Sustainability science and the management of renewable energy technologies

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Research problem

- Conventional research in renewable energy technological systems addresses fundamental and applied knowledge for the problems of sustainable development
  - Efficiency of energy conversion and utilization of work
  - Access to energy for development
  - Reduction in global warming emissions
- Success with these technical concerns is not enough
  - Does not address social-ecological complexity
    - Interactions between sub-systems

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Issues with assessing technological systems in the R&D phases

Geisler, 2002

- Technology is not judged by its existence alone, nor is its mere existence a sufficient condition for successful usage
- We cannot evaluate technology unless and until we put it in the context of social (and environmental) and economic phenomena
- Technology is not defined and evaluated by what it is, but by the criteria outside itself – by its actual and potential users

Practical indicators to measure SD performances should address the conceptual framework of the emerging field of sustainability science

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What is sustainability science?

- The study and integration of particular issues and aspects of radical, systemic approaches to innovation and learning for ecological and social sustainability
  - Recognises negative feedback loops associated with social-ecological systems and technology
  - Role of technological life cycles to enhance the sustainability of complex social-ecological systems
    - Concentrating on the design of devices and systems to produce more social good with less environmental harm

Technology management

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What is technology management?

- Technology is a way or ways of carrying through any economic purpose, and may be embodied in products and/or processes
  - Technologies may exist as pure method or pure information; or they may be embodied in physical plant or machinery

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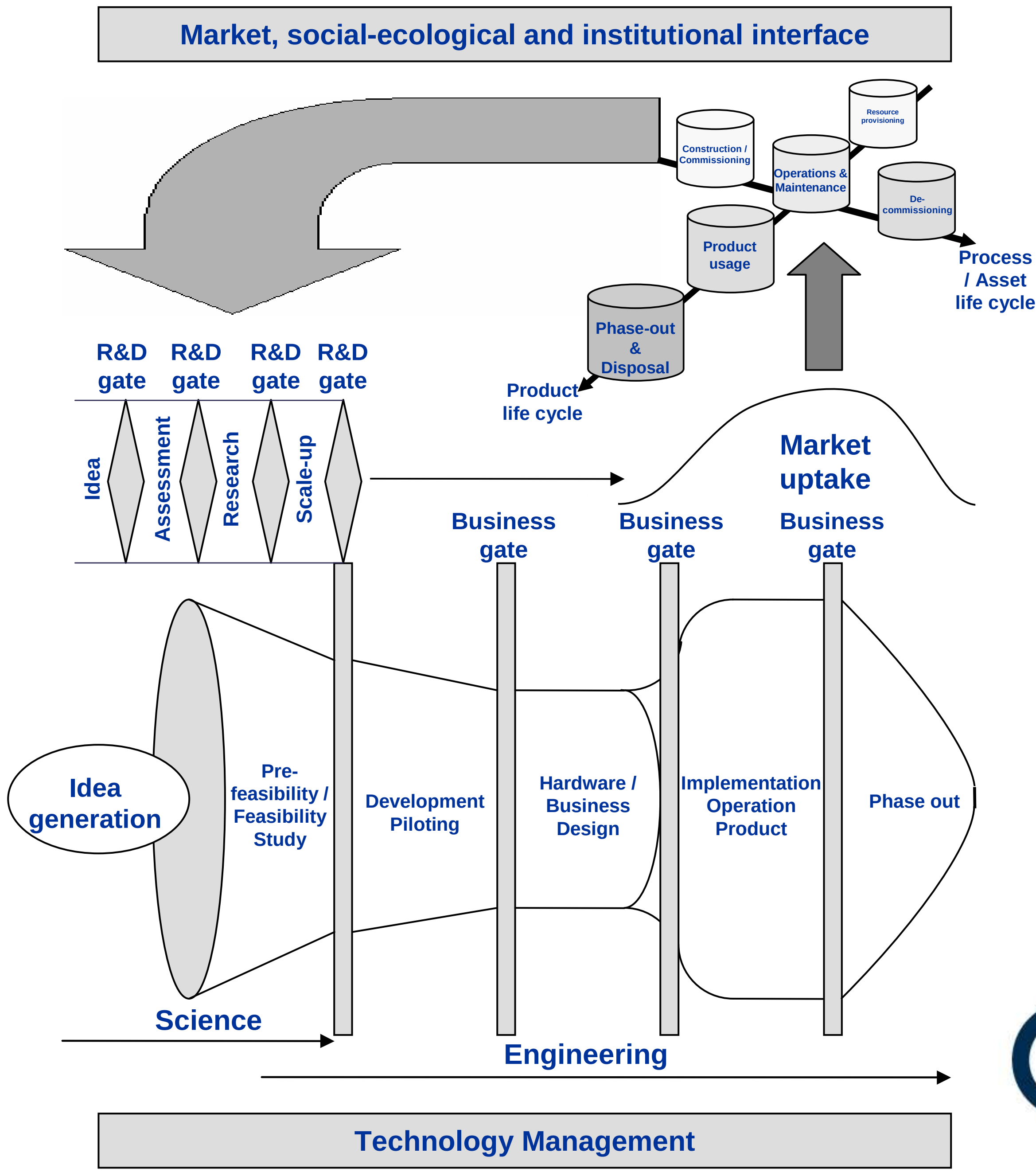

