Systems Thinking: teaching resources

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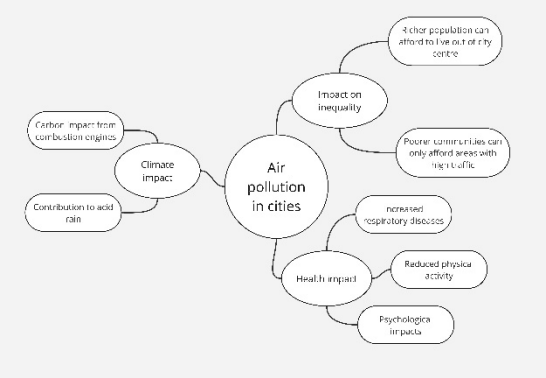


Introduction

This resource contains example learning outcomes, learning activities, and systems thinking tools and resources to introduce students to systems thinking for Education for Sustainable Development (ESD).

Go to CIE's introductory Learn more about Education for Sustainable Development (ESD) webpages for more on the theory and practice behind embedding systems thinking for ESD.

If you have any resources that you use in your teaching that you think will be support student system thinking competency development and will be accessible to other subject areas, please contact cie@liverpool.ac.uk

Example learning outcomes for systems thinking competencies

A student with systems thinking competency can:

Knowledge

- Describe the relationships between environmental, social, and economic systems, at scales from local to global level.
- Identify the tensions between the 17 SDGs and recognise their interconnections.
- Recognise that a collective effort is not necessarily just a simple sum of each individual's effort but is likely to be more complex and have multiple drivers that may be personal, political, or communal.
- Identify that positive or negative environmental change may arise from economic growth.
- Describe how power structures and political systems influence sustainable development.

Skills

- Recognise and understand relationships.
- Analyse complex systems.
- Consider how a system's constituent parts interact and operate at different scales and across time.
- Work with interconnectedness and complexity in a systemic context, synthesising diverse information and data to offer a range of potential solutions.
- Identify the interactions between social, economic, and environmental systems.
- Assess a problem from different scales and perspectives.

Attributes and values

- Think systemically, in terms of recognising connections and interactions between factors, and understand that actions often have multiple consequences.
- Deal with and manage uncertainty.
- Appreciate the root causes of unsustainable development including environmental, social, and economic actions, and their links to cultural considerations.
- Identify the factors that have the biggest potential for driving constructive change.

Extracted from: QAA Education for Sustainable Development guidance, 2021.

Example learning activities for systems thinking

Suggestions for learning activities that you can adapt into your teaching to introduce systems thinking for sustainability to your students:

Introducing systems thinking into your teaching

Aims:

- Preparatory activity to introduce students to real-world examples of sustainability related systems.
- Assist students to understand systems and complex systems within the context of your subject area.

Learning activities:

- Relevant to your subject area, introduce into your teaching real-world case studies and other resources illustrating different sustainability related systems.
- This could be a natural system (carbon in the environment), economic system (finance and insurance of climate change adaptation), or social system (factors underpinning climate induced inequality) for example.
- Illustrate how the system is more than the sum of the components and the unpredictable nature of complex systems.

Systems Thinking and How It Can Help Build a Sustainable World: A Beginning Conversation - Millennium Alliance for Humanity and the Biosphere, MIT.

Introduction to exploring systems

Aims:

- To enable students at an introductory level to explore a specific complex sustainability related system and associated sub-systems.
- Introduce different techniques to modelling systems.

Learning activities:

- For a selected system, ask students to describe key components, interrelations, boundaries, and related sub-systems.
- Tools such as EPOSA, rich pictures, storytelling, other media, or the iceberg model can be used and are relatively straightforward for students to understand. (See the systems thinking diagramming techniques section below.)

Exploring systems in greater depth

Aims:

- To enable students to systematically explore a specific system and sub-systems in greater depth.
- Introduce analytical systems diagramming approaches.

Learning activities:

- For a selected system, ask students to describe key components, interrelations, boundaries, and related sub-systems.

