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Citizens and science in the Anthropocene

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The challenge: competent citizenship and reflective science for purposeful collaborative inquiry in the Anthropocene

The Anthropocene, the age in which humankind meets planetary boundaries, calls into question prevailing social practices and ways of knowing, including practices of how we produce science and technology (Maggs & Robinson, 2016). Transforming social practices such that they match planetary limits will require new ways of co-creating knowledge, social practices and technologies (Wiek & Lang, 2015; Schneidewind et al., 2016; Grunwald, 2016), as well as re-inventing how we conceive of citizenship at the local, national and planetary scales (Giddens, 2009). The transformation of society and the associated learning process can be conceived as complex process that brings along changes across different levels of social organisation, including in the personal, cultural, organisational, institutional and systemic spheres (O'Brien & Sygna, 2013). Transformation can thus be considered a social process with a psychological dimension that opens up new human potential for reconsideration of how we relate to ourselves, others and our environment. In such a process technologies can be conceived as an expression of prevailing values and worldviews. The recognition of how prevailing values can serve as ordering principles for attributing attention and resources at different levels of social organization (individual lifestyle decisions to whole nations or regions) should be an integral part of research and technological design and development. The networked society of the twenty-first century offers as yet untapped processes for co-design and co-creation that aim to better understand and express shared values in pluralist societies. Such processes for co-creation of new knowledge and technologies in processes of collaborative inquiry and design assume not only profound changes in how science may be practiced (see also Chapter 18 by Ravetz), but also a new notion of competent citizens.

In the remainder of this chapter we first explore in more detail what rights and responsibilities may be associated with citizenship in the Anthropocene, before we revisit implications for science in the Anthropocene as detailed in the various chapters of this book. The conceptual and methodological tools presented in this book have been selected as we consider them as particularly useful for the 'Anthropocene' – eventual drastic changes in our environment whose consequences are unpredictable. And with ecological awareness, the elements of the theoretical framework include layers of context, as society, culture and environment. Consideration of values, ethics and long-term consequences are integrated into the analysis. With transformative sustainability science, our theoretical framework includes ourselves as individuals engaged on social learning and personal growth. For this, it embeds us in a world of deep complexity and of uncertainty and ignorance. Subsequently, we present a research project designed to draw on a large range of conceptual tools and methods presented in this book, to engage citizens in collaborative inquiry for changing social practice for sustainable water governance. We conclude with an outlook for the practice of transformative sustainability science.

What is citizenship in the Anthropocene?

We conceive of citizenship in the Anthropocene in five dimensions. Building on Giddens (2009, p. 198) we consider civic, political, social and ecological citizenship, but we also add the fifth dimension of digital citizenship. Each dimension of citizenship holds rights and responsibilities with respect to contributing to a sustainable stewardship of our planet. *Civil citizenship* includes the respect for mutual property rights. Citizens can foster sustainability, for example, by holding producers or firms to account by engaging actively and critically in participatory democracy. *Political citizenship* includes, for example, active democratic participation by the exertion of voting rights and free speech. This in turn requires making and acting upon judgments on policies and possibly also seeking opportunities for participation in policy making. In order to foster sustainability, citizens can not only vote based on their judgments on political action plans for sustainability, but also engage for environmental and social justice, for example, by joining a social movement concerned with fair distribution. *Social citizenship* includes rights and obligations for collective provision of welfare and social benefits. Along with Giddens we add the fourth, less conventional dimension of *ecological citizenship* (Smith, 1998), which presents us with "new obligations to non-human animals, future generations of human beings, and maintaining the integrity of the natural environment. This requires a transformed human experience of nature and the self as tightly bound together" (Giddens, 2009, p. 198).

