Tetsukazu Yahara *Editor*

Decision Science for Future Earth

Theory and Practice

Springer

Decision Science for Future Earth

Tetsukazu Yahara
Editor

Decision Science for Future Earth

Theory and Practice

Springer

Editor
Tetsukazu Yahara
The Institute of Decision Science for a
Sustainable Society (IDS3)
Kyushu University
Fukuoka, Fukuoka, Japan

ISBN 978-981-15-8631-6 ISBN 978-981-15-8632-3 (eBook)
https://doi.org/10.1007/978-981-15-8632-3

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

We are now at a major turning point in human history, at least in the following three points: First, with the progress of globalization, the connection between local social-ecological systems around the world has strengthened more than ever, and the world in which we live is being integrated into one earth system. We first noticed this connection due to global climate change, eventually biodiversity loss also occurred within the global linkage, and now, through the pandemic of COVID-19, we are keenly aware that local social-ecological systems around the world are strongly connected to each other. Second, the human population, which has continued to grow over the last 60,000 years, has finally slowed significantly, and it is projected that population decline will begin in many countries by 2050. In some countries, including Japan, the population has already begun to decline, and various new challenges for sustainable social growth are emerging. Third, a vast amount of knowledge that anyone can access on the Internet has been accumulated, and online teaching materials have been enriched. Consequently, the methods of education, research, and innovation are rapidly changing to more open ones using the Internet. The pandemic of COVID-19 provides an opportunity to accelerate this trend. Conversely, SNS with some leaders from different countries often spreads inaccurate information instantly and can have a major impact on the decision-making of citizens and governments. We are now faced with the difficult problem of how to select reliable knowledge from a vast amount of information and how to make good decisions. This book has been edited to present new scientific directions that contribute to such decision-making.

This book was created through a graduate school education reform program called "Kyushu University Graduate Education and Research Training Program in Decision Science for a Sustainable Society" (2013–2019), which was adopted by the all-round type of the Program for Leading Graduate Schools promoted by the Japan Society for the Promotion of Science (JSPS). The JSPS Program for Leading Graduate Schools was implemented to train sophisticated graduate students who will lead societies across the boundaries of various disciplines and contribute to solving serious problems that threaten the sustainability of human societies. In the

all-round type program, JSPS called for training graduate students in a wide range of areas covering humanities, social sciences, life sciences, and other natural sciences and engineering. At the request of former Kyushu University President Setsuo Arikawa, we designed the "Kyushu University Graduate Education and Research Training Program in Decision Science for a Sustainable Society" with the intention of developing decision science as an all-round type new science. In 2013, when this program was designed, the international research program Future Earth was established. As one of the members of the DIVERSITAS Science Committee, I was involved in a discussion on the concept design of Future Earth, a program whose goal is to integrate natural and social sciences related to global environmental issues into one earth system science. As a reform of graduate school education that contributes to this goal, we designed the course of "Kyushu University Graduate Education and Research Training Program in Decision Science for a Sustainable Society" to train graduate students through transdisciplinary research based on co-design/co-production with stakeholders that was highlighted by Future Earth. I myself have experienced the process of forming consensus through persistent discussions with various stakeholders and promoting the resolution of social issues at various sites of biodiversity conservation. We believe that gaining this kind of experience is extremely important in developing the next generation of scientists who will tackle social issues such as biodiversity conservation, recovery from disaster, public health, and local community development. Yukihiro Shimatani of river engineering, Naoki Nakajima of telemedicine, Kaoru Izumi of public administration, myself, and others shared this idea and established five modules of environment, disaster, health, governance, and human decision-making in a new graduate education program. This proposal was adopted in 2013 by the JSPS Program of Leading Graduate Schools. After that, at Kyushu University, we implemented the graduate education and research training program in decision science for a sustainable society as a minor course that all graduate courses can take. The Institute of Decision Science for a Sustainable Society of Kyushu University was formed as an organization to implement this program.

In 2015, a fund of Japan Science and Technology Agency (JST) to promote the Future Earth Initiative was launched, and the research proposal from the Institute of Decision Science for a Sustainable Society of Kyushu University was adopted by JST for feasibility research of this initiative. Then, in September 2016, it was adopted for full-scale research, and for three years until August 2019, a project called "A Transdisciplinary Research by Networking Solution-Oriented Interdisciplinary Sciences of Environment, Disaster, Health, Governance and Human Cooperation" was implemented. Whereas the JSPS Program of Leading Graduate Schools is a graduate school education reform project, the JST Future Earth Initiative Promotion Project was aimed at conducting research and development that would significantly contribute to Future Earth. In this research project, transdisciplinary research was conducted by staff of the Institute of Decision Science for a Sustainable Society of Kyushu University while educating and collaborating with graduate students in various fields who participate in the graduate education and research

training program in decision science for a sustainable society. This book has been edited based on the results of this research project.

Future Earth's vision of building a problem-solving-oriented earth system science through transdisciplinary research based on co-design/co-production with various stakeholders is a major challenge in modern science. With the intention of making a significant contribution to this challenge, we have continued our efforts to develop a transdisciplinary science focused on decision-making. All social problems are the result of human decision-making, and our decision-making holds the key to solving these problems. It is, however, not easy to answer the question of how we can make good decisions. Once the norms and indicators for choosing options are agreed upon, it may be possible to find an optimal solution through an optimization model that considers costs, risks, and benefits. However, since the norms of decision depend on values, a decision may be good for some but bad for others. For such issues that are influenced by values, it is difficult to obtain an "optimal" solution based solely on objective evidence. Rather, that decision can only be made through agreements and compromises that adjust for differences in values. Then, how can a science-based approach contribute to this difficult decision-making problem?

This book develops theoretical considerations for this question in three chapters. Chapter 1 of Part 1 provides conceptual and systematic consideration of decision science based on human evolutionary biology. Since the cognitive system behind human decision-making is a product of evolution, its evolutionary biological understanding is thought to hold the key to developing decision science. As a product of this consideration, we propose co-design guidelines that take into account human cognitive biases created by evolution. In Chap. 2 of Part 2, based on a comparison of the cases of transdisciplinary research described in Chaps. 3–6, theoretical consideration is given to the relationship between science/scientists and society. Future Earth depends on the idea that science meets and needs society. Chapter 2 examines this premise itself and considers the grounds for the usefulness, effectiveness, and acceptance of science or scientific methods for society. Based on this consideration and also our experience in various cases, we propose indicators to evaluate the process of co-design/co-production in transdisciplinary research. In Chap. 7 at the beginning of Part 3 on natural resource management, a mathematical model is used to theoretically consider the strategy of natural resource management in which the dynamics of ecosystems and human decision-making influence each other. Although it is difficult to find an optimal solution to a value-sensitive problem, it is possible to model the dynamics of human decision-making and predict what consequences individual decisions will have under the interaction with ecosystems. This prediction may help build a consensus on options between stakeholders with different values. In addition to these theoretical considerations, the results of case studies on public health, disaster prevention, land use, and community development are presented in Part 2, the results on natural resource management are presented in Part 3, and the results on post-earthquake reconstruction processes are presented in Part 4. In April 2016, we experienced a large earthquake in Kyushu. How we can contribute to the recovery process from this earthquake has become a new issue in our problem-solving research project as well as in our graduate education reform activity.

The main feature of our project is that researchers from various fields (including natural sciences and social sciences) related to the five major themes of environment, disasters, health, governance, and human decision-making have been involved for six years since 2014. This book is the result of collaborative research through mutual involvement in social problem-solving, mutual consensus formation, and collaboration with various stakeholders on co-design/co-production efforts. These achievements include a significant contribution to the integration of natural and social sciences that Future Earth aims for. However, some challenges remain. Three theoretical chapters, Chapter 1 from the perspective of evolutionary biology, Chap. 2 from the perspective of social science, and Chap. 7 based on the mathematical theory of coupled social-ecological dynamics, are still rather separated. Efforts for integrating these theoretical considerations have just begun. In addition, meta-analysis of various case studies is also just beginning. However, we believe that the theoretical considerations and case studies presented in this book have resulted in a solid foundation for developing decision science that contributes to the creation of a sustainable society.

In the Kyushu University Graduate Education and Research Training Program in Decision Science for a Sustainable Society, Salvatore Arico (UNESCO), Anantha Duraiappah (UNESCO MGIEP), Thomas Elmqvist (Stockholm Resilience Centre), Anne Larigauderie (IPBES), Simon Levin (Princeton University), Harold Mooney (Stanford University), and Hugh Possingham (University of Queensland) are international advisory board members. We thank them for their warm encouragement and professional advice for our efforts to reform postgraduate education and develop transdisciplinary research. The graduate school education reform activity was funded by the JSPS Program of Leading Graduate Schools, and the transdisciplinary research was funded by the JST Future Earth Initiative Promotion Project. In addition, we received financial support from Kyushu University through these projects. We would like to thank former President Setsuo Arikawa, President Chiharu Kubo, and Director Hiroto Yasuura for their continuous encouragement of our efforts.

Fukuoka, Japan Tetsukazu Yahara

Contents

Part I
The Conceptual Framework of Decision Science for a Sustainable Society

Chapter 1
Decision Science for Future Earth: A Conceptual Framework

Tetsukazu Yahara, Wataru Tanaka, Yukako Inoue, Jounghun Lee, Kun Qian, Firouzeh Javadi, Nariaki Onda, Fumihiko Yokota, Kumi Eguchi, Mariko Nishikitani, Kimiyo Kikuchi, Akira Kawasaki, Yukyong Jeong, Jun'ichiro Ide, Tetsuji Ota, Takahiro Fujiwara, Tadatsugu Hosoya, Yuichi Kano, Megumi Sugimoto, Ashir Ahmed, Yukihiro Shimatani, Shota Tokunaga, Ai Nagahama, Michikazu Hiramatsu, and Takahiro Murakami

T. Yahara (✉)
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan

Department of Biology, Kyushu University, Fukuoka, Japan

Kyushu Open University, Fukuoka, Japan

W. Tanaka
Faculty of Engineering, Nagasaki University, Nagasaki, Japan

Y. Inoue
Research Institute for Future Design, Kochi University of Technology, Kochi, Japan

J. Lee
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan

Department of Biology, Faculty of Sciences, Kyushu University, Fukuoka, Japan

K. Qian · F. Javadi · F. Yokota · K. Eguchi · Y. Jeong · T. Hosoya · Y. Kano · M. Hiramatsu · T. Murakami
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan

N. Onda
Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Japan

M. Nishikitani
Faculty of Medical Sciences, Kyushu University, Fukuoka, Japan

Weatherhead East Asian Institute, Columbia University, New York, NY, USA

K. Kikuchi
Faculty of Medical Sciences, Kyushu University, Fukuoka, Japan

A. Kawasaki
Faculty of Regional Design and Development, University of Nagasaki, Nagasaki, Japan

J. Ide
Department of Applied Chemistry and Bioscience, Chitose Institute of Science and Technology, Chitose, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_1

Abstract The purpose of this chapter is to review progress in our understanding of human behavior and decision-making relevant to future earth research agenda, and propose Decision Science as a hub of knowledge networks connecting disciplinary and interdisciplinary sciences with the practice of problem-solving. This review is composed of four sections. First, we describe the conceptual framework of "decision science for a sustainable society" and argue that evolutionary biology of the human nature is key to construct this framework. Second, we review how our group decision-making often fails due to various cognitive biases and argue that participatory approaches of co-design and co-production do not guarantee reasonable decision-making. Third, we review success stories of problem-solving in local communities and consider how we can connect those successes in local communities to successful national and global decision-making. Fourth, learning from both failures and successes, we argue that the adaptive learning of society is a process enabling us to transform our society toward a sustainable future. We review some positive global trends toward sustainability and consider the cognitive processes and behavioral mechanisms behind those trends that would provide clues for finding successful ways to transform our society.

Keywords Adaptive learning · Adaptive comanagement · Cognitive biases · Evolution · Social transformation · Trans-disciplinary science

1 Introduction

Since the *Homo sapiens* started their migration from Africa to other continents around 60,000 years ago (Ingman et al. 2000), our population has continuously increased until now (Hawks et al. 2007). The increasing pressure on the environment has resulted in global environmental problems such as climate change, eutrophication, ocean acidification, and biodiversity loss (Diamond 2005; Rockström et al.

T. Ota · T. Fujiwara
Faculty of Agriculture, Kyushu University, Fukuoka, Japan

A. Nagahama
Graduate School of Systems Life Science, Kyushu University, Fukuoka, Japan

A. Nagahama
Graduate School of Systems Life Science, Kyushu University, Fukuoka, Japan

A. Nagahama
Graduate School of Systems Life Science, Kyushu University, Fukuoka, Japan

A. Nagahama
Graduate School of Systems Life Science, Kyushu University, Fukuoka, Japan

A. Nagahama
Graduate School of Systems Life Science, Kyushu University, Fukuoka, Japan

2009; Hoegh-Guldberg and Bruno 2010; Hooper et al. 2012). Considering evidence suggesting that mankind's growing influence on the environment may depart significantly from the natural behavior of the planetary environment, the term "Anthropocene" was proposed to characterize the present human-dominated geological epoch, following the Holocene (Crutzen 2002). In this Anthropocene, human communities are facing an array of challenges called Grand Challenges (Reid et al. 2010) that will have a serious influence on human well-being and the sustainability of the environment. Addressing these major challenges, an internationally coordinated research program, Future Earth, was launched in 2013 by integrating three environmental change research programs: IGBP, IHDP, and DIVERSITAS (Future Earth 2013; Leemans 2016). Subsequently, the Sustainable Development Goals (SDGs), including goals for ending poverty, protecting the planet, and ensuring prosperity for all people, were adopted at the UN Sustainable Development Summit in 2015 (UN 2015). Future Earth is expected to play a leading role in developing science to support the achievement of SDGs.

In its Initial Design document, Future Earth (2013) identified three highly aggregated research themes covering both natural and social sciences: dynamic planet, global development, and transition to global sustainability. The organization proposed new approaches to co-designing and co-producing solution-oriented science, knowledge, and innovation for global sustainable development. These proposals are based on the concept of transdisciplinary science that emphasizes the importance of co-design with stakeholders (Mauser et al. 2013). However, the development of the Future Earth research platform initially created many tensions between the interdisciplinary activities of earlier environmental change research programs and the leadership of the highly aggregated agenda, and the transdisciplinary approach of the Future Earth transition team, the funders, and the sponsors—including ICSU/ISSC (Leemans 2016). Those tensions were resolved by accepting all the previous projects of the global change programs under the three-themed research platform of Future Earth, but further efforts are needed to fill the gap between the researchers in the original international global change programs and the new transdisciplinary research agenda of Future Earth. In particular, the transdisciplinary research agenda remains highly conceptual, and the following key questions remain open for further exploration and discussion:

1. How can we successfully co-design our projects with various conflicts of interest?
2. How can we develop solution-oriented trans-disciplinary science by integrating natural and social sciences?
3. How can we transform our society for a sustainable future?

Here, we propose that Decision Science, an integrative science of human behavior and decision-making, is key to answering those questions, although it is not the only key, and other possibilities are of course worthy to be considered. Every social problem is a consequence of human behavior and decision-making. The need to consider human behavior and decision-making in the development of Future Earth is already identified in the Strategic Agenda 2014 (Future Earth 2014) in which 62 key research priorities are listed as a result of consultation processes with global environmental change research communities and stakeholders as well as an open online

survey. Among those priorities, the following key questions on human behavior and decision-making are clearly addressed under the three-themed research framework of Future Earth.

- Dynamic planet: How can computational models of human individual and collective behavior be integrated into Earth system models of global environmental change? What new aspects need to be developed, combining neuroscience, psychology, anthropology, sociology, and economics? How do such models alter our understanding of future behaviors, risks, and trade-offs?
- Global development: What are the strengths and weaknesses of different decision-making approaches for balancing trade-offs inherent in socio-environmental systems from local to global scales? What are their impacts on the provision and regulation of ecosystem services?
- Transformation toward sustainability: What is the nature and role of narratives (particularly around development, futures, justice, risk and disasters, and conflicts) in driving human behavior and social change, including decision-making? In what ways might these narratives influence risk mitigation and inspire transformative action toward sustainability?

To answer those questions, we need to integrate various disciplinary perceptions of human behavior and decision-making including psychology, anthropology, economy, sociology, philosophy, and evolutionary biology. Recent efforts for this integration resulted in the publication of some seminal books, including Kahneman (2011), Pinker (2011), Haidt (2012), Greene (2013), and Henrich (2017), and many peer-reviewed papers reviewed in those books. However, this progress has been mostly neglected in the discussions to develop Future Earth since the proposal of the Grand Challenges (Reid et al. 2010).

The purpose of this chapter is to review progress in our understanding of human behavior and decision-making relevant to Future Earth research agenda, and propose Decision Science as a hub of knowledge networks connecting disciplinary and interdisciplinary sciences with the practice of problem-solving. This review is composed of four sections. First, we describe the conceptual framework of "decision science for a sustainable society" and argue that evolutionary biology of the human nature is key to construct this framework. Second, we review how our group decision-making often fails due to various cognitive biases and argue that participatory approaches of co-design and co-production do not guarantee reasonable decision-making. Based on this understanding of cognitive biases, we propose a guideline for co-design in transdisciplinary projects of Future Earth. Third, we review success stories of problem-solving in local communities and consider how we can connect those successes in local communities to successful national and global decision-making. Fourth, learning from both failures and successes, we argue that the adaptive learning of society is a process enabling us to transform our society toward a sustainable future. From a viewpoint of evolutionary biology, this process is analogous to the adaptive evolution of organisms and understanding this analogy provides a key to integrating natural and social sciences toward solution-oriented studies contributing to a sustainable society. We review some positive global trends

toward sustainability and consider the cognitive processes and behavioral mechanisms behind those trends that would provide clues for finding successful ways to transform our society.

2 Conceptual Framework of Decision Science for a Sustainable Society

2.1 Science of IDEA Cycle, an Iterative Process of Decision-Making and Adaptive Learning

Decision-making is a process of linking scientific knowledge with solutions to social problems: disciplinary and interdisciplinary sciences such as environmental, disaster, health, and social sciences provide stakeholders with some knowledge-based options for solving a social problem whereas stakeholders must make a decision on a particular option to be prioritized and executed (Fig. 1.1). In this decision-making process, knowledge-based options are usually hypothetical because our knowledge on a particular social problem such as ecosystem deterioration is always associated with high level of complexity and uncertainty as well as conflicts of interest (Matsuda et al. 2005; Ravetz 2006). Thus, to determine which option is "better," we need efforts for building consensus or developing compromise among stakeholders through participatory approaches. This process of decision-making is influenced not only by objective knowledge but also by the subjective nature of human cognition that is often largely biased (Kahneman 2011). For managing this decision-making process, we need to deepen our understanding of the human cognition systems behind various human behaviors that are designed as an outcome of evolution (Pinker 2011).

Future Earth is trying to fill the gap between science as the active knowledge producer and society as the passive recipient in the knowledge production process by promoting a process of co-design and co-production of knowledge (Mauser et al.

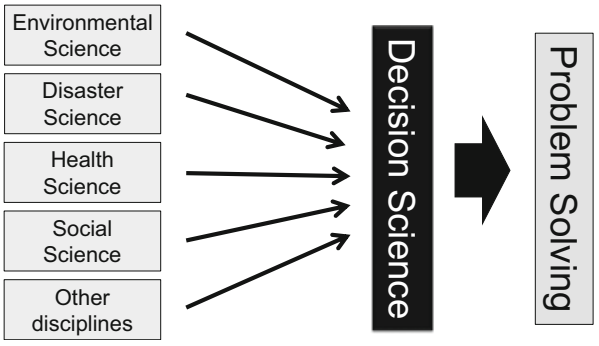


Fig. 1.1 A role of decision science, connecting between disciplinary and interdisciplinary sciences and problem-solving processes

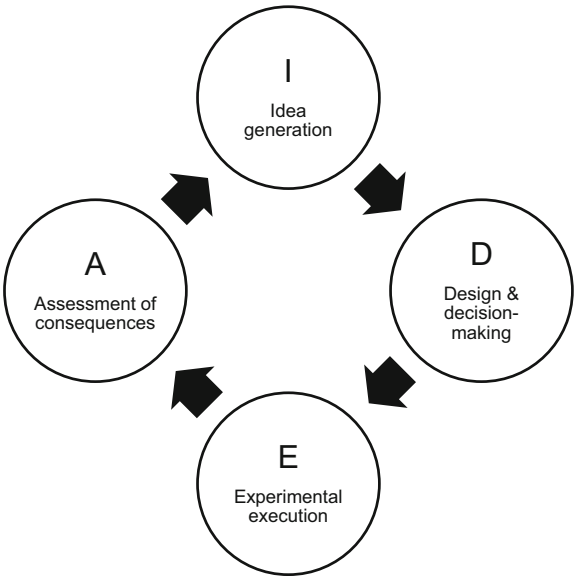


Fig. 1.2 A framework of IDEA cycle composed of four phases; idea generation (I), design and decision-making (D), experimental execution (E), and assessment of consequences (A)

2013). We regard this participatory process as a cycle of idea generation (I), design and decision-making (D), experimental execution (E), and assessment of consequences (A) designated as the IDEA cycle (Fig. 1.2). Decision science for a sustainable society is trying to deepen our understanding of the IDEA cycle by considering how we can develop cooperation in each phase of the cycle.

"I" (Idea generation) is a phase where we generate various ideas by framing problems, understanding the system behind problems, developing hypotheses, and creating various options. Because many social problems remain unsolved by ordinary thoughts (Ravetz 2006), it is often crucial to discover overlooked ideas that may be effective for solving problems. Thus, the idea generation process with stakeholders needs not only scientific idea generation for solving problems but also so-called design thinking including consideration of the emotional content of the situation (Simon 1969; Brown and Kātz 2009). In science, an idea generation process to find the simplest and most likely hypothesis is called abduction (Peirce 1903) that is now a target of intensive studies in computer science (Magnani 2011) and cognitive science (Thagard 2014). While design thinking is widely used in business sectors (Brown and Kātz 2009), it is mostly neglected in scientist communities, including Future Earth; the unpublished thesis by Perderwitz (2017) may be the only exception. Integration of scientific and design thinking would be helpful in facilitating participatory processes of co-design and co-production.

"D" (Design and Decision-making) is a phase where we design and select a specific option from various options developed in the I phase. In scientific research, this phase corresponds to the process of designing experiments. In environmental policy-making, cost-benefit analyses have been widely used to find optimal decisions but as linkages of various problems have been recognized, many different

categories of benefits and cost must be evaluated, such as health impacts, property damage, ecosystem service losses, and other welfare effects (Pearce et al. 2006). More recently, risk-benefit analyses have been developed and the importance of risk communication considering various cognitive biases to risks has been widely recognized (Fischhoff and Kadvany 2011). The conflicts due to different interests and different allowances of risks would be resolved under the process of Experimental execution and Assessment of consequences, stated below, if stakeholders could agree on a particular option. However, consensus building among stakeholders is a challenging process in many circumstances. To manage conflicts, it is important to allow many stakeholders to participate in the option design process.

"E" (Experimental execution) is a phase for executing the adopted option with the collaboration of various stakeholders. In this phase, maintaining cooperation of community members is essential for success. On the other hand, it is well known that cooperation in a large community is unstable due to the increase of non-cooperating members (Dunbar's number: Dunbar 1993). This problem has been noticed and categorized in different disciplines as the tragedy of the commons (Hardin 1968), collective action problem (Olson 1965; Sanders 1992), free-rider problem (Grossman and Hart 1980), and social dilemmas (Axelrod 1984; van Lange et al. 2013). How we can protect the commons and develop cooperation for a sustainable society by overcoming social dilemmas remains a big question of decision science.

"A" (Assessment of consequences) is a phase where we assess and learn from the consequences of Experimental execution that often result in unexpected and unfavorable results. Learning from assessments is a process associated with adaptive management (Holling 1978; Walters 1986; Gunderson and Holling 2002), an iterative process of decision-making now widely adopted in the management of natural resources and environments in the face of uncertainty. Through this process, we can accumulate knowledge and improve our capacity for solving problems by "learning by doing" (Borrini-Feyerabend et al. 2004) or "learning from doing" (Bell and Morse 2013). In this phase, it is important that we are constantly "adaptive" by assessing consequences and improving options under the changing conditions.

2.2 Relationship of the IDEA Cycle with Some Previous Concepts

The concept of the IDEA cycle is based on some preceding ideas. First, IDEA cycle is a modification of the PDCA or PDSA cycle widely used in the quality management initiatives of the mass production industry (Moen and Norman 2009) and healthcare (Taylor et al. 2013). The PDCA or PDSA cycle has its roots in Shewhart (1939) who corresponded the three steps in the mass production process (specification, production, and inspection) to the steps in the scientific method (making a hypothesis, carrying out an experiment, and testing the hypothesis), respectively.

Later, Deming (1950) added the fourth step of research and emphasized the importance of constant rotation of the cycle composed of design (Plan), production (Do), sales (Check), and research (Action), now called the PDCA cycle. Therefore, while the PDCA cycle was designed for quality control of mass production, the four steps correspond to the dynamic process of acquiring scientific knowledge. However, in the case of participatory or transdisciplinary processes for solving social problems, we need to clarify the decision context by defining what problem is being addressed, why it is important, and how it is related to other decisions previously made (the first step of the structured decision making; see Gregory et al. 2012). This process is corresponding to the review process in the scientific method and the Introduction part of the standard structure of scientific papers. In the three steps of the scientific method modeled by Shewhart (1939), this review process is lacking. In the IDEA cycle, this process is categorized as the I phase. Following this I phase, the D phase is placed in the IDEA cycle instead of the P phase of the PDCA cycle. This phase is named D (Design and Decision-making) in order to emphasize the importance of experimental design for a countermeasure to be implemented and group decision-making based on consensus building among various stakeholders. Following this D phase, the E (Experimental execution) phase is placed instead of the Do phase in the PDCA cycle. Here, experimental nature of this execution process is emphasized. The Check and Action phases of the PDCA cycle are merged into the A (Assessment) phase of the IDEA cycle. The four phases of the IDEA cycle can be related to Introduction, Material and Methods, Results, and Discussion in the standard structure of scientific papers.