You could extend the information that you ask students to include:

Multiple perspectives:

- Who or what are the key stakeholders in this situation?
- What stakes (individual values and motivations) do they have?
- What are the different ways in which the situation can be framed or understood – by whom?

Interconnections:

- How do the elements within the situation (components, stakeholders, knowledge, etc.) interconnect?
- What patterns emerge from these relationships in action - with what consequences, and for whom?

Boundaries

- Define scope and scale.

- Are other boundaries possible – and feasible?

Influences:

- What drives the systems in question in particular directions
- Identify drivers, trends, enablers, blocks, leverage points.

Developed from: An introduction to systems thinking and systems design – concepts and tools (Learning for Sustainability, 2018).

- Introduce students to the following systems diagramming tools:

The Open University (Diagrams in systems thinking) has an sequenced and iterative approach to systems diagramming using the following techniques - it may not be appropriate in your teaching context for your students to complete all of these techniques:

1. **Rich pictures** – quickly captures initial perceptions and emotions of a system and related sub-systems in a visual and non-verbal form.
2. **Spray diagrams** – classify and analyse themes and components developed from the rich picture.
3. **Systems map** – identifying major systems and sub-systems (with distinct purposes) components and entities. Makes understanding of the system explicit, including decisions about where to draw boundaries.
4. **Influences map** – how different components, sub-systems and systems influence (e.g. power over, strength of relationship, control) each other.
5. **Multiple cause diagrams** – cause and effect relationships between components in the system. Focusing on the factors that give rise to the dynamic behaviours of the system that can be measured.
6. **Causal loops diagrams** – related to multiple cause diagrams, maps logic of causal relationships. Can be used as the basis for quantitative systems dynamics models.

Simulating complexity

NetLogo (Uri Wilensky, Center for Connected Learning and Computer-Based Modelling, Northwestern University) complexity simulation in a graphic and visual way. Netlogo includes pre-created complex systems from a range of social, economic and environmental contexts that your student can interact with.

Aims:

- NetLogo provides an accessible software simulation tool that enable students to explore the dynamics of complex systems.
- Illustrates the unpredictability of complex system when changing one or more components.

Learning activity:

- Individually or in small groups ask student to adjust single or multiple system component to review the impact on the system.

NetLogo Web for access to the software (free to use on the web) and support resources.

Life Cycle Assessment (LCA)

ISO standards for the environmental impact of products (E-CLA) can be introduced to students as a systems thinking learning activity alongside emerging social lifecycle analysis approaches (S-LCA):

ISO 14040:2006: Environmental management — Life cycle assessment — Principles and framework

Guidelines for social life cycle assessment of products and organizations 2020.

Aims:

- Introduce students to the theory and principles in LCA approaches.
- Introduce students to international standards (ISO14040) for environmental LCA and emerging approaches to social LCA.

Learning activities:

- Introduce students to the concepts and processes that underpin the environmentally focused life cycle assessment (E-LCA ISO14040) and emerging S-LCA frameworks.
- For a given product, ask students to simulate completing an assessment at an introductory level using process stages in the E-LCA framework:
    - Goals and scope.
    - Life cycle inventory.
    - Impact assessment.
    - Interpretation.

Using the S-CLA guidelines you could also ask students to simulate completing the process using the stakeholder categories and impact sub-categories as part of the assessment:

    - Worker – child labour, fair salary, health and safety etc.
    - Local community – access to material resources, cultural heritage etc.
    - Value chain actors (not-consumers) – fair competition, promoting social responsibility etc.

- Consumer – Health and safety, feedback mechanisms etc.
- Society – public commitments to sustainability issues, contribution to economic development etc.
- Children – education provided in the local community etc.