Last but not least, in this book we consider a fifth dimension – *digital citizenship* in a networked society also brings with it new sets of rights and responsibilities that will have profound implications on how we can cope in the Anthropocene. Wals and Peters in Chapter 2 highlight the need to reconsider prevailing ways of social coordination in democracies in the twenty-first century, including the role of social media in networked societies and its relation to the production and use of science and 'facts' in electoral politics. Formalizing and embracing new sets of rights and responsibilities as digital citizens may help to distribute responsibilities to contribute to and verify the digital commons and how it is ethically used for the common good and for coping in the Anthropocene. Digital citizenship could include, for example, rights of accessing quality information on the Web (for example, Wikipedia) and tapping into collective intelligence in virtual spaces (such as for the co-creative development of the Linux operating system described in the book *Reinventing Discovery* (Nielsen, 2012). Responsibilities include managing your digital footprint (information you place on the Web about yourself) and your digital shadow (what others place on the Web about you) and contributing to the respect of security and privacy (Negroponte, 1995). Resources such as Wikipedia will not work when only tapped; contributing to building the science commons will only work if it is a truly co-creative effort, to ensure the credibility and quality of information by contribution of one's micro-expertise where it matters, for verification and improvement. Some thought leaders even predict that judging and serving as a jury of peers will be something expected and drawn upon as part of a web-based commons (Schmidt & Cohen, 2013). Reporting in the digital age is made easy, be it on peers and perspectives, distributional issues or states and flows in the environment.

Citizenship in the Anthropocene may even be defined to include rights and responsibilities that combine those of ecological citizenship and digital citizenship described earlier, if we would like to become truly democratic and rely on distributed knowledge co-creation about the state of the environment and changes in social practice and how they relate to each other. In Chapter 3 we have learnt how vital new information flows and learning can be in designing balancing feedback regulatory loops – for example, in growth-driven runaway industrial resource- and energy-using material flows. Should citizens assume the responsibility to engage in collaboratively driven, participatory-sensing activities in order to contribute to regulatory processes towards a healthy earth system? How might we all contribute to co-creating situated knowledge on changes in the environments we are part of in order to understand local complexity and lived experiences in different groups? Actively and critically engaging with associated rights and responsibilities requires the capacity for self-directed learning also about civic affairs and competencies for effective political action, co-sensing and acting locally. What social processes and technologies are suitable? What are the social and technological challenges? These are, in our view, core research questions for the future of civic and citizen science in networked societies.

Science for the Anthropocene: methods to engage in systems- and future-oriented dialogues across different expertise and interests to transform social practice

The basic premise of this book is that in the Anthropocene, nature becomes a task for culture, not as something to dominate, but as a source of ways to organize life in view of boundaries, for transforming our societies' aspirations and lifestyles for their sustainability, in diversity and longevity. The emergence of new social imaginaries,[1] based on a sophisticated understanding of our conceptions of the social, natural world and how they interrelate, will play an important role in transformative science and our ability to assume new responsibilities in view of contributing to shaping more desirable futures (Jasanoff, 2015). Most, if not all, chapters in Part I of this book on conceptual tools and methods provide examples on how such transformative dialogues can be structured and guided that promise to result in new powerful ideas, metaphors or prototypes from co-design that can serve to seed effective changes in social practice. Of the three chapters on understanding complex social-ecological-technological systems, a particularly effective approach towards this goal is described in Chapter 5 by Newell and Proust. Collaborative conceptual mapping of complex dynamic systems has as a main goal the production of simple, low-order models with a limited number of variables to characterize their relationships – one main outcome this research approach aims for is powerful metaphors that inspire concerted action in the face of shared challenges (Newell, 2012; Newell & Doll, 2015). Similarly, methods outlined in Chapter 6 by Drenth and colleagues to explore alternative futures are drawn upon in projects like Robinson's scenario projects (Vervort et al., 2015). The key is drawing together sophisticated understandings from natural and engineering sciences with a greater role for social science and humanities to explore human agency in diverse actors groups as creatively as possible (Maggs & Robinson, 2016; Castree, 2016; O'Brien, 2015). Based on such an understanding, human-centred co-design methods described in Chapter 8 by Gericke et al. then can serve to innovate, with the goal of developing prototypes for social practices and technologies that serve to express as well as live particular sets of values.