Second, the IDEA cycle incorporates the idea of adaptive management developed independently of the PDCA cycle by Holling (1978). Adaptive management is an iterative approach to environmental impact assessment and management of ecosystems in the real world with many uncertainties, aiming at reducing uncertainty over time via repeated ecosystem monitoring. It is a learning process to improve management in the future by getting new knowledge through monitoring, while trying to achieve the best short-term outcome based on current knowledge. Holling et al. (2002) referred to an idea of transformational learning that involves several levels in the process of adaptive management, but did not use the term adaptive learning. The term adaptive learning has been used to describe artificial intelligence web-based educational systems (Brusilovsky 2003), but here we propose to use "adaptive learning" for describing iterative learning processes in general by including learning through adaptive management. Reed et al. (2006) used this term to describe a learning process in which participatory approaches and expert-led methods are integrated to develop sustainability assessment at local scales. The IDEA cycle as a whole can be viewed as a process of adaptive learning. This is a kind of selection process similar to the adaptive evolution of organisms (Ridley 2016) but the similarity and difference between adaptive learning and adaptive evolution remain to be clarified.

Third, the scheme of the IDEA cycle is partly similar to the conceptual model of transdisciplinary study developed by Lang et al. (2012) which includes a sequence of three phases: Phase A of problem framing and team building, Phase B of knowledge

creation, and Phase C of integration and application. Those three phases correspond to co-design, co-production, and co-dissemination steps proposed for Future Earth (Mauser et al. 2013). However, neither conceptual models (Lang et al. 2012; Mauser et al. 2013) specify the decision-making phase. As is explained above, by adopting a particular option for further steps of experiment and learning ("learning from doing"), we select a particular option among some hopeful candidates. This is corresponding to a process of science in which scientists select a particular hypothesis to be tested and design experiments to test it. Because of the high uncertainty, it is often difficult to determine which hypothesis is most likely. In addition, the most preferable hypothesis (option) may differ among stakeholders due to differences of interests, values, and risk perceptions. Thus, decision-making should not solely rely on the optimization under cost-benefit tradeoffs but consider cognitive processes of various interests, values, and risk perceptions (Fischhoff and Kadvany 2011). This decision-making can be made only by building consensus or developing compromise under some trust among stakeholders. On the other hand, it is important to design the "experiments" well so that the hypothesis can be tested by the results or consequences (Barnerjee and Dufro 2011).

Fourth, the IDEA cycle is related to the idea of Structured Decision-Making (SDM; Gregory et al. 2012) in which the decision-making process under different interests is considered as a series of structured processes. SDM is a decision-structuring approach for public resource management under conflicts derived from multi-stakeholders with different perspectives. This difference impedes the technical analysis of the problem because the problem is often emotionally charged. Therefore, despite existing technical decision tools and theory, we often fail to dissect the problem and decide where to apply those tools, due to people's mental shortcuts, biases, or groupthink. To encourage focusing on facts rather than conflicts and controversies, SDM proposes a sequence of collective thinking realized by six processes: (1) Clarifying the decision context, (2) Defining objectives and evaluation criteria, (3) Developing alternatives, (4) Estimating consequences, (5) Evaluating trade-offs, and (6) Implementation and monitoring. In SDM, it is recommended to focus on understanding objectives, measures, uncertainty, and ranges of alternatives by avoiding weighing the alternatives and pursuing consensus, which may cause unnecessary conflicts among stakeholders with different values. The agreed-upon objectives and measures constitute evaluation criteria and methods that form a framework for comparing alternatives. After setting the framework, searching and developing creative alternatives by participants will be critical to problem solving by deepening participants' understanding about objectives and constraints to the objectives. Open dialogues about the trade-offs can contribute to deriving negotiable points by clarifying agreed and disagreed points among stakeholders. SDM also incorporates the adaptive management approach in the Implementation and monitoring phase where it is expected that local people can establish skills in monitoring, just as in the A phase of the IDEA cycle.

SDM provides a practical guide to build a common understanding under trust and partnership among stakeholders so that decision-making on agreeable alternatives can be negotiated. This SDM approach has been successfully applied to the

Table 1.1 Comparison of five models for decision-making processes

IDEA cycle	Adaptive management	PDCA cycle	Future earth	SDM
Set-up	Set-up			Problems, objectives
Idea generation				Alternatives
Design and decision	Decision making	Plan	Co-design	Consequences, trade-offs, optimization and decision
Experimental action	Monitoring	Do	Co-production	Action
Assessment	Assessment	Check, action	Co-dissemination	

management of environmental problems spanning water use planning, air quality, climate change, wildfire risks, parks and recreation, fish and wildlife harvest, and oil and gas development by assisting stakeholders in constructing their own solutions (Gregory et al. 2012). Despite these successes, SDM has some shortcomings relating to its applicability. As shown by the multiple processes, participants should commit to each process implementation that may be technically intensive, although the knowledge itself is provided by initially organized technical working groups and expert panels. In addition to considerable efforts for understanding technical issues, participants should enjoy long discussions to achieve agreements on objectives and measures, which should be demanding on the participants. How we can maintain the cooperation of participants over this long process of SDM remains a question to be considered in further studies.

Among the five models of decision-making processes (Table 1.1), IDEA cycle identifies the first step as a process reviewing the backgrounds of a problem and developing various ideas for its solution. This process is corresponding to processes (1)–(3) in SDM, where the context behind a problem is reviewed, objectives of a problem solving are discussed, and alternative options are developed. This review process is not specified in PDCA cycle, adaptive management cycle, and the three-stage model of Future Earth.

As is summarized above, the three-stage model of transdisciplinary science in Future Earth is one of the few ideas for facilitating the collaboration of scientists and stakeholders toward social problem solving. Compared with other ideas, this model has some shortcomings, given the complexity of decision-making processes under social conflicts, difficulty of cooperation under social dilemmas, and the importance of adaptive management and learning to reduce uncertainty and find better options. The IDEA cycle helps recognize those issues by incorporating ideas developed by previous studies including adaptive management (Holling 1978) and structured decision-making (Gregory et al. 2012) into a simple, four-phase framework.

More specifically, the IDEA cycle helps to identify the following key questions in decision science for a sustainable society. How can we integrate scientific and design thinking in the idea generation phase? How can we build consensus on a particular option to be adopted (or a hypothesis to be tested)? How can we organize and

maintain cooperation through experimental executions under social dilemmas? How can we improve our capacity for solving problems through adaptive learning? All of those questions are related to human cognition, decision-making, and behavior that are at least partly genetically determined as a consequence of evolution from our ancestors to modern humans. Thus, understanding human nature from the viewpoint of evolutionary biology provides a fundamental base of decision science for a sustainable society. This viewpoint is explained in further detail in the following section.

2.3 Evolutionary Theory as a Basis of Decision Science for a Sustainable Society

Future Earth is aiming at developing research to better understand changing "social-ecological systems" (Berkes and Folke 1998; Gunderson and Holling 2002; Folke et al. 2005) by integrating different disciplines from the natural and social sciences, engineering, and humanities (Future Earth 2013). However, achievements of previous efforts for this integration are not fully reviewed in the design process of Future Earth. Here, we briefly review that an integration of natural and social sciences and humanities has been successfully developed by using evolutionary theory as a universal integrator, or "universal acid" (Dennett 1995), and this integration is relevant to sustainability science. Dennett (1995) called Darwin's theory of evolution by natural selection "Darwin's dangerous idea" in that it "eats through every other explanation for life, mind and culture." This vision of the integration of natural and social sciences goes back to the proposal of Sociobiology (Wilson 1975). Although this proposal triggered a strong controversy (Segerstrale 2000), social scientists and humanity researchers gradually accepted evolutionary theory and developed new disciplines of human cognition and behavior including evolutionary psychology (Barkow et al. 1995; Dunbar et al. 2005; Dunbar 2014; Buss 2014) and behavioral economics (Kahneman 2003, 2011). Further, as was predicted by Dennett, evolutionary theory has been incorporated into studies of almost all aspects of human life, including institutions (North 2005), morality (Haidt 2007, 2012; Greene 2013), politics (Heath 2014), and human history in relation to the environment (Diamond 2005), violence (Pinker 2011) and many other aspects of our society (Pinker 2018; Ridley 2016). Consequently, many themes of social science and humanity research are now at least partially integrated with the rapid advance in natural science on human nature, including human genome research and neuroscience. Those integrations provide many innovative understandings of human behavior and decision-making that are relevant to sustainability science.

First, there is increasing evidence that human populations are genetically variable in political attitudes, moral foundations, personalities, and cognitive ability, all of which can influence human behavior and decision-making. The dichotomy of cooperation and confrontation in human societies may result partly from this

variability. Genetic variation in political attitudes (e.g., conservative vs. liberal) is now well documented (Bouchard et al. 2003; Gerber et al. 2010; Hatemi et al. 2011; Oskarsson et al. 2015) and the heritability of various traits associated with political attitudes is 30-60% (Hatemi and McDermott 2012). This variation of political attitudes is associated with difference in moral beliefs among people (Haidt 2012). According to the moral foundation theory (Haidt 2007; Graham et al. 2013), human morality is derived from multiple innate mental systems called moral foundations including care, fairness, loyalty, authority, and sanctity, each shaped by a different evolutionary process. Graham et al. (2013) suggested that care foundation is advantageous for parents to protect their own child, fairness foundation is advantageous for an individual to develop cooperation with one's own direct interaction partners in non-zero-sum exchanges, like trades, loyalty foundation is shaped up by intergroup competitions, authority foundation is shaped up by dominance hierarchies, and sanctity foundation is derived from the emotion of disgust that evolved to avoid risks from pathogens and parasites. Haidt and Graham (2007) and Graham et al. (2009) showed that more conservative people have moral intuitions with more emphases on loyalty, authority, and sanctity foundations and less emphases on care and fairness foundations than more liberal people. Gerber et al. (2010) showed that political attitudes vary with openness, one of Big Five personality traits associated with creativity and intelligence and more liberal people tend to have higher openness. Further, Oskarsson et al. (2015) showed that political attitudes vary with cognitive ability and suggested cognitive ability is a causal mechanism linking genes and political attitudes. Both openness and cognitive ability are highly heritable (Bouchard and McGue 2003). These findings suggest that we are genetically different in attitudes to various social issues and thus for transforming our society toward sustainability, we need to develop social environments that facilitate cooperation among people with different moral beliefs.

Second, our species is highly cooperative, violating the standard economic assumption that everyone in the economy is rational and selfish (Bowles and Gintis 2011). Theoretical and experimental research has been accumulated to understand how humans can continue to work together to overcome the temptation to exploit other people's efforts (Yamagishi 1986; Sigmund et al. 2001; Fowler 2005; Henrich 2006; Rockenbach and Milinski 2006; Egas and Riedl 2008; Boyd et al. 2010). This cooperative nature is widely observed in not only modern societies but also hunter-gather societies where band-level cooperation on sharing a large game is maintained under strong consensus about holding down dominant behaviors (Boehm 2008, 2012). Boehm (2008) suggested that this "egalitarian syndrome" is considered to be a consequence of natural selection on the self-monitoring and self-controlling capacities to avoid punishments from the society (bond) when breaking the rules that was shared and internalized by language. Whereas the details of selection pressure on human cooperation remain controversial (Bowles and Gintis 2011), strategies such as direct/indirect reciprocity, retaliation, and reputational considerations are hopeful mechanisms for maintaining cooperation among individuals. Although cooperation incurs significant cost to individuals, if people live in small groups, interact repeatedly, distinguish each other, and expect like treatment from others,

then cooperation can evolve with the help of these mechanisms (Nakamaru and Iwasa 2006; Sigmund 2007; Puttermann et al. 2011; Guala 2012; Iwasa and Lee 2013). Under these mechanisms, ingroup favoritism or empathy within the group can also evolve because discrimination of ingroup members from outsiders can promote cooperation by allowing a person to interact with more reliable co-players. While ingroup favoritism or empathy within the group provides a basis of cooperation in a community, it also causes conflicts among communities. To solve various social problems, we need to develop some agreement or meta-morality to avoid conflicts among groups or "them" and develop cooperation in a larger community or "us" (Greene 2013).

Third, our decision-making based on a moral foundation is intuitive and driven by a cognitive system called System 1 (Haidt 2012; Greene 2013). According to Kahneman (2011), human cognitive systems are composed of System 1: responsible for intuitive decision; and System 2: responsible for rational decision. This dual-process model was first proposed by Evans (1989) and has been supported by subsequent psychological studies (see Evans 2008; Evans and Stanovich 2013), and also by brain research (Brewer et al. 2011; Brewer 2017). This is, of course, a much-simplified model of highly complicated systems but useful to understanding many cognitive biases inherent in System 1. While System 1 is always operating to instantaneously respond to information continuously inputted from external environments to the brain, System 2 is driven by sending a particular task to the brain by paying attention. System 2 is a costly process consuming much sugar in the brain and paying attention means paying a biochemical cost. Thus, our brain tends to make decision-making by System 1 unless careful thinking using System 2 is required by alarming signals or social requests. System 1 is considered to have evolved as an adaptation to minimize the cost of responding to various external signals. Therefore, System 1 is usually effective in our ordinary life, but it has many cognitive biases that often cause serious mistakes in decision-making (Kahneman 2011). For example, once a person accepts a belief or hypothesis, System 1 seeks and accepts evidence supporting the accepted belief or hypothesis and avoids thinking well using System 2 by paying attention to inconvenient evidence. Even scientists are not free from this trend, known as confirmation bias (Nickerson 1998), and thus they often claim conflicting views on social issues, accelerating social confrontation. Those cognitive biases discovered by psychologists demonstrated the background of the limitation of our rationality (boundary rationality, Simon 1947). As such cognitive bias became widely known, the difficulty of rational problem-solving has been emphasized by distinguished scholars thinking about the transformation of our societies (Haidt 2012; Greene 2013; Heath 2014). In the co-design process of transdisciplinary research in Future Earth, we should carefully avoid failures from those cognitive biases. This issue is considered in detail in the next section.

3 Learning from Failures and Guidelines for Co-design

3.1 Vulnerability of Group Decision-Making

Future Earth emphasizes the importance of co-design with various stakeholders (Mauser et al. 2013), but group decision-making, including co-designs between scientists and stakeholders, does not necessarily result in successful outcomes (Janis 1972, 1982; Kerr and Tindale 2004; Brodbeck et al. 2007). Co-design by scientists, government, and the private sector is a process that has been widely pursued in Japan and successfully supported the high economic growth since the 1950s. However, decision makings based on co-design by scientists, government, and the private sector resulted in some big accidents including the Fukushima nuclear power plant disaster (Aoki and Rothwell 2013; Labib and Harris 2015). According to Labib and Harris (2015), the likelihood of a serious accident was foreseen, but design shortcomings were neither investigated nor addressed. To avoid such a failure in the co-design process, we need to understand how group decision-making can fail in general. It is well known in social psychology that group decision-making often fails due to various cognitive biases (Kahneman 2011; Lu et al. 2012; Montibeller and von Winterfeldt 2015). In this section, we first review our current understanding of vulnerabilities and cognitive biases associated with group decision-making. Second, we consider how we can deal with those vulnerabilities and cognitive biases and propose guidelines for avoiding co-design failures in transdisciplinary projects.

Janis (1972) coined the term "groupthink" to describe the failure of group decision-making based on a comparative analysis of high- and low-quality decisions made by policy-making groups during six historical events in the United States. He found that some of the historic fiascos were the result of faulty decision-making by groups dominated by concurrence-seeking behavior, which refers to the tendency of group members to avoid controversy and reach a consensus decision without a critical evaluation of alternative viewpoints. Janis (1982) concluded that "groupthink," which he defined as "a mode of thinking that people engage in when they are deeply involved in a cohesive ingroup, when the members' strivings for unanimity override their motivation to realistically appraise alternative courses of action," often resulted in a tragic outcome. Janis (1982) identified the following three major antecedent conditions that make a group vulnerable to "groupthink": cohesiveness of a group, structural fault like homogeneity of members' background, and context like high stress and low self-esteem. Further, he identified three major symptoms of "groupthink," including overestimation of the group, closed-mindedness, and pressures toward uniformity, while seven symptoms of defective decision-making lowered the probability of successful outcomes, including incomplete survey of alternatives and failure to work out contingency plans. Janis's "groupthink" model is described in many social psychology textbooks even though empirical tests do not always support the relationship between the antecedent conditions and symptoms (Baron 2005; Rose 2011). Baron (2005) argued that "we are familiar with

groupthink symptoms and processes because the concurrence seeking, illusion of consensus, self-censorship and ingroup defensiveness described by Janis are far more widespread phenomena than he envisioned."

While the concept of "groupthink" is a heuristic approach to evaluate the quality of policymaking, some critiques of the model have appeared since the early 1980s (McCauley 1989). First, Longley and Pruitt (1980) criticized that the "groupthink" theory is not a logical progression of ideas, but a grab-bag of phenomena that were correlated with each other in sampled cases. Second, Hart (1991) criticized that some cases of policy failure were chosen first, and then "groupthink" analysis was applied to see whether the decision process was affected by it. This methodology is biased toward selective interpretation of the case study material. Baron (2005) and Rose (2011) have reviewed other critiques as well as evidence supporting or dismissing the "groupthink" model. As is summarized by Baron (2005), Janis (1972, 1982) assumed that strong group cohesion is likely to induce "groupthink" when supported by some secondary conditions, such as insulation of the group, directive leadership, lack of fair group norms, and homogeneity of member attitude or ideology. However, it remains uncertain how primary and secondary conditions influence outcomes of group decision-making.

As far as we know, the mathematical model of Furuta and Kondo (1992) is the only available tool for analyzing the influence of group cohesion and secondary conditions on outcomes of group decision-making. In their "group reliability analysis," they developed a mathematical model describing the success probability (the probability of correct judgment by a group) as a sigmoid function of the judgment ability of each member and the influence from other members (strength of group coherence). They found that the success probability generally increases with the strength of group coherence, but decreases above an optimal level of group coherence if group members are isolated from outside information and criticism by sharing a common attitude or if a group contains members with insufficient judgment ability. This study theoretically supported the idea of Janis (1972, 1982) that group cohesion can evoke the failure of "groupthink" when supported by some secondary conditions (particularly, the insulation of the group). It is notable that the model of Furuta and Kondo (1992) was developed in the Department of Nuclear Engineering, with the goal of improving group performance and safety in the nuclear power sector. This indicates that Japanese scientists involved in the nuclear power sector were aware of the susceptibility to "groupthink," but this knowledge was not successfully utilized to improve nuclear power policy.

Some research topics related to the "groupthink" model have been studied rather independently. First, the hidden profile paradigm (Stasser and Titus 1985; Stasser 1988) directed a surge of research on the failure of group decision-making due to people's tendency to discuss and incorporate shared (known to all members) information rather than unshared (known to a single member) information (Wittenbaum et al. 2004; Brodbeck et al. 2007; Lu et al. 2012; Sohrab et al. 2015). This hidden profile paradigm provides a demonstration of the concurrence-seeking tendency specified by Janis (Baron 2005). Second, group polarization (Myers and Lamm 1976; Sustain 2002), a phenomenon where a group tends to make decisions that

are more extreme than the initial preference of its members, has been extensively studied by social psychologists. This phenomenon occurs because the tendency to conform is so strong in our society that group members adjust their judgments to the dominant one even if it requires them to abandon the direct evidence of their own senses (Sustain 2002). Third is pluralistic ignorance, a phenomenon where all members in a group tend to reject a norm privately, but finally accept it because everyone incorrectly assumes that the other members are agreeable to it (Katz and Allport 1931). A classic example of this phenomenon can be seen in "The Emperor's New Clothes," a well-known fairy tale written by Hans Christian Andersen. Pluralistic ignorance has been demonstrated by organizational studies in various social contexts (Halbesleben and Buckley 2004; Miyajima and Yamaguchi 2017). Even though members individually disapprove of the status quo or have a better plan, the group finally makes a decision without anybody's real support. Fourth, various cognitive biases in individual decision-making have been extensively studied (Kahneman 2011; Montibeller and von Winterfeldt 2015). Those cognitive biases influence group decision-making tendencies, including concurrence-seeking and group polarization. Watkins and Bazerman (2003) argued that cognitive biases are one of the main causes of organizational failure to prevent predictable crises like the accident at the Fukushima nuclear power plant. In the next section, we consider the argument of Watkins and Bazerman (2003) and review how cognitive biases cause group decision-making to fail.

3.2 Predictable Surprise

Watkins and Bazerman (2003) coined the term "predictable surprise" to describe the failure to prevent predictable crises. To distinguish unavoidable surprise from predictable surprise, they developed the so-called "RPM process" composed of recognition, prioritization, and mobilization. If the leader fails to recognize the threat, prioritize appropriate options to mitigate the threat, or mobilize effective responses to the threat, the resultant failure is a predictable surprise. They analyzed various cases where leaders and organizations failed to take effective measures against foreseeable crises, and identified psychological, organizational, and political vulnerabilities that were behind such failures (Watkins and Bazerman 2003; Bazerman and Watkins 2004). Among them, psychological vulnerabilities are associated with various cognitive biases of System 1 (Kahneman 2011).

While more than 180 cognitive biases have been proposed (Manoogian 2016; Ellis 2018), there is no widely accepted classification of those biases. Here we adopt the Haselton et al.'s (2015) three-way classification of heuristics, error management biases, and artifacts because it is based on an evolutionary understanding of the human cognitive systems. According to Haselton et al. (2015), heuristics and error management biases are consequences of adaptive evolution, whereas artifacts arise when we encounter situations that are not adapted in the process of evolution. Among those three categories, heuristics and error management biases are relevant

Table 1.2 Psychological vulnerabilities listed by Watkins and Bazerman (2003) and evolutionary classification of cognitive biases

Classification based on EMT	Terms in predictable surprise (Watkins and Bazerman 2003)	Synonyms and relevant theory
Heuristics	Vividness –Greater exposure to media coverage distorts people's judgment	Availability heuristic
	Scanning failure (selective attention) – Selective attention occurs when decision makers dismiss or ignore information that is inconsistent with their expectations	Confirmation bias
Error management: threat-relevant bias	Positive illusion (Unrealistic optimism about the future) and Excessive disregard for the future – People's tendency to prefer present benefit over future benefit – Would you prefer to receive $10,000 today or $12,000 a year from now? – Most homeowners fail to buy more expensive, energy-efficient appliances even though they would recoup the extra costs in less than a year	Normalcy bias, time inconsistency, present bias, prospect theory
	Maintain the status quo – People's tendency to hesitate over trade-offs that require the infliction of a smaller harm to avoid a situation that would cause greater harm	Status quo bias, omission bias, prospect theory
Error management: biases in interpersonal perception	Interpret events in an egocentric manner (egocentrism) – Our views on environmental and societal issues, such as acid rain and global warming, are biased in a self-serving manner – Difficulty in the fair distribution of responsibilities and costs for global environmental issues	Self-serving bias, Ingroup favoritism
Error management: biases in self-judgment	Positive illusion (unrealistically positive self-evaluations) – People's tendency to overestimate their achievements and underestimate their negligence	Self-enhancement, better-than-average effect, reduction of cognitive dissonance
	Positive illusion (illusion of control) – Experienced dice players believe that "soft" throws are more likely to result in lower numbers	Self-deception

to psychological vulnerabilities discussed by Watkins and Bazerman (2003) (Table 1.2).

3.2.1 Heuristics

Heuristics, often called mental shortcuts, are a limited number of rules by which people can reduce the complex tasks of assessing likelihoods and predicting values into simpler judgmental operations (Tversky and Kahneman 1974). Because these rules work well in many situations, cognitive systems rely on heuristics to solve adaptive problems to reduce the cost of decision-making (Gigerenzer 2007; Gigerenzer and Gaissmaier 2011; Haselton et al. 2015). However, these rules often lead to systematic errors of decisions. Tversky and Kahneman (1974) argued that three heuristics underlie a wide range of false intuitive decisions: representativeness, availability, and anchoring.

In the representativeness heuristics, people estimate the likelihood of a person pursuing a particular occupation based on the degree to which he or she is representative of, or similar to, the stereotype of an occupational role. Using the representativeness heuristics, we tend to assume that a doctor in charge of emergency surgery is a man, not a woman. In the availability heuristics (Tversky and Kahneman 1973), people assess the probability of an event by the ease with which instances could be brought to mind. Using availability heuristics, people find it easier to recall bad pieces of news, and consequently tend to believe that the world is getting worse. Also, the availability heuristic makes people underestimate unfamiliar events. Anchoring is a phenomenon where different starting points lead to different estimates, which are biased toward the initial values that people assume at the starting point.

These heuristics are associated with confirmation bias (Wason 1960), or the tendency of people to seek information that matches their expectations and to fail to detect new crises, even when information that contradicts expectations is available. Confirmation bias emanates from a cognitive shortcut or heuristic that simplifies complex inferential tasks (MacCoun 1998). Watkins and Bazerman (2003) described this situation as "scanning failures," which they argued occur when organizations focus on familiar information and fail to collect available information. In the case of the 9/11 attacks in the United States, there was a widespread belief among the domestic intelligence community that Osama bin Laden was unlikely to strike within the country and likely to attack an overseas facility of the United States, even though available information indicated the threat of attack on an internal facility (Watkins and Bazerman 2003).

3.2.2 Error Management Biases

According to the error management theory (EMT) (Haselton and Buss 2000; Haselton and Nettle 2006), which applies the principles of signal detection theory

for the evolution of cognitive biases, error management biases can arise as a consequence of evolutionary adaptation in cases where biased responses resulted in lower error costs than unbiased responses. According to EMT, the cognitive mechanism can produce two types of errors: (1) false positives (an error caused by taking an action that would have been better not to take), and (2) false negatives (an error caused by not taking an action that would have been better to take). EMT predicts that an optimal decision would minimize not the total costs of false-positive errors and false-negative errors, but the net effect of errors on fitness. If one error consistently reduces fitness more than another error, a bias will evolve toward avoiding the former error. Haselton and Nettle (2006) explained this asymmetry by means of an example of an animal detecting a snake. For that animal, the cost of expected death by approaching a potentially venomous snake is much larger than the cost of moving away from the snake. Thus, it is advantageous to acquire a predator avoidance strategy for snakes. In fact, it is well known that many animals, including humans, are predisposed to produce a fear response to snakes and spiders (Shibasaki and Kawai 2009; Hoehl et al. 2017).