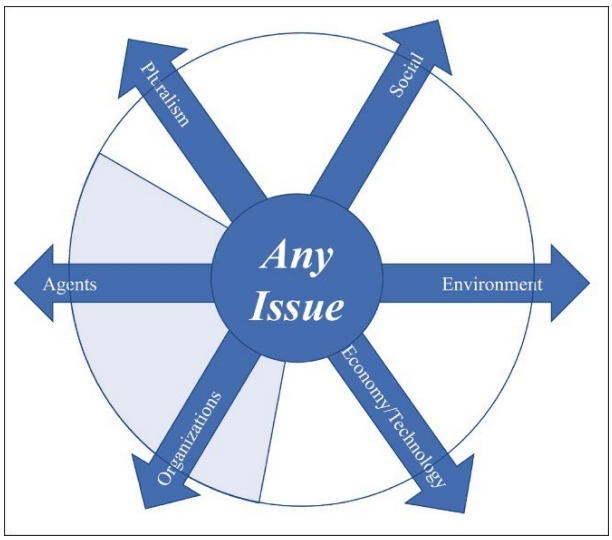
Sustainability topics for systems thinking learning activities

The UN's Sustainable Development Goals can be a good source of complex sustainability issues to draw on for any systems thinking learning activity. Go to the UN Sustainable Development Goals (SDGs) teaching resources guide.

Systems Change Lab – (environment focused) select the 'Systems' section. Outlines key systems (power, industry, cities, finance etc.) and 70 critical shifts that need to be made to secure a sustainable future.

Systems thinking diagramming techniques

EPOSA



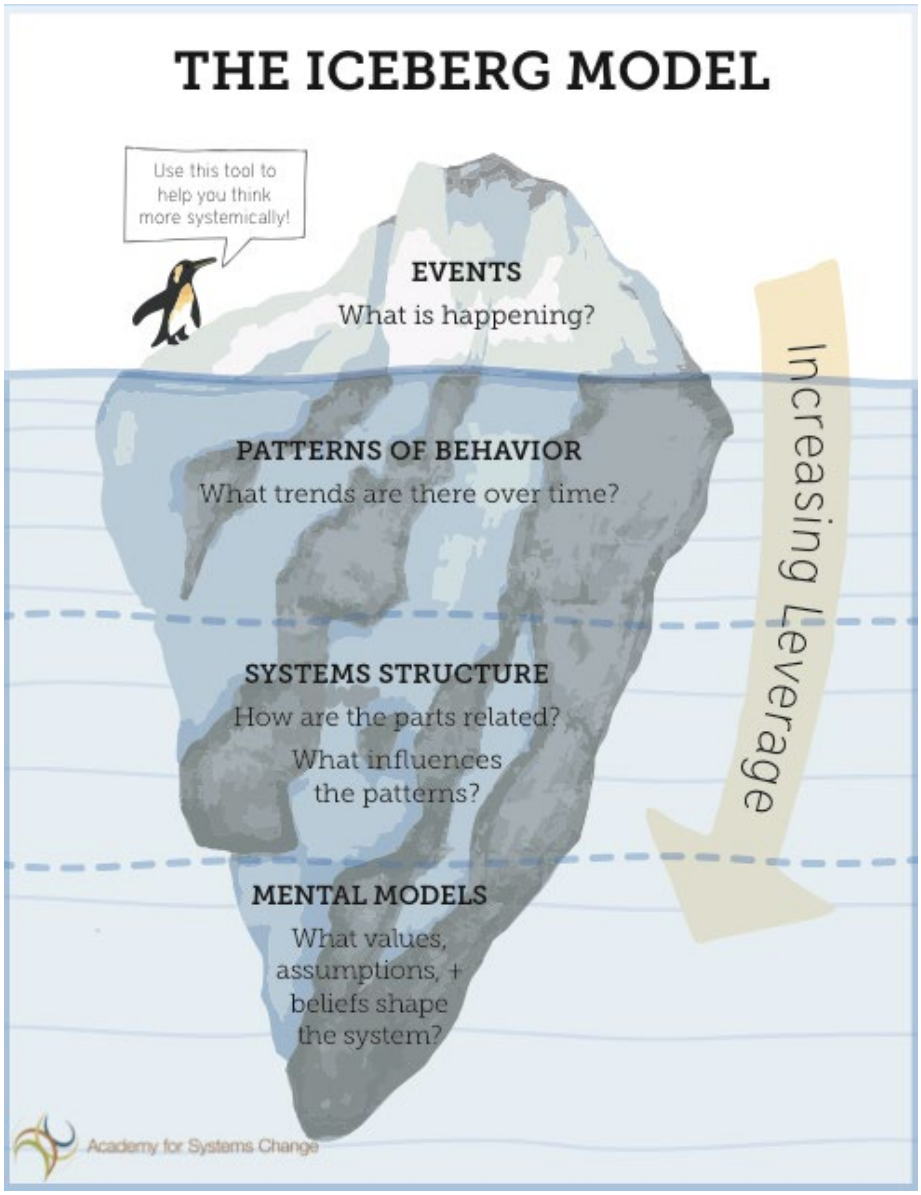
EPOSA (environmental, pluralism, organisation, social, economy/ technology, agents) is a simple paper-based graphic template designed to enable students to structure and explore their understanding of a complex issue.