In this book we also point to citizen science as one more answer (Wals et al., 2014; Wals and Peters, Chapter 2). For example, Muki Haklay's definition also describes a new approach to science which aims to produce situated knowledge, embracing diverse values and worldviews, with the goal to transform: "Extreme Citizen Science is a *situated, bottom-up practice* that takes into account local needs, practices and culture and works with broad networks of people *to design and build new devices and knowledge creation processes that can transform the world*."[2] Again, the emphasis is also on the learning collective that produces a whole that is greater than the sum of its parts. For socially robust solutions, governance processes benefit from the input of diverse and conflicting viewpoints and interests. Citizen and civic science projects such as those by Haklay's group or described in Chapter 14 by Tran and König, and in Section 18.5 in this chapter have been credited with a broad range of benefits (UBA, 2016). These include the more meaningful engagement of citizens when they are empowered and equipped to monitor data about their own environment. Also, there is an enhanced understanding of the nature of scientific knowledge and of the meaning of data (validity and reliability) when citizens are actively engaged in scientific inquiry. Capacity building of local expertise brings the discovery of how easy and quickly one can become an expert in a specific issue in their own local environment. Access to cheap information communications technology (ICT), with enormous monitoring and storing capacity, makes 'doing science' easier and more affordable. Enhanced understanding of complex systems by monitoring social, technological and environmental change in parallel for reflection about complex systems and how to better act upon them is in reach now. Last but not least, by self-monitoring the impact of one's own actions, the citizen can become more reflective and effective in bringing about change. These two chapters open up new spaces for knowledge co-creation in citizen science approaches with more distributed roles. This, however, can also be seen as problematic if science is seen as a 'certified' knowledge. An essential part of the transformative social learning that takes place in sustainability science, including economics, is that participants come to recognize, and come to terms with, the limitations of their own knowledge and the constraints of their own ignorance. This has been referred to by Sheila Jasanoff (2003) as 'technologies of humility'.

Chapter 17 by Manhart and Chapter 2 by Wals and Peters are key on how to conceive of learning in such social processes, aiming at dialogue across differences and learning we posit in this book as the ultimate goal. The design of powerful and engaging virtual learning environments will play a key role on whether this societal project will bear fruit and become scalable and extend its reach and influence, or whether it risks being nipped before it can blossom (Medema et al., 2014). The Internet and the networked society provide a learning environment that changes constantly through changing and dynamic participation. Meaning-making in such an environment relies fully on engagement in a social process that hopefully is not just taking place in the virtual realm but has complementary spaces in localities and social institutions. Emerging technologies shape the collective nature of participation with these media and reinforce peer-to-peer learning. Transformative learning by blogging is becoming part of everyday life, as shown in the following quote by a pupil: "I blog to learn about my views and how others receive them and take a different stance."

Science for the Anthropocene: heuristic tools

In this book, we present diverse approaches for co-creating meanings of sustainability in ways that draw on science and serve to transform social practice – in particular, sectoral challenges. Each chapter presents a set of conceptual tools in some cases, with a case study in which a particular approach to scientific analysis has contributed to this goal. Heuristics are particular means or methods for organizing information and then taking action; they illustrate a varied practice rather than aiming to legislate for an approved methodology. The chapters in Parts II and Part III of this book have provided a variety of heuristics. Some are expressed as graphs, others as lists or tables and still others are conveyed discursively in texts. In every case, they help us to organize our experiences and understandings so as to make them more effective. It is clear that behind every heuristic there is an assumption about reality.

In Chapter 9 by Dendoncker and Crouzat the concept of ecosystem services is put to use in research in human geography by focusing attention on development trajectories and path dependencies by looking at past agricultural revolutions. An associated research project embedded in a municipality has proven an effective space and process for directing attention to systemic interactions and re-framing values attributed to ecosystem services in an effective manner. The ecosystems services concept directs attention at human values and at environmental change and their interdependence by design. The question framed largely from economics on the internalization of externalities such as environmental impacts from diverse agricultural practices on ecosystems looks at 'values' and 'measures', but also what knowledge is relevant to think about emergent futures by starting with a historical analysis of past drivers of change. Chapter 16 takes up the question of economics and fundamental assumptions and conceptions as embedded barriers to systemic thinking and revisits the merits and limitations of the concept of ecosystem services under these aspects.

