

Addressing sustainability challenges with a broader concept of systems, target, and transformation knowledge

Systems, targets and transformations are guiding metaphors of environmental and sustainability research. Is the framing of these concepts still adequate to address today's wicked sustainability challenges?

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GAIA 28/4 (2019): 386–388 | **Keywords:** sustainability, systems knowledge, target knowledge, transdisciplinarity, transformation knowledge

Addressing environmental problems and devising strategies for sustainable development requires fundamentally new approaches that consider the often intractable nature of societal issues and acknowledge humans as actors with diverse cultures and agencies. We live in a time characterised by a storm of imminent disasters with many problems being wicked, that is, of high factual uncertainties and high socio-political disagreement (UN 2019). Our society is globalized and culturally diverse. Transdisciplinary research on sustainability and environmental problems aims at addressing such wicked and socially and epistemologically diverse societal problems. One of the

key conceptual and methodological tools to structure transdisciplinary research are the three forms of knowledge first introduced to the European research context by *ProClim* (1997) and since then widely used and cited. The underlying idea is that research can contribute to societal problem-solving by producing knowledge about what is (*systems knowledge*), what should be (*target knowledge*), and how we come from where we are to where we should be (*transformation knowledge*). The metaphors used to characterise the three forms of knowledge – systems, target, transformation – reflect the historical roots of these concepts in the emerging environmental sciences of the 1970s and 1980s. Systems analysis of environmental systems such as the atmosphere or biosphere and of coupled socioecological systems (and associated data-intensive and global-scale monitoring programmes) emerged as the core of research on complex issues, hence the term *systems knowledge*. An interest in environmental and risk assessments associated with the emergence of environmental ethics (and often utilitarian arguments) led to a focus on qualitative or quantitative targets of environmentally sound behaviours and technologies, hence the term *target knowledge*. To reach the goals of a sustainable development, a transformation of socioeconomic or political institutions (although within the overall political

and economic order), for instance through research in environmental economics, was envisioned, hence the term *transformation knowledge*.

We argue in this essay that the three knowledge forms – and their strong metaphors – partly enshrine old paradigms of science-based societal problem-solving that need to be critically reflected, revised or broadened to be able to effectively tackle today's wicked sustainability challenges. While a strong belief in systems analysis, measurable targets and a managerial transformation of socioeconomic institutions (within the existing economic system) underlies some influential contemporary sustainability science (e.g., Sachs et al. 2019), it does not reflect how many other environmental and sustainability scholars think (Fazey et al. 2018, Kueffer et al. 2017). It is meanwhile widely acknowledged that environmental and sustainability problems cannot be solved by first analysing their causal roots, then forming a consensus on specific targets, and finally devising solutions that build on specific technical, institutional or (solely rationally and ethically motivated) behavioural changes, but that sustainability-oriented endeavours require iterative and recursive approaches (Hirsch Hadorn et al. 2008). Besides, the understanding of each of the three types of knowledge has been broadened. Empirical knowl-

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<https://doi.org/10.14512/gaia.28.4.12>

edge relevant for sustainability transgresses systems-analytical knowledge about socioecological systems, and a comprehensive and undisputed bird-eyed view of the relevant causal drivers of environmental issues can often not be achieved. The hope to reach a consensus on specific targets can hinder rather than enable transdisciplinary discourses that are participatory, inclusive and pay attention to power-relationships and diversity. A trust in technical innovations and the social engineering of institutional transformations (including through instrumentalized participatory processes) – or more generally the idea that specific solutions can be defined and implemented – misrepresents problems that do not have easy solutions. Such an ambition can hinder alternative ways to assist people with diverse social and cultural backgrounds, and faced with contrasting personal and societal challenges to access, interpret, represent, engage with, negotiate, share, and use knowledge.

In this essay, we propose a different framing for each knowledge form – thereby opening perspectives for understanding them in a more pluralistic and integrative way. In particular, we ask how alternative ways of producing, using, and applying knowledge may enable and empower diverse people to act responsibly in our time.

From producing systems knowledge to nurturing critical thinking

The present understanding of systems knowledge is limited by the fact that many sustainability problems are too complex to be fully grasped. Any research approach, however complex it may be, can only rea-

as a necessary condition for environmental valuation and actions has drawbacks as well. It makes environmental expertise vulnerable to attacks by vested interests, and it can delay action. It can also lead to high opportunity costs by diverting research efforts from developing and implementing solutions. Further, an emphasis on knowledge that can only be produced through specialised expertise or tools narrows the range of people that can participate in framing problems (which is an inherently value-laden endeavour). There are also a number of more specific critique points of systems analytical frameworks (see also table 1 in Kull et al. 2018). These include: fundamental differences of social from natural systems; difficulties in incorporating contingency; poor compatibility with multiple perspectives, feelings, and interpretations; discomfort with an emphasis on generalisation and simplification; difficulties in addressing questions of power; and problems with a perceived ideology of control.