(See Appendix 1: template EPOSA diagram plus a completed example that you can print off to use with your students)

Using multimedia for systems thinking

Digital or other story telling - storytelling is a powerful tool for learning as humans are hardwired to make sense of their lives and their surroundings through stories.

The Iceberg model

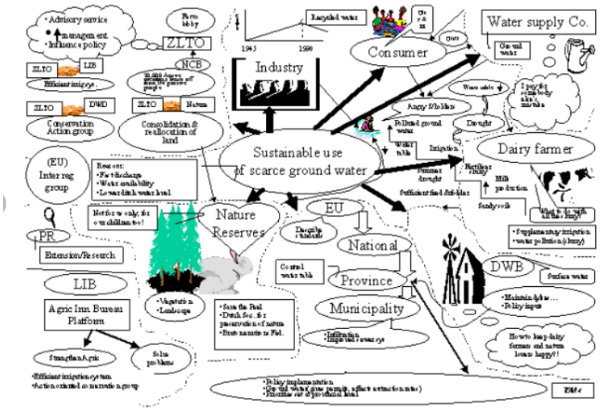


The Iceberg Model: Donella Meadows Project – accessible model for students to explore a system; events, patterns of behaviour, system structure, and mental models.

See Appendix 2 for an Iceberg Model Word template you can use with your students.

Diagrams in systems thinking - practical 'how to' resources from the Open University on a range of systems thinking tools.

Rich pictures



Taken from: [A conceptual map of land conflict management: Organizing the parts of two puzzles]

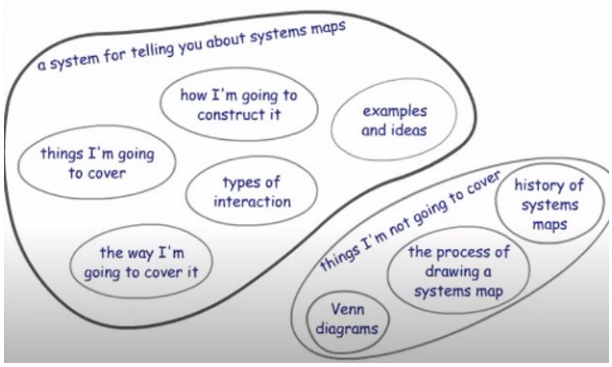
[Rich pictures] uses visual metaphors and can be more intuitive to some audiences. Useful when there is no common language of analysis and discussion between stakeholders.

Purpose of rich pictures is to gather in one place, on one sheet of paper, all the data about a complex messy situation that you have collected. Using pictures or drawings is helpful in being able to collect it all together on one piece of paper, so that you can see everything together.

Spray diagrams

[Spray diagrams] - simple, fast technique for extracting the important ideas from a rich-picture etc situation, conversation, presentation or written article and getting them down on paper in a way that is meaningful to you.

