Chapter 14
Designing Sustainable Futures: Interdisciplinary Science and Social Creativity

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Abstract In every region and every nation in the world, people face the difficult challenges of learning to design and maintain healthy societies with limited natural resources—including water, land, and energy—under rapidly changing global to local conditions. These challenges are contained within the framework of the 17 United Nations Sustainable Development Goals (SDGs) for 2030. Responding to the challenges of the SDGs at local to global scales must address the fundamental complexity of social–ecological systems. This requires understanding the technical, ecological, and geological conditions at multiple scales of time and space and equally importantly, understanding and designing for the future in the appropriate social, political, economic, and cultural contexts. In this talk, I want to discuss two critical questions that arise from these complex systems challenges: (1) How can we build the capacity to innovate for societal well-being by learning to think and act across traditional disciplinary lines? (2) How can we enhance the value of technology and engineering by engaging the knowledge, creativity, and cooperation of all parts of society in designing for their future?

Keywords Resource governance · Complex system science · Interdisciplinary research · Transdisciplinary research · Innovation for societal well-being · Inquiry and experiential learning

14.1 Introduction

The theme of this conference on "Current and Future State of Water Resource Management and Environmental Issues in Central Asia" is part of a larger set of challenges to the sustainability and quality of life for all of human society due to rapid and profound changes in the resources and bio-geo-physical, economic, and social conditions on Earth.

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The changes in the conditions for life on Earth comes not only from natural cycles and phenomena that we are familiar with throughout Earth's known history, but now are increasingly driven by human actions across the world at multiple temporal and spatial scales. We have to look at water resources, as well as energy, air pollution, climate change, food production, and land use changes, ocean temperature and acidification, and many others as critical human-influenced challenges to the necessary conditions for the well-being and even survival of human society. This profound shaping of the environment and conditions on Earth by humanity as active agents was represented as the "Anthropocene Era," a term coined by Paul Crutzen [1] and actively debated by stratigraphers and scientists ever since. Compelling evidence for this recent departure from the past patterns of human interaction with the environment can be seen in the many examples of the rapid onset and steep increase, particularly since the 1950s, in both earth system trends and socio-economic trends in the so-called "hockey stick" graphs [2].

The consequences of human impact and resource extraction in the Anthropocene Era have led to the recognition of the limitations of certain vital resources and living conditions on Earth. These were highlighted in the "Planetary Boundaries" papers [3, 4] in which the authors argue that for example, nitrogen and phosphorus flows, ocean acidification, land system changes, and biodiversity are at or approaching potential irreversible tipping points beyond which the consequences for human society could be devastating.

In response to the accumulating evidence of the high risk of undermining the conditions necessary for the long-term sustainability of human society, the United Nations adopted the 17 Sustainable Development Goals (SDGs) in 2015 [5]. While there are many specific targets under each of these goals, the SDGs are national and global aspirations, not mandatory directives.

The adoption of the goals was important as a step toward developing new strategies for moving toward sustainable futures in the diverse cultures and contexts of human societies. However, the 17 SDGs cannot be fulfilled in a linear managerial process, because they are inextricably interdependent in many cases and more generally, because the challenges of the Anthropocene Era are fundamentally due to the fact that human society is a complex system embedded in the complex bio-geophysical system of Earth. Such complex systems are not amenable to traditional reductionist scientific approaches. They require new, collaborative interdisciplinary, and transdisciplinary methods and perspectives [6].

The topic of this conference, "Current and Future State of Water Resource Management and Environmental Issues in Central Asia", clearly identifies the context in which the relevant SDGs must be addressed in this part of the world. Goal 6—"Ensure availability and sustainable management of water and sanitation for all"—is obviously directly in line with the topic of the conference. Well before the UN agreement for the SDGs, the topic has been discussed for the post-Soviet era of independent republics in terms of water management [7]. But the water management issues in Central Asia are interdependent with other systems that are identified in other SDGs. For example, Goal 7—Ensure access to affordable, reliable, sustainable, and modern energy for all, Goal 13—Take urgent action to combat climate change and its impacts, ongoing research points to this interdependence and the difficult technical, social, and environmental challenges that Central Asia (and other parts of the world, as well) face in avoiding, mitigating, or adapting to global changes at multiple spatial and temporal scales [8, 9].

