Theories of change in sustainability science

Understanding how change happens

Science-based initiatives generate particular changes towards sustainable development. But why and how does this work? Theories of change (ToCs) can help in understanding the theoretical assumptions and modes of knowledge production associated with these initiatives: ToCs trigger debate among the stakeholders and evaluators of an initiative regarding the hypothesized and observed effects of actions as well as regarding underlying assumptions about how change happens. Therefore, they can strengthen the effectiveness of research, practice, and education in sustainability science.

Christoph Oberlack, Thomas Breu, Markus Giger, Nicole Harari, Karl Herweg, Sarah-Lan Mathez-Stiefel, Peter Messerli, Stephanie Moser, Cordula Ott, Isabelle Providoli, Theresa Tribaldos, Anne Zimmermann, Flurina Schneider

Theories of change in sustainability science. Understanding how change happens | *GAIA* 28/2 (2019): 106–111
Keywords: 2030 Agenda, pathways to impact, sustainability science, theories of change

The *2030 Agenda for Sustainable Development (2030 Agenda)* marks a historic moment by reframing sustainable development in terms of 17 *Sustainable Development Goals* (UN 2015). As a globally negotiated and ratified resolution, the *2030 Agenda* provides a normative compass that urges all countries and stakeholders – including civil society, business, and governments – to realize societal transformations in a short period of time. Transformations towards sustainable development involve fundamental changes in political, technological, societal, ecological, economic, and cultural relations (Feola 2015). They are intrinsically linked to societal learning and changes in knowledge systems (Jasanoff 2004, Cornell et al. 2013). Thus, the ways in which universities and research organizations interact with broader societal knowledge and governance systems in this historic moment may be decisive in shaping transformations.

Scholars increasingly emphasize the importance of sustainability science as an interdisciplinary field that engages in and seeks to foster transformations towards sustainable development through activities including generation of scientific evidence and theory, education, practices of knowledge co-production, critical thought, and integration of alternative perspectives (Kates 2011). While researchers hold diverging views about the normative and political dimensions of science (Kläy and Schneider 2015, Schneidewind 2015), there is wide agreement regarding the inaccuracy of notions of linear science-policy interfaces (Pielke Jr. 2007, Pregernig 2014). Ambitions of contributing to sustainability through science are also widely shared (Van der Heel 2018), but success rates vary (Zscheischler et al. 2018). Part of the challenge lies in the complexity of the systems that sustainability science seeks to address (Van Kerkhoff 2014). They feature contested values and goals, non-linear and cross-scale effects, unforeseen contingencies, and emergent system properties. These call for adaptive management, monitoring, and evaluation activities that enable reflexivity and social learning (Rogers 2008, Cundill et al. 2012, Ison 2018). Use of suitable tools that enable research and education to serve and interact with society (Peters and Wals 2013) appear critical to realize the transformative ambitions of sustainability science (Moser 2016, Ott and Kiteme 2016). In this respect, "theories of change" are a promising, but underdeveloped and underutilized tool in sustainability science. This may have to do with the term "theory", which raises the expectation of a higher degree of systematicity.

Theories of change: definition

Theories of change (ToCs) are defined as the mental representations and theoretical assumptions that explain how and why activities of an initiative (e.g., projects, programmes, organizations) generate particular changes (Mason and Barnes 2007). While the precise methods and processes of constructing and using ToCs vary across initiatives (Mason and Barnes 2007), they generally trigger debate among stakeholders and/or evaluators of an initiative regarding the hypothesized and observed effects of actions as well as regarding underlying assumptions about how change happens (Blamey and Mackenzie 2007). These assumptions can be critically reflected on over time, and project activities can be adapted according to the actual experiences of implementation. Thus, ToCs are not only theories but also modes of knowledge produc-

Dr. Christoph Oberlack | +41 31 6313061 | christoph.oberlack@cde.unibe.ch
PD Dr. Flurina Schneider | flurina.schneider@cde.unibe.ch
both: University of Bern | Centre for Development and Environment (CDE) *and* Institute of Geography | Mittelstr. 43 | 3012 Bern | Switzerland

© 2019 C. Oberlack et al.; licensee oekom verlag.
This Open Access article is published under the terms of the Creative Commons Attribution License CC BY 4.0 (http://creativecommons.org/licenses/by/4.0).
https://doi.org/10.14512/gaia.28.2.8
Submitted October 18, 2018; revised version accepted April 12, 2019.