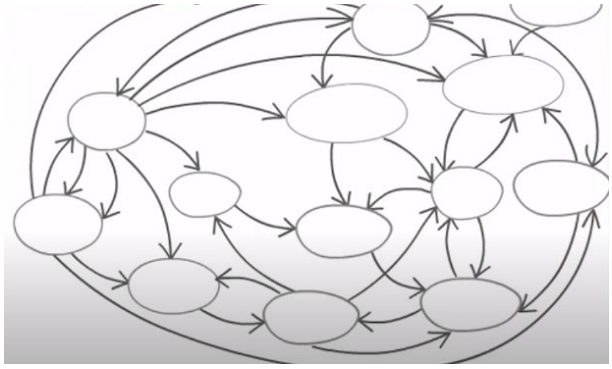
Systems maps



Systems maps – shows components of the system and environment from the perspective of the person drawing the map. It is possible to depict a different perspective of the same situation by placing the boundary at different points on the same systems map.

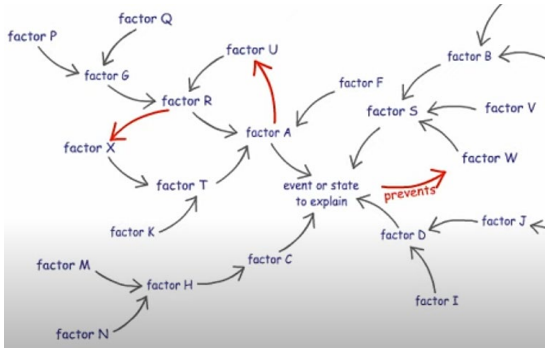
The main uses of systems maps are to help you to begin to decide how you are going to structure a situation and to communicate to others the system you have chosen to study.

Influence diagrams



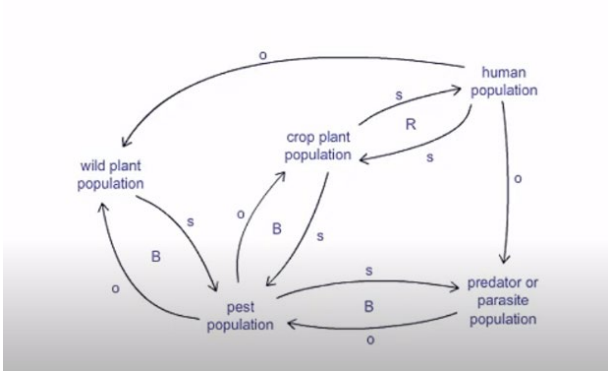
Influence diagrams - is a straightforward development from a systems map that explores the influences between the components that you have included on the map. It therefore represents how the components both of the system and its environment interact and shows the important relationships that exist among them. It presents an overview of areas of activity, or organisational and other groupings, and their main interrelationships.

Multiple cause diagrams



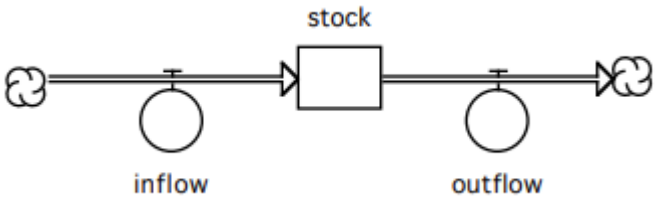
Multiple cause diagrams - the purpose of this type of diagram is to consider events, and states of things, and to explore the causal connections between them. It is useful for finding out why something went wrong or keeps recurring. These diagrams have an important feature in that they identify feedback loops. Understanding unpredictable dynamics is often helped by unravelling the interaction between different feedback loops.

Causal loop diagrams



Causal loop diagrams - are used to graphically depict dynamic interrelationships among variables you may not have considered before. They allow you to see how parts of a system that are separated by location or time might nonetheless interact to generate problems.

Stocks and flows diagram



Stocks and flows diagram – (Donella Meadows Project) stocks (quantity of material or information that has built up over time) are the foundation of any system that change over time through the action of flows; draining, births, deaths, production, consumption etc. Helps students to understand the behaviour over time of complex systems.