Chapter 10 on food systems by Davila and Dyball uses a graphical framework from human ecology (see also Dyball & Newell, 2015) to identify relations between environmental changes, human health and quality of life, prevailing cultures and powerful institutions. This framework is remarkable in having very few elements and no quantification beyond ±, and yet it is capable of illustrating quite complex situations. The framework was designed to be adapted for use in association with the visioning process and proved effective for fostering dialogue across differences, even in workshops with illiterate farmers and agronomist experts and policy makers in the Philippines. The use of this heuristic in this chapter shows by example that precise quantification of complex situations is not necessary for an effective analysis, and it opens up the possibility that it is not feasible anyway. This insight could be quite transformative of practice in studies of sustainability, the environment and more. In this respect, our approach is implicitly challenging the dominant assumption about reality and our knowledge of it. Each of these chapters provides salient tools and advice on how to implement methods that allow for the co-creation of at least one or several of the four types of knowledge in diverse groups.

Chapters 11 to 13 on energy transition focus on governance and technological change, also with reference to the Dutch conception of the multi-level perspective as heuristic for socio-technical transitions. This conceptual tool helps to relate transition events across different scales and levels of social organisation. Limitations include necessary choices of boundaries (the focus is often on a 'system' at the national scale and on changes in the 'systemic structure'; research rarely manages to include a diversity mapping of felt experiences of diverse actors). Empirical studies based on this heuristic often used post-hoc analyses, in which arguably, data can be selected in terms of their good fit to make a particular point of interest using this heuristic (how do you define boundaries will direct attention, and allow to develop a message and research insights by design).

Chapter 15 by Ravetz et al. on tracking change and evaluation in turn problematizes how we can learn and the need for tracking change with numbers, as well as complementary representations, changes of which are analysed over time.

The Luxembourg Nexus project as example of a project designed according to the guidance in this book

With the growing realisation of planetary limits and systemic interactions several so-called 'Nexus projects' that seek to co-create knowledge on interacting water, food and energy systems, considering their social, ecological and technological dimensions have sprung up over the last five years (see, for example, Abson et al., 2017; Stirling, 2015).[3] In Luxembourg a similar project has been developed in parallel, which was designed based on the exact conception of transformative sustainability science presented in this book.

The project's overarching goal is to contribute to reconfiguring the science–policy–practice interface relating to the governance of water and food systems in Luxembourg; interactions with the energy system are also considered, but fewer resources can be attributed to more detailed research on the energy sector in the initial phases of the project. The policy and regulatory context for water systems is one of the most forward-looking sets of policies and laws in the EU. Related EU law creates an institutional openness to more transformative approaches to the practice of science, thus reducing potential barriers and offering pre-existing institutional arrangements for collaborations across different interests and expertise, such as river partnerships. The European Water Framework Directive (2000/60/EC) recognizes that in view of the growing complexity, new approaches to water governance and knowledge processes informing water use are required. The definitions of 'water quality' and associated standards now include a wide range of human considerations beyond science. The law requires involvement of stakeholders in water governance, including citizens, at the EU, national and local levels. Related Sustainable Development Goals of the United Nations and associated targets and measures adopted as part of the Agenda 2030 also invite innovative governance approaches based on new forms of collaborations between diverse stakeholders, including public authorities, enterprises, research scientists and citizens. In Luxembourg, the EU Directive was transposed to national law in 2008 (Loi du 19 décembre 2008 relative à l'eau); it presents a legal basis for five river partnerships in which stakeholders make contractual commitments to improve water governance (www.flusspartnerschaft.lu). Government plans for adapting and implementing Agenda 2030 are being drawn up. Vision 2020 of the European Statistical System calls for the generation of data and statistics from more diversified sources.

Accordingly, the project aims to build communities engaged in more sustainable water governance that are networked across three spatial scales, including the level of the individual river partnerships, the national level of water governance in Luxembourg and leading actors by collaboratively developing futures and the international scale by joining the Earthwatch Initiative freshwater watch. Each community will have its set of indicators with associated quality criteria. The minimum set of indicators used across all communities are the technical indicators of phosphate and nitrate levels as well as turbidity and stream flow of the international fresh water watch project (more akin to contributory citizen science; see Chapter 14). The lower levels will be more co-designed sets of data for knowledge co-creation processes based on joint framing of what matters most and what might be actionable knowledge for each of the communities in Luxembourg. The national indicators will be a mix of mandated EU data and Luxembourg-specific indicators emerging from the scenario process.