BOX 1: The *OneMap Myanmar* initiative

Among other initiatives, *OneMap Myanmar (OMM)* has been facilitating a multi-stakeholder review of land concessions and land uses for oil palm plantations in Tanintharyi region in Southern Myanmar since 2016. A theory of change (ToC) has guided *OMM's* engagement. It identifies improved land tenure security as the main goal of this review, to be reached by improvements in data quality and availability, technical and analytical capacities, knowledge and evidence-based, multi-stakeholder deliberations at regional and local levels. *OMM's* central assumption about change is that embedding technical components of spatial data analysis, web applications, and participatory field surveys within a broad multi-stakeholder process will help actors build common understanding of issues, negotiate possible solutions and trade-offs, and thus facilitate decision-making and issue resolution. Central activities are multi-stakeholder processes, joint data generation and verification, and technical capacity building. Progresses and challenges are regularly assessed against this ToC.

tion among stakeholders and/or evaluators of an initiative to scrutinize, plan, monitor and reflect on whether, how, and why particular activities of an initiative trigger particular changes. The ToC concept originated in the 1990s as a theory-driven approach to evaluate the impacts of social programmes (Bickmann 1987, Connell et al. 1995, Weiss 1997). While ToC thinking arose in, and is now widespread among, development organizations (sometimes in the guise of "impact monitoring", Herweg and Steiner 2002), it has rarely been applied in universities and other research organizations to date (Paina et al. 2017).

This paper argues that ToCs constitute tools that can and should be applied more extensively to strengthen the relevance, reflexivity, learning ability, and effectiveness of sustainability science. We first propose an understanding of ToCs in sustainability science and illustrate their diversity. We then present ten propositions on how to leverage the potentials and to confront the challenges of working with ToCs in sustainability science.

Methodologically, this paper is based on a systematic process of reflection on ToCs, conducted at the Centre for Development and Environment (CDE) of the University of Bern, Switzerland, in 2018. The process involved a literature review, a centre-wide retreat with 45 participants, and a survey of CDE members comprising 25 respondents representing diverse projects implemented at CDE in the last ten years. These data sources informed a critical appraisal carried out by the present authors in five workshops.

Theories of change in sustainability science

In our experience and view, ToCs can serve to generate a shared understanding among involved actors regarding pathways to impact of science-based initiatives for sustainable development. ToCs feature seven important components:

1. They start from a *sustainability goal or problem* in a particular context,
2. they diagnose *contextualized causes* of unsustainability, and
3. explain *how transformations* in the system of concern unfold.
4. They characterize what the *role of knowledge* in this process might be, and
5. specify *activities* and *pathways* that lead to intended outcomes and impacts.
6. They may further hypothesize how actors acquire new or adapt existing knowledge, or *how they learn* from each other.
7. Moreover, they depict *epistemological assumptions,* including ideas regarding what constitutes "good science", what constitutes appropriate roles for scientists, and how scientific knowledge relates to other forms of knowledge.

In short, ToCs in sustainability science articulate the relations between sustainability goals, diagnoses, knowledge gaps, context conditions, activities, pathways to impact, and epistemological assumptions (Dhillon and Vaca 2018). Box 1 provides an example.

Table 1 illustrates some of the variety of ToCs that exist. Each of the six rows provides an example of a generic ToC, derived from our discussion of projects conducted at CDE, with a particular focus on how formulation of pathways to impact enables reflection on the roles of scientists as practitioners. >

TABLE 1: Generic types of theories of change (ToCs) in sustainability science. Each row describes selected components of a particular type of ToC. Other elements not depicted here include: goals, diagnoses of problems and knowledge gaps, expected outcomes, roles of non-scientific actors, and epistemological positions.