Life Cycle Analysis

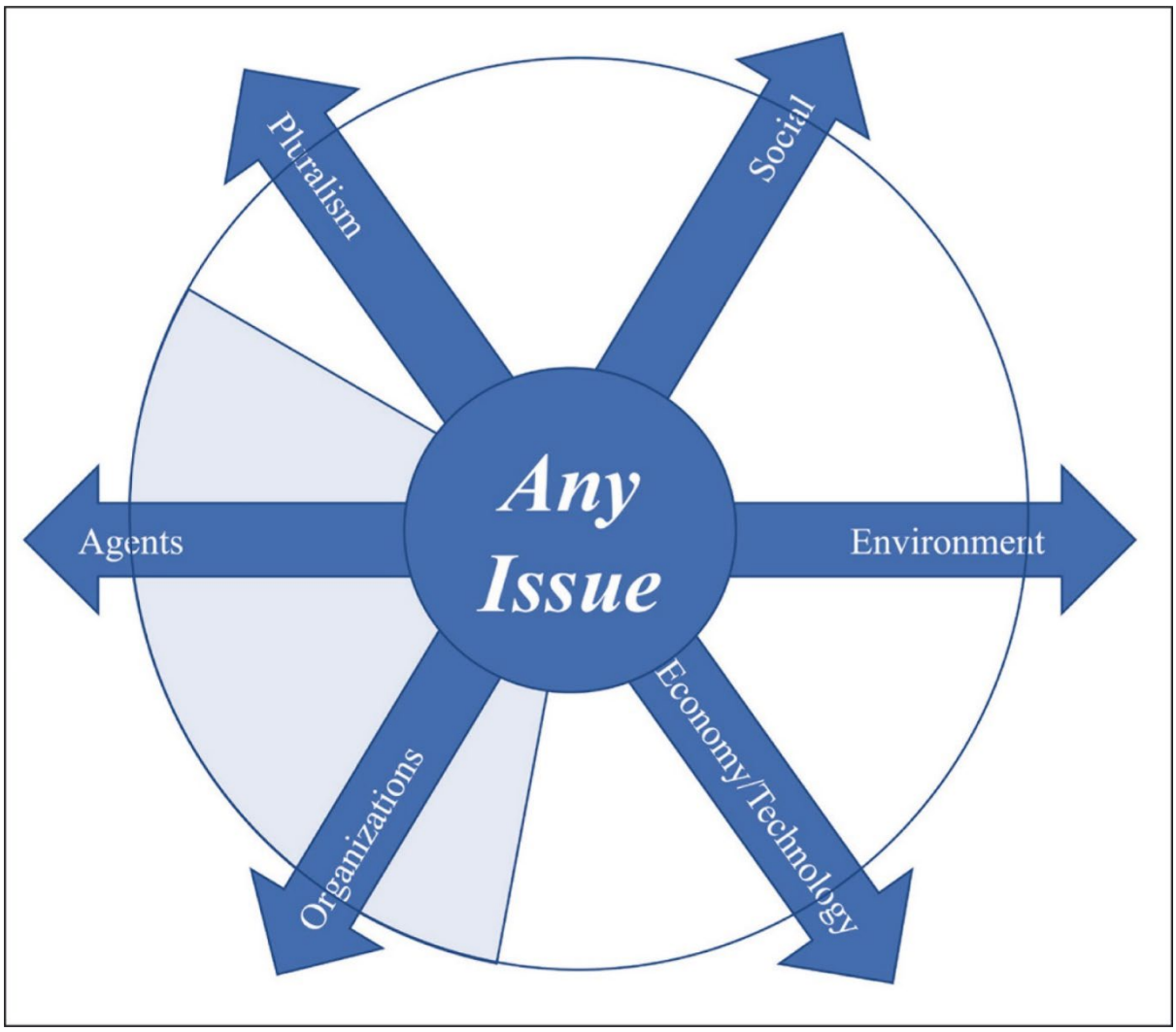
ISO 14040:2006: Environmental management — Life cycle assessment — Principles and framework

Guidelines for Social Life Cycle Assessment of Products and Organisations 2020 (UNEP, 2020)

Additional resources

Systems thinking tools: a user's reference guide (Systems Thinker)

Appendix 1: EPOSEA template and instructions for students



Key

Environment: ecological issues.
Pluralism: different perspectives.
Organisations: legal and political decision-making structures.
Social: social justice issues.
Economy/ technology: financial issues.
Agents: individuals (groups & you!) that are making decisions.