Taylor and Brown (1988, 1994) reviewed psychological research associated with mental health, and determined that people hold positive illusions in three domains: (1) people view themselves in unrealistically positive terms, (2) people believe they have greater control over environmental events than they actually have, and (3) people hold views of the future that are brighter than base-rate data can justify. Positive illusions include previous psychological findings such as better-than-average effect (Festinger 1954), optimism bias (Weinstein 1980), self-deception (Gur and Sackeim 1979), self-enhancement (Shrauger 1975), and illusion of control (Langer 1975). EMT explains that positive illusions are caused by the asymmetrical costs between a false-positive error and a false negative toward a future success. If a future victory provides a splendid reward, trying and failing (false positive) does not matter, whereas failing to try (false negative) could be costly, especially in competitive contexts (Haselton et al. 2015). Positive illusions drive organizational leaders to ignore the risk of crises and make poor decisions as they respond to emerging crises with mildly distorted positive perceptions of themselves, an exaggerated sense of personal control, and overly optimistic expectations about the future (Taylor and Brown 1988; Taylor and Armor 1996).

In addition to positive illusions, EMT also explains status quo bias, or the tendency of "doing nothing or maintaining one's current or previous decision" (Samuelson and Zeckhauser 1988; Ritov and Baron 1992). This is the tendency to avoid trying an action that may fail (false negative) when the cost of trying and failing (false positive) is larger than the expected benefit of trying. Status quo bias makes organizational leaders or organizations stick to a current option or default situation if they believe that changing the current state of affairs would be costly, even when a rational alternative is available. Normalcy bias (Omer and Alon 1994) is another type of error management bias causing false-negative errors. It is the tendency of people to underestimate the likelihood of and damage from a catastrophe even in the face of signs of the disaster. They consequently believe that it would not affect them and that they are safe, while hesitating to evacuate even after the

occurrence of the disaster. It is one of the main causes of the cognitive failure to detect a predictable surprise. For people in an emergency situation, such as rising floodwater levels around their house, failing to traverse a submerged area (false positive) seems much more costly than failing to evacuate by staying at home (false negative).

Failures of group decision-making are caused by not only personal cognitive biases, but also structural faults of organization and errors resulting from group dynamics. Watkins and Bazerman (2003) listed four types of organizational failures to respond to predictable crises. First, "scanning failures" occur when a group fails to scan the environment and collect sufficient information, due to the lack of organizational resources or inadequate attention toward predictable crises. Second, even if a group succeeds in collecting sufficient information, "integration failures" occur when it fails to assimilate fragmentary information possessed by individuals or subgroups and to analyze that information to produce actionable insights. Third, "incentive failures" occur when people fail to act on available insights for predictable crises because they lack the incentive to do so. Fourth, "learning failures" occur when a group fails to glean lessons from past failures and disseminate those lessons to a relevant part of the group.

In the process of co-design and co-production in transdisciplinary research with various stakeholders, we should make efforts for avoiding these failures. Many of these failures are associated with the vulnerabilities of group decision-making, such as groupthink, hidden profile paradigm, group polarization, and pluralistic ignorance, as we reviewed above. However, decision support schemes, such as IDEA cycle and SDM, do not focus on the impact of cognitive biases and group dynamics on the outcome of decisions. In the next section, we consider the guidelines to deal with these vulnerabilities.

3.3 Guidelines for Co-design Among Stakeholders

Reducing or eliminating cognitive biases from decision-making, called debiasing, is a process that is crucial for ensuring successful group decision-making in co-design involving multiple stakeholders. In his influential textbook, Fischhoff (1982) pointed out that the debiasing process requires a psychological approach to change human behavior. Following a more recent review (Larrick 2004), Bazerman and Moore (2008) recognized psychological barriers to change human behavior and suggested a general debiasing strategy by applying the Lewin's change model (Lewin 1947) to debiasing processes. The Lewin's change model is a three-step model of human behavioral changes consisting of unfreezing, changing, and refreezing processes. First, unfreezing is the process of motivating individuals to change their decision-making strategies. This process unfreezes the notion that their decision-making processes do not require improvement by making individuals aware of vulnerabilities to biases using such means as the quiz-and-feedback format. Second, changing is the process of learning improved decision-making strategies

and replacing old strategies with new ones. This process includes explaining concrete examples of general biases related to decision-making, and training people to consider the opposite or alternative hypothesis to their tentative conclusions. Third, refreezing is the process of making new decision strategies permanent. In order to secure the change, frequent applications of new strategies and overviews of past training are necessary. Further details of debiasing techniques are summarized in "A User's Guide to Debiasing" (Soll et al. 2015).

The debiasing technique summarized above is called the "modify the decision maker" approach (Soll et al. 2015). Another approach called "modify the environment" (Soll et al. 2015) seeks to provide the environment in which people naturally make a better decision when unaided (Klayman and Brown 1993). "Nudge" (Thaler and Sunstein 2003) is a way to influence human behavioral changes by pushing individuals toward better choices without limiting their liberty. An example of "nudge" is the presumption of consent, rather than unwillingness, to increase the number of organ transplant donors. Under such a policy, citizens are presumed to be consenting to become donors if they suffer brain death, even though they have the opportunity to register their unwillingness to donate by checking the box on their driving license. This is the strategic use of status quo bias. However, there is criticism that such a policy is a kind of paternalism. Gigerenzer (2014) argued that it is more important to improve citizens' judgment ability and risk literacy rather than assuming that citizens' decision-making needs to be guided by the government.

The studies summarized above focused on biases in decision-making by individuals. Few studies have focused on biases or errors in group decision-making, such as groupthink, hidden profile paradigm, group polarization, and pluralistic ignorance (Schulz-Hardt et al. 2006; Schwenk 1990). Co-design is the collective process to elicit an agreement among various independent stakeholders and to make a decision using their collective wisdom. To manage this co-design process, we must highlight the importance of not only debiasing for individuals, but also reducing biases or errors in group decision-making.

There are two classical techniques of debiasing in group decision-making: devil's advocacy (Herbert and Estes 1977) and dialectical inquiry (Mason 1969). Devil's advocacy is the technique for stimulating conflicts. In devil's advocacy, a group member or a subgroup is assigned the role of the devil's advocate whose task is to criticize the options on the table. When a consensus is reached on a particular option as a solution to the decision problem, the devil's advocate creates counterarguments to this solution and tries to identify its weaknesses. The group should then investigate these criticisms. Following the review, the particular option is either accepted or rejected.

Dialectical inquiry is the technique of investigating competing ideas or perspectives and involves the following steps. First, teams of decision makers are established. Second, each team is instructed to generate and evaluate alternative options and then recommend the best one. Third, after hearing each team's recommendation, the teams' and the organization's top leaders discuss and select the best parts of each option and synthesize a final plan.

These techniques and conditions are effective in considering counterarguments and evaluating options fairly based on reason or the controlled process of decision-making (Haidt 2006). On the other hand, Haidt (2006) argued that we need to pay more attention to emotion or the automatic process of decision-making. His argument is based on the dual-process model of decision-making. He differentiated between the automatic and the controlled processes corresponding to System 1 and System 2 of Kahneman (2011), respectively. He explained why we are vulnerable to biases using the metaphor of a rider on the back of an elephant. In Haidt's metaphor, the elephant (emotional side) influences most of the rider's (rational side) decisions. The elephant rider seems to be in charge, but actually has limited control over what the elephant does. Thus, for effective decision-making, we need to strike a balance between the emotional and rational sides. Whereas both devil's advocacy and dialectical inquiry are debiasing techniques that rely on reason (using controlled processes or System 2), we need to develop communications that appeal to emotion (using automatic processes or System 1) by building trust and resolving conflicts among stakeholders.

Conflicts among stakeholders are associated with both relationships and tasks. While relationship conflicts among group members often decrease group performance, task conflicts increase group performance only when those are weakly associated with relationship conflicts (de Wit et al. 2012). Trust building is important in mitigating the negative influence of relationship conflicts on group performance (Simons and Peterson 2000). In past studies on building trust and resolving conflicts, the role of good leaders (Hahn et al. 2006), face-to-face discussions (Wilson et al. 2006; McKnight et al. 2002), collaborative efforts (Sherif et al. 1954), and agreeable common goals (reframing) has been highlighted. Controversy in group decision-making is associated with high group performance and high-quality decisions under mutual trust and cooperative relationships among group members as we reviewed above. Devil's advocacy or dialectical inquiry provides a direct way to structure controversy cooperatively by organizing critical subgroups. However, these are not commonly applicable for the co-design process in decision-making, where there is often no hierarchical relationship between stakeholders and it is uncomfortable for many stakeholders to organize critical discussion among them without emotional entanglement. To keep the co-design process in group decision-making constructive and cooperative, we make the following recommendations that can serve as a guideline to ensure diversity of opinions among group members based on the "modifying the environment" approach:

1. Group decision makings often fail if group members sharing a common attitude are isolated from outside information and criticism. To avoid this failure, do not exclude stakeholders with different views from the process of co-design. Also, actively listen to the opinions of diverse groups of people.
2. Group decision makings often fail due to group dynamics including the tendency to conform. To avoid this failure, open the information required for decision-making and the process of discussion to the public.

3. Group decision makings often fail if critiques and competing ideas are neglected. To avoid this failure, perform an external review of the co-designed research plan.
4. Trust building is important in mitigating the negative influence of critical discussion on group performance. Build trust among stakeholders with different views by setting agreeable common goals and promoting face-to-face discussions and collaborative efforts.

4 Learning from Successes in Local Communities

4.1 Seeds of a Good Anthropocene and Efforts for Adaptive Comanagement

Whereas Earth system changes can have catastrophic and irreversible impacts on human societies (Lenton et al. 2008; Schellnhuber 2009; Rockström et al. 2009; Future Earth 2013), efforts to prevent deleterious changes in local environments have developed steadily and have been successful, at least on a local scale. Bennett et al. (2016) called these initial successes "seeds of a good Anthropocene" and developed a database of 100 initiatives representing a diversity of practices, worldviews, values, and regions. The seeds were categorized into six classes: agroecology, green urbanism, future knowledge, urban transformation, fair futures, and sustainable futures. The database can help researchers understand the processes that lead to the emergence and growth of initiatives that fundamentally change human–environmental relationships.

Bennett et al. (2016) clustered their six classes of seeds into two major categories: seeds of local socioecological systems (agroecology, green urbanism, and urban transformation) and seeds of knowledge and institutions (future knowledge, fair futures, and sustainable futures). As an example of the former (agroecology), Bennett et al. (2016) introduced Satoyama, a traditional Japanese agricultural landscape system, in which different land uses including farm fields, rice paddies, irrigation canals and ponds, and settlements form a cohesive system, providing a diversity of ecosystem services (Takeuchi 2010; Dublin and Tanaka 2014). As an example of the latter (future knowledge), they introduced GreenMatter, an initiative aimed at driving transformation in graduate-level skills associated with biodiversity conservation in South Africa. While the "seeds of a good Anthropocene" can be classified into these categories, some efforts, including the Satoyama Initiative (International Partnership for the Satoyama Initiative [IPSI] 2010), are directed toward both sustainability of socioecological systems and knowledge generation for sustainable futures.

In parallel with the "seeds of a good Anthropocene" project, the International Social Science Council (ISSC) promoted its Transformations to Sustainability (T2S) program for innovative, social science-led research on sustainable futures. In 2014, T2S, funded by the Swedish International Development Cooperation Agency (Sida)

and implemented in partnership with the National Research Foundation of South Africa, selected 38 projects for funding. The early achievements of these projects are introduced in a special issue of *Current Opinion in Environmental Sustainability* (Moser 2016a). Papers in this issue describe 16 case studies in which researchers spent 6 months developing trust and co-designing projects with various stakeholders (Moser 2016b). In one example, the DIALAQ (DIALogic exploration of futures and pathways for sustainable farming on overexploited AQuifers) project involved farmers, public administrators, municipalities, nongovernmental organizations (NGOs), elected representatives, and various academic partners, building on trust that had already been established (Richard-Ferroudji et al. 2016). In the "research-for-action" project, focused on rangeland sustainability, participants from diverse regions including Mongolia, Kenya, and the United States built trust and fostered a learning community by allowing for cross-cultural, cross-sector, and cross-discipline differences (Galvin et al. 2016). Some of these projects faced the challenge of working across differences in background, training, experiences, needs, ideologies, and interests (Moser 2016b).

While Future Earth is promoting transdisciplinary projects co-designed by scientists and stakeholders, as in the T2S program, global efforts to close the gap between science and society in knowledge generation processes have been ongoing since at least the 1970s. First, the UNESCO Man and the Biosphere Programme (MAB), launched in 1976, used collaboration among various stakeholders (including local communities and scientists) to maintain ecological and cultural diversity and secure ecosystem services for human well-being by harmonizing conservation efforts with the local development needs. Second, since the 1990s, many efforts have been made to develop adaptive comanagement of various natural resources including forests, fisheries, bodies of water, wildlife, wetlands, protected areas, coasts and coral reefs, and agriculture (Berkes 2009; Plummer et al. 2012). Third, in the International Partnership for the Satoyama Initiative (IPSI) founded in 2010, collaboration between local communities and scientists has been pursued to develop sustainable comanagement of socioecological production systems.

The MAB is a UNESCO Intergovernmental Scientific Programme that aims to establish a scientific basis for the improvement of relationships between people and their environments (UNESCO 1996; Reed and Price 2019). Each biosphere reserve designated under the MAB Programme is composed of three elements: core areas, a buffer zone, and a flexible transition area. The buffer zone surrounding core areas is an area used for activities that contribute to conservation objectives, such as ecotourism, education, and research. The flexible transition area is an area containing farmlands and villages, and the resources in that area can be sustainably used by various stakeholders.

From 1976, when the MAB Programme started, to 1995, 324 biosphere reserves were designated in 82 countries (UNESCO 1996). By May 2020 this network had grown to include 701 sites in 124 countries (UNESCO 2020). At the International Conference on Biosphere Reserves held in 1995, the program's early achievements were reviewed, and a new strategy and statutory framework for biosphere reserves were developed (UNESCO 1996). The statutory framework identified three

functions of biosphere reserves: biodiversity conservation, sustainable economic and human development, and logistic support for education, research, and monitoring. The new strategy emphasized efforts to involve various stakeholders in decision-making processes and stated that "Bring together all interest groups and sectors in a partnership approach to biosphere reserves both at site and network levels," in one of ten key directions (UNESCO 1996). Subsequently, adaptive comanagement of natural resources, involving diverse stakeholders in decision-making processes, has been developed in multiple biosphere reserves, and its effectiveness has been supported by performance analyses (Schultz et al. 2011; Plummer et al. 2017).

Adaptive comanagement (ACM) is an extension of adaptive management (Holling 1978; Walters 1986) that incorporates participatory approaches (Berkes 2009). Plummer et al. (2012) suggest that attempts at adaptive comanagement began with a pioneering project at the Center for International Forestry Research (CIFOR) in 1997, but the biosphere reserve strategy (UNESCO 1996) is another root. Plummer et al. (2012) reviewed the history and achievements of adaptive comanagement since the 2000s, drawing on 108 sources. While this systematic review revealed considerable variability in defining what constitutes success or failure in ACM, it identified social networks, learning, and stakeholder participation as three important factors contributing to success, and conflicts of interest, power asymmetries, and insufficient resources as three major factors contributing to failure. However, the authors argue that it is difficult to determine how these variables contribute to particular goals and outcomes, because many studies do not adequately define the goals of ACM. After this review, Plummer et al. (2017) examined processes and outcomes in four UNESCO biosphere reserves where the goals of ACM were clearly specified. They showed that ACM efforts in all four reserves had many positive results, including ecological and livelihood effects. Similarly, Cosens et al. (2018) reviewed ACM, or adaptive governance, in water management projects for six watersheds in the United States, in which goals for sustainability and water resource resilience were clearly defined. Again, they found many positive results and identified the role of laws in triggering and facilitating adaptive governance. In addition, Leach and Pelkey (2001) reviewed 37 studies on watershed partnerships and identified 28 lessons for successful management by synthesizing 210 conclusions collected from these studies. Among these lessons, the two most frequently identified keys to success were funding and effective leadership. Wondolleck and Yaffee (2000) published a book entitled "Making collaboration work," reviewed many practices of American natural resource management, and derived 8 lessens for success, including common ground building, interaction among diverse groups, collaborative process, open and holistic mind-set, a sense of responsibility and ownership, partnerships of people, proactive and entrepreneurial behavior, and resources from numerous sources.

ACM has been developed in the activities of IPSI that was organized during the 2010 Convention on Biological Diversity (CBD) COP10. IPSI serves as a global effort for biodiversity conservation through the revitalization and sustainable management of socioecological production landscapes and seascapes, or SEPLS (International Partnership for the Satoyama Initiative [IPSI] 2010). IPSI promotes

activities that maintain the typical mosaic pattern of land and water uses and natural habitats in SEPLS, which ensures the maintenance of biodiversity and the sustainable provision of ecosystem services for human welfare. IPSI also provides a platform for sharing traditional and modern knowledge that can contribute to the sustainable management of SEPLS (International Partnership for the Satoyama Initiative [IPSI] 2010; Duraiappah et al. 2012). IPSI has grown to comprise 240 member organizations spanning many sectors, with activities in most countries listed as parties to CBD. IPSI published four volumes of thematic assessment reports (UNU–IAS and IGES 2015, 2016, 2017, 2018), collecting more "seeds of a good Anthropocene" and reviewing successful case studies from various countries.

IPSI adopted the following three approaches to maintaining and rebuilding socioecological production systems in which land and natural resources are used and managed in a more sustainable manner: (1) consolidating wisdom on securing diverse ecosystem services and values, (2) integrating traditional ecological knowledge and modern science to promote innovation, and (3) exploring new forms of comanagement systems or evolving frameworks of "commons" while respecting traditional communal land tenure. The IPSI webpage introduces 280 case studies from Africa, the Americas, Asia, Oceania, and Europe, of which 38 are reviewed in detail in the thematic assessment reports (UNU–IAS and IGES 2015, 2016, 2017, 2018). In the second report, Subramanian et al. (2016) identified the following general principles for successful management of SEPLS: (1) mobilize knowledge toward action, (2) foster and leverage inclusive participation, and (3) use adaptive planning and management for activities. These three principles are similar to the key directions identified by the MAB Programme, and the second and the third principles are based on the concept of adaptive comanagement (Folke et al. 2002; Carlsson and Berkes 2005; Plummer et al. 2012).

4.2 Lessons Learned from Efforts for Adaptive Comanagement

As summarized above, both global and local efforts for sustainable natural resource management resulted in a convergent view emphasizing adaptive comanagement (Folke et al. 2002; Carlsson and Berkes 2005; Berkes 2009; Plummer et al. 2012), which combines the learning function of adaptive management (Holling 1978; Walters 1986) with the linkage function of collaborative management (Carlsson and Berkes 2005; Folke et al. 2005). Efforts have been made to review the achievements of various adaptive comanagement projects and identify lessons learned (Folke et al. 2005; Plummer et al. 2012; Chaffin et al. 2014; Cosens et al. 2018). These reviews have identified at least three factors contributing to the success of ACM. First, adaptive learning, or iterative knowledge generation, is critically important to manage socioecological systems, in which social and ecological systems are strongly coupled and their changes are often nonlinear and complex (Folke

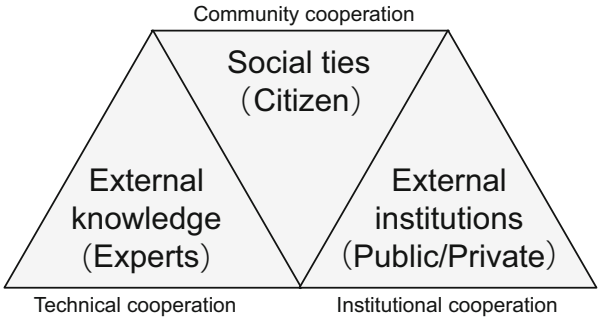


Fig. 1.3 Cooperation triangle: a scheme of community governance supported by external knowledge and external institutions

et al. 2005). Second, institutions, including markets and laws (North 2005; Cosens et al. 2018) and self-organization of communities (Ostrom et al. 1999; Ostrom 2000, 2009) can support cooperation in large communities by reducing instability under collective action problems (Olson 1965; Sanders 1992) or social dilemmas (Axelrod 1984; van Lange et al. 2013). Third, visionary leaders play a key role in building trust, making sense, managing conflict, linking actors, initiating partnerships among actor groups, compiling and generating knowledge, and mobilizing broad support for change (Folke et al. 2005).

Based on these reviews as well as our own experience (described later), we propose "cooperation triangle" as a general scheme of organizational cooperation in adaptive comanagement practices (Fig. 1.3), in which cooperative governance in a local community is supported by external knowledge and external institutions. Using this scheme, we emphasize the importance of promoting the evolution of external knowledge and institutions and internal social ties in local communities that connect local governments, social capital, and social memory. In this scheme, we distinguish between knowledge and institutions from outside a community and those available inside the community, because most co-design processes start from interactions between community insiders and outsiders that provide access to new knowledge and institutions (Folke et al. 2005; Moser 2016b). While a community has its own local knowledge and institutions, external knowledge and institutions also play critical roles in local processes of adaptive governance and problem-solving. As noted above, the two most frequently identified keys to success for watershed governance are funding and effective leadership (Leach and Pelkey 2001); these are associated with external institutions and knowledge.

In the scheme of cooperation triangle (Fig. 1.3), we distinguish between knowledge and institutions because each has different historical trajectories of change, defined by different processes of cultural evolution (Richardson and Boyd 2006; Ridley 2016; Henrich 2017). Much as language evolves through the gain and loss of homologous words through time (Bouckaert et al. 2012), knowledge evolves through the gain and loss of alternative ideas (Parson and Clark 1995). In particular, scientific knowledge evolves through the gain and loss of alternative hypotheses examined through empirical tests. Adaptive learning is another way of describing this process of knowledge evolution. On the other hand, the evolution of institutions

involves not only learning but also designing. For example, new or revised laws are designed by governments to meet the needs of society.

Scientists are now one among many actors involved in knowledge generation, rather than serving as objective and independent specialists expected to deliver knowledge to managers and citizens (Folke et al. 2005). Recently, there have been at least three notable changes in knowledge generation processes. First, the rise of citizen science has enabled nonexpert citizens to engage with science, particularly on environmental issues, in collaboration with scientists working in local contexts (Bonney et al. 2014; Wals et al. 2014). Consequently, the gap between scientists as active knowledge producers and society as passive recipients (Mauser et al. 2013) has been bridged. Second, there has been increasing appreciation for insights from traditional knowledge, which often supported sustainable natural resource use for hundreds or thousands of years (Ludwig et al. 2001), as well as for local knowledge embedded in ordinary community life (Folke et al. 2005; Henrich 2017). The Intergovernmental Platform of Biodiversity and Ecosystem Services (IPBES) conceptual framework (Diaz et al. 2015) explicitly included efforts for integrating indigenous, local, and practitioners' knowledge with modern science. Third, in adaptive comanagement processes in local communities, science cannot be separated from social, ethical, and economic issues, including values and equity, and nobody can be an expert in all aspects of these complicated issues (Ludwig et al. 2001). Thus, mutual learning among diverse experts and stakeholders is needed to share and integrate knowledge from various disciplines and finding agreeable and effective options.

Under these changes, not only scientists but also other stakeholders are now active in compiling and generating the knowledge required for problem-solving and adaptive governance in local communities. As a result, it is increasingly challenging to mobilize knowledge from various disciplines and sources, develop common understanding among stakeholders, and finding agreeable visions and options for solving problems. To respond to these challenges, solution-oriented transdisciplinary science has been developed by integrating natural and social sciences and other knowledge useful for stakeholders involved in problem-solving practices. As is described in the next section, technical collaboration among diverse experts trained for transdisciplinary science is extremely helpful for ecosystem comanagement, post-disaster recovery processes, and other solution-oriented social projects.

External institutions including government agencies, the private sector, and NGOs can provide funds and human resources to help solve problems through adaptive governance in local communities. Funding is key to the success of adaptive comanagement (Leach and Pelkey 2001), and laws can provide both barriers and bridges to adaptive governance (Cosens et al. 2018). A good example of the role of law in adaptive governance is found in Japan, where environmental administration has changed dramatically since the 1990s as a series of new laws have been enacted. These include the Basic Environment Law (1993), the Act on Conservation of Endangered Species of Wild Animals and Plants (1993), Environmental Impact Assessment Act (1997), the Revised River Law (1997), the Act on Promotion of Global Warming Countermeasures (1998), the Act on Promotion of Nature

Restoration (2002), and the Basic Act on Biodiversity (2008). Through implementation of these environmental laws, increasing budgets have been allocated to adaptive governance of biodiversity conservation, nature restoration, and ecosystem management, and collaborations between citizens and administration have been developed. For example, the Revised River Law promoted adaptive comanagement of rivers by considering not only water control and water use but also biodiversity conservation and environmental sustainability (Shimatani 2005; Nakamura et al. 2006). These new environmental laws have been successful in developing adaptive comanagement systems for wetlands, grasslands, forests, and socioecological production landscapes and seascapes in local Japanese communities.