ACTIVITY	MAIN PATHWAYS TO IMPACTS	MAIN ROLES OF SCIENTISTS
basic research	developing scientifically valid and reliable knowledge for deliberation and decision-making; input for other activities	producer of scientific knowledge
education for sustainable development	providing knowledge and fostering competences of future decision-makers, developing a critical mass of change agents	teacher, lecturer, mentor, facilitator
mandated policy advice	advice for evidence-based decision-making, synthesis assessments, capacity building	advisor, based on professional expertise
public debate	awareness raising, public debate and deliberation	contributor in public debate (e.g., media, events) based on professional expertise
open access to data and knowledge	providing accessible and transparent data and knowledge, usable knowledge tools, possibility of public adaptation of knowledge	technical expert, professional expert
multi-stakeholder processes	supporting co-production of knowledge, social learning, technical cooperation, creation of new actor networks, conflict transformation	facilitator, mediator, professional expert, technical expert

ToCs could become a key component of the methodological toolbox of sustainability science. First, ToCs can serve as a tool in projects that adopt transdisciplinary methodology (Hirsch Hadorn et al. 2008). Here, ToCs can structure transdisciplinary processes of debate, planning, and reflection regarding projects' presumed pathways to impact. In other words, they can be used to scrutinize transformation knowledge (Pohl and Hirsch Hadorn 2008). Second, ToCs can help to reshape the role of non-scientific actors in empirical research. Rather than viewing non-scientific actors solely as passive sources of data, "indigenous" knowledge, or "local" knowledge (e. g., as experiment subject, survey, or interview respondent) and/or as potential "end users" of scientific knowledge, ToC approaches acknowledge non-scientific actors as agents with active roles in a scientific project (e. g., as co-producers of knowledge; facilitators, networkers, or opponents of a project). Third, ToC approaches enhance project planning and impact monitoring (Herweg and Steiner 2002). For example, they go beyond planning instruments like "logical frameworks" (logframes) by articulating underlying assumptions regarding how change unfolds in a particular system of concern (Dhillon and Vaca 2018). They can thus better satisfy the shared desire of researchers, practitioners, and donors to realize richer, systemic understandings of development (Stein and Valters 2012).

How can theories of change enhance sustainability science? Ten propositions

This section presents ten propositions regarding use of ToCs to enhance the relevance, reflexivity, learning ability, and effectiveness of sustainability science at project and organizational levels, based on the reflection process and survey data. For each proposition, we present a challenge facing science-based initiatives, the corresponding potential of ToCs, and remaining challenges of working with ToCs. Indeed, ToCs are neither panaceas nor static checklists; to be useful, they must be embedded in a continuous process of critical reflection and joint learning.

Proposition 1: ToCs facilitate the development of meaningful and attainable project goals.

While it is common for scientific projects to focus on developing systems knowledge (Pohl and Hirsch Hadorn 2008), operationalizing meaningful and attainable goals for transformative action is seldom a straightforward task in scientific endeavours. In view of this challenge, it is critical that project stakeholders formulate and share ownership of goals and transformative pathways based on an explicit ethical stance. A ToC process enables deliberation in groups, and furthers the formulation and reflection of context-specific, just, legitimate, and realistic goals. To ensure this, many of the projects we reviewed made sure to include processes like stakeholder workshops in the early stages of research so as to discuss and refine project goals. Most respondents saw it as a useful, necessary exercise. However, not all referred to it explicitly as part of a ToC process.

Proposition 2: ToCs facilitate project planning by explicitly articulating critical assumptions regarding the links of the project with societal transformations.

Limited relevance and effectiveness of scientific insights for policy and practice can sometimes be attributed to lack of clarity about how a scientific initiative relates to societal transformations (Zscheischler et al. 2018). Joint development of a ToC forces project members to diagnose as precisely as possible the current state of the system, including perceptions of it. Building on this diagnosis, the ToC development process urges them to develop explicit hypotheses about how intended transformations could unfold. Through in-depth dialogue, the tacit knowledge and implicit suppositions of actors become explicit and debatable. Scientific theories of societal transformation can reinforce or correct claims about transformations and the potential roles of the project therein. ToCs highlight the activities that are particularly critical to realize transformative ambitions. This aids in formulating, fine-tuning, and sequencing project activities. It also helps in developing risk management strategies and allocating staff and financial resources in view of goals and pathways to impacts (Thornton et al. 2017). Identification of risks and respective mitigation strategies was included in many of the projects reviewed. However, we found no commonly agreed way of using ToC in project planning, and projects varied in the level of sophistication of their ToCs.

