](https://eprints.ncrm.ac.uk/id/eprint/4206/1/Sys_Mapping_NCRM_BATH_2018_for_sharing.pdf#page=8.00)

The Systems Thinker (website)