While external knowledge and institutions are provided to local communities by outsiders, these communities have their own knowledge systems and institutions. The problem-solving ability of a local community is determined by how well these knowledge and institutions are utilized, and it is the social ties that determine the level of this utilization. Social ties are strengthened by historical accumulation of social capital and social memory. According to Folke et al. (2005), social capital is the capital built by investing in social relationships, including trust, leadership, and networks of horizontal or vertical collaboration. Similarly, Pretty and Ward (2001) define social capital as relations of trust, reciprocity, common rules, norms, sanctions, and connectedness in institutions. Folke et al. (2005) emphasize that governance systems for ecosystem management require a civil society with a certain level of social capital. In addition to social capital, they argue that social memory is also key to adaptability in local societies because local governance systems must continuously learn and generate knowledge about ecosystem dynamics.

Compared to our deeper understanding of the evolution of knowledge (e.g., Berkes 2009) and institutions (e.g., North 2005), our understanding of the evolution of social ties still remains rather vague. To describe the complex structure of social ties more quantitatively, analytical approaches, and quantifiable models such as the network analysis may be helpful. While Lubell et al. (2014, 2017) applied non-modular network analyses to describe the coordinating roles of actors and institutions in comanagement, it would be beneficial to add a modular structure to the network analysis, considering the tendency of ingroup favoritism. Using this structure commonly used in the analysis of biological communities (e.g., Olesen et al. 2007), actors can be classified into network hubs, module hubs, connectors, and peripherals based on connectivity within and between modules. Community members who belong to one of the modules and interact more closely within the module tend to show goodwill and loyalty to ingroup members but often have doubts and hostility about external members (Greene 2013). To develop cooperation not only within an ingroup ("us"; Greene 2013) but also with an outgroup ("them"), a leader who can work as a connector plays a critical role. A connector is a person who can connect an ingroup with outgroups and play an important role in coordinating conflicts between an ingroup and an outgroup. The development of social ties can be seen as the evolution of connectivity in social networks supported by activities of connectors. To promote collaboration through the community, it is considered effective to increase numbers of connectors by providing opportunities for members

to interact with members of different modules in an organization or community. To enhance this interaction, leaders in a community can play major roles.

The role of the leaders has been emphasized in literature on adaptive governance (Folke et al. 2005). According to Gladwell (2000), the leaders are often mavens (altruistic individuals with social skills) or connectors (individuals who know many people with a diversity of acquaintances). Bodin (2017) argued that appointing a specifically designated coordinator with some authoritative capacities can be effective for mediating risky relationships. However, there is insufficient common understanding regarding what a leader is and properties that define a leader. Recently, evolutionary biology was taken into account (Bastardoz and van Vugt 2019), and the relationship between the Big Five personalities and leadership was discussed (Judge et al. 2009). The big five personalities including openness, conscientiousness, agreeableness, extroversion, and neuroticism are associated with the following qualities needed in leaders: vision, self-management, devotion, passion, and risk management. Humans are diverse in their personalities, both genetically and empirically (Vukasovic and Bratko 2015). For this reason, human resources with outstanding capabilities in perception, self-management, devotion, passion, and risk management are rare. From an evolutionary viewpoint, it is considered advantageous to follow the leader's decision as a follower, when decision-making as a leader is more costly than following a leader (King and Cowlishaw 2009; Bastardoz and van Vugt 2019). In many cases, a leader pays a larger cost (time, effort, and other resources) in organizing and sustaining a cooperative team by managing noncooperative activities in a collective action. Consequently, leaders who are willing to devote to building and maintaining a team required for social transformation are always a limited resource. Then, how can we find good leaders who are needed to transform our society toward a sustainable future? In the following section, we distinguish two types of leaders, game changers and mediators, and argue that scientists can play a significant role as game changers.

4.3 Lessons from Transdisciplinary Projects at the Institute of Decision Science for a Sustainable Society (IDS3)

In this section, based on our experience in transdisciplinary studies at the Institute of Decision Science for a Sustainable Society (IDS3), we consider the roles of scientists in adaptive governance as the leaders on social problem-solving processes and social transformation for sustainability. While scientists are major participants in the knowledge generation processes, it has been found that they also play leading roles in adaptive governance in communities. Here, we consider the roles of scientists in adaptive governance as "game changers" and "mediators" (Fig. 1.4).

As emphasized by Folke et al. (2005), collaboration in governance networks by a community in need of change requires entrepreneurial leaders. Entrepreneurial leaders can provide innovative visions and options for decision-making toward

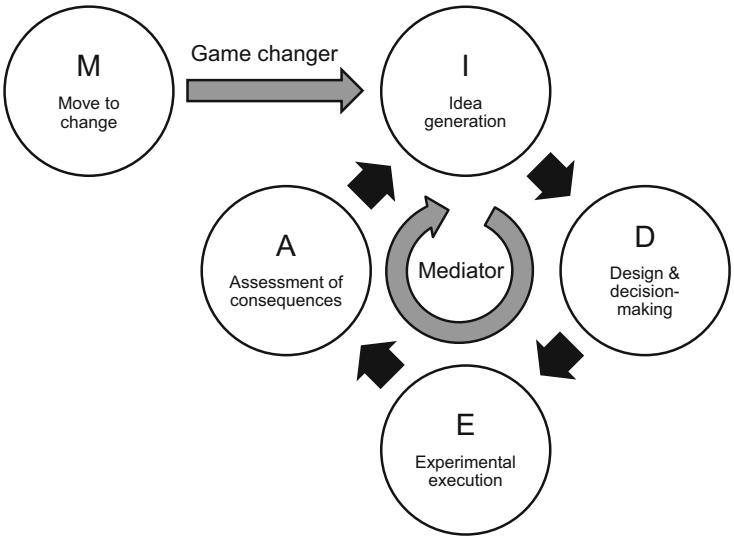


Fig. 1.4 A modified scheme of the IDEA cycle incorporating the roles of game changers and mediators

change and reorganization, and coordinate collaboration between stakeholders by initiating partnerships among actors, building trust, managing conflict, and mobilizing available resources for change. We define an entrepreneurial leader who initiates and catalyzes collaboration for change as a "game changer." A community in need of change is often trapped by social dilemma (Axelrod 1984; van Lange et al. 2013) that can be modeled as a public goods game (Isaac and Walker 1988; Bowles and Gintis 2011); action for change is costly to each actor, even if change is beneficial for all community members. Additionally, expected outcomes of change are often uncertain and complicated. Under these circumstances, it is not easy to initiate collaboration for change. A game changer is an altruistic person who is willing to do the heavy lifting to resolve dilemma and start a rotation of the IDEA cycle that involves idea generation, design and decision-making, experimental executions, and assessments of consequences (Fig. 1.4). While people other than scientists can play the role of a game changer, scientists who are employed by public institutions, rather independent of various economic interests, and have scientific knowledge required for both short-term and long-term decisions are more likely to act as game changers.

After activation of change, social adaptation to new environments and transformation to a desirable state often requires long-term effort and collaboration between stakeholders. In this process, stakeholders are required to make continuous efforts for rotating the IDEA cycle (Fig. 1.4). Bodin (2017) suggests that specific actors are required to act as "risk mediators" to maintain collaborative endeavors under tight bonding structures. In our experience, scientists can serve as mediators not only in managing risks of unstable cooperation but also evolve knowledge, institutions, and social ties under intimate interactions. Below, we introduce five successful cases

where scientists played critical roles as game changers and then as mediators of the evolution of knowledge, institutions, and social ties. In these examples, scientists developed various mediation mechanisms including a science committee, academic societies for area studies, and social businesses. The first three case studies are from Japan, followed by Cambodia and India. In the three Japanese cases, local communities faced difficulties associated with deer overdominance, an aging society, and devastation by floods. In Cambodia, people coped with the loss of forests by developing community forestry. In India, people have developed social businesses for medical support in villages. While some of these projects have long histories of collaboration between stakeholders, others have developed more recently. By comparing these heterogeneous cases, we demonstrate how scientists can perform as game changers and mediators.

4.3.1 Ecosystem Comanagement in Yakushima, Japan

The island of Yakushima, Kagoshima Prefecture, spans an area of 504.9 km^2 and is located 60 km south of Kyushu Island. Yakushima harbors pristine forest vegetation from its sea level to its highest peak (1936 m), including lowland broad-leaved forests and highland coniferous forests, where over 40 endemic plant species have been discovered (Yahara et al. 1987). Most forested areas are protected and managed as national parks by the Ministry of Environment or national forests by the Forestry Agency. Additionally, the continuous landscape from Yakushima's seashore to its highest peak is registered as a UNESCO World Natural Heritage Site as well as a UNESCO Biosphere Reserve.

As reviewed by Yahara (2006), population declines of threatened plant species due to deer browsing was first reported by scientists in the Red Data Book published by Environment Agency in 1997. Scientists organized an assessment project between 2004 and 2006 to measure the increase in deer population and declines in plant species. While conducting assessments, project teams developed collaborations with the island's citizens as well as administrations of the Ministry of Environments, the Forestry Agency, Kagoshima Prefecture, and Yakushima Town. The assessment project provided convincing evidence of deer population increases and declines in threatened plant species to citizens and administrations (Yahara 2006). In 2009, the Ministry of Environment and the Forestry Agency established the World Natural Heritage Regional Science Committee by inviting both citizen scientists living on the island and external professional scientists to participate in the management of the World Heritage Site area (Okano and Matsuda 2013). The administrations of Kagoshima Prefecture and Yakushima Town joined the administration team and this alliance enabled the four largely isolated governments to discuss the ecosystem of Yakushima at the same table. Since 2009, the science committee has played a key role in planning ecosystem management in Yakushima and worked for monitoring and management of deer, developing common understanding based on data, and building consensus among stakeholders on measures against undesirable ecosystem changes. Activities of the science committee further evolved with the

invitation of social scientists to discuss other issues including the overuse of tourism. The 2009 foundation of the science committee was a successful turning point in the adaptive governance of Yakushima driven by significant contributions of scientists, who in this case, served, as game changers.

Since 2009, scientists contributed significantly to the processes of adaptive governance by not only providing scientific knowledge (e.g., providing a mathematical model for zone-based management of the deer population; Fujimaki et al. 2016), but also by mediating the evolution of knowledge, institutions, and social ties. Notably, the Society for Yakushimaology, an academic society of area research on Yakushima, was founded in 2013 in a collaboration between 200 members including professional scientists and citizen scientists (Matsuda et al. 2015). A group of scientists who have achievements in on-site research in Yakushima, including primatologists, botanists, and hydrologists, made efforts negotiating with the mayor, administrators, and citizens of Yakushima Town. As a result, the Society for Yakushimaology was founded in 2013 as a collaboration with the municipal administration, and until 2019 it organized six annual meetings providing platforms for mutual learning among participants including hunters, ecotourism guides, and citizens, on both natural and social sciences and basic and solution-oriented research on Yakushima.

4.3.2 Citizenship Education in an Aging Society of Tsushima, Japan

Tsushima, an island 132 km north of Kyushu Island, Japan and 50 km south of Busan, Korea, has a population of 32,000. Tsushima's society is facing the threat of a rapidly aging and declining population (Kawaguchi and Araki 2016). The aging of farmers has made it difficult to continue paddy cultivation. Consequently, large areas of rice paddy fields were abandoned and changed to wastelands. The increase in abandoned paddies has not only decreased agricultural productivity but also negatively impacted biodiversity. Many aquatic organisms lived in these paddy fields, which served as alternative habitats for wetlands. The decrease in aquatic animals, especially frogs, may threaten an endemic subspecies of wildcat (*Prionailurus bengalensis euptilurus*) due to food limitation (Kawaguchi and Araki 2016). Other consequences of abandoned paddies are increases in populations of boar and deer, which are damaging to both agricultural produce and natural vegetation.

Adaptive comanagement of social-ecological systems in Tsushima has been developed by the city government since 2011, when it received a subsidy from the Ministry of Internal Affairs to hire external personnel for local community development. This subsidy system was founded in 2009 by the Japanese government to support community development in areas facing rapid aging and population decline. Using this subsidy, the city government hired graduates, including PhD holders, who worked as game changers by promoting a "Field Campus" project. Field Campus was aimed at inviting external researchers and graduate students to carry out on-site research in Tsushima. As Tsushima does not have any universities, high school

students who wish to pursue higher education leave Tsushima and seldom return. "Field Campus" is an effort to overcome the issue of the lack of universities in Tsushima, and scientists of some universities including Kyushu University, Nippon University, Rikkyo University, and Yokohama National University have responded to this project (see Itonaga 2014; Maeda 2014). To support Field Campus, in 2014, the city government established a plan for community development by promoting cooperation between the Tsushima area and universities. Starting in 2015, the city government began hosting an academic meeting called the "Tsushimaology Forum." Our IDS3 team from Kyushu University joined the Field Campus project in 2014 and initiated some transdisciplinary projects in Tsushima (Tokunaga and Akiho 2018).

A project named "Treasures of the Island Project" was developed in cooperation with Tsushima City Administration, Kami Tsushima High School, Tsushima Chamber of Commerce, and Kyushu University, aiming at providing high school students with the opportunity to discover and learn about local attractions. After twenty meetings to discuss and co-design the project, six groups of high school students made field reports on questions including "How can we increase jobs in Tsushima?", "What is the attractiveness of local foods in Tsushima," and "What are needs of Korean tourists?" Scientists and graduate students of Kyushu University supervised and facilitated group projects of high school students, who then presented their findings in meetings open to citizens. After joining this project, high school students' scores for willingness to participate in local community development were found to have significantly increased (Tokunaga and Akiho 2018). As the activity of Kyushu University is supported by a time-bounded grant from JSPS, Kami-Tsushima High School plans to continue this education using their own budget. This is another successful example of the evolution of knowledge, institutions, and social ties mediated by scientists.

4.3.3 Recovery from Flood Damage in Asakura and Toho, Japan

Asakura City, Toho Village and the adjacent region located in northern Kyushu Island suffered serious floods caused by torrential rainfall on July 5, 2017 (Kawano and Kawamura 2020). At least 40 people were killed as hilly slopes collapsed causing landslides and bringing down large numbers of trees. Due to severe sediment run off, infrastructure including roads, bridges, and buildings were destroyed. In response to this disaster, Kyushu University organized Support Team for Recovery, Rehabilitation, and Reconstruction that was joined by 52 professors from various faculties including technology, agriculture, science, and arts, and initiated activities including surveys and support for those who had been evacuated (Mitani 2018). Support Team was intended to continue supporting a long-term process needed for immediate response to the disaster, repairing from the disaster, and restoration of ordinary lives, where urgent, short-term, and long-term decision makings must be integrated (Fig. 1.5; Shimatani 2016). Professors at Kyushu University's Disaster Risk Reduction Research Center took leadership organizing

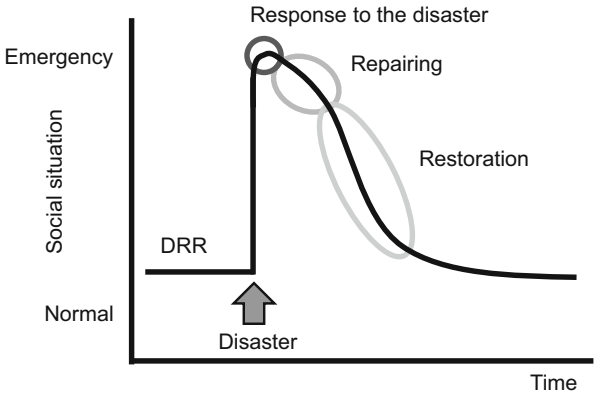


Fig. 1.5 Scheme of urgent, short-term, and long-term decision-making after a disaster (Shimatani 2016)

Support Team and worked as game changers. After the emergency response phase, Support Team joined meetings of affected people in 17 villages, provided them with aerial photographs of villages depicting where and how severely landscape and infrastructure were damaged, and asked them to write their requests on post-its and stick them on particular damaged sections on aerial photographs (Shimatani et al. 2020). Notably, experts of various disciplines including civil engineering, forestry, and ecology joined meetings and facilitated citizen discussion. Administrators of municipalities and the Ministry of Land, Infrastructure, Transport, and Tourism also participated. Village meetings proved to be extraordinary opportunities for bridging fragmentation of both academia and administration, and mediating collaborative interactions among citizens, administrators, and scientists (Shimatani et al. 2020). On September 13, 2017, Support Team held an open meeting for citizens to introduce early findings from surveys, summarize progress in various activities including volunteers and cultural support, and discuss challenges and needs for recovery. On December 17, 2018, Kyushu University, Asakura City, and Toho Village had a joint open meeting to share knowledge and experiences during the recovery process and visions for future reconstruction. The role of scientists here shifted from game changers to mediators of a long-term reconstruction process. Continued support for this process still remains a challenge.

4.3.4 Supporting Community Forestry in Cambodia

Collaboration between Kyushu University and the Forest Administration of Cambodia began in the 2000s when Dr. Heng Sokh studied at the graduate course of Kyushu University. Since then, many staff members of the Forest Administration have enrolled and earned PhDs at Kyushu University and returned to jobs at the Forest Administration. In his pioneering paper, Sokh and Iida (2001) reviewed practices of community forestry in Thailand, Vietnam, Laos, the Philippines, and Indonesia and concluded that most practices had five key factors: (1) a well-defined community organization, (2) security of rights on land and trees, (3) economic

benefits to local communities, (4) evaluation and monitoring, and (5) strong support from NGOs and central and local governments. On the other hand, they argued that some projects of community forestry in Cambodia are underway without evaluation and monitoring, and more efforts for monitoring are needed to improve project implementation. Since then, increasing efforts for monitoring community forestry achievements have been made as a result of collaborations between the Forestry Administration and Kyushu University. Most recently, Lonn et al. (2018) made a country-scale analysis of biophysical factors affecting forest coverage changes in community forestry areas from 2005 to 2016 using a dataset of 197 projects and high-resolution maps of forest coverage. Results showed that probability of forest loss increased with community forestry size and decreased with elevation and slope, suggesting that smaller areas are more effective for community forest management at lower elevations with gentle slopes. Results also showed that the probability of forest loss was lower if a community forest was located closer to villages and markets but further from the main roads, suggesting that cooperation is more stable under situations that many people can observe. In the development of community forestry under the collaboration between the Forestry Administration and Kyushu University, Dr. Sokh functioned as a game changer. Since his initiation of the collaboration, various projects have developed as collaborations between the Forestry Administration and Kyushu University, including assessments of wood fuel consumption patterns (Top et al. 2004), forest biomass estimation (Kajisa et al. 2009), tree water use in a community forestry site (Miyazawa et al. 2014), monitoring plant species and phylogenetic diversity (Toyama et al. 2015), and studies on flora and vegetation of a national park (Zhang et al. 2016). In these projects, scientists worked as mediators of the evolution of knowledge and social ties.

4.3.5 Development of Portable Health Clinic as Social Business in India

The Portable Health Clinic (PHC) is a remote health service system using a set of medical sensor devices in a briefcase and software enabling telecommunications on medical examinations (Ahmed et al. 2013). A set of devices in a briefcase is designed to determine essential indicators for physical examination including body temperature, blood pressure, blood tests, and urine tests. PHC was developed by a collaboration of Kyushu University (KU) and the Grameen's social business (Yunus 2007, 2010), and has been used to develop a remote health services in Bangladesh (Nakashima et al. 2013; Hossain et al. 2019). In India, the Portable Health Clinic (PHC) research project started in March 2016 as a community-based health check-up services in a collaboration of KU, Grameen Communications (GC) company of the Grameen Organizations in Bangladesh, and Biyani Group of Colleges (BGC) in India. This collaboration was developed since the 6th Asia Telemedicine Symposium held in Fukuoka, Japan in 2012 where a research director of BGC expressed interest in PHC. More details of this project and its lessons are provided in Sect. 2.2 (Yokota et al. 2018).

Noncommunicable diseases such as hypertension, diabetes, and kidney diseases have been an increasing social issue in India as in other developing countries. To address these problems, the primary objectives of the PHC project in India were:

- To increase access to basic health check-ups and telemedicine services.
- To increase community health awareness, knowledge, attitude, and behaviors for prevention of noncommunicable diseases.
- To reduce incidents of disease complications and comorbidities such as hypertension, diabetes, dyslipidemia, and anemia.

To achieve these objectives, the PHC project in India aimed to provide sustainable mobile health check-up services in collaboration with local government agencies, industries, and communities in the state of Rajasthan, India.

During the initial phase from March 2016 to April 2017, these objectives were shared and agreed upon among KU, GC, and BGC. In this pilot phase, development of the research plan, training workshops, implementation of research, data analysis, and data feedback workshops were conducted in collaboration with KU, GC, and BGC. The game changer who enabled the launch of these pilot activities was the BGC research director. In the following phases described in Sect. 2.2 (Yokota et al. 2018), a coordinating staff of BGC acted as a mediator of these activities under the leadership of the BGC research director, and researchers of KU also acted as mediators of the evolution of knowledge and social ties by improving the PHC system and incorporating community needs.

In the processes of co-design and co-implementation of the PHC project in India (Yokota et al. 2018), the following lessons from the success of Grameen's social business (Yunus et al. 2010) have been consulted:

1. Challenging conventional wisdom and basic assumptions: This lesson encourages changes to the current rules of public games.
2. Finding complementary partners: This lesson emphasizes the importance of cooperation as a major success of social businesses.
3. Undertaking a continuous experimentation process: This lesson is similar to the idea of the adaptive management (Holling 1978; Walters 1986) in that it facilitates knowledge acquisition through experimental execution.
4. Favoring social profit-oriented shareholders: This is a vision unique to Grameen's social business that pursues positive links between all stakeholders, including shareholders.
5. Clearly specifying the social profit objective: This is another vision unique to Grameen's social business, which aims to generate social profit rather than financial profit.

Compared to the four transdisciplinary projects above, the PHC project in India is unique in having the above visions of social business development shared by the Grameen Organizations. Currently, a PHC service is being designed as a health insurance system for employees of a private company in Rajasthan, India. The new proposal, drafted by KU and BGC, was shared with the company manager to discuss the feasibility of continuing the PHC project as a company's health insurance. The

development of PHC projects as social businesses is in progress not only in India but also in Bangladesh, Pakistan, and Thailand (Grameen Comunitations 2020).

4.4 The Roles of Scientists to Drive the Evolution of Knowledge, Institutions, and Social Ties

In this chapter, we reviewed successful cases of adaptive governance and social transformation. Collaboration between scientists and society has developed since the 1970s, long before 2013 Future Earth initiative. UNESCO's Biosphere Reserve is the root of adaptive co-management of natural resources, and the Grameen's social business that began in 1976 can be regarded as another pioneering effort to promote adaptive governance on poverty alleviation. These efforts consist of three key elements: knowledge production and social learning, improvement of institutions including laws and business, and strengthening social ties. In addition, these processes proceed due to interaction.

The important lesson from various successful examples of adaptive governance and social transformation is that the role of scientists in starting and mediating the evolution of knowledge, institutions, and social ties within a community is often very large. Scientists can work as game changers by specifying a problem, organizing stakeholders, and promoting a project that will initiate social change. Scientists can also act as mediators and as continuous catalysts for social transformation. While scientists are now one among many actors involved in knowledge generation (Folke et al. 2005), they can also play significant roles as game changers and mediators of social transformation. To be successful in fulfilling these roles, scientists must follow the co-design guidelines we developed in Sect. 1.2. In order to strengthen the role of such scientists, it is necessary to establish a framework for evaluating and supporting not only research achievements but also activities that contribute to social transformation. Moreover, a new knowledge system is needed to support activities of scientists in transdisciplinary sciences, and this chapter addresses this need.

5 How can We Transform Our Society Toward a Sustainable Future?

In this section, we will further integrate lessons learned from past failures (Sect. 3) and successes (Sect. 4) to provide a more general discussion of how we can promote social transformation toward a sustainable future. As shown in Sect. 4, adaptive comanagement on natural resources has had many successful examples, at least locally. There are also many successful examples of local efforts for poverty alleviation, public health assistance, and community education. On the other hand, it is more difficult to solve global problems where the stakes are more complex and

conflicts are larger. Then, how can we connect local success to global problem-solving?

There are two major factors behind the difficulty of the problem. First, human cooperation is unstable in large groups, and given this nature, global cooperation is the most difficult task. Secondly, there are often complex and serious conflicts among countries and ethnic groups over trade, territory, religion, culture, and history. Providing a comprehensive perspective to solve these difficulties is beyond the scope of this chapter. However, based on lessons we have gained so far from the local success and failure, we could expect the following directions to be key clues to global problem-solving: (1) facilitating the participatory process, (2) mediating conflicts among groups with different views, (3) improving institutions represented by subsidies and legal regulation, (4) enhancing education and adaptive learning, and (5) promoting behavior based on hope rather than fear.

5.1 Promoting Participatory Process

Let us start by considering international cooperation that has been developed through participatory processes in biodiversity issues. Many biodiversity issues are local, but the ecosystem itself has no border, and there are various linkages between ecosystems. First, as represented by migratory birds and fish, many animals live across borders, and multilateral cooperation is necessary for the conservation of these animals (Barkin and DeSombre 2000; Runge et al. 2015). Secondly, the local environmental burden is linked globally by trade (Lenzen et al. 2012). For example, the decline in tropical forests in Southeast Asia is closely related to timber consumption in countries of other areas, including Japan, China, and the United States (Nishijima et al. 2016). Changes in consumer consumption behaviors and corporate decision-making in these major countries are needed to conserve tropical forests. Third, as represented by UNESCO Biosphere Reserves and World Heritage, there are international mechanisms that contribute to regional development. By strengthening these linkages, it is possible to increase opportunities for local citizens to recognize that global issues are their problems. In Yakushima and Tsushima, academic societies on area studies involving citizen scientists have been developed through collaboration between citizens and experts. These attempts can provide a good opportunity for citizens to become aware of the link between local issues and global issues. Organizing collaboration between citizens and experts in regional projects such as UNESCO Biosphere Reserves and networking them internationally would be a hopeful option for developing participatory processes that connect local and global scales (Sato et al. 2018).

Another possibility to connect the local scale with the global scale is the biodiversity observation network. Unlike climate change observation, the cooperation of many citizens is particularly effective for biodiversity observation (Chandler et al. 2017). Citizen participation platforms such as iNaturalist (Cobb et al. 2019) and international cooperation on specific organisms such as migratory birds (Kirby et al.