From our perspective, an extended understanding of the task of clarifying the knowledge basis of environmental and sustainability issues should emphasize a continuous process of nurturing critical thinking. This includes intellectual curiosity, literacy in scientific and other forms of carefully produced knowledge, and the ambition and capabilities to continuously deepen, revise and debate knowledge. Actors should be held accountable to remain as truthful as possible to the normative reference of factual correctness or – in the case of solutions – to the honest motivation to produce the socially and ecologically best-

shaping a problem and its solutions. The challenge to deal with widespread ambiguity, ignorance, and unknown unknowns rather requires that we understand knowledge production as a process – a process that will never achieve to produce definite knowledge but will continuously strive to make best-possible provisional knowledge widely available by inviting honest dialogue and protecting it from wilful distortion. Sustainability scholars might often have the role to assist diverse actors in assessing the quality of existing knowledge rather than to produce novel knowledge.

From target knowledge to nurturing virtues and cultures of responsibility

The present conceptualisation of target knowledge highlights the importance of reaching consensus on the norms and values of a more desirable development, and to assess the consequences of actions as good or bad. Hence, target knowledge appears to have affinities to consequential ethical frameworks. A prominent form of consequentialism is utilitarianism, which is indeed widely used in environmental assessments. But relying on a purely consequential assessment of targets is problematic in a time characterised by global threats such as climate change or the overexploitation of natural resources. These threats are the result of unlimited growth, for which no easily attainable solutions exist. It is also often impossible to assess whether the multitude of consequences and side-effects of an action at vastly contrasting spatial and temporal scales lead to a net benefit. Moreover, a focus on end results of actions can lead to despair and paralysis, and might be

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sonably understand a limited number of aspects of the multitude of interacting environmental problems and solutions. Sound empirical knowledge is indispensable for finding solutions. However, adhering to an unrealistic ideal of irrefutable knowledge

possible solutions given available knowledge and experience and practical constraints. Such an understanding moves beyond an inherent assumption that facts can clarify social disputes by comprehensively understanding the causal factors

considered impossible. Alternative ethical frameworks are for instance deontological ones that assign fundamental rights to humans or nonhumans, or virtue ethics that values traits of actors such as compassion, humility, creativity, or responsibility. >

Against this backdrop, we argue that research should also contribute to nurturing a culture of responsibility and environmental virtues, such as a feeling of wonder when encountering other species and ecosystems, and defend a shared belief in fundamental

processes. We might more often than not have to re-learn forgotten knowledge and skills, or re-appreciate what still works (including solutions of marginalized social groups that do not have the power and voice to be heard). Rather than attempting to pro-

sustainability by shifting the focus from producing a body of knowledge to nurturing robust, responsible, evidence-based, and diverse sociocultural processes of producing knowledge, deliberating values, and taking action.

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rights (such as that every living being has a right to a life in dignity). We certainly also need to acknowledge not only diverse cultural values but also diverse underlying ways of ethical reasoning and other forms of experiencing ethics (such as spiritual or emotional ones). Hence, academia also has the responsibility to foster the capability of ethical reasoning and self-reflection in order to enable people to become aware of their own value bases and enter a dialogue on multiple cultural values (Schneider et al. 2019).

From transformation knowledge to nurturing empowerment and agency

The present conceptualisation of transformation knowledge has affinities with an ideology of controllability and an assumption that actors are solely rational decision-makers. But many of our environmental and sustainability problems are not easily controllable, and the idea of controllability might lure us into developing ineffective solutions or in concentrating on controllable problems that are not wicked. There is clear evidence that human beings are not simple rational actors but rather much more complex social, cultural, psychological, and spiritual beings. Further, *transformation* is a metaphor that tends to put novelty, disruption, and radical change in the limelight (although mostly without questioning fundamental realities such as our dependence on growth or the legacy of colonialism) (e.g., Sachs et al. 2019), while neglecting the cherishing of the existing, old-growing solutions and evolving adaptation

processes. We might more often than not have to re-learn forgotten knowledge and skills, or re-appreciate what still works (including solutions of marginalized social groups that do not have the power and voice to be heard). Rather than attempting to produce specific solutions or transformation strategies, we might primarily need to overcome paralysis and encourage creativity, empowerment, solidarity, and thereby agency. This implies that as experts and knowledge brokers we might rather want to promote capabilities (Nussbaum 2011) to on the one hand radically rethink a society that is based on endless growth, consumerism, and inequality, and to on the other hand experiment with manifold locally-rooted potential solutions. In this context, artistic work and culturally embedded forms of knowing might often be better vehicles for such ambitions than reports, data-based analysis or formal participatory deliberations (Kueffer et al. 2017).

Rethinking knowledge

The crisis of sustainability is also a crisis of the knowledge society. We have to fundamentally rethink how we produce, evaluate, and use knowledge on wicked and contested issues. Widespread ignorance, incommensurable worldviews, and unprecedented urgency to act forces us to rethink what it means to produce knowledge about what is, what should be, and how we come from where we are to where we should be. Growing work in fields such as the environmental humanities (Kueffer et al. 2017) – that bring forward the complementary expertise of the humanities, critical perspectives such as eco-feminism and post-colonialism, indigenous knowledge and the sensibilities of artists – have helped us to propose in this article a more inclusive understanding of the role of sciences for

The idea for this article was born as a result of the workshop *Transformative social sciences and humanities – Opportunities and limitations in Switzerland* organized by the Swiss Academic Society for Environmental Research and Ecology (saguf) on November 16, 2018 in Bern. saguf promotes critical dialogue about the methodological and conceptual basis of environmental and sustainability research.

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