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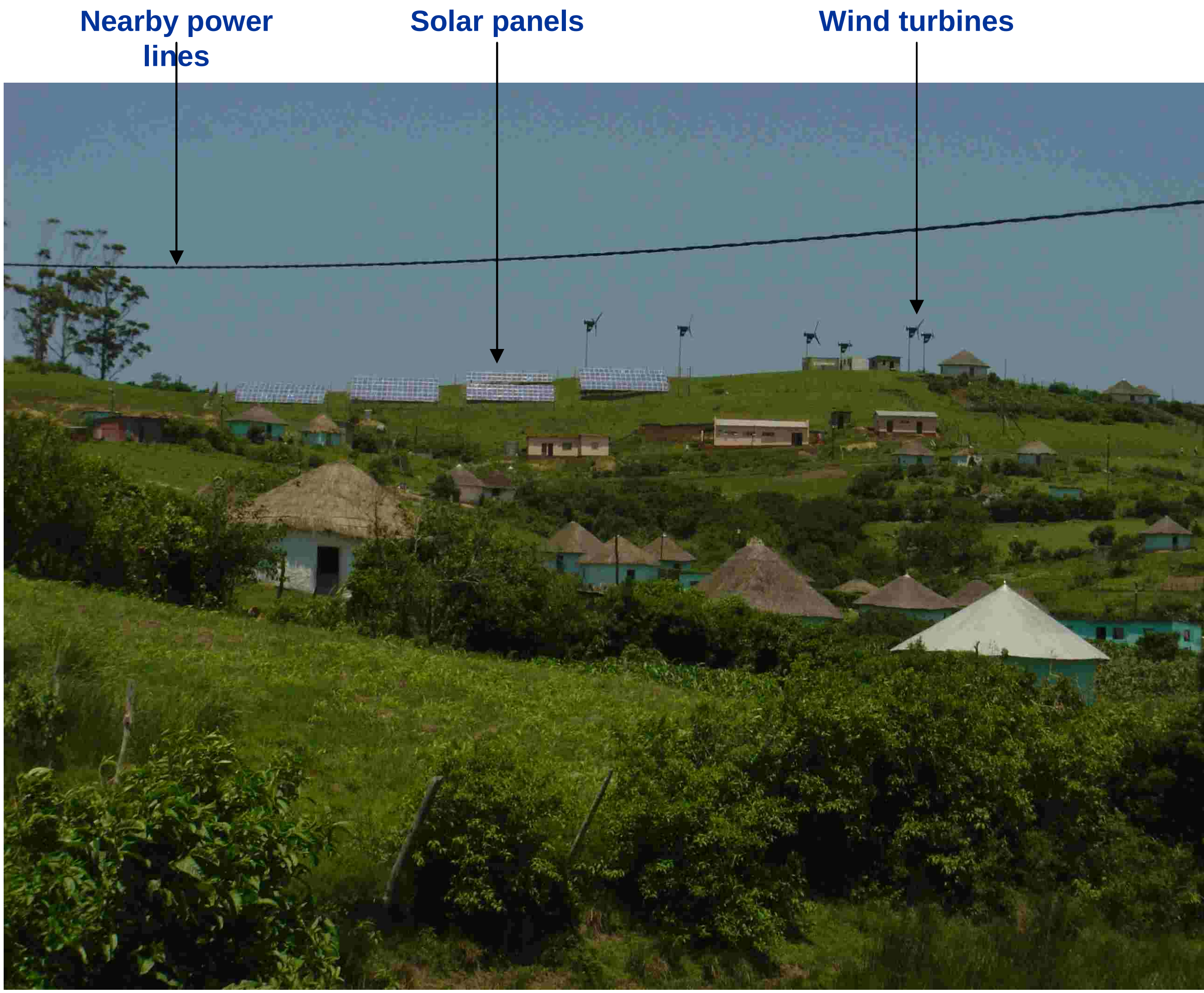
Theories of sustainability science as they relate to indicators of technologies