2008) have already been well developed. Recently, citizen participatory monitoring utilizing advanced technologies such as environmental DNA has been developed (Miya et al. 2015; Valentini et al. 2015). In order to link such local biodiversity observations to global observations such as GEO BON, both national level observation networks and regional level observation networks such as APBON (Nakano et al. 2014) are important (Navarro et al. 2018).

A variety of international cooperation has been developed through participatory processes in issues other than biodiversity. According to the comprehensive review of Charnovitz (1997), history of NGO participation in national and global governance dates back to 1775 when the Pennsylvania Society for Promoting the Abolition of Slavery was founded. Since then, participation of NGOs pursuing peace, worker solidarity, and new international regimes gradually emerged until 1919 when the Paris Peace Conference was held and the League of Nations was organized. After the disengaged stage under World War II, participations of NGOs were formalized in 1945 under the United Nations, and activated even under the Cold War from 1950 to 1971. Since the end of the Cold War, NGO participation in international governance have been intensified through its growth in number, size, and diversity. Both UN Economic and Social Council (ECOSOC) and the UN General Assembly have developed and strengthened relationships with NGOs in the planning process of international conferences.

While participatory processes in national and global governance have been successfully developed as summarized above (Charnovitz 1997), such national and international cooperation often faces difficulties due to conflicts among various groups including nationalist groups, ethnic groups, and political groups. In the following section, we will consider the ingroup favoritism behind various conflicts in human society, and how we can avoid conflicts and develop cooperation between groups.

5.2 *Reducing Conflicts Among Groups with Different Value Systems*

The phenomenon of human cooperation becoming unstable in large groups has been widely recognized through research on the tragedy of the commons (Hardin 1968), collective action problems (Olson 1965; Sanders 1992), free-rider problem (Grossman and Hart 1980), and social dilemmas (Axelrod 1984; van Lange et al. 2013). On the other hand, it is also true that humans have developed cooperation in large-scale societies and achieved civilization. Cooperation in such large-scale societies have been developed through the self-organization of communities (Ostrom et al. 1999; Ostrom 2000, 2009) and the implementation of various institutions, including markets and laws (North 2005; Cosens et al. 2018). The biological foundation of the community self-organization and institutional development is human moral behavior that evolved with human ability of planning and self-control,

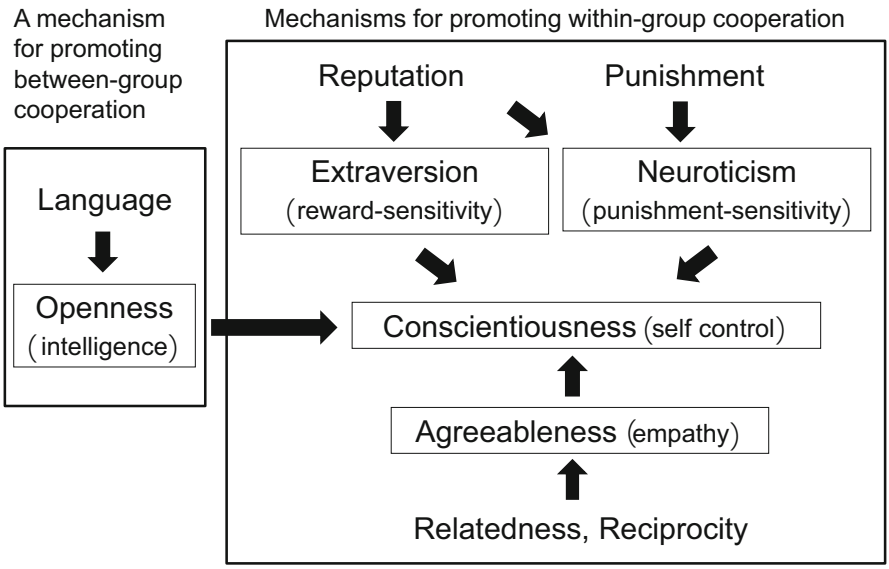


Fig. 1.6 Big five personalities as mechanisms for promoting human cooperation

associated with advanced language ability and two personality traits: openness and conscientiousness (Fig. 1.6). With this development of planning ability, humans have acquired the ability to carry out planned violence. Greene (2013) argued that the "action plan monitoring module" associated with the moral emotion evolved as a device to suppress this violence. This idea is consistent with Boehm's (2008) study that morality against violence is widespread in hunting and gathering societies. The research on hunter-gatherer societies reviewed by Boehm (2008) showed that direct punishments for those who broke the rules and indirect pressure through reputation are widespread, suggesting that those are major social factors to maintain moral behavior.

Punishment and reputation are widely incorporated into the model of the evolution of human cooperative behavior, but these studies suggested that cooperation in large groups is difficult to be maintained only by these factors (Bowles and Gintis 2011). Selection mechanisms that prompted the evolution of human cooperative behavior in large groups have yet to be established. Recently, however, there have been increasing agreements on the role of culture in the evolution of large-scale cooperation. First, Bowles and Gintis (2011) argued that the evolution of human cognitive capacities allowed the formulation of social norms, and the emergence of social institutions regulating these norms, and consequently these institutions facilitated human cooperation within groups. Second, Boyd and Richerson (2009) discussed that the evolution of learning ability favored by ordinary natural selection resulted in culturally evolved cooperative social environments, and social selection within groups favored genes that enhanced pro-social behaviors. Third, Henrich and McElreath (2003) formulated how a process of cultural group selection under the

interaction between cultural and genetic transmission can promote the evolution of enhanced pro-social behaviors in a large community. More recently, Henrich (2017) comprehensively reviewed empirical evidence showing how cultural evolution promoted human cooperation in the process of human civilization. In all of these discussions, researchers suggested that the evolution of human cooperation was promoted within groups under escalating human conflicts among groups.

One of the human characteristics that promote cooperation in a large group is pro-social punishment behavior (behavior that attempts to punish noncooperators even if they are costly to the punisher). Greene (2013) thought that the pro-social punishment behavior is associated with moral emotion supported by the action plan monitoring module, and that this nature has evolved as a means of solving within-group cooperation problems represented by the tragedy of commons. Like the above researchers, he argued that this property is not a mechanism that promotes collaboration among groups, but rather a mechanism that favors competition among groups. Different groups often have different moral systems shared within each group. For this reason, competition between groups with different morality (moral tribes) tends to create emotional conflicts over morality. Here, the moral emotion that evolved as a means of solving the cooperation problems within the group itself is the source of conflict between groups. Greene (2013) named this situation "the tragedy of common morality." According to Greene (2013), in order to solve this situation, it is necessary to switch from intuition-based decisions (like the automatic mode of a camera) linked to moral emotion to reason-based decisions (like the manual mode).

The moral emotions that bring about "the tragedy of common morality" as described by Greene (2013) are considered to be associated with the four of big five personality factors: extroversion, neuroticism, conscientiousness, and agreeableness (Fig. 1.6). Extraversion is a sensitivity to positive reputation and is associated with positive emotions when praised. Neuroticism is a sensitivity to punishment and negative reputation, and is associated with negative emotions with a sense of shame and guilt. These sensitivities allow humans to monitor how their actions are evaluated by others, and based on these sensitivities, humans can control their actions with conscientiousness. In addition, agreeableness is a personality factor that promotes cooperation among ingroup members and is associated with empathy.

As Haidt (2006) explained using a metaphor of elephants (intuition) and elephant riders (reasons), the power of elephants (intuitions) is often too strong to be controlled by elephant riders (reasons). For this reason, Haidt emphasized that efforts to improve the relationship between elephants (intuition), such as trust, are more important in mediating social conflicts, rather than the rational argument between elephant riders. Greene (2013), however, argues that resolution by rational argument is effective in mediating conflicts among groups with different moral views. Like Structured Decision Making proposed by Gregory et al. (2012), Greene (2013) encourages stakeholders to share a specific understanding of trade-offs and pursue reasonable compromises. While Haidt (2006) recommended to use intuition related to extroversion, neuroticism, conscientiousness, and agreeableness, Greene (2013) relied on openness-based reason to resolve social conflicts between groups.

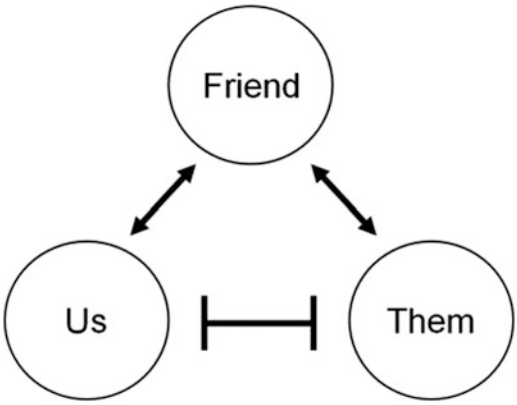


Fig. 1.7 A trichotomous model of human group relationship

Greene's argument on "Moral tribes" (Greene 2013) is based on the dichotomy of ingroup ("us") and outgroup ("them"). In human hunter-gatherer societies, however, tribes were connected by various interactions including knowledge exchange, mating, and trades, and the mode and strength of interactions (cooperation and competition) varied between groups (Bowles and Gintis 2011). In historical societies, presence or absence of support from friendly states greatly affected the survival of civilization (Diamond 2005). Thus, the dichotomy of ingroup ("us") and outgroup ("them") may oversimplify the relationships among human groups or "moral tribes." Even in modern human societies, relationships between groups are not limited to those between two parties, but interactions between groups of three or more parties are common (Tooby et al. 2006). In an interaction between three parties, for example, the third group may be friendly with both "us" and "them" (Fig. 1.7). Under this interaction, we manifest a distaste for exploitation or unfairness by others not only to ingroup members (us) but also to the third group valued by us, and this emotion may alleviate conflicts with the second group. Under such an interaction between multiple groups, we use "theory of group mind" (Tooby et al. 2006) by considering a group as a person. This is a conceptual extension of "theory of mind," a specialized set of cognitive mechanisms that enable us to interpret mental states of others behind their behaviors (Baron-Cohen et al. 1985). In fact, we tend to consider as if a group (e.g., a company and a university) has a favor or some hostility toward us, assuming that a group has mind. According to Tooby et al. (2006), a theory of group mind is a mind system that evolved as an adaption to engage in complex n-party interactions. Using this system, the moral emotion that originally evolved as a means of solving cooperation problems between groups may be extended to solve the cooperation problems between groups. Thus, not only our reasoning abilities but our moral emotion may also help us resolve conflicts between "moral tribes."

5.3 Improvement of Institutions

As a lesson from local successes of adaptive comanagement, it has been confirmed that the improvement of institutions greatly contributes to its success. For example, in the ecosystem management on Yakushima, the establishment of the Yakushima World Natural Heritage Regional Science Committee has brought about significant ongoing progress. Institutional improvement is also important for improving sustainability at the national level, and the development of a series of environmental laws in Japan since the 1990s is a good example. Needless to say, institutional improvements have greatly contributed to solving global problems. The IPCC plays a major role in consensus building on international measures against climate change and the development of international cooperation. Similarly, IPBES has announced regional and global assessments, as an international mechanism that contributes to the sustainability of biodiversity and ecosystem services.

In this way, the importance of institutional improvement is empirically clear, but basic issues such as how the institution changes and evolves and what social mechanisms are behind the institutional evolution are still not fully understood. North (2005) published a book "Understanding the Process of Economic Change" that considered these issues and proposed a pioneering theoretical framework. North (2005) regarded an institution as a deliberate effort to control the environment around us. This environment includes a natural environment and an artificial environment that we have created. The artificial environment is the legal and normative system itself, which defines the framework for human interaction. Natural science has developed various technologies to deal with the natural environment and reduced its uncertainty by deepening our understanding of the natural environment. However, North (2005) argued that the introduction of new institutions often increased the uncertainty of artificial environments and forced humans to constantly adapt to the new environment. This argument of North (2005) can be seen as applying the Red Queen model on the coevolution of organisms in ecosystems (Ridley 1993; Benton 2009) to institutional evolution. Antagonistic coevolution between a host and its parasite causes an escalation of trait evolution through adaptive evolution that enhances attack and defense. This process is called "Red Queen Model" after the episode of the fable by Louis Carroll, "Alice in the Looking Glass," where the Red Queen said by pulling the hands of Alice, "Now, here, you see, it takes all the running you can do, to keep in the same place." North (2005) thought that there is the evolution of human belief in the background of institutional evolution, and that the coevolution of institution and belief created a red queen-like permanent change.

There remains, however, a significant problem with the discussion in North (2005). His economic considerations are based on the assumption that selfish incentives in competitive markets will result in institutional change. Contrary to this assumption, even in seemingly competitive markets, not only selfish competition but also altruistic cooperation will motivate changes in institutions, as represented by the Grameen's social business (Yunus 2010; Yunus et al. 2010).

Required is not only institutional changes that reduce transaction costs under selfish competition, but also institutional changes that promote cooperation between stakeholders to achieve widely agreed goals such as the SDGs. Through institutional changes that promote such altruistic cooperation, we have realized cooperation in a large-scale society that far exceeds the Dunbar's number (Dunbar 1993). Such efforts have been expanded from the local/national scale to the international scale, and the United Nations organization, treaties represented by UNFCC and CBD, and the international assessment organizations (IPCC and IPBES) have been established. Expanding a participatory approach from the local/national scale to international mechanisms is considered to be one of the goals of future institutional changes.

5.4 Strengthening Education and Adaptive Learning

The environmental uncertainty surrounding us can be reduced not only by institutions but also by the accumulation of knowledge (North 2005). In this regard, strengthening education and adaptive learning is an effective approach for building the capacity of various actors to solve various social problems. On the other hand, the knowledge we have accumulated so far exceeds the amount that one person can learn in a lifetime. Also, the division and specialization of knowledge generating scientists have created a division of knowledge, often making it difficult to integrate and use diverse knowledge for problem-solving (Hayek 1979; North 2005). Thus, it is important not only to create new knowledge, but also to integrate available knowledge and to provide a comprehensive overview of the knowledge necessary to solve a problem. As an effort in this direction, we wrote this chapter and tried to systematize the understanding of human decision-making that should be shared among stakeholders struggling with solving various social problems. Through deepening the understanding of the natural environment by natural science, we have developed various technologies to deal with the natural environment and reduced uncertainty. Similarly, by deepening our understanding of human decision-making and behavior, we can develop ways to better coordinate human relationships and human social actions and reduce uncertainty about the human environment (Gigerenzer 2007).

The whole body of knowledge we have accumulated throughout human history is called the collective brain (Henrich 2017). Cognitive abilities of a human individual are not always superior to an individual chimpanzee, but owing to our ability of using language and the collective brain, we have built prosperity through civilization and solved various problems throughout human history. Then, how can we enhance individuals' learning abilities and better use the collective brain to create a sustainable society?

In the process of education and learning, we accumulate knowledge as various memories. This memory includes declarative memory and non-declarative memory. The former can be shared as written knowledge and used for rational judgment. On the other hand, the latter serves as an intuitive toolbox available to individuals when

faced with challenges (Gigerenzer and Selten 2002; Gigerenzer 2007). Experts experienced in specific fields have a wealth of non-declarative memory in this toolbox. While opinions are divided among experts on which of our cognitive skills, intuition, and reason, is more useful for solving problems (Gigerenzer and Gaissmaier 2011; Haidt 2012; Greene 2013; Marewski et al. 2013), the usual but obvious answer is that both are important. As emphasized by Bazerman and Watkins (2004), decisions that rely only on intuition tend to result in failures due to various cognitive biases. On the other hand, the reason is thought to be the main driver of reducing violence throughout human history (Pinker 2011) and improving our societies in many other aspects (Pinker 2018). Greene (2013) suggested that switching between intuition (auto mode) and reason (manual mode) depending on the situation, maybe a useful way of mediating social conflicts, by combining the advantages of the two cognitive systems. However, recent advances in neuroscience showed that fast response by intuition and slow response associated with attention and cognition are sequential and highly integrated (Schultz 2016).

As an evolved organism, we are adaptive learners always pursuing positive rewards. A reward is broadly defined as "an object, event, stimulus, situation, or activity that generates positive learning, induces approach behavior, is maximized in economic decisions, and evokes positive emotions such as pleasure and desire" (Schultz 2017). In our reward-pursuing behavior, we have a prediction on a reward level, and often face an error that means a discrepancy between what is happening and what is predicted to happen. If an error is more beneficial than a prediction, we are motivated to pursue a signal associated with more rewards. This is a process of reinforcement learning based on a positive reward prediction error signaling that is driven by fast and slow dopamine responses in our brain (Schultz 2016). To advance citizens' adaptive learning for sustainability, therefore, we need to provide adequate rewards, and a goal is one of the most hopeful rewards because our human actions are mostly goal directed (Snyder 2015). SDGs are examples of such goals. To make those goals more effective for motivating citizen's interest and goal-directed behavior, we need to show that those goals are achievable.

5.5 *Acting Based on Hope Rather than Fear for a Sustainable Future*

A positively motivated state for a particular goal is called hope. According to the hope theory (Snyder 2015), hope is based on an interactive sense of goal-directed energy and successful pathways. When people face difficulties to achieve a goal, high-hope people can find plausible alternate pathways and have positive emotions stemming from perceptions of successful goal pursuit. On the other hand, low-hope people fail to find alternate pathways and are trapped with negative emotions as a product of unsuccessful goal pursuit. An important role of scientists is to identify the pathway to success and to give the public high-hope.

We have solved some problems and made better societies at least in part although we are still certainly facing many difficult problems. Yunus et al. (2010) pointed out this fact in his seminal book "Social Business Revolution" and emphasized the importance to make a wish list for a better society and make efforts to realize those goals, rather than worrying about pessimistic predictions. His wish list is similar to SDGs that are now globally agreed. Another perspective for a positive change of the world has been repeatedly emphasized by Hans Rosling, a creator of Gapminder (https://www.gapminder.org/), through his influential TED talks (see also Rosling et al. 2018). Gapminder is an attractive tool for visualizing changes in the world's population and various statistics related to it. Rosling used Gapminder to point out that with the development of the economy, child survival increased in many countries, the number of children per woman decreased, and the human population is turning from increasing to decreasing. Countries that have contributed significantly to global population growth are poor African countries with low child survival and high numbers of children per woman. However, many countries in Africa are getting out of this situation and are following the trajectory of many other countries toward higher child survival and fewer children per woman. Gapminder convincingly shows that the crisis of population growth and the food crisis are solvable issues. The modern food problem stems from the fact that the product is not delivered to those who need it, rather than a lack of productivity. Following Rosling, Max Roser visualized on the website "Our World in Data" (https://ourworldindata.org/) that various positive changes are taking place in the global community. Ridley (2010), see also 2015) argued that humanity has achieved prosperity through the evolution of social systems that enabled continuous innovations through non-zero sum games of exchanging knowledge and trading goods. According to him, the modern time is the most flourished in human history and is even getting better.

In parallel with these claims, many scientists have gathered evidence supporting that the world is getting better, and argued that our society can be transformed toward a sustainable future by making further efforts. Among them are Banerjee, Duflo, and Kremer who won the 2019 Nobel Memorial Prize in Economic Sciences "for their experimental approach to alleviating global poverty." Reviewing their research findings, Banerjee and Duflo (2011) published a book entitled "Poor Economics," and clarified that there is no general method for effectively supporting developing countries, but by devising effective methods according to individual conditions, various subsidies certainly contribute to development. In particular, the psychological status and the various difficulties in daily life of poverty people are beyond the imagination of people without poverty in developed countries. This knowledge of understanding their specific circumstances is a clue to solution and our decision science has a similar principle to them on a hands-on approach.

In 2011, two other scholars argued that the world is getting better. First, Pinker (2011) gave numerous evidence that violence is decreasing throughout human history, demonstrating that modern society is in an era of expanding human rights that should be called a "rights revolution." Second, Kenny (2011) gave evidence on further social issues and claimed that the world is "Getting better." Following these books published in 2011, further publications including "The Big Ratchet" on

agricultural production (DeFries 2014), "How Science Makes Us Better" (Shermer 2015), "Progress" in globalization (Norberg 2016), and "Enlightenment Now" (Pinker 2018) have provided more convincing evidence that the world is improving.

Of course, these achievements are the result of continuous efforts, and further stronger efforts are needed to make the world more sustainable. However, rather than a message that appeals to the negative emotion such as fear and threat that the world is facing a crisis, it is better to convey a positive and hopeful message that we can improve the world based on lessons learned from past successes. Negative messages can be effective for the purpose of drawing more attention to an issue, but may have the opposite effect for the purpose of persuading or changing behavior (Lang 2006). This is because the fear response arises from the negative messages leading to fight–flight or freeze reactions, which are useless in solving problems (Moser and Dilling 2004). Further, negative messages may diminish the beneficial effects of positive emotions associated with hope and consequently keep people away from the problem or even increase skepticism about the existence of the problem (Fischer et al. 2012; O'Neill and Nicholson-Cole 2009). Thus, negative messages may strengthen status quo bias (Samuelson and Zeckhauser 1988) or normalcy bias (Omer and Alon 1994). Moreover, when a negative message arouses fear, the neural signal may skip the cortex, which is linked to cognitive processes associated with creativity (McDonald 2018). This means that negative messages may prevent coming up with creative solutions for the problem.

We scientists need to avoid excessive fear messages, but that does not mean ignoring global issues. We instead believe education and hopeful messages are two effective factors in shaping public awareness and changing human behavior for solving the global issues such as climate change. Education can promote the rational thinking (Gigerenzer 2014, 2015), and can also debias positive illusions (Taylor and Brown 1994). Lee et al. (2015) showed that "educational attainment is the single strongest predictor of climate change awareness." However, in the top 100 universities and liberal arts colleges in the United States, the probability that a student takes at least one climate change course via the core curriculum is as low as 0.17. On the other hand, the public knows too little about the science of climate change, and political affiliation and political ideology had a large effect for climate change beliefs (Kahn et al. 2012; Hornsey et al. 2016). Thus, we need to advance education to change some conservative skepticism students and citizens about climate change. In this education, it is important to show hopeful pathways to mitigate and adapt to climate change because hopeful message with a concrete countermeasure is effective for leading behavior change (Fischer et al. 2012; O'Neill and Nicholson-Cole 2009). The hope for a better future not only plays as an important role for motivating people to participate in actions that contribute to solutions (Moser and Dilling 2004), but also affects the self-efficacy of people who believe that their actions affect the resolution of global issues such as the climate change (Armstrong et al. 2018). The same goes for solving many other issues presented in SDGs.

5.6 *Evolution of Institutions and Knowledge Toward a Sustainable Future*

We humans are the only species that developed sophisticated civilization on earth. Through this civilization process, humans have changed the global environment significantly. However, humans have not only continued to destroy nature, but have also made efforts to use it wisely and make it sustainable. Agriculture, first started in the fertile crescent, can be seen as the first attempt to use natural resources sustainably (Yahara 2011). In the fertile crescent, a balance between agricultural production and the natural ecosystems had been maintained until it was broken under the rapid population growth under modernization (Jaradat 1998). Agricultural production has enabled the establishment of a state with various institutions (Diamond 1997), and those institutions contributed to decrease violence (Pinker 2011). Also, the accumulation of knowledge associated with agriculture prompted the development of early scientific efforts including biology, humanity, mathematics, physics, and metaphysics. For example, Aristotle's Historia Animalium and Theophrastus's Historia Plantarum written in the fourth century BC were the first systematization of Zoology and Botany, respectively. In the latter, Theophrastus described the techniques of ancient Greeks to regenerate olives and other plants in a sustainable manner. Since the first civilization in the fertile crescent, humans have continually improved institutions and knowledge and this process can be viewed as cultural evolution (Henrich and McElreath 2003; Ridley 2016; Henrich 2017; Wilson 1975).

One of the most influential human-generated knowledge is Darwin's theory of evolution. It has enabled a unified understanding of the whole world of biodiversity, as well as an understanding of how the human body and mind are designed by natural selection. Furthermore, evolutionary theory has proved useful in understanding social transformation as cultural evolution. Biological evolution and cultural evolution consist of five comparable phases (Fig. 1.8). In the first phase, an individual in a biological population acquires a new mutation, and an individual in a society conceives a new idea. In the second phase, a new mutation is combined with existing mutations in the process of recombination, and a new idea is combined with existing ideas in the process of ideation, i.e., creation of an advanced idea by combination. In the third phase, recombination produces phenotypic changes of an individual, while creation of an advanced idea results in changes of various social elements including institutions, knowledge, technology, goods, arts, and language. These elements can be regarded as "social phenotypes." In the fourth phase, a particular phenotype increases in a biological population by natural selection, and a particular social phenotype spreads in a society by social selection. In the fifth phase, adaptive evolution takes place in a biological population and social transformation proceeds in a human community.

Adaptive evolution and social transformation have two important similarities. First, there is no ultimate goal in either process. Second, which phenotype is advantageous varies with time and space. On the other hand, social evolution is unique in that it is driven by human's ability to predict, design, and change the

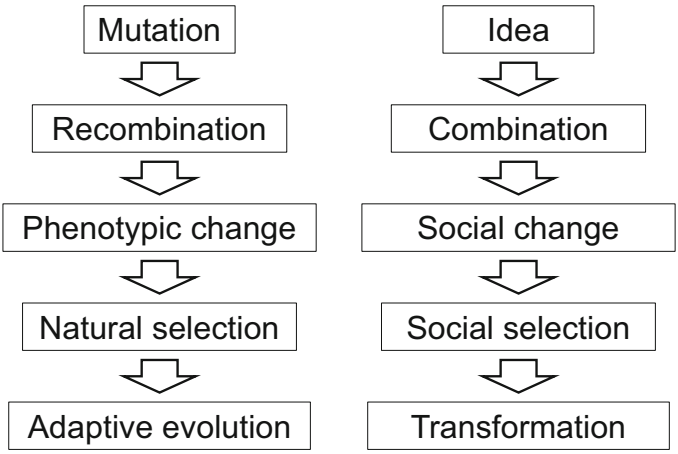


Fig. 1.8 Comparison of biological evolution and cultural evolution

future. Therefore, human societies are capable of realizing not only short-term adaptation to the current environment, but also long-term adaptation to future environmental changes. Social evolution is unique also in that it is driven not only by competition but also by the high degree of human cooperation. Consequently, social elements beneficial not only to individuals but also to society as a whole have been selected. These two uniquenesses have driven the process of continuous improvement in human society.