Proposition 3: ToCs must be embedded in a continuous reflection process to remain adaptive and embrace surprises.

Rapidly changing contexts often require realignment of project designs. ToCs must also remain adaptive. Once elaborated and agreed upon, ToCs provide a mental model representing a project approach at a given time. However, tension can arise between the explicit knowledge formalized in ToCs and the evolving tacit knowledge generated in the day-to-day practices of project members. To remain a useful tool over time, formalized ToCs require ongoing critical reflection and adjustments to ensure that they meaningfully reflect new conditions, new information, and can update strategies. We found that this occurred especially in long-term projects (five to ten years), in which regular internal and external project reviews could be organized, creating space for processes of reflection.

Proposition 4: The ToC process must embrace non-linearity and unintended effects.

As noted, sustainability science typically addresses complex systems, in which linearity and causality between activity and impact can only be established in very narrow subsystems (Rogers 2008, Van Kerkhoff 2014). Critics of ToCs point to their tendency to depict linear relationships between activities and outputs, outcomes, and impacts. They also accuse ToC approaches of focusing too much on optimistic scenarios, while disregarding unintended effects. In the course of many interventions, linear models and optimistic expectations are disrupted by unforeseen contingencies, emergent outcomes, feedback loops, and counter-movements (Rogers 2008, Van Kerkhoff 2014). Thus, projects must conduct criti-

cal assessments of potential unintended effects. Our review identified complementary tools such as stakeholder mapping, SWOT (strengths, weaknesses, opportunities, and threats) analysis, and participatory scenario building as useful in this regard. To embrace the non-linearity of transformations, one of the reviewed initiatives rooted their ToC in adaptive governance (Folke et al. 2005). Results showed that ToCs are best embedded in a continuous reflection and learning process, rather than a static workplan.

Proposition 5: ToCs support continuous critical reflection and learning by providing indicators and procedures for project evaluation.

Metrics for evaluating transdisciplinary research are an important subject of current debate (Zscheischler et al. 2018). Early ToCs were developed to support evaluations of development cooperation projects (Vogel 2012). For sustainability science, spelling out the pathways to impacts, as in ToCs, can point to important indicators and procedures that go beyond academic metrics of scientific publications and citations. Further, monitoring project progress against a formulated ToC enables critical reflection and validation of assumptions about how change happens and why progress does or does not work out. This helps to improve the performance of ongoing projects, but also aids formulation of more promising ToCs for future projects. For example, one reviewed project found that carefully facilitated stakeholder meetings successfully enhance solution finding through open dialogue in which participants strive to understand each other's perspectives, rather than fight for their own interests. However, once the project participants returned to their "real life" institutional settings, shaped by strategic reasoning and established power relations, they had to re-adopt the positions defended there; one vetoed the reached agreement. Reflecting on this experience, the project team concluded that the next ToC must focus more on existing power relationships outside the stakeholder meetings in order to achieve project goals. Participants also reported that hidden agendas and power asymmetries can jeopardize success, and thus demand special attention when planning knowledge co-production.

Proposition 6: ToCs help address attribution gaps, while acknowledging that unknowns will remain.

Virtually every initiative confronts factors beyond its control, for example concerning societal agreement or learning beyond the project's reach (Blamey and Mackenzie 2007). Moreover, outcomes frequently emerge from many concurrent dynamics and activities (Young et al. 2006). Attribution of outcomes to a single project thus systematically faces an attribution gap. ToCs can reduce, but not eliminate, the problem of causal attribution (van Tulder and Keen 2018). In-depth discussion among project stakeholders about causal effects – stipulated in a mutually agreed ex ante ToC – supports deliberative evaluations of whether, how, and why a project had an impact as well as what other factors may have had an impact. Discussion of impact pathways can be supported by a ToC that structures the analysis, and facilitates naming of unknowns as they crop up. Without a ToC, discussions of impact may remain vague and the corresponding analysis may emphasize short-term results lacking transformative potential.

