

Sustainability Science

Dr Ariane König, University of Luxembourg

The existential problems of civilization in the 21st century are complex as most relate to interactions between humans and their environment, in a world that is experiencing accelerating changes in the technological, cultural, political, economic and environmental spheres. Moreover, changes in all these spheres are globally interconnected and interdependent. Traditional disciplinary fields of 'normal' science can only play a limited role in resolving such complex problems.ⁱ Experts in different fields of knowledge in the natural and social sciences often fail to understand each other.^{ii, iii} Sustainability science is an approach to research that seeks to draw on different forms of expertise to improve our understanding of complex dynamic human-environment interactions, whilst also understanding different interests and stakes associated with particular sustainability challenges.^{iv v}

Seeing sustainability as part of science can be problematic for a number of reasons. First, sustainability is a normative concept: it often describes what is 'desirable' for human-environment interactions. At least as problematic is the focus on human-environment interactions, as this requires to acknowledge, complexity, place-based knowledge (rather than just abstract scientific knowledge that can be expressed in formulae or models that claim universal validity), contradictions associated with different expertise and interests, uncertainty, and ignorance. This is at odds with social norms widely associated with science since the post war period, including disinterestedness and universality^{vi}; however, these norms are still very much the basis for determining career rewards in research organisations.

Sustainability science defies easy classification in relation to scientific disciplines. One challenge in drawing insights from many different fields of knowledge, is that most disciplines have a distinct understanding of what science is, what role it plays in society, where it derives its authority and legitimacy from, and how it is done; and therefore the fields differ in how scientists in these fields feel about their professional identity and its role in society. Moreover, the *quality* of an 'integrated understanding' that is derived from drawing on diverse fields of knowledge cannot be judged based on criteria or review procedures from any one of the implied fields. Issues of quality criteria and processes are hence of central concern in sustainability science.^{vii} Accordingly, challenges to establish sustainability science initiatives in more traditionally-oriented research organisations abound. Systemic change in the university system is therefore considered at the core of any strategy to foster and catalyse sustainability science-informed transformations in society at large.^{viii ix}

The possibility to juxtapose different ways of describing problems and different ways of knowing helps to better understand how different facets of complex problems might be related to each other and acted upon. Meanings of 'sustainability' that shape what 'purpose' is seen for sustainability science usually depend on the local context and people involved in addressing a specific challenge, such as water scarcity that can also impact local food production and electricity generation. Four broad discourses can be distinguished in academia (although this is by no means an exhaustive list...) that have all different interpretations about meanings of sustainability and purpose of sustainability science: Scholars from the field of economics often highlighting the need to better internalize environmental externalities in situations of market failure, as is the case for common goods such as clean air or water^x; the Noble Laureate Elinor Ostrom for example researched about how communities whose livelihoods depend on scarce common pool resources such as fish stocks or fragile Alpine land have learned to. On the other hand, more practice-oriented sciences such as engineering and urban planning, discourses on *ecological modernization* direct attention to technological innovation, and ask how public investment

and market forces can be improved to reduce pollution at its source.^{xi} Some scholars in the fields of philosophy and the learning sciences have yet another notion of where change is needed most: Proponents of *deep ecology* say that humans need a fundamental transformation in consciousness of how we as humans relate to nature, non-human animals and to each other and in consequence not 'doing things better' but instead 'doing better things'.^{xii} Last but not least there are groups of sceptics who feel this civilization will fail to undergo the required radical change without a Damocles sword hanging visibly above its head. Research associated with this stance of '*Doomerism*' often has a focus on building community resilience and adaptive management processes for coping in pending crisis.

Not only are there different view points in what changes are needed first in society. Research approaches drawn upon in sustainability science are very diverse: They can be disciplinary, interdisciplinary or transdisciplinary; conducted by scientists alone, or in collaborative processes with stakeholders, embedded in practice. Such research can be predominantly concerned with one system, such as nature, society, or technology; or it can be designed to better understand or transform interactions between them. One example of research that has gained great attention of policy-makers world wide, aims to better understand the range of natural variation in, and anthropogenic impacts on the earth system in order to deduce global and regional 'boundaries' or limits to human activities that should be respected.^{xiii xiv} On the other hand, research may be more concerned with social systems, problematizing actors and agency, and how sets of human values can serve as ordering principles in society.^{xv} Ways of knowing can be conceived as inductive or deductive language-based reasoning, or knowledge can be seen as emergent from interactions between people and their environment.

Some leading scholars distinguish between descriptive and transformative sustainability science.^{xvi xvii} In transformative sustainability science the stated goal is to fundamentally change human environment interactions in a process that is designed to question prevailing values, world views, and ways of knowing and doing. Such research at best achieves to combine approaches that are critical and solution-oriented. A combination of collaborative systems thinking, exploring alternative futures^{xviii} and building normative and strategic capacities in groups is deemed at the core of sustainability science initiatives. Sustainability in this case is considered an emergent phenomenon from a societal conversation that is scientifically informed.^{xix}

Transformative sustainability science can also be understood as a transformative social learning process, which relies on scientific inquiry in diverse groups of stakeholders and experts (König, 2015).^{xx} The relation of learning across different scales of social organization matters,^{xxi} building on prevailing conceptions of social learning in environmental management and human ecology.^{xxii xxiii} This conception of learning is rooted in John Dewey's work (1938), who assumes that knowledge is constructed for action, and that learning can be mediated by iterative cycles of making hypothesis, systematic inquiry testing hypotheses in practice, observation and reflection.