More specifically, a series of workshops will engage stakeholders in two river partnerships to explore systems dynamics, as well as policy makers and experts on water and agriculture, to explore futures with a systems point of view at the national level. The series of workshops on systems and futures based on methods described in Chapters 5 and 6 of this book will then also serve to inform the co-design process of a citizen science tool and associated sets of indicators for monitoring changes in social practice, technologies and the environment. The tool will be structured with an agreed indicator set for participatory monitoring to create actionable knowledge for improved water governance.

The project serves to develop methods, including conceptual and computer-based tools, to structure social learning processes for transformative change for sustainability, with a focus on water governance. The methods to be further developed in the projects include collaborative conceptual systems mapping with the aim of developing simple low order conceptual systems models as basis for a shared understanding amongst diverse stakeholder groups. One main goal will be to generate shared representations of systems dynamics, including interdependencies between social, technology and environmental subsystems. Such shared representations on what matters most to present stakeholders will help to identify jointly feedback loops, reasons for 'lock-ins' in unsustainable social practices, and leverage points for policy-making and changes in social practice, as a basis for future concerted action and possible monitoring initiatives with the citizen science tool. Systems methods will build on approaches described in this book in Chapter 3 by König, Chapter 5 by Newell and Proust, and Chapter 10 by Davila and Dyball.

A variety of methods will be used to collaboratively explore futures. Water governance and food production both today reveal clear interdependencies of how actions in the present can co-shape or restrict future spheres of activity in most places in the world, including in Luxembourg. The role of diverse ways to expect and conceive of different futures has a key role in arguments and motivations to change practice in the present (Grunwald, 2016). In particular, scenarios and visioning serve to structure collaborative processes for future-oriented explorations of systems and values, to better understand and discuss from diverse perspectives opportunities to collectively shape the future or constraints to future fields of actions. The scenarios will serve to explore alternative futures, risks uncertainties and possible surprises. A vision, in contrast, is a normative collaboratively developed desired future for joint orientation and giving a direction to changes in social practice. The two methods are complementary, as visions without scenarios easily miss out on potential risks, uncertainties or threatening cliffs that might prove avoidable. Diverse methods for collaboratively deploring alternative futures that we will draw upon this project are described in Chapter 6 by Drenth et al.

The previous methods of structuring stakeholder dialogues to explore systemic relationships and alternative futures will inform the co-design of a citizen science tool for participatory monitoring and representing system dynamics and feedbacks as the basis for concerted action by stakeholders (see also Chapter 14 by Tran and König). The citizen science tool kit and associated indicators for monitoring and representations of data via web tools will be designed to service all communities based on insights from the collaborative mapping of systems dynamics. The scenario process for future orientation will potentially point at indicators relating to strategically important leverage points to change undesirable trajectories, taking account of interdependencies and feedbacks between social, technological and ecological changes. Co-design approaches for the citizen science tool and database structure and functionalities will be based on approaches described in Chapter 8 by Gericke et al. Co-design approaches for the citizen science tool and database structure and functionalities will be based on approaches described in Chapter 8 by Gericke et al.

The project will also develop new approaches to document and evaluate transformative learning, including based on assessing changes in communication and behaviour at the individual, organisational and systemic level that can be associated with the engagement of diverse stakeholders in these processes. The documentation and analysis of different discourses in diverse groups, areas of agreement and contradictions based on discourse analysis will play a central role in better informing judgment on acceptable and feasible actions. The conception and evaluation of learning will be that presented in Chapters 1 and 2 by Wals and Peters, and Chapter 17 by Manhart.

We will foster and evaluate learning from collaborative conceptual systems mapping and scenario development at the individual, organisational and systemic level in all stakeholders who engage in this process. Evaluation of impacts and outcomes of transformative research projects will include documentation of:

- **Changes in communication** indicating changes in 'expectations', 'conceptions and perceptions of realities', statements of purpose and goals over time, for example, with respect to sustainability and their evaluation, areas of accountability assumed by individuals and organisations, as well as transient or stabilised changes in social practice.
- **The emergence of new technologies**, including new uses and users of technologies, and social technologies such as measurement regimes will also be assessed and evaluated.
- **Evidence of transformative learning** at the individual, organisational and systemic level that is to be collected includes enriched systems dynamics understanding; improved value judgements; improved action judgments; and evidence for improved capacity to engage cognitive switching between viewpoints in dialogue and between past, present and alternative future worlds.
- **Environmental change and impacts from human action** will be assessed as far as this is possible in the given time frame. This will depend on existing baseline data and on the timeline for the development of the citizen science tool and its level of adoption and use in river partnerships. The need for research on learning from citizen science has been highlighted in research on environmental education, the learning sciences and community-based monitoring.