Proposition 7: The ToC process can aid team building.

While ToCs are typically formulated at the start of a project, changing team compositions and advances in implementation can lead to diverging ideas among project members about how change happens in the project context. This is especially the case in multidisciplinary and multicultural settings. Devoting time to reflect upon, and update, shared or distinct assumptions about how change happens can help to recognize and address diverging views within teams. This process can strengthen teams by consolidating a collectively created perspective and clarifying the different roles and activities of project members. For this reason, several of the projects reviewed invested considerable resources in joint ToC reviews. They were found to enable shared understanding among diverse and geographically distributed team members.

Proposition 8: ToC practice requires enabling operational conditions.

ToCs are resource-intensive due to their continuous, participatory character. As noted, ToCs are especially useful if elaborated collaboratively and employed in an ongoing process of critical reflection and learning. This requires that project members and stakeholders are willing and able to spend sufficient time and resources actively engaging in the process. Our review showed that ToC use was particularly successful when projects explicitly budgeted and planned the process in advance, and agreed on joint meetings from the beginning. Nevertheless, we also found that joint elaboration of ToCs with all project stakeholders, often from different backgrounds, can be challenging, and compromise may be necessary to agree on goals. Indeed, establishing shared goals is essential to developing ToCs that can be used to generate transformation knowledge.

Proposition 9: ToCs help to shape the interfaces between disciplinary, interdisciplinary, and transdisciplinary activities.

ToCs can support joint transdisciplinary programming by engaging project stakeholders in an in-depth discussion of project activities, pathways to impacts, assumptions about change, knowledge gaps, and expected outcomes. ToCs may provide a shared object for debates between scientific and societal actors, helping them build a joint, cumulative understanding of how and why particular activities did or did not produce particular changes. Nevertheless, ToC processes alone are seldom sufficient to overcome underlying epistemological differences between stakeholders from different disciplines. In some of the reviewed cases, targeted workshops were necessary to address and jointly define the conceptual foundation of a given transdisciplinary endeavour.

Proposition 10: ToCs can facilitate cumulative learning at organizational levels.

The ToC approach can provide organization-level benefits when embedded in an organizational learning process involving larger >

numbers of similar projects. Deliberations on ToCs at the organizational level can be useful in two ways: first, for individuals within organizations, ToCs can enable mutual learning between staff conducting similar activities and using similar ToCs in different contexts, thereby promoting self-reflexive learning processes. Second, for organizations as a unit, longer-term learning processes regarding the validity of specific ToCs can help to build detailed, cumulative organizational knowledge about how, why, and under what conditions specific activities are effective or not. Such experience can refine organization-level ToCs reflecting the contextual and practical nuances of different contexts and activities in which an organization is engaged. Moreover, organization-level ToCs can support members in gaining greater clarity about the pathways and critical assumptions of the organization's mission. Complementing individual job descriptions and organizational missions with a ToC can help members reflect on their own roles and competencies within the organization's setup (Dhillon and Vaca 2018).

Conclusions

Based on these ten propositions, we conclude that broader adoption of ToCs in sustainability science is a crucial step towards realizing the transformative ambitions and expectations of science in the *2030 Agenda*. Nevertheless, ToCs are not a panacea or even necessary in all cases. ToC processes require sufficient resources as well as willingness and open-mindedness among participating stakeholders, including scientists; this involves additional effort beyond the immediate project activities. Evaluators of scientific projects have only recently begun to request descriptions – usually without detailed instructions – regarding how a given scientific project will contribute to societal impacts. Further, disagreement and confusion about the use of ToCs can complicate, rather than facilitate, the transformative ambitions of an initiative (Van Tulder and Keen 2018). Finally, many ToCs have also been criticized for falling back into linear thinking (Van Tulder and Keen 2018). Nevertheless, if integrated in a process of critical reflection and learning, ToCs can support adaptive planning, implementation, learning, and evaluation at project and organizational levels. Systematic refinement of particular ToCs is needed to validate and build cumulative knowledge about the contexts in which they apply, and about the particular pathways to impact through which sustainability science can effect societal transformations towards sustainable development.