In this conceptual chapter, we argued that decision-making and adaptive learning through the IDEA cycle is effective to accumulate new knowledge and improve institutions under the cooperation of various stakeholders. We also argued that evolutionary biology or Darwin's idea is helpful to develop solution-oriented transdisciplinary science by integrating natural and social sciences. Based on a review of cognitive nature behind human conflicts and cooperation, we proposed a guideline for co-design in transdisciplinary projects. Further, we reviewed past successes in adaptive comanagement of natural resources and demonstrated that institutions, knowledge, and social ties are the keys to transforming our society toward a sustainable future. Finally, we proposed five strategies for transforming our society by connecting local and global efforts toward a sustainable future. We are surely facing global environmental problems, the global threats of emergent disease, the global risk of stagnation, and many other issues that are embedded in SDGs. At first glance, these problems seem difficult to solve. However, all of these problems are resolvable by improving social elements including institutions and knowledge and strengthening social ties. The key role of scientists in this resolution process is to integrate the various disciplines needed to solve problems, show potential solutions, and present specific options and pathways to a solution. Our efforts to systematize Decision Science by integrating natural, social, and humanity sciences using evolutionary theory as an integrator will contribute to this resolution process. We believe

this is one of the most promising ways to support global efforts for transforming our society into a sustainable future.

Acknowledgement This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

Ahmed A, Inoue S, Kai E, Nakashima N, Nohara Y (2013) Portable health clinic: a pervasive way to serve the unreached community for preventive healthcare. In: Distributed, ambient, and pervasive interactions - First international conference, DAPI 2013, Held as Part of HCI International 2013, Proceedings, pp 265–274. https://doi.org/10.1007/978-3-642-39351-8_29

Aoki R, Rothwell G (2013) A comparative institutional analysis of the Fukushima nuclear disaster: Lessons and policy implications. Energy Policy 53:240–247

Armstrong AK, Krasny ME, Schuldt JP (2018) Communicating climate change: A guide for educators. Comstock Publishing Associates, New York, p 144

Axelrod R (1984) The evolution of cooperation. Basic Books, New York, p 264

Barkin JS, DeSombre ER (2000) Unilateralism and multilateralism in international fisheries management. Glob Gov 6:339–360

Barkow JH, Cosmides L, Tooby J (1995) The adapted mind: evolutionary psychology and the generation of culture. Oxford University Press, Oxford, p 684

Barnerjee AV, Dufro E (2011) Poor economics: a radical rethinking of the way to fight global poverty. Public Affairs, New York, 320 p

Baron RS (2005) So right it's wrong: groupthink and the ubiquitous nature of polarized group decision making. Adv Exp Soc Psychol 37:219–253

Baron-Cohen S, Leslie AM, Frith U (1985) Does the autistic have a 'theory of mind'? Cognition 21:37–46

Bastardoz N, van Vugt M (2019) The nature of followership: evolutionary analysis and review. Leadersh Q 30:81–95

Bazerman MH, Moore DA (2008) Judgment in managerial decision making, 7th edn. Wiley, New York, p 230

Bazerman MH, Watkins MD (2004) Predictable surprises: the disasters you should have seen coming and how to prevent them. Harvard Business School Press, Cambridge, p 336

Bell A, Morse S (2013) Measuring sustainability: Learning from doing. Routledge, London, p 206

Bennett EM, Solan M, Biggs R, McPhearson T, Norstrom A, Olsson P, Pereira L, Peterson GD, Raudsepp-Hearne C, Biermann F, Carpenter SR, Ellis E, Hichert T, Galaz V, Lahsen M, Milkoreit M, Martin-Lopez B, Nicholas KA, Preiser R, Vince G, Vervoort J, Xu J (2016) Bright spots: seeds of a good anthropocene. Front Ecol Environ 14:441–448

Benton MJ (2009) The red queen and the court jester: species diversity and the role of biotic and abiotic factors through time. Science 323:728–732

Berkes F (2009) Evolution of co-management: role of knowledge generation, bridging organizations and social learning. J Environ Manag 90:1692–1702

Berkes F, Folke C (1998) Linking social and ecological systems for resilience and sustainability. Beijer Dis Paper Ser 52:1–16

Bodin Ö (2017) Collaborative environmental governance: achieving collective action in social-ecological systems. Science 357:1114

Boehm C (2008) Purposive social selection and the evolution of human altruism. Cross-Cult Res 42:319–352

Boehm C (2012) Moral origins: the evolution of virtue, altruism, and shame. Basic Books, New York, p 432
Bonney R, Shirk JL, Phillips TB, Wiggins A, Ballard HL, Miller-Rushing AJ, Parrish JK (2014) Next steps for citizen science. Science 343:1436–1437
Borrini-Feyerabend G, Pimbert M, Farvar MT, Kothari A, Renard Y (2004) Sharing power: learning by doing in co-management of natural resources throughout the world. IIED and IUCN/CEESP/CMWG, Cenesta, Tehran, p 473
Bouchard TJ, McGue M (2003) Genetic and environmental influences on human psychological differences. J Neurobiol 54:4–45
Bouchard TJ, Segal NL, Tellegena A, McGuea M, Keyesa M, Krueger R (2003) Evidence for the construct validity and heritability of the Wilson–Patterson conservatism scale: a reared–apart twins study of social attitudes. Personal Individ Differ 34:959–969
Bouckaert R, Lemey P, Dunn M, Greenhill SJ, Alekseyenko AV, Drummond AJ, Gray RD, Suchard MA, Atkinson QD (2012) Mapping the origins and expansion of the Indo–European language family. Science 337:957–960
Bowles S, Gintis H (2011) A cooperative species: human reciprocity and its evolution. Princeton University Press, Princeton, p 262
Boyd R, Richerson PJ (2009) Culture and the evolution of human cooperation. Philos Trans R Soc B 364:3281–3288
Boyd R, Gintis H, Bowles S (2010) Coordinated punishment of defectors sustains cooperation and can proliferate when rare. Science 328:617–620
Brewer JA (2017) The craving mind: from cigarettes to smartphones to love - why we get hooked and how we can break bad habits. Yale University Press, New Haven, p 256
Brewer JA, Worhunskya PD, Grayb JR, Tangc YY, Weberd J, Kobera H (2011) Meditation experience is associated with differences in default mode network activity and connectivity. Proc Natl Acad Sci U S A 108:20254–20259
Brodbeck FC, Kerschreiter R, Mojzisch A, Schulz-Hardt S (2007) Group decision making under conditions of distributed knowledge: the information asymmetries model. Acad Manag Rev 32:459–479
Brown T, Kātz B (2009) Change by design: how design thinking transforms organizations and inspires innovation. Harper Business, New York, p 272
Brusilovsky P (2003) Adaptive and intelligent web–based educational systems. Int J Artif Intell Educ 13:159–172
Buss D (2014) Evolutionary psychology: the new science of the mind. Psychology Press, Hove, p 496
Carlsson L, Berkes F (2005) Co-management: concepts and methodological implications. J Environ Manag 75:65–76
Chaffin BC, Gosnell H, Cosens BA (2014) A decade of adaptive governance scholarship: synthesis and future directions. Ecol Soc 19:56
Chandler M, See L, Copas K, Bonde AMZ, López BC, Danielsen F, Legind JK, Masinde S, Miller-Rushing AJ, Newman G, Rosemartin A, Turak E (2017) Contribution of citizen science towards international biodiversity monitoring. Biol Conserv 213:280–294
Charnovitz S (1997) Two centuries of participation: NGOs and international governance. Michigan J Int Law 18:183–286
Cobb NS, Gall LF, Zaspel JM, Dowdy NJ, McCabe LM, Kawahara AY (2019) Assessment of North American arthropod collections: prospects and challenges for addressing biodiversity research. PeerJ 7:e8086
Cosens BA, Gunderson L, Chaffin BC (2018) Introduction to the special feature practicing panarchy: assessing legal flexibility, ecological resilience, and adaptive governance in regional water systems experiencing rapid environmental change. Ecol Soc 23:4
Crutzen PJ (2002) Geology of mankind: the anthropocene. Nature 415:23
de Wit FR, Greer LL, Jehn KA (2012) The paradox of intragroup conflict: A meta–analysis. J Appl Psychol 97:360–390. https://doi.org/10.1037/a0024844

DeFries R (2014) The big ratchet: how humanity thrives in the face of natural crisis. Basic Books, New York, p 288
Deming WE (1950) Elementary principles of the statistical control of quality. JUSE, Tokyo
Dennett D (1995) Darwin's dangerous idea: evolution and the meanings of life. Penguin, New York, p 592
Diamond J (1997) Guns, germs and steel: a short history of everybody for the last 13,000 years. WW Norton & Co, New York, p 480
Diamond J (2005) Collapse: how societies choose to fail or succeed. Viking, New York, p 608
Diaz S et al (2015) The IPBES conceptual framework — connecting nature and people. Curr Opin Environ Sustain 14:1–16
Dublin DR, Tanaka N (2014) Indigenous agricultural development for sustainability and "Satoyama". Geogr Environ Sustainability 7:86–95
Dunbar R (1993) Coevolution of neocortical size, group size and language in humans. Behav Brain Sci 16:681–735
Dunbar R (2014) Human evolution. Pellican, New Orleans, p 256
Dunbar R, Barrett L, Lycett J (2005) Evolutionary psychology: a beginner's guide. Oneworld Publications, London, p 234
Duraiappah AK, Nakamura K, Takeuchi K, Watanabe M, Nishi M (eds) (2012) Satoyama–satoumi ecosystems and human well–being: socio–ecological production landscapes of Japan. United Nations Press, Tokyo, p 480
Egas M, Riedl A (2008) The economics of altruistic punishment and the maintenance of cooperation. Proc R Soc B 275:871–878
Ellis G (2018) So, what are cognitive biases? In: Ellis G (ed) Cognitive biases in visualizations. Springer, Cham, pp 1–10
Evans JS (1989) Bias in human reasoning: Causes and consequences. Psychology Press, Hove, p 160
Evans JS (2008) Dual-processing accounts of reasoning, judgment, and social cognition. Annu Rev Psychol 59:255–278
Evans JS, Stanovich KE (2013) Dual-process theories of higher cognition: advancing the debate. Perspect Psychol Sci 8:223–241
Festinger L (1954) A theory of social comparison processes. Hum Relat 7:117–140
Fischer J, Dyball R, Fazey I, Gross C, Dovers S, Ehrlich PR, Brulle RJ, Christensen C, Borden RJ (2012) Human behavior and sustainability. Front Ecol Environ 10:153–160
Fischhoff B (1982) Debiasing. In: Kahneman D, Slovic P, Tversky A (eds) Judgement under uncertainty: heuristics and biases. Cambridge University Press, New York, pp 422–444
Fischhoff B, Kadvany J (2011) Risk: a very short introduction. Oxford University Press, Oxford, p 162
Folke C, Carpenter S, Elmqvist T, Gunderson L, Holling CS, Walker B (2002) Resilience and sustainable development: building adaptive capacity in a world of transformations. Ambio 31:437–440
Folke C, Hahn T, Olsson P, Norberg J (2005) Adaptive governance of social-ecological systems. Annu Rev Environ Resour 30:441–473
Fowler JH (2005) Altruistic punishment and the origin of cooperation. Proc Natl Acad Sci U S A 102:7047–7049
Fujimaki A, Shioya K, Tagawa S, Matsuda H (2016) A theoretical approach for zone–based management of the deer population on Yakushima Island. Popul Ecol 58:315–327
Furuta K, Kondo K (1992) Group reliability analysis. Reliab Eng Syst Saf 35:159–167
Future Earth (2013) Future Earth initial design: report of the transition team. International Council for Science (ICSU), Paris, p 98
Future Earth (2014) Strategic research agenda 2014: priorities for a global sustainability research strategy. International Council for Science (ICSU), Paris, p 25
Galvin KA, Reid RS, Fernandez-Gimenez ME, ole Kaelo D, Baival B, Krebs M (2016) Co-design of transformative research for rangeland sustainability. Curr Opin Environ Sustain 20:8–14

Gerber AS, Huber GA, Doherty D, Dowling DM, Ha SE (2010) Personality and political attitudes: relationships across issue domains and political contexts. Am Polit Sci Rev 104:111–133
Gigerenzer G (2007) Gut feelings: the intelligence of the unconscious. Penguin, New York, p 299
Gigerenzer G (2014) Risk savvy: how to make good decisions. Viking, New York, p 336
Gigerenzer G (2015) On the supposed evidence for libertarian paternalism. Rev Philos Psychol 6:361–383
Gigerenzer G, Gaissmaier W (2011) Heuristic decision making. Annu Rev Psychol 62:451–482
Gigerenzer G, Selten R (eds) (2002) Bounded rationality: the adaptive toolbox. MIT Press, Cambridge, p 394
Gladwell M (2000) The tipping point—how little things can make a big difference. Back Bay Books, New York, p 304
Graham J, Haidt J, Nosek BA (2009) Liberals and conservatives rely on different sets of moral foundations. J Pers Soc Psychol 96:1029–1046
Graham J, Haidt J, Kolevaa S, Motylc M, Iyera R, Wojcikd SP, Ditto PH (2013) Moral foundations theory: the pragmatic validity of moral pluralism. Adv Exp Soc Psychol 47:55–130
Grameen Comunitations (2020) Portable Health Clinic. http://grameen.technology/post/32/portable-health-clinic. Visited May 22, 2020
Greene J (2013) Moral tribes: emotion, reason, and the gap between us and them. Penguin Press, New York, p 432
Gregory R, Failing L, Harstone M, Long G, McDaniels T, Ohlson D (2012) Structured decision making: a practical guide to environmental management choices. Wiley-Blackwell, Oxford, p 312
Grossman SJ, Hart OD (1980) Takeover bids, the free–rider problem, and the theory of the corporation. Bell J Econ 11:42–64
Guala F (2012) Reciprocity: weak or strong? What punishment experiments do (and do not) demonstrate. Behav Brain Sci 35:1–15
Gunderson LH, Holling CS (2002) Panarchy: understanding transformations in human and natural systems. Island Press, Washington, DC, p 570
Gur RC, Sackeim HA (1979) Self-deception: a concept in search of a phenomenon. J Pers Soc Psychol 37:147–169
Hahn T, Olsson P, Folke C, Johansson K (2006) Trust–building, knowledge generation and organizational innovations: the role of a bridging organization for adaptive co-management of a wetland landscape around Kristianstad, Sweden. Hum Ecol 34:573–592
Haidt J (2006) The happiness hypothesis: finding modern truth in ancient wisdom. Basic Books, New York, p 320
Haidt J (2007) The new synthesis in moral psychology. Science 316:998–1002
Haidt J (2012) The righteous mind: why good people are divided by politics and religion. Penguin, New York, p 528
Haidt J, Graham J (2007) When morality opposes justice: conservatives have moral intuitions that liberals may not recognize. Soc Justice Res 20:98–116
Halbesleben JRB, Buckley RM (2004) Pluralistic ignorance: historical development and organizational applications. Manag Decis 42:126–138
Hardin G (1968) The tragedy of commons. Science 162:1243–1248
Hart P (1991) Irving L. Janis' victims of groupthink. Polit Psychol 12:247–278
Haselton MG, Buss DM (2000) Error management theory: a new perspective on biases in cross-sex mind reading. J Pers Soc Psychol 78:81–91
Haselton MG, Nettle D (2006) The paranoid optimist: an integrative evolutionary model of cognitive biases. Personal Soc Psychol Rev 10:47–66
Haselton MG, Nettle D, Murray DR (2015) The evolution of cognitive bias. In: Buss DM (ed) Handbook of evolutionary psychology. Wiley, New York, pp 724–746
Hatemi PK, McDermott R (2012) The genetics of politics: discovery, challenges, and progress. Trends Genet 28:525–533

Hatemi PK, Gillespie NA, Eaves LJ, Maher BS, Webb BT, Heath AC, Medland SE, Smyth DC, Beeby HN, Gordon SD, Montgomery GW, Zhu G, Byrne EM, Martin NG (2011) A genome-wide analysis of liberal and conservative political attitudes. J Polit 73:271–285
Hawks J, Wang ET, Cochran GM, Harpending HC, Moyzis RK (2007) Recent acceleration of human adaptive evolution. Proc Natl Acad Sci U S A 104:20753–20758
Hayek FA (1979) The political order of a free people. University of Chicago Press, Chicago, p 244
Heath J (2014) Enlightenment 2.0: restoring sanity to our politics, our economy, and our lives. HarperCollins Publishers, New York, p 432
Henrich J (2006) Cooperation, punishment, and the evolution of human institutions. Science 312:60–61
Henrich J (2017) The secret of our success: how culture is driving human evolution, domesticating our species, and making us smarter. Princeton University Press, Princeton, p 445
Henrich J, McElreath R (2003) The evolution of cultural evolution. Evol Anthropol 12:123–136
Herbert TT, Estes RW (1977) Improving executive decisions by formalizing dissent: The corporate devil's advocate. Acad Manag Rev 2:662–667
Hoegh-Guldberg O, Bruno JF (2010) The impact of climate change on the world's marine ecosystems. Science 328:1523–1528
Hoehl S, Hellmer K, Johansson M, Gredebäck G (2017) Itsy bitsy spider. . .: infants react with increased arousal to spiders and snakes. Front Psychol 8:1710
Holling CS (1978) Adaptive environmental assessment and management. John Wiley & Sons, Chichester, p 377
Holling CS, Carpenter SR, Brock WA, Gunderson LH (2002) Discoveries for sustainable future. In: Gunderson LH, Holling CS, Light SS (eds) Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, pp 395–417
Hooper DU, Adair EC, Cardinale BJ, Byrnes JEK, Hungate BA, Matulich KL, Gonzalez A, Duffy JE, Gamfeldt L, O'Connor MI (2012) A global synthesis reveals biodiversity loss as a major driver of ecosystem change. Nature 486:105–108
Hornsey MJ, Harris EA, Bain PG, Fielding KS (2016) Meta-analyses of the determinants and outcomes of belief in climate change. Nat Clim Chang 6:622–626
Hossain N, Yokota F, Sultana N, Ahmed A (2019) Factors influencing rural end-users' acceptance of e-health in developing countries: a study on portable health clinic in Bangladesh. Tele-med e-Health 25:221–229
Ingman M, Kaessmann H, Paabo S, Gyllensten U (2000) Mitochondrial genome variation and the origin of modern humans. Nature 408:708–713
International Partnership for the Satoyama Initiative [IPSI] (2010) The Satoyama initiative. Ministry of the Environment Japan and United Nations University, Tokyo
Isaac RM, Walker JM (1988) Group size effects in public goods provision: the voluntary contributions mechanism. Q J Econ 103:179–199
Itonaga K (2014) Preface: expectation for Tsushima model. Biocity 58:6–9
Iwasa Y, Lee JH (2013) Graduated punishment is efficient in resource management if people are heterogeneous. J Theor Biol 333:117–125
Janis IL (1972) Victims of groupthink: a psychological study of foreign–policy decisions and fiascoes. Houghton Mifflin, Boston, p 320
Janis IL (1982) Groupthink: psychological studies of policy decisions and fiascoes. Houghton Mifflin, Boston, p 368
Jaradat AA (1998) Biodiversity and sustainable agriculture in the fertile crescent. In: Albert J, Bernhardsson M, Kenna R (eds) Transformations of Middle Eastern natural environments: legacies and lessons. Yale University Press, New Haven, pp 31–57
Judge TA, Piccolo RF, Kosalca T (2009) The bright and dark sides of leader traits: a review and theoretical extension of the leader trait paradigm. Leadersh Q 20:855–875
Kahn DM, Peters E, Wittlin M, Slovic P, Ouellette LL, Braman D, Mandel G (2012) The polarizing impact of science literacy and numeracy on perceived climate change risks. Nat Clim Chang 2:732–735

Kahneman D (2003) Maps of bounded rationality: psychology for behavioral economics. Am Econ Rev 93:1449–1475
Kahneman D (2011) Thinking, fast and slow. Penguin Books, New York, p 499
Kajisa T, Murakami T, Mizoue N, Top N, Yoshida S (2009) Object–based forest biomass estimation using Landsat ETM+ in Kampong Thom Province, Cambodia. J For Res 14:203–211
Katz D, Allport F (1931) Students' attitudes: a report of the Syracuse University reaction study. Craftsman Press, New York, p 408
Kawaguchi M, Araki S (2016) Tsushima biosphere reserve: conservation and wise use of the SATOJIMA environment. Jpn J Ecol 66:147–154
Kawano T, Kawamura R (2020) Genesis and maintenance processes of a quasi-stationary convective band that produced record-breaking precipitation in northern Kyushu, Japan on 5 July 2017. J Meteorol Soc Jpn 98:33
Kenny C (2011) Getting better: why global development is succeeding–and how we can improve the world even more. Basic Books, New York, p 256
Kerr NL, Tindale RS (2004) Group performance and decision making. Annu Rev Psychol 55:623–655
King AJ, Cowlishaw G (2009) Leaders, followers, and group decision making. Commun Integrat Biol 2:147–150. https://doi.org/10.4161/cib.7562
Kirby JS, Stattersfield AJ, Butchart SHM, Evans MI, Grimmett RFA, Jones VR, O'Sullivan J, Tucker GM, Newton I (2008) Key conservation issues for migratory land- and waterbird species on the world's major flyways. Bird Conserv Int 18:S49–S73
Klayman J, Brown K (1993) Debias the environment instead of the judge: an alternative approach to reducing error in diagnostic (and other) judgment. Cognition 49:97–122
Labib A, Harris MJ (2015) Learning how to learn from failures: the Fukushima nuclear disaster. Eng Fail Anal 47:117–128
Lang A (2006) Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. J Commun 56:S57–S80
Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci 7:25–43
Langer EJ (1975) The illusion of control. J Pers Soc Psychol 32:311–328
Larrick RP (2004) Debiasing. In: Koehler DJ, Harvey N (eds) Blackwell handbook of judgment and decision making. Blackwell, Oxford, pp 316–337
Leach WD, Pelkey NW (2001) Making watershed partnerships work: a review of the empirical literature. J Water Resour Plan Manag 127:378–385
Lee TM, Markowitz EM, Howe PD, Ko CY, Leiserowitz AA (2015) Predictors of public climate change awareness and risk perception around the world. Nat Clim Chang 5:1014–1020
Leemans R (2016) The lessons learned from shifting from global–change research programmes to transdisciplinary sustainability science. Curr Opin Environ Sustain 19:103–110
Lenton T, Held H, Kriegler E, Hall JW, Lucht W, Rahmstorf S, Schellnhuber HJ (2008) Tipping elements in the earth's climate system. Proc Natl Acad Sci U S A 105:1786–1793
Lenzen M, Moran D, Kanemoto K, Foran B, Lobefaro L, Geschke A (2012) International trade drives biodiversity threats in developing nations. Nature 486:109–112
Lewin K (1947) Group decision and social change. In: Newcomb TM, Hartley EL (eds) Readings in social psychology. Holt, New York, pp 330–344
Longley J, Pruitt DG (1980) Groupthink: a critique of Janis's theory. In: Wheeler L (ed) Review of personality and social psychology, vol 1. Sage, Beverly Hills, pp 74–93
Lonn P, Mizoue N, Ota T, Kajisa T, Yoshida S (2018) Biophysical factors affecting forest cover changes in community forestry: a country scale analysis in Cambodia. Forests 9:273. https://doi.org/10.3390/f9050273
Lu L, Yuan YC, McLeod PL (2012) Twenty–five years of hidden profiles in group decision making: a meta-analysis. Personal Soc Psychol Rev 16:54–75

Lubell M, Robins G, Wang P (2014) Network structure and institutional complexity in an ecology of water management games. Ecol Soc 19:23
Lubell M, Jasny L, Hastings A (2017) Network governance for invasive species management. Conserv Lett 10:699–707
Ludwig D, Mangel M, Haddat B (2001) Ecology, conservation, and public policy. Annu Rev Ecol Syst 32:481–517
MacCoun RJ (1998) Biases in the interpretation and use of research results. Annu Rev Psychol 49:259–287
Maeda T (2014) Development of a base for academic and international exchange through human resources circulation. BIOCITY 58:36–42
Magnani L (2011) Abduction, reason, and science: Processes of discovery and explanation. Springer, New York, p 205
Manoogian J (2016). The Cognitive Bias Codex. https://medium.com/better-humans/cognitive-bias-cheat-sheet-55a472476b18
Marewski JN, Bröder A, Glöckner A (2013) Some metatheoretical reflections on adaptive decision making and the strategy selection problem. J Behav Decis Mak 31:181–198
Mason RO (1969) A dialectical approach to strategic planning. Manag Sci 15:B403–B414
Matsuda H, Yahara T, Takemon Y, Hada Y, Hasegawa M, Hidaka K, Hotes S, Kadono Y, Kamata M, Kanda F, Kato M, Kunii H, Mukai H, Murakami O, Nakagoshi N, Nakamura F, Nakane K, Nishihiro M, Nishihiro J, Sato T, Shimada M, Shiosaka H, Takamura N, Tamura N, Tachikawa K, Tsubaki Y, Tsuda S, Washitani I (2005) Guideline for nature restoration projects. Jpn J Conserv Ecol 10:63–75
Matsuda H, Yumoto T, Okano T, Tetsuka K, Fujimaki A, Shioya K (2015) An extension plan of Yakushima Biosphere Reserve as a case study of consensus building of islanders. J Ecol Environ 38:241–247
Mauser W, Klepper G, Rice M, Schmalzbauer BS, Hackmann H, Leemans R, Moore H (2013) Transdisciplinary global change research: the co–creation of knowledge for sustainability. Curr Opin Environ Sustain 5:420–431
McCauley C (1989) The nature of social influence and groupthink: compliance and internalization. J Pers Soc Psychol 57:250–260
McDonald P (2018) Sustainability management: research insights from social cognitive neuroscience. Bus Strateg Environ 27:1355–1367
McKnight DH, Choudhury V, Kacmar C (2002) The impact of initial consumer trust on intentions to transact with a web site: a trust building model. J Strateg Inf Syst 11:297–323
Mitani Y (2018) A special issue for Northern Kyushu heavy rain in July 2017. West Jpn Nat Disast Inf Center News 58:2–39
Miya M, Sato Y, Fukunaga T, Sado T, JPoulsen JY, Sato K, Minamoto T, Yamamoto S, Yamanaka H, Araki H, Kondoh M, Iwasaki W (2015) MiFish, a set of universal PCR primers for metabarcoding environmental DNA from fishes: detection of more than 230 subtropical marine species. R Soc Open Sci 2:150088
Miyajima T, Yamaguchi H (2017) I want to but I won't: pluralistic ignorance inhibits intentions to take paternity leave in Japan. Front Psychol 8:1508. https://doi.org/10.3389/fpsyg.2017.01508
Miyazawa Y, Tateishi M, Komatsu H, Ma V, Kajisa T, Sokh H, Mizoue N, Kumagai T (2014) Tropical tree water use under seasonal waterlogging and drought in central Cambodia. J Hydrol 515:81–89
Moen R, Norman C (2009) Evolution of the PDCA cycle. In: Proceedings of the 7th ANQ Congress, Tokyo
Montibeller G, von Winterfeldt D (2015) Cognitive and motivational biases in decision and risk analysis. Risk Anal 35:1230–1251
Moser SC (2016a) Editorial overview: Transformations and co–design: co-designing research projects on social transformations to sustainability. Curr Opin Environ Sustain 20:v–viii
Moser SC (2016b) Can science on transformation transform science? Lessons from co–design. Curr Opin Environ Sustain 20:106–115