How to use this tool

1. Use the provided template or draw the six axies of the diagram on a large sheet of paper.
2. Select a sustainable development issue you want to work on.
3. 'Brainstorm' by adding key words to the six dimensions.

4. Make connections as you add key words.
5. Then, go back and think critically about your key words:
   a. Identify any gaps in the map.
   b. Make connecting lines between key words.
   c. Add notes to capture any cause-effect between the different key words.
   d. Check data you have on each area and identify further learning that is needed.

An example

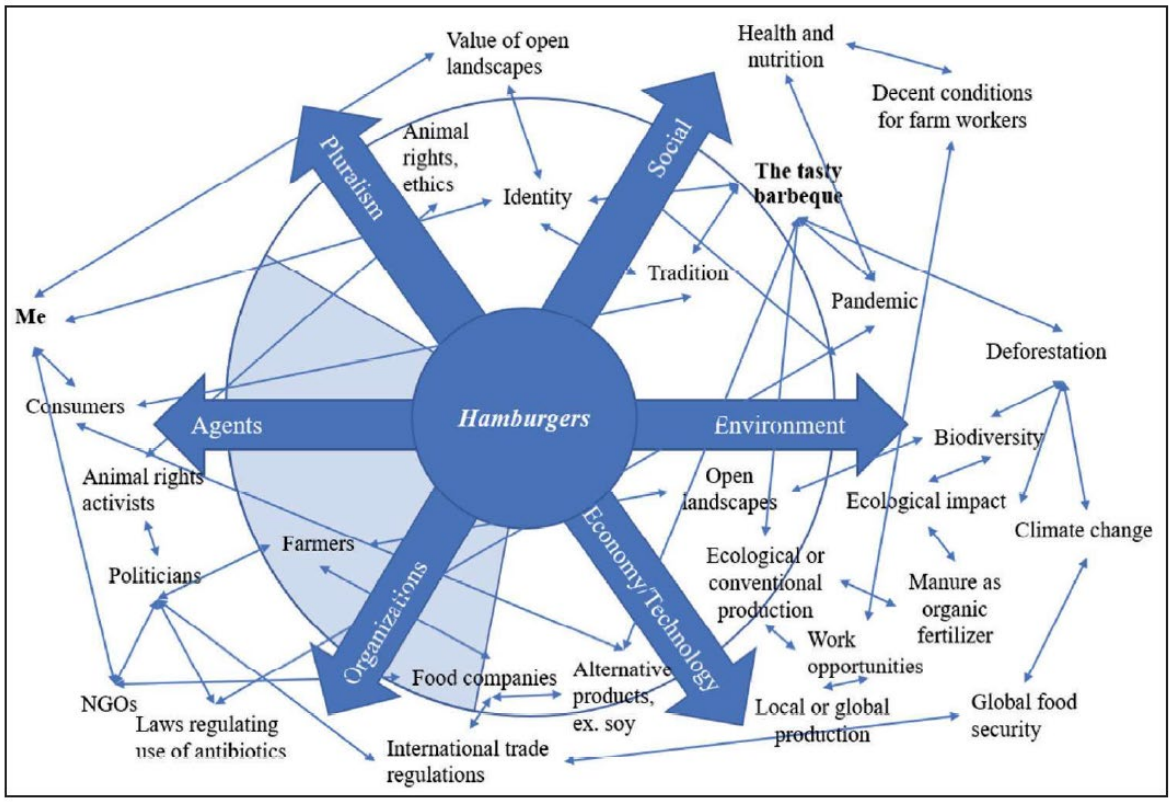


Figure 2 EPOSEA map for a Hamburger Sustainability Story, Far from Complete

Appendix 2: The Iceberg Model for Systems Thinking

Events: what's happening?	
Patterns & trends: what trends are there over time?	
Systems structures & drivers: how are the parts related? What influences the patterns?	
Mental models: what values, assumptions, beliefs shape the system?	

Developed from: Systems Thinking Resources (The Donella Meadows Project)