References

Bickmann, L. 1987. The functions of program theory. In: *Using program theory in evaluation.* Edited by L. Bickmann. San Francisco: Jossey-Bass. 5–18.

Blamey, A., M. Mackenzie. 2007. Theories of change and realistic evaluation: Peas in a pod or apples and oranges? *Evaluation* 13/4: 439–455.

Connell, J. P., A. C. Kubisch, L. B. Schorr, C. H. Weiss. 1995. *New approaches to evaluating community initiatives: Concepts, methods, and contexts.* Queenstown, MD: Aspen Institute.

Cornell, S. et al. 2013. Opening up knowledge systems for better responses to global environmental change. *Environmental Science and Policy* 28: 60–70.

Cundill, G., G. S. Cumming, D. Biggs, C. Fabricius. 2012. Soft systems thinking and social learning for adaptive management. *Conservation Biology* 26/1: 13–20.

Dhillon, L., S. Vaca. 2018. Refining theories of change. *Journal of Multi-Disciplinary Evaluation* 14/30: 64–87.

Feola, G. 2015. Societal transformation in response to global environmental change: A review of emerging concepts. *Ambio* 44/5: 376–390.

Folke, C., T. Hahn, P. Olsson, J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30: 441–473.

Herweg K., K. Steiner. 2002. *Impact monitoring and assessment. Instruments for use in rural development projects with a focus on sustainable land management.* Volume 1. Wabern, CH: Buri.

Hirsch Hadorn, G. et al. (Eds.). 2008. *Handbook of transdisciplinary research.* Berlin: Springer.

Ison, R. 2018. Governing the human-environment relationship: Systemic practice. *Current Opinion in Environmental Sustainability* 33: 114–123.

Jasanoff, S. 2004. *States of knowledge: The co-production of science and the social order.* London: Routledge.

Kates, R. W. 2011. What kind of a science is sustainability science? *Proceedings of the National Academy of Sciences* 108/49: 19449–19450.

Kläy, A., F. Schneider. 2015. Zwischen Wettbewerbsfähigkeit und nachhaltiger Entwicklung: Forschungsförderung braucht Politikkohärenz. *GAIA* 24/4: 224–227. DOI: 10.14512/gaia.24.4.4.

Mason, P., M. Barnes. 2007. Constructing theories of change: Methods and sources. *Evaluation* 13/2: 151–170.

Moser, S. C. 2016. Can science on transformation transform science? Lessons from co-design. *Current Opinion in Environmental Sustainability* 20: 106–115.

Ott, C., B. Kiteme. 2016. Concepts and practices for the democratisation of knowledge generation in research partnerships for sustainable development. *Evidence and Policy* 12/3: 405–430.

Paina, L. et al. 2017. Using theories of change to inform implementation of health systems research and innovation: Experiences of Future Health Systems consortium partners in Bangladesh, India and Uganda. *Health Research Policy and Systems* 15/2: 109.

Peters, S., A. E. J. Wals. 2013. Learning and knowing in pursuit of sustainability: Concepts and tools for transdisciplinary environmental research. In: *Trading zones in environmental education: Creating transdisciplinary dialogue.* Edited by M. E. Krasny, J. Dillon. New York: Peter Lang. 79–104.

Pielke Jr., R. A. 2007. *The honest broker: Making sense of science in policy and politics.* Cambridge, UK: Cambridge University Press.

Pohl, C., G. Hirsch Hadorn. 2008. Core terms in transdisciplinary research. In: *Handbook of transdisciplinary research.* Edited by G. Hirsch Hadorn. Dordrecht: Springer. 427–432.

Pregernig, M. 2014. Framings of science-policy interactions and their discursive and institutional effects: Examples from conservation and environmental policy. *Biodiversity and Conservation* 23/14: 3615–3639.

Rogers, P. J. 2008. Using programme theory to evaluate complicated and complex aspects of interventions. *Evaluation* 14/1: 29–48.

Schneidewind, U. 2015. Transformative Wissenschaft. Motor für gute Wissenschaft und lebendige Demokratie. *GAIA* 24/2: 88–91. DOI: 10.14512/gaia.24.2.5.