Moser SC, Dilling S (2004) Making climate hot. Environment 46:32–46
Myers DG, Lamm H (1976) The group polarization phenomenon. Psychol Bull 83:602–627
Nakamaru M, Iwasa Y (2006) The coevolution of altruism and punishment: role of the selfish punisher. J Theor Biol 240:475–488
Nakamura K, Tockner K, Amano K (2006) River and wetland restoration: lessons from Japan. Bioscience 56:419–429
Nakano S, Yahara T, Nakashizuka T (2014) Asia-Pacific biodiversity observation network: integrative observations and assessments. Springer, Tokyo, p 429
Nakashima N, Hiramatsu T, Ghosh PP, Islam R, Kobayashi K, Inoguchi T (2013) Evaluation of "Portable Health Clinic" with BAN standard for 10K subjects in Bangladesh. Conf Proc IEEE Eng Med Biol Soc 2013:1672–1675
Navarro LM, Fernández N, Guerra C, Guralnick Daniel Kissling RW, Londoño MC, Muller-Karger F, Turak E, Balvanera P, Costello M, Delavaud A, Serafy G, Ferrier S, Geijzendorffer I, Geller G, Jetz W, Kim E-S, Kim H-J, Martin CS, McGeoch MA, Mwampamba TH, Nel JL, Nicholson E, Pettorelli N, Shaepman M, Skidmore A, Pinto IS, Vergara S, Vihervaara P, Xu H, Yahara T, Gill M, Pereira HM (2018) Monitoring biodiversity change through effective global coordination. Curr Opin Environ Sustain 29:158–169
Nickerson RS (1998) Confirmation bias: a ubiquitous phenomenon in many guises. Rev Gen Psychol 2:175–220
Nishijima S, Furukawa T, Kadoya T, Ishihama F, Kastner T, Matsuda H, Kaneko N (2016) Evaluating the impacts of wood production and trade on bird extinction risks. Ecol Indic 71:368–376
Norberg J (2016) Progress: ten reasons to look forward to the future. Oneworld Publications, London, p 256
North DC (2005) Understanding the process of economic change. Princeton University Press, Princeton, p 187
O'Neill S, Nicholson-Cole S (2009) "Fear won't do it" promoting positive engagement with climate change through visual and iconic representations. Sci Commun 30:355–379
Okano T, Matsuda H (2013) Biocultural diversity of Yakushima Island: mountains, beaches, and sea. J Marine Island Cult 2:69–77
Olesen JM, Bascompte J, Dupont YL, Jordano P (2007) The modularity of pollination network. Proc Natl Acad Sci U S A 104:19891–19896
Olson M (1965) The logic of collective action. Harvard University Press, Cambridge, p 192
Omer H, Alon N (1994) The continuity principle: a unified approach to disaster and trauma. Am J Community Psychol 22:273–287
Oskarsson S, Cesarini D, Dawes CT, Fowler JH, Johannesson M, Magnusson PKE, Teorell J (2015) Linking genes and political orientations: cognitive ability as mediator hypothesis. Polit Psychol 36:649–665
Ostrom E (2000) Collective action and the evolution of social norms. J Econ Perspect 14:137–158
Ostrom E (2009) A general framework for analyzing sustainability of social–ecological systems. Science 325:419–422
Ostrom E, Burger J, Field CB, Norgaard RB, Policansky D (1999) Revisiting the commons: local lessons, global challenges. Science 284:278–282
Parson EA, Clark WC (1995) Sustainable development as social learning: theoretical perspectives and practical challenges for the design of a research program. In: Gunderson LH, Holling CS, Light SS (eds) Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, pp 428–460
Pearce D, Atkinson G, Mourato S (2006) Cost–benefit analysis and the environment: Recent developments. Organization for Economic Co-operation and Development, Paris
Peirce CS (1903) Pragmatism as a principle and method of right thinking. Harvard lectures on pragmatism. Included in Charles Sanders Peirce Collected Papers 5. http://www.textlog.de/peirce_pragmatism.html

Perderwitz D (2017) Designing transdisciplinary sustainable science: a comparative analysis of a transdisciplinary research framework. Master Thesis in Environmental Studies and Sustainability Science, Lund University Centre for Sustainable Studies. https://lup.lub.lu.se/student-papers/search/publication/8916852
Pinker S (2011) The better angels of our nature: why violence has declined. Viking, New York, p 832
Pinker S (2018) Enlightenment now: the case for reason, science, humanism, and progress. Penguin, New York, p 576
Plummer R, Crona B, Armitage DR, Olsson P, Tengö M, Yudina O (2012) Adaptive co-management: a systematic review and analysis. Ecol Soc 17:11
Plummer R, Baird J, Dzyundzyak A, Armitage D, Bodin Ö, Schultz L (2017) Is adaptive co-management delivering? Examining relationships between collaboration, learning and outcomes in UNESCO biosphere reserves. Ecol Econ 140:79–88
Pretty J, Ward H (2001) Social capital and the environment. World Dev 29:209–227
Puttermann L, Tyran JR, Kamei K (2011) Public goods and voting on formal sanction schemes. J Public Econ 96:1213–1222
Ravetz J (2006) The no-nonsense guide to science. New Internationalist Publications, Oxford, p 142
Reed M, Price M (2019) UNESCO biosphere reserves: supporting biocultural diversity, sustainability and society. Routledge, Abingdon, p 342
Reed MS, Fraser EDG, Dougill AJ (2006) An adaptive learning process for developing and applying indicators with local communities. Ecol Econ 59:406–418
Reid WV, Chen D, Goldfarb L, Hackmann H, Lee YT, Mokhele K, Ostrom E, Raivio K, Rockström J, Schellnhuber HJ, White A (2010) Earth system science for global sustainability: Grand challenges. Science 330:916–917
Richard-Ferroudji A, Faysse N, Bouzidi Z, Menon RT, Rinaudo JD (2016) The DIALAQ project on sustainable groundwater management: a transdisciplinary and transcultural approach to participatory foresight. Curr Opin Environ Sustain 20:56–60
Richardson PJ, Boyd R (2006) Not by genes alone: how culture transformed human evolution. University of Chicago Press, Chicago, p 342
Ridley M (1993) The red queen: sex and the evolution of human nature. Penguin, New York, p 416
Ridley M (2010) Rational optimist: how prosperity evolves. Harper, New York, p 448
Ridley M (2016) The evolution of everything: how new ideas emerge. Harper, New York, p 369
Ritov I, Baron J (1992) Status–quo and omission biases. J Risk Uncertain 5(1):49–61
Rockenbach B, Milinski M (2006) The efficient interaction of indirect reciprocity and costly punishment. Nature 444:718–723
Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin EF, Lenton TM, Scheffer M, Folke C, Schellnhuber J, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Liverman D, Richardson K, Crutzen P, Foley J (2009) A safe operating space for humanity. Nature 461:472–475
Rose JD (2011) Diverse perspectives on the groupthink theory–a literary review. Emerg Leadership Journey 4:37–57
Rosling H, Rosling O, Ronnlund AR (2018) Factfulness: ten reasons we're wrong about the world – and why things are better than you think. Flatiron Books, New York, p 352
Runge CA, Watson JEM, Butchart SHM, Hanson JO, Possingham HP, Fuller RA (2015) Protected areas and global conservation of migratory birds. Science 350:1255–1258
Samuelson W, Zeckhauser R (1988) Status quo bias in decision making. J Risk Uncertain 1:7–59
Sanders T (1992) Collective action: theory and applications. University of Michigan Press, Ann Arbor, p 237
Sato T, Chabay I, Helgeson J (eds) (2018) Transformations of social-ecological systems: studies in co-creating integrated knowledge toward sustainable futures. Springer, Singapore, p 430
Schellnhuber HJ (2009) Tipping elements in the earth system. Proc Natl Acad Sci U S A 106:20561–20563

Schultz W (2016) Dopamine reward prediction error signaling: a two-component response. Nat Rev Neurosci 17:183–195
Schultz W (2017) Reward prediction error. Curr Biol 27:R365–R377
Schultz L, Duit A, Folke C (2011) Participation, adaptive co-management, and management performance in the world network of biosphere reserves. World Dev 39:662–671
Schulz-Hardt S, Brodbeck FC, Mojzisch A, Kerschreiter R, Frey D (2006) Group decision making in hidden profile situations: dissent as a facilitator for decision quality. J Pers Soc Psychol 91:1080–1093. https://doi.org/10.1037/0022-3514.91.6.1080
Schwenk CR (1990) Effects of devil's advocacy and dialectical inquiry on decision making: a meta-analysis. Organ Behav Hum Decis Process 47:161–176
Segerstrale U (2000) Defenders of the truth: the battle for science in the sociobiology debate and beyond. Oxford University Press, Oxford, p 493
Sherif M, Harvey OJ, White JB, Hood WR, Sherif CW (1954) Intergroup conflict and cooperation: the Robbers Cave experiment, University Book Exchange. Norman 10:150–198
Shermer M (2015) The moral arc: how science makes us better people. Henry Holt & Co, New York, p 541
Shewhart WA (1939) Statistical method from the viewpoint of quality control
Shibasaki M, Kawai N (2009) Rapid detection of snakes by Japanese monkeys (*Macaca fuscata*): an evolutionarily predisposed visual system. J Comp Psychol 123:131–135
Shimatani Y (2005) Review on research on ecological engineering in JSCE. J JSCE 804:3–9
Shimatani Y (2016) Environment and disaster prevention. J Jpn Soc Hydrol Water Res 29:105–106
Shimatani Y, Nakano K, Taura F (2020) Record of 2017 village meeting after heavy rain disaster in northern Kyushu: 46 reconstruction newspapers published at 17 villages –From despair to hope. Amazon Services International, p 185
Shrauger JS (1975) Responses to evaluation as a function of initial self-perceptions. Psychol Bull 82:581–596
Sigmund K (2007) Punish or perish? Retaliation and cooperation among humans. Trends Ecol Evol 22:593–600
Sigmund K, Hauert C, Nowak M (2001) Reward and punishment. Proc Natl Acad Sci U S A 98:10757–10762
Simon H (1947) Administrative behaviour. Free Press, New York, p 384
Simon H (1969) The sciences of the artificial. MIT Press, Cambridge, p 248
Simons TL, Peterson RS (2000) Task conflict and relationship conflict in top management teams: the pivotal role of intragroup trust. J Appl Psychol 85:102–111
Snyder CR (2015) Hope theory: rainbows in the mind. Psychol Inq 13:249–275
Sohrab SG, Waller MJ, Kaplan S (2015) Exploring the hidden–profile paradigm: a literature review and analysis. Small Group Res 46:489–535
Sokh H, Iida S (2001) Community forestry models in southeast Asia and Cambodia – a comparative study. J Fac Agric 46:113–121
Soll JB, Milkman KL, Payne JW (2015) A user's guide to debiasing. In: Keren G, Wu G (eds) Wiley-Blackwell handbook of judgment and decision making. Wiley, New York, pp 924–951
Stasser G (1988) Computer-simulation as a research tool: the discuss model of group decision-making. J Exp Soc Psychol 24:393–422. https://doi.org/10.1016/0022-1031(88)90028-5
Stasser G, Titus W (1985) Pooling of unshared information in group decision making: biased information sampling during discussion. J Pers Soc Psychol 48:1467–1478. https://doi.org/10.1037/0022-3514.48.6.1467
Subramanian SM, Chakraborty S, Ichikawa K (2016) Toward mainstreaming concepts and approaches of socio–ecological production landscapes and seascapes (SEPLS): lessons from the field. In: UNU–IAS and IGES (ed) Mainstreaming concepts and approaches of socio–ecological production landscapes and seascapes into policy and decision–making (Satoyama initiative thematic review 2). United Nations University Institute for the Advanced Study of Sustainability, Tokyo, pp 1–12
Sustain CR (2002) The law of group polarization. J Polit Philos 10:175–195

Takeuchi K (2010) Rebuilding the relationship between people and nature: the Satoyama initiative. Ecol Res 25:891–897
Taylor SE, Armor DA (1996) Positive illusions and coping with adversity. J Pers 64:873–898
Taylor SE, Brown JD (1988) Illusion and well–being: a social psychological perspective on mental health. Psychol Bull 103:193–210
Taylor SE, Brown JD (1994) Positive illusions and well-being revisited: separating fact from fiction. Psychol Bull 116:21–27
Taylor MJ, McNicholas C, Nicolay C, Darzi A, Bell D, Reed JE (2013) Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. BMC Qual Saf https://doi.org/10.1136/bmjqs-2013-001862
Thagard P (2014) The cognitive science of science: explanation, discovery, and conceptual change. MIT Press, Cambridge, p 378
Thaler RH, Sunstein CR (2003) Libertarian paternalism. Am Econ Rev 93:175–179
Tokunaga S, Akiho R (2018) Consideration for building community-based citizenship education: treasure of the Island project of Kami Tsushima High School as a case study. Decis Sci 4:5–32
Tooby J, Cosmides L, Price ME (2006) Cognitive adaptations for n-person exchange: the evolutionary roots of organizational behavior. Manag Decis Econ 27:103–129
Top N, Mizoue N, Kai S, Nakao T (2004) Variation in woodfuel consumption patterns in response to forest availability in Kampong Thom Province, Cambodia. Biomass Bioenergy 27:57–68
Toyama H, Kajisa K, Tagane S, Mase K, Chhang P, Samreth V, Ma V, Sokh H, Ichihashi R, Onoda Y, Mizoue N, Yahara T (2015) Effects of logging and recruitment on community phylogenetic structure in 32 permanent forest plots of Kampong Thom, Cambodia. Philos Trans R Soc B 370:20140008
Tversky A, Kahneman D (1973) Availability: a heuristic for judging frequency and probability. Cogn Psychol 5:207–232
Tversky A, Kahneman D (1974) Judgment under uncertainty: heuristics and biases. Science 185:1124–1131
UN (2015) Transforming our world: The 2030 agenda for sustainable development. Outcome document for the UN summit to adopt the post–2015 development agenda: draft for adoption
UNESCO (1996) Biosphere reserves: the Seville strategy & the statutory framework of the world network. UNESCO, Paris
UNESCO (2020) Biosphere reserves. https://en.unesco.org/biosphere. Retrieved on 5 May 2020
UNU–IAS and IGES (2015) Enhancing knowledge for better management of socio-ecological production landscapes and seascapes (SEPLS) (Satoyama Initiative Thematic Review vol. 1). United Nations University Institute for the Advanced Study of Sustainability, Tokyo
UNU–IAS and IGES (2016) Mainstreaming concepts and approaches of socio-ecological production landscapes and seascapes into policy and decision–making (Satoyama Initiative Thematic Review vol. 2). United Nations University Institute for the Advanced Study of Sustainability, Tokyo
UNU–IAS and IGES (2017) Sustainable livelihoods in socio-ecological production landscapes and seascapes (Satoyama Initiative Thematic Review vol. 3). United Nations University Institute for the Advanced Study of Sustainability, Tokyo
UNU–IAS and IGES (2018) Sustainable use of biodiversity in socio–ecological production landscapes and seascapes and its contribution to effective area–based conservation (Satoyama Initiative Thematic Review vol. 4). United Nations University Institute for the Advanced Study of Sustainability, Tokyo
Valentini A, Taberlet P, Miaud C, Civade R, Herder J, Thomsen PF, Bellemain E, Besnard A, Coissac E, Boyer F, Gaboriaud C, Jean P, Poulet N, Roset N, Copp GH, Geniez P, Pont D, Argillier C, Baudoin JM, Peroux T, Crivelli AJ, Olivier A, Acqueberge M, Le Brun M, Møller PR, Willerslev E, Dejean T (2015) Next–generation monitoring of aquatic biodiversity using environmental DNA metabarcoding. Mol Ecol 25:929–942
van Lange PAM, Joireman J, Parks CD, Dijk EV (2013) The psychology of social dilemmas: a review. Organ Behav Hum Decis Process 120:125–141

Vukasovic T, Bratko D (2015) Heritability of personality: a meta–analysis of behavior genetic studies. Psychol Bull 141:769–785
Wals AEJ, Brody M, Dillon J, Stevenson RB (2014) Convergence between science and environmental education. Science 344:583–584
Walters CJ (1986) Adaptive management of renewable resources. Macmillan, New York, p 374
Wason PC (1960) On the failure to eliminate hypotheses in a conceptual task. Q J Exp Psychol 12:129–140
Watkins MD, Bazerman MH (2003) Predictable surprises: the disaster you should have seen coming. Harv Bus Rev 81:72–80
Weinstein ND (1980) Unrealistic optimism about future life events. J Pers Soc Psychol 39:806–820
Wilson EO (1975) Sociobiology: the new synthesis. Belknap Press of Harvard University Press, Cambridge, p 720
Wilson JM, Straus SG, McEvily B (2006) All in due time: The development of trust in computer-mediated and face-to-face teams. Organ Behav Hum Decis Process 99:16–33
Wittenbaum GM, Hollingshead AB, Botero IC (2004) From cooperative to motivated information sharing in groups: moving beyond the hidden profile paradigm. Commun Monogr 71:286–310
Wondolleck JM, Yaffee SL (2000) Making collaboration work: lessons from innovation in natural resource management. Island Press, Washington, DC, p 277
Yahara T (2006) Deer increase and the extinction risk of wildlife. In: Yumoto T, Matsuda H (eds) Deer eat world heritage. Bun–ichi Sogo Shuppan, Tokyo, pp 168–187
Yahara T (2011) 50,000-year history of human environmental use and lessons for a society in harmony with nature. In: Yumoto T, Matsuda H, Yahara T (eds) What is environmental history. Bun-ichi Sogo Shuppan, Tokyo, pp 75–104
Yahara T, Ohba H, Murata J, Iwatsuki K (1987) Taxonomic review of vascular plants endemic to Yakushima Is., Japan. J Fac Sci 14:69–119
Yamagishi T (1986) The provision of a sanctioning system as a public good. J Pers Soc Psychol 51:110–116
Yokota F, Biyani M, Islam R, Ahmed A, Nishikitani M, Kikuchi K, Nohara Y, Nakashima N (2018) Lessons learned from co-design and co-production in a portable health clinic research project in Jaipur District, India (2016–2018). Sustain 10:4148. https://doi.org/10.3390/su10114148
Yunus M (2007) The nobel peace prize 2006 - nobel lecture. Law Business Rev Am 13:267–275
Yunus M (2010) Building social business. The new kind of capitalism that serves humanity's most pressing needs. Public Affairs Books, New York, p 256
Yunus M, Moingeon B, Lehmann-Ortega L (2010) Building social business models: lessons from the Grameen experience. Long Range Plan 43:308–325
Zhang M, Tagane S, Toyama H, Kajisa T, Chhang P, Yahara T (2016) Constant tree species richness along an elevational gradient of Mt. Bokor, a table–shaped mountain in southwestern Cambodia. Ecol Res 31:495–504

Part II
Lessons Learned from Trans-Disciplinary Studies in Local Communities

Chapter 2
How Can We Develop a Co-design, Co-production, and Co-delivery Process Toward a Sustainable Local Society? Comparative Study on Transdisciplinary Research Projects

Yasunori Hanamatsu, Takahiro Fujiwara, Nariaki Onda, Tatsuro Sato, Tomomi Yamashita, and Fumihiko Yokota

Abstract This chapter will introduce the results of a comparative, interdisciplinary joint research on transdisciplinary research (TD), conducted by three social science researchers and three natural science researchers who work at the Decision Science Center for a Sustainable Society, Kyushu University (Institute of Decision Science for a Sustainable Society, Kyushu University, IDS3). Since the beginning of IDS3's Future Earth project, or before the project became a global research program, all of us had engaged with TD research in our own local fields and disciplines, to solve local social problems while interacting with various social stakeholders. Our disciplines include public health, forest management, natural regeneration in paddy fields, small hydropower generation, local governance, and tourism promotion. While sharing the results of our TD projects among ourselves, we found some common questions and problem perspectives on Future Earth, mainly from the point of view of social science. In this chapter, we will present the outcome of our

Y. Hanamatsu (✉)
Faculty of Law, Kyushu International University, Kitakyushu, Japan
e-mail: hanamatsu@law.kiu.ac.jp

T. Fujiwara
Faculty of Agriculture, Kyushu University, Fukuoka, Japan

N. Onda
Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Japan

T. Sato
Disaster Risk Reduction Research Center, Graduate School of Engineering, Kyushu University, Fukuoka, Japan

T. Yamashita
Academic Research and Industrial Collaboration Management Office, Kyushu University, Fukuoka, Japan

F. Yokota
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_2

comparative joint research, including our common questions, perspectives, and problem setting on Future Earth and TD research. Then, we will propose some hypothetical indicators for the conditions and requirements for achieving successful "co-design/co-production/co-delivery."

Keywords Stakeholding · Scaling · Framing · Coordination · Sensitivity · Legitimacy

1 Introduction

This part will introduce the results of a comparative, interdisciplinary joint research on Transdisciplinary Research (TD), conducted by three social science researchers and three natural science researchers who work at the Decision Science Center for a Sustainable Society, Kyushu University (Institute of Decision Science for a Sustainable Society, Kyushu University, IDS3).

Since the beginning of IDS3's Future Earth project, or before the project became a global research program, all of us had engaged with TD research in our own local fields and disciplines, to solve local social problems while interacting with various social stakeholders. Our disciplines include public health, forest management, natural regeneration in paddy fields, small hydropower generation, local governance, and tourism promotion. While sharing the results of our TD projects among ourselves, we found some common questions and problem perspectives on Future Earth, mainly from the point of view of social science. Then, we set up a collaborative research group in the summer of 2017 and held several study meetings to answer our own questions.

In this chapter, we will present the outcome of our comparative joint research, including our common questions, perspectives, and problem setting on Future Earth and TD research. Then, we will propose some hypothetical indicators for the conditions and requirements for achieving successful "co-design/co-production/co-delivery" (Future Earth 2013).

2 Questions and Perspectives

2.1 Scale-Sensitivity

The first problem perspective is the geographical scale of the research topic. Future Earth aims to resolve global issues such as global warming and global-scale loss of biodiversity. We can frequently see several words that focus on the global scale in the Future Earth-related documents such as "dynamic planet," "global sustainability," "global change," "global innovation," "globally recognized model," and "global environmental and social change" (Future Earth 2013, 2014). The Future

Earth Initial Science Report clearly states that Future Earth will limit its scope to research that helps solve global issues (Future Earth 2013). On the other hand, the effects and responses to non-global geographical and spatial scales such as national, regional, and local are also mentioned. However, they are recognized just as an "object" affected by global environmental change, or as a "means" to take action toward global sustainability. In particular, local scales and actors must be mobilized for global problem solving, and local-scale initiatives are expected to be "scaled up" to a global scale (Future Earth 2013, 2014).

However, in our experience of TD research for problem-solving on a local site, various initiatives for sustainability on local sites are not necessarily taken for the purpose of resolving global issues. Sustainability problems that arise only within a local context are certainly present and being tackled on a local scale, in line with the actual needs of the relevant local communities. They may eventually lead to global sustainability; however, this is not their main purpose. Local stakeholders are rarely aware of the scale-up logic. They may use global knowledge such as academic knowledge in the problem-solving process. However, resolving local issues in cooperation with local actors to meet local needs does not aim at global sustainability. Then, are such local-scale initiatives toward local sustainability *not* covered by Future Earth research?

How is the hierarchy that the upper, global scale is given priority over the lower, local-scale justified? (Jasanoff 2010; O'Brien and Barnett 2013; Turnhout and Boonman-Person 2012; Jonas 2015). Environmental changes are extending on a global scale, yet the act of prioritizing the global scale as the main object and purpose of problem-solving creates yet another problem. Scale-setting or scale-framing that gives a priori priority to the global scale is a political action in itself, referred to as "politics of scale" by scholars of political geography (Kurtz 2003; Smith 1992; Swyngedouw 1997, 2004; Yohannan et al. 2014). By putting too much emphasis on global environmental change and sustainability, Future Earth seems to have fallen into a trap of "scale politics" whether consciously or unconsciously.