- **Scientific impact** will be evaluated based on the number and quality of publications and presentations at scientific conferences and eventually their citations.

There are three main innovative aspects of the project. First, the framework for collaborative conceptual systems mapping will direct attention to exploring interdependencies and feedbacks between social, ecological *and technological* change. Frameworks to date focus either on complex social-ecological systems or on human–environment interactions, often leading to a neglect of the influence of accelerating technological change on how humans relate to each other and the environment. Second, the project aims to build communities engaged in more sustainable water governance that are networked across three spatial scales (river partnerships, the national level and the global Earthwatch Initiative). Each community will have its set of indicators with associated quality criteria. Last but not least, at the start of the project we will conduct a detailed study relying on interviews and workshops on what is 'actionable knowledge' for different groups with stakes in water quality and security, including farmers, municipalities, households, and firms, that will inform how we organise our workshops to explore systemic relationships and futures as well as the co-design process for the citizen science tool.

Outlook

Existential challenges in the Anthropocene will likely centre on distributional issues and raise questions on both environmental and social justice relating to the distribution of resources, as well as of knowledge, technologies and learning. At the same time, questions are raised on the adequacy of ways we produce science and technology. Established practices to produce science in particular fields of knowledge are experiencing difficulties from within science and its social institutions, in particular due to fragmentation and perverse career incentives for researchers (see also Chapter 18 by Ravetz). From the outside of science loom new demands for which the current organisation of knowledge production proves largely inadequate.

On top of that come new but related threats of democratic disengagement, social media–fuelled post-truth politics. Some scientists see this development as more reason for expert-driven technocratic and somewhat coercive approaches to regulating for sustainability. However, how well such approaches can really seize complexity, and in particular implications of the distributional issues, remains open to question. Such approaches to producing science for sustainability policy will not allow scanning the future for the possible unexpected, surprising or desirable implications of such changes in the short and long term from multiple perspectives in a way warranted in pluralist and societies which are becoming ever more diverse.

In the face of these possible future outlooks we join John Dewey in his conviction that the only cure for a lack of democracy is more democracy (see also Chapter 2 by Wals and Peters). This book seeks to contribute to and to inspire the design social processes, conceptual and methodological tools, as well as supportive virtual spaces for the co-creation, tracking and evaluation of social transformation. In the face of existential challenges of sustainability we need to better understand complex circumstances in the face of accelerating and interdependent change in the social, technological, environmental spheres. We need more awareness and reflective attention to how we engage with the material world, and how scientific knowledge, technological objects and social orders are co-produced. We need to reflect and act upon how culture, values and facts we consider, as well as our conceptions of the material and the social are entangled, and view technological design as an expression of prevailing values that influence how we relate to each other and the world we live in.

The development and practice of transformative science for sustainability seems to open at least as many questions, including research questions, as it holds promise. Core questions include in particular those of quality criteria, quality control and validation of outcomes and impacts. Promises of the potential wider adoption of such practices include that they may contribute to reconfiguring and improving the science-policy-practice interface in a way that is appropriate for effectively networked societies. Emergent changes in expectations and social practice promise to be meaningful to many rather than to just a few. Furthermore, these practices may enable us to learn and reflect on progress for coping with the Anthropocene in a manner far more empowering than a mere flat belief in technological determinism. In sum, transformative sustainability science offers to all who choose to engage the opportunity to see the world with new eyes and to develop intentions and practices on how to transform it collaboratively.

Notes

1 Social imaginaries are powerful ideas and metaphors for representing ways of living that we aspire to, that together make up a creative and symbolic dimension of the social world, that help to foster changes in expectations and eventually in social practice, including in behaviours and technologies.

2 Muki Haklay. www.ucl.ac.uk/excites/home-columns/full-what-is-extreme-citizen-science/ (emphasis added)

3 Examples include the UK Nexus Networked organised from the University of Sussex www.thenexusnetwork.org, a joint project by Lang and Wiek and their colleagues largely based at Leuphana University and Arizona State University.

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