Stein, D., C. Valters. 2012. *Understanding theory of change in international development: A review of existing knowledge.* JSRP Paper 1. www.theoryofchange.org/wp-content/uploads/toco_library/pdf/UNDERSTANDINGTHEORYOFChangeSteinValtersPN.pdf (accessed May 6, 2019).

Thornton, P. K. et al. 2017. Responding to global change: A theory of change approach to making agricultural research for development outcome-based. *Agricultural Systems* 152: 145–153.

UN (United Nations). 2015. *Transforming our world: The 2030 Agenda for sustainable development.* https://undocs.org/A/RES/70/1 (accessed April 23, 2019).

Van der Heel, S. 2018. Science for change: A survey on the normative and political dimensions of global sustainability research. *Global Environmental Change* 52: 248–258.

Van Kerkhoff, L. 2014. Developing integrative research for sustainability science through a complexity principles-based approach. *Sustainability Science* 9/2: 143–155.

Van Tulder, R., N. Keen. 2018. Capturing collaborative challenges: Designing complexity-sensitive theories of change for cross-sector partnerships. *Journal of Business Ethics* 150/2: 315–332.

Vogel, I. 2012. *Review of the use of "Theory of Change" in international development. Review report.* UK Department of International Development. www.theoryofchange.org/pdf/DFID_ToC_Review_VogelV7.pdf (accessed May 6, 2019).

Weiss, C. H. 1997. How can theory-based evaluation make greater headway? *Evaluation Review* 21/4: 501–524.

Young, O. R., F. Berkhout, G. C. Gallopin, M. A. Janssen, E. Ostrom, S. van der Leeuw. 2006. The globalization of socio-ecological systems: An agenda for scientific research. *Global Environmental Change* 16/3: 304–316.

Zscheischler, J., S. Rogga, A. Lange. 2018. The success of transdisciplinary research for sustainable land use: Individual perceptions and assessments. *Sustainability Science* 13/4: 1061–1074.

CONTRIBUTING AUTHORS

Dr. Christoph Oberlack

PD Dr. Flurina Schneider

Dr. Karl Herweg

Prof. Dr. Peter Messerli

Dr. Theresa Tribaldos

all: University of Bern, Centre for Development and Environment (CDE) *and* Institute of Geography, Bern, Switzerland

Prof. Dr. Thomas Breu

Markus Giger

Nicole Harari

Dr. Sarah-Lan Mathez-Stiefel

Dr. Stephanie Moser

Dr. Cordula Ott

Dr. Isabelle Providoli

Dr. Anne Zimmermann

all: University of Bern, Centre for Development and Environment (CDE), Bern, Switzerland

Christoph Oberlack
Born 1983 in Erlangen, Germany. PhD 2015. Deputy head of cluster *Sustainability Governance* at the Centre for Development and Environment (CDE) and postdoctoral researcher at the Institute of Geography, University of Bern, Switzerland. Research interests: sustainability governance, land, climate change adaptation, archetypes.

Flurina Schneider
Born 1976 in Biel, Switzerland. PhD 2008, habilitation 2016. Head of cluster *Land Resources* at the Centre for Development and Environment (CDE), University of Bern, Switzerland. Research interests: sustainability, justice, land and water, transdisciplinary and transformative research.

GAIA Masters Student Paper Award

The international journal GAIA – Ecological Perspectives for Science and Society invites Masters students to participate in the 2020 GAIA Masters Student Paper Award.

Masters students are encouraged to submit their results from research-based courses or from Masters theses in the field of transdisciplinary environmental and sustainability science.

Submission guidelines and more information:
www.oekom.de/zeitschriften/gaia/student-paper-award
Deadline for submission: November 4, 2019.

The winner will be selected by an international jury and will be granted a prize money of EUR 1,500 endowed by the Selbach Umwelt Stiftung and Dialogik gGmbH, as well as a free one-year subscription to GAIA, including free online access. The winner may also be invited to submit his or her paper for publication in GAIA.

DIALOGIK gemeinnützige Gesellschaft für Kommunikations- und Kooperationsforschung mbH
Selbach Umwelt Stiftung
GAIA