Trans-disciplinarity	Successful transformation of technologies into marketable commodities requires knowledge and skills from a variety of different specialist fields of science / engineering
Resilience	The resistance and robustness of an integrated system against surprises, which includes risk-based measures and precautionary regulations; the capacity to buffer change, learn and develop
Complexity	Deals with the study of complex systems, i.e. are composed of many elements that interact in complex ways; and the ability to model the structures with few parameters
Adaptive management	Adaptive resource management is an iterative process of optimal decision-making in the face of uncertainty, with an aim to reducing that uncertainty over time via monitoring
Adaptive capacity	As applied to human social systems, the adaptive capacity is determined by: • The ability of institutions and networks to learn, and store knowledge and experience • Creative flexibility in decision-making and problem solving • The existence of power structures that are responsive and consider the needs of all stakeholders

Research approach: Descriptive case study - Lucingweni village



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Conversion and application of the renewable energy system

	Unit power (kWh)	Units	Capacity power (%)	Efficiency losses (%)	Power supplied (kWh/day)
Solar PV	0.1	540	15	32	~ 129
Wind turbine	6.0	6	25	32	~ 143

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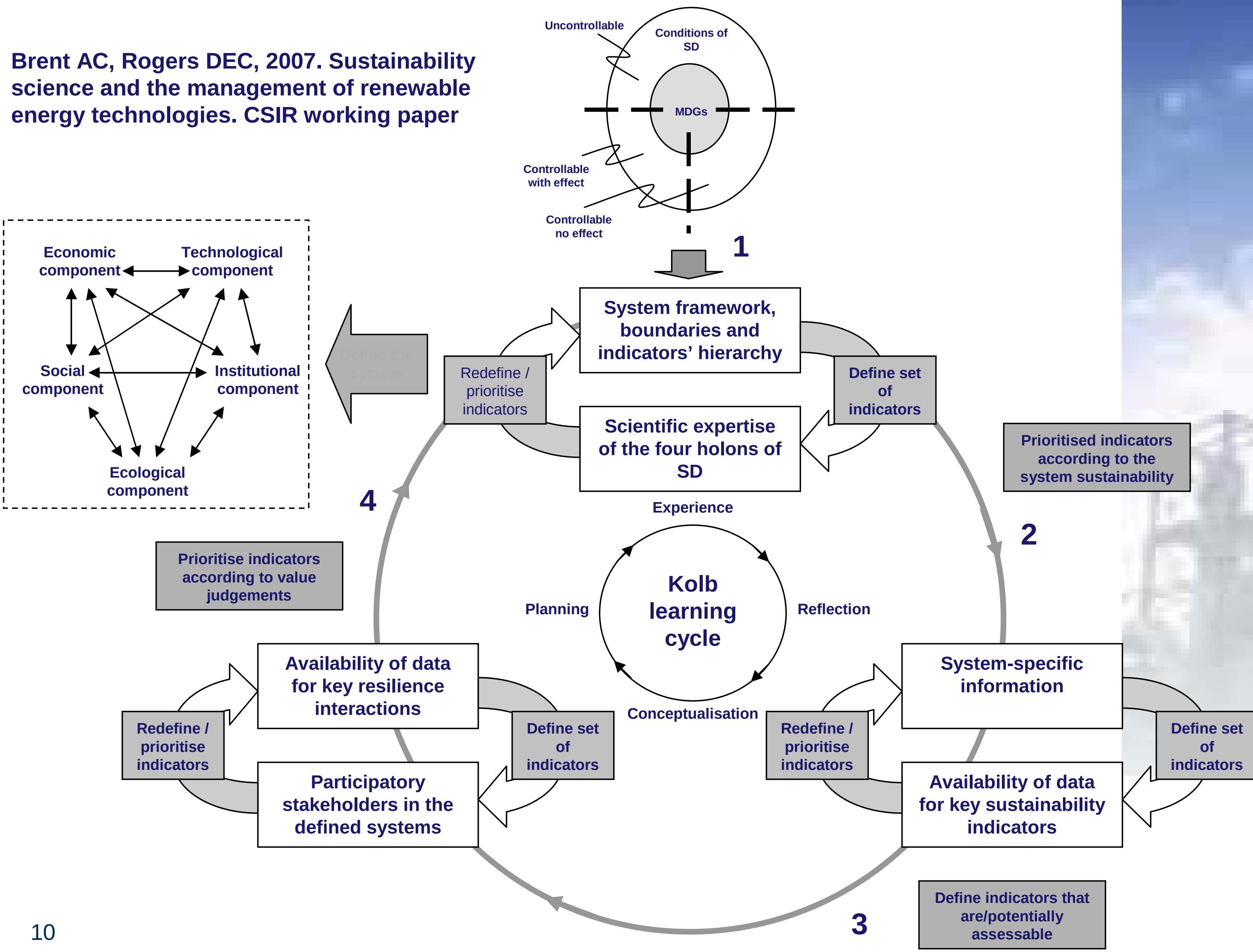
Brent AC, Rogers DEC, 2007. Sustainability science and the management of renewable energy technologies. CSIR working paper