The future of water resource management and environmental in Central Asia is a very important example of the profound challenges of complex systemic risks to the ecosystems and social systems of the world. I want to discuss how academic scientists and engineers in collaboration with practitioners and civil society can approach the challenges in more effective ways.

14.2 Systems, Sustainability, and Society

In order to explore the strategies needed to improve the capacity of science to tackle these complex problems, the Global Sustainability Strategy Forum (GSSF), was founded in 2018 as a joint project of the Arizona State University in the US and the Institute for Advanced Sustainability Studies (IASS) in Potsdam, Germany, with funding from the Volkswagen Foundation. In the first of four GSSF events, 17 experts in sustainability science from different parts of the world met in March 2019. The five days of intense discussion focused on what changes in the social and natural sciences and in the education of scientists and society are needed to build the capacity to address the complex system challenge of sustainability more effectively.

The most important conclusions from the deliberations of the expert panel in the global sustainability strategy forum were that science and society must begin designing for long term desirable change, rather than focusing on maintaining or returning to prior patterns of living that seemed stable, but were unsustainable. That means there must be a greater focus on understanding social dynamics driving us towards unsustainable patterns of living, rather than being concerned primarily with mitigating the environmental consequences of unsustainable behaviors. This requires using complex systems science to address the sustainability challenges of socio-environmental systems [10]. It also requires learning from the past to understand the present and to imagine a more positive future. It is important here to emphasize the necessity of using imagination and the ability to go beyond linear extrapolation and path dependence to be able to emerge successfully from our current conundrum [11].

These changes in science require a change in our educational strategies to build the capacity for transformative interdisciplinary and transdisciplinary research for sustainability. We need the capacity to do complex systems research for the needs of present and future societies. In addition to the understanding of complex system science, we need to develop the process of co-designing research and co-producing knowledge with diverse knowledge holders and stakeholders in the society [12–14]. Scientists need to engage with the creativity and insights of their fellow citizens of Earth in open mutual learning dialogues with all sectors of society for developing new practices and policies. Dealing effectively with the issues of water management and environment in Central Asia requires the depth of local knowledge of the hydrological, social, economic, and environmental details in Central Asia. Excellent generic knowledge and global perspectives are insufficient to find creative, robust, and meaningful solutions in the cultural and contextual differences of different regions. This is the basis for engaging with local knowledge holders and stakeholders in transdisciplinary research [15, 16].

Fundamental to science in its relationship with society is the recognition that society is deeply embedded within the natural systems on which it is entirely dependent. The challenges of avoiding transgression of the planetary boundaries and overdrawing limited resources are rooted in societal challenges, rather than solely environmental or technological ones. This follows from the observation that societies each define what is relevant and valuable in their relationship to the local and global environment [17]. Consequently, the central issue is not simply the bio-physical or technological conditions in a particular place, but how the people in that location or community view their environment and circumstances.

If members of a community think that some intervention in the conditions of their community are needed, who has the authority, agency, and responsibility to act? Do individuals feel that they have agency, knowledge, and responsibility to act? Agency means that an individual (or the members of a group) is capable of doing something and has the necessary resources with which to act. If the person or group is capable of acting, do they feel responsible for acting? In other words: can I act and should I act?

However, acting for a sustainable future is not a single intervention at one point in time. It will require a process of learning how to act individually and collectively as conditions and challenges change. We must continually learn and co-design and innovate to meet the changing needs of societies in moving toward sustainable futures in which the well-being of all is taken into account in a just and equitable way.