Transformative learning then emerges from dialogue between groups with diverse sets of values and world views, in which each group is brought to reflect on and creatively re-consider their own ways of thinking and doing.^{xxiv} A tall order! In particular, because education largely trains us to break down problems in order to understand isolated cause-effect relationships, rather than to think con-jointly in terms of system elements, their relation, interactions and interdependence, loose patterns of change, and making judgments on harmonies or disharmonies. Less mentioned dimensions in education for sustainability science thus include the practice of cognitive switching between diverse perspectives, and emotional security in the face of uncertainty. These constitute promising areas for research.

Endnotes

- ⁱ Kuhn TS: *The Structure of Scientific Revolutions*. 3rd ed. Chicago: The University of Chicago Press; 1962.
- ⁱⁱ Jerneck A, Olsson L, Ness B, Anderberg S, Baier M, Clark E, Hickler T, Hornborg A, Kronsell A, Lovbrand E, Persson J: Structuring sustainability science. *Sustainability Science* 2011, 6:69-82 <http://dx.doi.org/10.1007/s11625-010-0117-x>.
- ⁱⁱⁱ Feyerabend PK: *Three dialogues on knowledge*. Oxford: Blackwell; 1991.
- ^{iv} Kates RW, Clark WC, Corell R, Hall JM, Jaeger CC, Lowe I, McCarthy JJ, Schellnhuber HJ, Bert Bolin, Dickson NM et al.: Sustainability science. *Science* 2001, 292(4):641-642 [http:// dx.doi.org/10.1126/science.1059386](http://dx.doi.org/10.1126/science.1059386) Retrieved from www.sciencemar.org.
- ^v Clark WC and Dickson NM: Sustainability science: The emerging research program, *PNAS* 2003, 100 (14): 8059 – 8061; www.pnas.org/cgi/doi/10.1073/pnas.1231333100
- ^{vi} Merton RK.:*The Sociology of Science: Theoretical and Empirical Investigations*. Edited and with an introduction by Norman W. Storer, The university of Chicago Press, 1973
- ^{vii} Funtowicz SO, Ravetz JR: Peer review and quality control. In *International Encyclopedia of the Social & Behavioral Sciences*, Vol 17. Edited by Wright JD. Oxford: Elsevier; 2015:690-694
- ^{viii} Sterling S: The sustainable university: challenge and response. In *The Sustainable University. Progress and Prospects*. Edited by Sterling S, Maxey L, Luna H. Taylor & Francis Group; 2014:17-50.
- ^{ix} Barth M: *Implementing Sustainability in Higher Education: Learning in an Age of Transformation*. (Earthscan). Routledge; 2015.
- ^x Constanza R: Time to leave GDP behind. *Nature* 2014, 505, 283–285.
- ^{xi} Hajer, M: *The politics of environmental discourse: Ecological modernization and the policy discourse*. Oxford, England: Oxford University Press, 1995.
- ^{xii} Peters S, Wals AEJ: Learning and knowing in pursuit of sustainability: concepts and tools for trans-disciplinary environmental research. In *Trading Zones in Environmental Education: Creating Transdisciplinary Dialogue*. Edited by Krasny M, Dillon J. Peter Lang; 2013:79-104
- ^{xiii} Rockström, J. et al. A safe operating space for humanity. *Nature* 2009, 461: 472-475.
- ^{xiv} Steffen W, et al., Planetary boundaries: Guiding human development on a changing planet, *Science* 2015, 347(6223): 736-746.
- ^{xv} Castree N: *Geography and Global Change Science: Relationships Necessary, Absent, and Possible*, Institute of Australian Geographers, 2015, 53(1):1–15; doi: 10.1111/1745-5871.12100
- ^{xvi} Miller TR, Wiek A, Sarewitz D, Robinson J, Olsson L, Kriebel D, Loorbach D: The future of sustainability science: a solutions-oriented research agenda. *Sustainability Science* 2013, 9:239-246 [http:// dx.doi.org/10.1007/s11625-013-0224-6](http://dx.doi.org/10.1007/s11625-013-0224-6)
- ^{xvii} Wiek A, Lang DJ: Transformational sustainability research methodology. In *Sustainability Science — An Introduction*. Edited by Heinrichs H, Martens P, Michelsen G. Springer; 2015:1- 12.
- ^{xviii} Swart RJ and Robinson J: The problem of the future: sustainability science and scenario analysis. *Global Environmental Change* 2004, 14: 137-146
- ^{xix} Robinson, J, Berkhout, T., Cayuela, A: Sustainable campus as societal test bed: The case of The University of British Columbia. In König A (ed). *Regenerative Sustainable Development of Universities and Cities*. Edward Elgar; 2013.

^{xx} König A: Towards systemic change: on the co-creation and evaluation of a study programme in transformative sustainability science with stakeholders in Luxembourg. *Current Opinion in Environmental Sustainability* 2015, 16:89–98. Share link to special issue: <http://www.sciencedirect.com/science/journal/18773435/16>

^{xxi} Wals AEJ, Brody M, Dillon J, Stevenson RB: Convergence between science and environmental education. *Science* 2014, 344:583-584.

^{xxii} Keen M, Brown VA, Dyball R (Eds): *Social learning in Environmental management: Towards a sustainable future*, Earthscan; 2005.

^{xxiii} Dyball R and Newell B Chapter 6. Systems and sustainability. *In Understanding Human Ecology: A systems approach to sustainability*. Routledge, 2015.

^{xxiv} Lotz-Sisistka H, Wals AEJ: Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction, *Current Opinion in Environmental Sustainability* 2015, 16: 73–80.