Interaction with different individuals and/ or groups

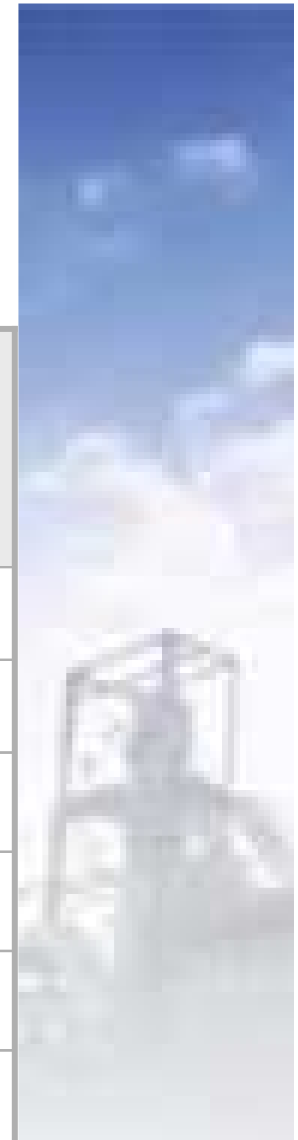
- Expertise
  - Hierarchical structure of MDG vs. practical indicators?
  - Relation of indicators?

Although the adaptive cycle and complex systems theory in general are useful integrating frameworks, disciplinary theories must be used to explain causes and effects in specific cases

- Stakeholders
  - Which aspects of the technology-economic-social-ecological-institution system are of most importance for the sustainability of the integrated system?

Overall prioritised assessable sustainability indicators for the systems

Indicator performance			Changes due to technological intervention		Unit
Holon	**Priority**	**Indicator**	**Designed for**	**Outcome after**	
Economic	A	PPP	none	none	US$/head/day
	A	Gini	none	none	% income lowest quartile
	A	Health	none	none	10 years of adult working life
	B	Education	some	some	years education working adults
	C	Access to basic services	some	Some	no units
	D	Affordability energy	yes	none	% of income/ disposable resources
	B	Positive return on energy investments	Some	none	% return



Comparison of prioritised indicators with overall integrated system performance

- Most important aspects were identified as:
  - Economic beneficiation of the technological intervention to the community
  - Ownership of the technological system by the community

- From an economic and institutional perspective the community expected that they would control a service similar to that provided by the national electricity grid
  - The capacity and reliability of the technological system proved insufficient to meet all of the community needs

→ **Behavioural changes**

Examples of insufficient design

- Small discrepancy between planned supply and demand
  - 272 kWh/day vs. 267 kWh/day
    - Unstable technical systems

- System did not consider all of the community's energy needs
  - Energy needed for heating and cooking purposes was not planned for
  - Consequence was the continual dependency on biomass in and around the village with the subsequent degradation of the ecosystem

Overall result of the case study

The technological intervention did not improve the conditions of the social sub-system, which resulted in the breakdown of trust between the cultural societal structures and the formal government structure

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The disregard of almost all of the indicators in the design stage resulted in an overall unsustainable system

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Demonstration of the learning model

- Provides a structured approach to prioritise assessable indicators for a specific type of technological intervention
  - Domain expertise are already knowledgeable about most issues in the field and much interaction with potential communities are subsequently not necessary, provided the expertise are familiar with the context where a technological intervention is planned
  - In this study only one learning cycle was completed
    - For new designed systems it is expected that multiple learning cycles will be associated with the phases in the technology life cycle

Considerations for technological system designers

- The complexity of social systems
  - Combined traditional and formal political leadership structures
  - Results in uncertainty for project planners and system designers

- The lack of resilience of the technology system to the demands from the social, economic and institutional systems
  - Comprehensive needs analyses
  - Cost dynamics
  - Ownership

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Implications for policy-making to promote renewable energy technologies

- Because social-ecological systems are self-organising, their evolution rarely follows the path intended by policy-makers
  - Governments are not free to invest or establish institutions at will, but must take account of the political influence of all stakeholders to promote sustainable systems
    - The capacity of such systems to self-organise is the foundation of their resilience

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Implications for policy-making to promote renewable energy technologies

- Rebuilding this capacity at times requires access to external resources
  - Excessive subsidisation can, however, reduce capacity
  - Cross-scale subsidisation should end when self-organisation becomes apparent, because cross-scale subsidisation can increase the vulnerability of the broader system
  - A long-term perspective is essential, i.e. cross-scale relationships should in the long term be mutually sustaining, neither exploitative from above nor parasitic from below

Closure and questions

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