Thus, a key challenge is changing to sustainable collective human behaviors, rather than focusing on mitigating the consequences of unsustainable behaviors. Addressing the challenge of the collective behavior change is the mission of the Knowledge, Learning, and Societal Change Alliance (KLASICA). KLASICA examines how knowledge, meaning-making, and collective behavior change are interconnected [18] by identifying and understanding the conditions under which collective behavior change toward sustainable futures occurs in the contexts of different communities and cultures. We are learning from narrative expressions of visions of the future and of social identities to understand better the dynamics of societal movements toward sustainable futures with regard to specific needs in different communities around the world [19]. The understanding, including insights gained by building models of social dynamics is being developed to find new solutions for effective actions on the pathways to sustainable futures.

14.3 Knowledge, Creativity, and Innovation for Society

Science and technology contribute knowledge to society that allows for changes in patterns of behavior and policy, but the challenge is to make those changes constructive in leading toward sustainable futures, rather than to fall victim to unintended consequences and technological fixes which may only exacerbate the problems. We need more than good technology and science by themselves. We need imagination and creativity and innovation for the needs of society. We must learn from the past to understand our current situation and to imagine a desirable future that provides for the well-being of our societies, including the futures of our children and their children and beyond. To do this we need to focus on the systemic risks of deeply entwined nature and society. We need to break from the path dependencies in our thinking and find other ways to look ahead. Can we imagine the future and think backward to find a new path forward, rather than thinking from the present toward the future in familiar incremental steps. To do this, scientists must engage collaboratively with diverse thinkers and knowledge holders to expand the creativity needed to innovate for the well-being of society. We need less linear and more associative pattern-sensitive thinking. We need new models to help expand our thinking, not only to try to predict future developments from those existing patterns. And we need to develop a continually adaptive governance process that makes use of science as a resource for evidence and processes responsive to the needs of policymakers [20, 21].

Fostering the engagement between scientists and society in new ways will require new approaches to learning across all of the ages of humanity from early childhood to lifelong learning. That's essential because we need to change the expectations in society about learning and about what science offers in helping to shape our future. This process of learning at all ages really should begin by stimulating curiosity and questions from learners at any age, rather than starting by handing out information known by experts. In many places around the world, this is not familiar as a way of learning. Teaching is practiced as a top-down process of imparting specific knowledge in traditional forms. Yet all children exhibit the curiosity that can open this process up for them and allow them to engage throughout their lives with both curiosity and mastery of essential ideas and skills (e.g., see [22, 23]). Teachers are familiar and comfortable with the way they were taught. So reforming teacher education in different cultures and circumstances is a challenging process [24]. Introducing learner-centered and project-based learning can contribute substantially to education that better enables societies to creatively innovate and adapt to changing circumstances around us.

The motivation to learn and to look more openly at the challenges of the world around us can only be done by stimulating and rewarding curiosity and by building relevant experience. Providing experiences with phenomena and asking deeper questions is part of the building of vocabulary for thinking that is based in knowledge of how things work. As part of this, we need to make the use of models an essential part of the learning process [25, 26]. There is a common practice of using results of models as the answers, rather than learning from the actual construction and use of models to create understanding. Models provide a way to safely explore new ideas and test assumptions. They are also a means for engaging people in exploring ideas as scenarios for discussion and thereby facilitating dialogue on complex issues including societal issues. Physical and electronic models and games can serve as important boundary objects that facilitate dialogue among diverse participants [27–29].

14.4 Engaging Society in Games, Exhibitions, and Dialogues

Models, games, and public exhibitions are important for engaging with the broader segment of society to support their understanding of key ideas for sustainability. Learning to engage in transdisciplinary dialogue with diverse members of society is essential to address complex issues that are rooted in the value systems of the society. That allows scientists to reach more broadly into the knowledge base and value systems for more effective use of the knowledge both of science and from society. Figures 14.1 and 14.2 illustrate transdisciplinary dialogues. In Fig. 14.1, the dialogue involved stakeholders and rights-holders from civil society, business, and governments on Arctic sustainability concerns.

The two examples of dialogues were undertaken for different reasons, but they have in common that they engaged participants in a discussion to begin to understand their different perspectives and decide how they can use their own knowledge and science to achieve better outcomes for their communities.

Figures 14.3 and 14.4 are examples of highly engaging exhibitions and toys designed by the author and used to stimulate open dialogues with people about their questions, ideas, and concerns.

Fig. 14.1 The image is of stakeholder and rights-holders in a dialogue organized by the author and colleagues at the Arctic Circle meeting in Reykjavik, Iceland in 2014 (photo by Ilan Chabay)

Fig. 14.2 A community meeting on earthquake recovery guided by a local Buddhist monk following a major earthquake near Nishihara, Kyushu Japan in 2016 (photo by Ilan Chabay)

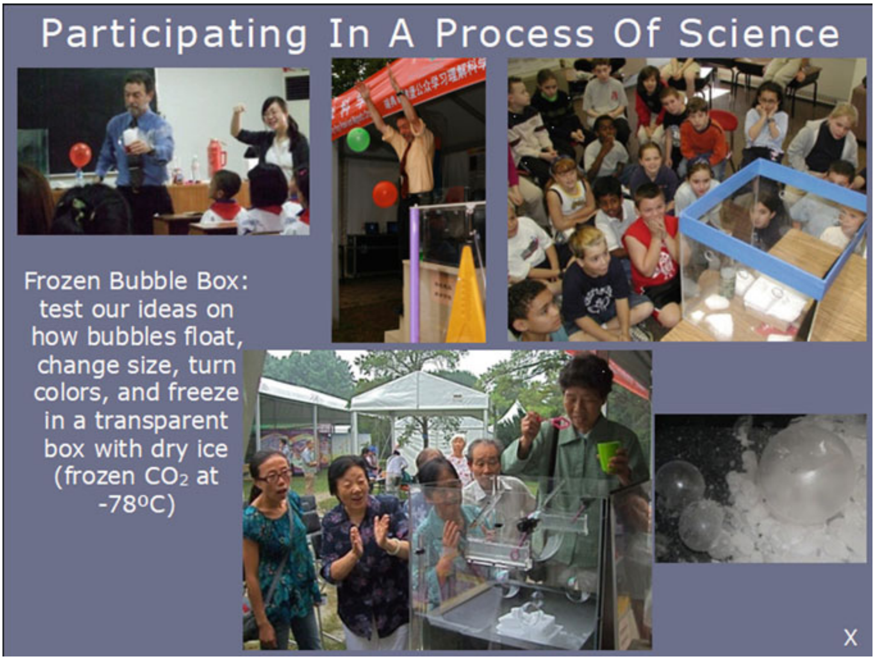

Fig. 14.3 A participatory activity called "Frozen Bubble Box" that simulates great curiosity and opens discussions on the process of doing science, on global warming, ocean acidification, and many other topics of chemistry, physics, and biology (photo by Ilan Chabay)

Fig. 14.4 Four images of an exhibit and game designed by the author that involves the production of oxygen and hydrogen from water as a clean fuel and illustrates in a visceral way the relationship between work, power, and energy (photo by Ilan Chabay)

Figure 14.5 shows a mobile exhibition used in Germany to engage people with questions about renewable energy and sustainability. In the center of the exhibits was a game that was played for only a short time (3–5 min), but which was highly memorable and provided a starting point for discussions on energy and renewable resources [30].

14.5 Conclusion

While the theme of this conference is water resource management in Central Asia, the wider context that I outlined here is that of the challenge of sustainability in different contexts and cultures. Managing or better yet governing resources are part of the challenge that the changes on Earth Pose for humanity. Finding new ways to address these daunting challenges to the future of human society will require new approaches to science, to learning, and to engaging between science and society. We will have to find the will and the way to develop collective behavior change based on scientific knowledge in combination with local knowledge and culturally traditional

Fig. 14.5 A mobile exhibition in Germany on renewable energy and sustainability (photo by Ilan Chabay)

knowledge. This will help different communities to find their own desirable future within the global coherence needed for the well-being of all societies. That is the fundamental challenge we must face and move forward in doing this together.

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