On the other hand, are there any local problems or solutions that do not directly have global implications but are not at all related to the problem of global scale, both physically and epistemologically? From the perspective of political geography, global is not a scale that exists independently of the local scale; rather, it is an accumulation of locality. Therefore, we can say that the reality of the global is "multi-local" (Herod 2011). On the other hand, from the viewpoint of governance, the idea of "multi-level governance" is important. In this concept, various governmental and non-state actors that have a cross-scale jurisdiction of global, regional, international, national, and local, will set and solve a problem while always interacting in a networked system (Bache and Flinders 2004; Latham 2002). In addition, the concept of multilevel governance does not employ any hierarchy that prefers a particular scale. It assumes that the political relationship between scales is "flat" and that different scales or frames can coexist (Jonas 2015; Yohannan et al. 2014). Therefore, the problem setting itself, which might initially focus on a single scale, is likely to change by interacting or communicating with other scales.

In this way, resolving local issues based on local needs in a local field should be included in the scope of Future Earth research, without premising that such local initiatives will directly contribute to sustainability on a global scale or will be scaled up to the global scale. Otherwise, the research range of Future Earth will be very limited and the value of Future Earth research will be reduced, while seemingly geographical scale is extended to the global scale.

2.2 Can Science Transform Society for Sustainability?

The second perspective is the relationship between "social transformation to sustainability" and the role of science. Future Earth aims for social transformation toward global sustainability. For that purpose, Future Earth will "deliver products and services that we societal partners need to meet these challenges," and these "products and services" refer to "integrated Earth system models" and "science-based data, tools, and resources" (Future Earth 2014). Furthermore, Future Earth will "pioneer approaches to co-design; and co-produce solutions-oriented science, knowledge, and innovation for global sustainable development" (Future Earth 2014). Such "science" and "knowledge" refer to not only natural sciences but also to those co-created with social science, humanities, and social partners (partners in society). However, it is assumed that some scientific or technological models and tools are developed, and based on them, social transformation is promoted.

Why do we have to transform society based on scientific knowledge, tools, and assessment? Are scientific methods and knowledge really needed to enhance the sustainability of society? Is it impossible to create a sustainable society without science? (Brown et al. 2010). Is it possible for science and scientists, who value neutrality and objectivity, to be a player in social transformation, along with other social stakeholders? (Pielke 2007).

Future Earth stands on the premise of the possibility and legitimacy of social transformation based on science. In this respect, Future Earth depends on the assumption that science will respond to the needs of and be useful for society. However, at the root of the concept of "useful science for society", there is an excessive expectation for science, as if scientific development will automatically contribute to the solution of problems such as global environmental problems (Asayama et al. 2017). From the viewpoint of social science, it is necessary to question the premise itself. In other words, the usefulness, efficacy, and acceptability of science or scientific methods for society must be considered and verified. Further, one should ask, on what conditions scientific knowledge, tools, and resources can help to improve the sustainability of society? In short, one must critically reconsider the premise "science can transform society for sustainability."

The problem of environmental change and sustainability—Future Earth's main target—is a problem of scientific uncertainty and a conflict of values. Therefore, it is often said that it is difficult to solve this problem only by the power of science. Such inherent problems in science have been noted in recent years as "trans-science"

(Weinberg 1972), "post-normal science" (Funtowicz and Ravetz 1993), "wicked problems" (Brown et al. 2010), and so on. This also indicates, on the contrary, that various nonscientific elements can influence social transformation. In that sense, the validity of the scientific method, the reasonable range of science toward social transformation, and the relationship between "scientific" and "unscientific" must be re-examined in resolving sustainability problems at all scales.

2.3 Interdisciplinary Research

The third perspective is the method of cooperation between natural science and social science in Future Earth research. Future Earth does not necessarily look at research only from a natural scientific perspective. It also strongly urges social scientists to collaborate with social stakeholders and links with social policies and practices (Stafford-Smith et al. 2012). In addition, it also recommends the complete "integration" of all scientific disciplines, including not only natural and social sciences but also humanities and science technology (Future Earth 2013, 2014). However, in the Future Earth documents, such "integration" first assumes the problem setting or goal of "global sustainability" and "social transformation" as set up by natural scientists. Then, it requires social scientists to develop a method to promote social transformation, to analyze and evaluate social issues and impacts arising in the course of social transformation, and to identify sociocultural, economic, institutional, and political barriers that discourage social transformation (Future Earth 2014).

However, is the role of social science only to implement the research design drawn by the natural sciences and to carry out a "saucer" to examine the social effect and influence of the research implementation? (Werlen 2015; Hanamatsu 2012). Is social science a contractor for the work of developing methods to solve the problems set by natural science and practice at the social level? Have social scientists been given sufficient opportunity to share a critical examination of the appropriateness of the problem settings and goals presented by natural science? (Werlen 2015). Fundamentally, the role of social science is to critically examine and recognize from all angles all phenomena, ideas, and representations that arise or may arise in human society. In that case, social scientists must examine the Future Earth project itself and critically reconsider Future Earth's way of problem setting such as global sustainability and social transformation. While Future Earth is aimed at "solutions-oriented research" (Future Earth 2014), social science is quite sensitive about who, and for what purpose, determined the problem setting and goal so that a solution can be offered afterward. In other words, we must look at the natural scientific view of "nature" and "world" that appears in the method of problem setting.

Similarly, the recent discussion of the "anthropocene" is based on the image and framing of the "desirable climate" or "desirable environment" provided by natural scientists, emphasizing the tremendous damage of climate change and the urgent need for a response. This trend requests all humankind and society to tackle such

urgent problems as if such a contribution was “fatal” and “inevitable” (Zalasiewicz et al. 2010). Even though climate change came to be extensively discussed in the political realm, it has been pointed out that “de-politicization” has occurred in that it becomes difficult to put objections to the problem setting and recognition (Swyngedouw 2011; Lövbrand et al. 2015). In this sense, social science must not only reveal the ideal way of using science and technology from the perspective of society, the appropriate position of scientists in society, and the conditions in which society accepts science and technology, but it should also re-examine critically and politically how the problem setting by natural science will affect people and society (Swyngedouw 2014).

Interdisciplinary research and integration of scientific disciplines do not imply that one discipline should capture the other. It is crucial to recognize that natural sciences and social sciences have their own unique logic in their purpose, culture, object, perspective, and methodologies. This is the starting point that could turn interdisciplinary research into a fruitful success (Werlen 2015). Three social scientists from our research group have been actively involved in collaborative research with natural science researchers. They have conducted cross-disciplinary research activities while utilizing the knowledge of both social science and natural science. The other three are natural scientists; however, since they have been involved in the local community for their research for a long time, they have a wealth of social experience and insight into society. Therefore, we thought that we should all share this understanding of interdisciplinary research and undertake a critical study of Future Earth research where the impact of natural scientific ideas seems to be strong, from the perspective of social science.

2.4 What Is Society? Who Are Stakeholders?

The fourth perspective is the need for a concrete consideration of “society” and “social stakeholders.” Future Earth recommends collaboration between science and society in response to global environmental change and realization of global sustainability (Future Earth 2013). However, in the Future Earth documents, the image of “society” is unclear; it is a general and abstract image. As a result, it seems to assume a planar, flat, abstract, and single society. However, society is originally diverse in context, multi-layered, and individually specific. It includes families, companies, schools, circles, civic organizations, settlements, districts, municipalities, states, national relations, regions, and the global. There exists different type of societies at all scales. What kind of society can Future Earth envision for its purpose?

In addition, Future Earth recommends that the knowledge necessary for social transformation should be created together with social partners (partners in society, or societal partners) or “stakeholders” (Future Earth 2014). What kind of people and organizations does Future Earth assume as partners and stakeholders in society? While any person who has interests in a problem or issue can be considered a

stakeholder, what kind of stakeholders does Future Earth research expect to cooperate with?

The Future Earth Initial Science Report enumerates major stakeholder groups in Future Earth studies: academic research (scientists, research institutes, universities, and scientific committees), research funders, governments (national, regional, and international), development groups (e.g., the World Bank), business and industry, media, and civil society (e.g., NGOs) (Future Earth 2013). As such, Future Earth seems to focus on people and organizations that have an influence on global social transformation and that can rationally act (Future Earth 2014). However, can we say that we have successfully collaborated with the "society" itself only by cooperating with specific governmental agencies or NGOs? Is this not just working with some of the social entities that exist at a certain level or scale of "society"? In other words, only a convenient subject that is useful for the transformation of society can be selected and recognized as a "stakeholder." As we will see later, such a political selection of stakeholders should be called "stakeholding" (Freeman et al. 2010; Mitchell et al. 1997). How should such "stakeholding" be done in Future Earth studies?

Also, are we researchers and scientists well aware that we will participate in a collaborative work as one of stakeholders who stand on equal footing with other stakeholders? Is it possible for scientists to participate as a stakeholder with a substantial interest and simultaneously be able to balance the "neutrality" and "objectivity" that scientists consider important? Furthermore, is it possible for scientists and researchers to be responsible for the role of the coordinator who is essential for working with society? The position of researchers and scientists in the collaborative process is a critical matter. However, Future Earth does not pay attention to this point.

The tendency of Future Earth to simplify and overgeneralize the concepts of "society" and "social stakeholder" is indeed paradoxical. Environmental and sustainability research deal with environmental change at the global level, and an urgent response to it as "the problem of human dimensions" (Future Earth 2013). As a result, on the one hand, the need for an urgent response to environmental change at the global scale has come to be properly understood; on the other hand, understanding of the diversity, multilayeredness, and dynamic change in society, and the social sensitivity to various concrete people and groups who live and work in a society is being lost (O'Brien and Barnett 2013). In other words, the greater emphasis on the influence of environmental change on the "human species" conversely deprives people of a concrete concern for individuals, societies, and stakeholders. This trend will reduce the value and scope of Future Earth research that seeks to collaborate with society.

The kind of society in which we often collaborate in TD research is the "local society." In such local societies, the local government and local businesses, illustrated by Future Earth as major stakeholders, are just part of the society; they are not representative of the local society. Then, is it possible to say that we collaborate with society itself by merely cooperating with such kind of people and organizations? Local people or residents are the main components of local society. In the

stakeholders' list of Future Earth documents, local people seem to be classified as "civil society." However, "civil society" is a very ambiguous and controversial concept, and there is a wide variety of definition and scope in what kind of persons are actually contained in "civil society" (Ehrenberg 2017). For example, a subject that is independent of the government, forms a nonprofit organization, and actively and rationally participates in a public political space is often referred to as civil society. In Future Earth documents, NGOs and indigenous peoples are often cited as civil society. Therefore, it is understood that Future Earth considers civil society as an active subject in social transformation. However, people living in a local society are not only such active residents. There are both "good citizens" and "bad citizens." It is often the case that many local people are regular citizens who are non-rational and indifferent to public matters (Edwards 2014). Actual collaboration with local society always requires a close relationship with not only active citizens or organizations but also concrete individuals who are, in some cases, indifferent or negative to public matters. Therefore, it is not possible to talk about collaboration with local society without communicating, discussing and cooperating with a concrete local society composed of such various individuals and organizations. Our research experience with the local society is likely to provide new insights into Future Earth research that tends to emphasize collaboration with society through a general and abstract image.

2.5 Taking the "Co-design/Co-production/Co-delivery" Process Seriously

Finally, the fifth perspective is about the meaning and purpose of "co-design/co-production/co-delivery" between science and society in Future Earth research. As mentioned above, Future Earth aims at "solutions-oriented research" and is intended to acquire scientific knowledge to respond to environmental changes and sustainability at the global scale. To obtain such scientific knowledge, scientists and social stakeholders are asked to cooperate with each other for "co-design/co-production/co-delivery" of knowledge (Future Earth 2014). In other words, Future Earth regards "co-design/co-production/co-delivery" as a means to obtain scientific knowledge that can lead to the resolution of problems set up by Future Earth. "Knowledge" (not necessarily scientific) which is obtained by "co-design/co-production/co-delivery" with social stakeholders, and "scientific knowledge, insights, data, and tools that scientists will acquire" are clearly distinguished. Here, unfortunately, Future Earth does not recognize that we can form a new type of knowledge that combines the extrascientific knowledge, perspectives, and experiences of social stakeholders, with the scientific data and the knowledge of academic experts (Van der Hel 2016). In Future Earth, "co-design/co-production/co-delivery" in collaboration between science and society is merely a means to justify that science is relevant and useful to society by showing that science is trying to meet the needs of society and that society accepts science as its user (Van der Hel 2016). Therefore, the knowledge obtained in

the process of "co-design/co-production/co-delivery" is neglected, and just the fact and alibi that "co-design/co-production/co-delivery" of knowledge is successfully done might be overemphasized.

However, as explained throughout this part, from our experiences of TD research on local sites, "co-design/co-production/co-delivery" is not a justification for the usefulness of science; it is a direct way to improve sustainability in local societies. The reason is that any effort to improve the sustainability in a local society is virtually impossible without trying to achieve the "co-design/co-production/co-delivery" with local stakeholders.

In recent years, in Japan, collaboration between universities including scientists and researchers and the local society is currently being actively implemented as an important objective, because "co-design/co-production/co-delivery" with the local society will have a great educational effect on university students and may also contribute to the revitalization of the local society. In such cases, the goal is not to acquire scientific knowledge or justify the usefulness of science.

Moreover, "co-design/co-production/co-delivery" with society cannot be easily achieved. It requires a lot of time, effort, money, and intellectual resources. In other words, "co-design/co-production/co-delivery" with society is not easy enough to be regarded as merely a means to acquire scientific knowledge for global sustainability (Moser 2016). In that sense, collaborative "co-design/co-production/co-delivery" with society is not an alibi for scientists but a major research activity and objective for achieving a sustainable local society.

On the other hand, science should be regarded as a factor that might work in the collaborative "co-design/co-production/co-delivery" process. In other words, science or scientific knowledge can be perceived as one of the driving forces and means to promote successful "co-design/co-production/co-delivery."

In this way, our questions on Future Earth and TD research from a social science perspective are as follows. What kind of conditions, requirements, factors, and processes can enable "co-design/co-production/co-delivery" with society to successfully work? Does science or scientific knowledge actually work as a driving force to promote "co-design/co-production/co-delivery?"

3 Problem Setting

Based on the above-mentioned issues, we set the following problem as a common viewpoint of joint research. Our interdisciplinary research group worked together to compare projects that have long tried to promote "co-design/co-production/co-delivery" with society for developing a sustainable local society. Then, we found some common perspectives for re-examining Future Earth research and developing more fruitful TD research. At what kind of scale does "co-design/co-production/co-delivery" tend to work better? What kind of conditions or factors are required for successful "co-design/co-production/co-delivery?" What kind of stakeholders should we cooperate with? What kind of processes should be followed? To sum

up, what kind of conditions, factors, and processes are necessary for a good "co-design/co-production/co-delivery"?

The key points about this problem setting are as follows. We should focus on the "co-design/co-production/co-delivery" process in a specific local society rather than a general abstract society, without premising that such a process will necessarily make a connection or direct contribution to the solution of global problems such as climate change and global sustainability. We should also focus on what kind of processes "co-design/co-production/co-delivery" will follow, and what we should pay attention to during each phase of the process, rather than emphasizing a fact or result of the "co-design/co-production/co-delivery" in a local society. Furthermore, we must properly understand that there are various overlapping scales in a local society (e.g., settlement, village, town, city, area, region, municipality, and province). In addition, we must recognize that stakeholders are often specifically selected as candidates from among the many actors or organizations, and understand that diverse "framings" of the problem can be simultaneously constructed by each stakeholder and that in some cases a gap or misfit can occur between these "framings." Moreover, from the social science perspective, it is also important to consider who should evaluate the process and results of the "co-design/co-production/co-delivery", because the consequences of the final assessment may change depending on the "framing" or perspective of the evaluator.

Society is a living subject created by whimsical humans. Therefore, the conditions, requirements, factors, and processes of "co-design/co-production/co-delivery" with society are not necessarily arranged from a genuinely scientific perspective. Likewise, other valuable knowledge that can be obtained during "co-design/co-production/co-delivery" is not necessarily scientific. However, we think it is important to rearrange them based on our own indicators from the social scientific perspective. Such indicators remain hypothetical; however, they can be a useful tool for clarifying the conditions, requirements, factors, and processes that would ensure successful "co-design/co-production/co-delivery."

4 Hypothetical Indicators

The indicators to measure the conditions, requirements, factors, and processes for promoting successful "co-design/co-production" are divided into four categories. First, Gap Analysis Indicators (GAI) verify consistency or gaps in understanding and perception among stakeholders about the collaborative work. Second, Social Consideration Indicators (SCI) show various matters requiring the attention of stakeholders and coordinators. Third, Social Evaluation Indicators (SEI) are considered in the social evaluation phase after the completion of co-production. Fourth, there are other considerations classified as Additional Factors (AF).

The hypothetical indicators which seem to belong to each category are as follows. All of these constitute a checklist that scientists and researchers need to carefully consider when collaborating with a local society. Again, it remains hypothetical, but

we think it is the most comprehensive list of indicators to date, enumerating all the factors that are considered important for comparing the Future Earth projects of our joint research members (Yokota et al. 2018).

However, we understand that it may not be a complete checklist that can be applied to other projects. In addition, we have not yet clarified which indicators are more important than others in each phase, what the conditions must be met in any "co-design/co-production/co-delivery" project, or whether there is a logical relationship between each of the indicators. We will examine such issues in future studies.

4.1 Gap Analysis Indicators

4.1.1 Stakeholding

Are appropriate people and organizations correctly selected as "stakeholders" who have a direct or indirect interest? How does the dynamic membership process of including or excluding stakeholders work? Which kinds of stakeholders are selected for what kinds of purposes? What method is used to set up a "limit" of the appropriate stakeholder?

4.1.2 Scaling

What is the geographical, human relational, and jurisdictional scale appropriate for dealing with the problem? How, and by whom, is such scaling set up? Does the problem originate from and can be resolved in a single scale or does it require multilayered scales?

4.1.3 Framing

From what point of view, and by whom, is the phenomenon recognized as a "problem"? Do all stakeholders agree on a single frame for the problem, or is there conflict over various possible frames? Can plural frames converge at a common perspective and coexist or do they clash with each other?

4.1.4 Priority

Is the problem properly recognized as something that should be prioritized among a myriad of "problems" in a society of the specific scale? Who, and by what criteria, decides the priority of problems, and what is their process?

4.1.5 Accountability

Who is responsible or accountable for the processes and results of resolving the problem? Is such a responsibility actually to be carried out? Do stakeholders successfully divide and share the task of problem-solving?

4.1.6 Time Setting

How much time is allowed for resolving the problem? To what extent is the problem an emergency? What is the time range necessary to solve the problem? Who can decide on setting the time?

4.1.7 Transition Process

If gaps occur in indicators 4.1.1-4.1.6 between stakeholders, does the transition process for coordinating these gaps properly function?

4.2 Social Consideration Indicators

4.2.1 Coordination Subject

Who coordinates, or who should coordinate? Is the coordination appropriate? Scientists and researchers are not necessarily responsible for the coordinator. In the context of independence and neutrality in science, other stakeholders (rather than researchers or scientists) should take on the responsibility of acting as coordinators. However, scientists or researchers may have to become coordinators reluctantly, depending on the course of problem.

4.2.2 Social Sensitivity (Awareness of Societal Sensitivity)

Can a coordinator understand and carefully consider the human relationships, history, culture, viewpoints of residents, and intrinsic diversity that exist in a society? Can they fully comprehend the sensitive nature of a society?

4.2.3 Social Capital

Does a coordinator have an established relationship of mutual trust with stakeholders and other people or organizations in local society? Do they carefully consider the various human relationships embedded in local society? (Putnam 1993, 2000).

4.2.4 Fairness/Justice

Does a coordinator demonstrate fair consideration for each stakeholder who has a different framing or priority in the decision-making processes?

4.2.5 Independence/Neutrality

Do stakeholders responsible for coordination roles (especially, scientists and researchers) successfully take an independent, neutral position toward all other stakeholders? Do they fully understand that, in some cases, they will act as one of the stakeholders and cannot remain neutral on a problem?

4.3 Social Evaluation Indicators

4.3.1 Legitimacy

Is the result of the "co-production" to be evaluated as legitimate or relevant by the wider society consisting of specialists, citizens, and potential stakeholders, distinct from the internal evaluation by the stakeholders directly involved in the "co-design/co-production" process? Would the decision-making process be regarded as legitimate by an outside observer? If the result of a "co-design/co-production" project receives a positive evaluation as legitimate by an outsider, it will be applicable to other cases, and finally, the phase of "co-delivery" (dissemination of results) will begin.

The indicator of legitimacy concerns both rationality (or relevance), which requires proper processes, and traditionality (or orthodoxy), in that the "co-production" follows the history, traditions, customs, and culture of the society (Coicaud 2002).

4.3.2 How to Decide?

How is the plan and method for the collaboration project decided?

4.3.3 Who Decides, for Whom and to Whom?

Who decides to start and implement the collaboration project, for whom and to whom?

4.3.4 Usefulness of Science

Are scientific knowledge and technology useful and effective for the planning and implementation of a collaborative project? How effective is the usefulness of science and can stakeholders successfully have trust in science regarding the "co-design/co-production/co-delivery" process distinguished from the authority or power that specific universities, researchers, and scientists usually have? When the usefulness of science is recognized, does it mean that the effectiveness and legitimacy of the scientific data and knowledge itself are evaluated, or the validity and significance of the act of "using science" are socially approved?

4.3.5 Social Sensitivity

Do stakeholders understand and carefully consider the human relationships, history, culture, viewpoints of residents, and intrinsic diversity that exist in a society? Can they fully comprehend the sensitive nature of a society?

4.4 Additional Factors

4.4.1 Personality

What kinds of impacts do the position, character, and personality of each stakeholder (especially those who show important leadership) have on the "co-design/co-production/co-delivery" process? Do the processes and results of "co-design/co-production/co-delivery" depend on the personal factors of a stakeholder?

4.4.2 Integration of Scientific Research and Education

Is the project conducted only as "scientific research" by researchers and scientists, or is it also combined with an educational program? In the latter case, does the integration of scientific research and education actually promote a successful "co-design/co-production/co-delivery" process?

5 Hypothetical Timeline

Based on the hypothetical indicators for assessing "co-design/co-production/co-delivery" as mentioned above, Fig. 2.1 shows a hypothetical timeline of the co-design, co-production, and co-delivery process. It also briefly indicates which

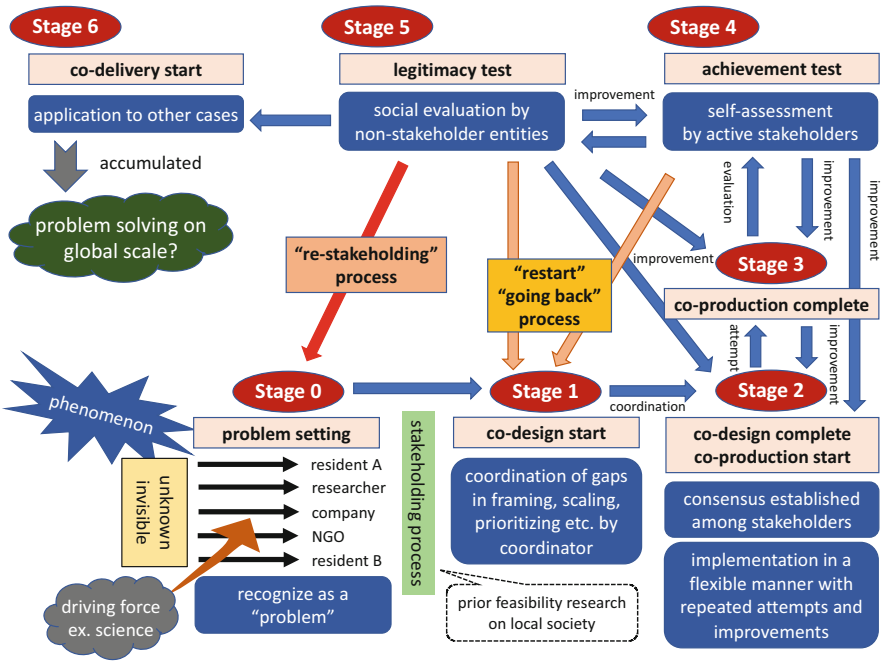


Fig. 2.1 Hypothetical timeline of the co-design, co-production, and co-delivery process

kind of conditions, requirements, and factors matter in which phase of the co-design/co-production/co-delivery.

First of all, some phenomena and events occur in local communities or societies. It is often merely a phenomenon at this point, and is not necessarily recognized as a "problem" that should be resolved. It may be an invisible potential phenomenon in nature or the society that no one local, such as residents or administration, is aware of yet. In that case, some actors outside the local society may alert them to the phenomenon. In particular, scientists have a role of scientifically examining the meanings, mechanisms, and impacts of potential phenomena in nature and society that are invisible to general people and finally "visualizing" an invisible phenomenon. In this sense, the activities of outsiders, including scientists, can be a driving force (a trigger for problem-solving) that raises awareness of a problem to people of a local society.

In some cases, local people notice a phenomenon by themselves, and in other cases, they are made aware by knowledge from an outsider such as scientist. Whatever the case may be, some actors in a local society begin to understand the meaning and influence of a phenomenon and at last recognize it as a "problem." Subsequently, general residents, local government, corporations, and NPOs begin to make a "problem setting," but at this point they still stop at "potential" stakeholders (Stage 0).

In order to solve the problem at the beginning of the collaborative project, "stakeholding" takes place to decide what kind of people and actors should be selected as "stakeholders." Each stakeholder usually has their own image of "framing," "scaling," and "prioritizing" the problem. They examine such images with each other and then the "co-design" phase begins (Stage 1). In the co-design process, stakeholders will check if the factors shown in the Gap Analysis Indicators (GAI) are consistently shared between themselves. When gaps between stakeholders are found, the coordination of these gaps is carried out under the leadership of a coordinator.

If the coordination of these gaps is concluded successfully and some kind of consensus or agreement is established, we can say that "co-design" has been achieved, and the next phase of "co-production" can start (Stage 2). However, it is essential that by the start of "co-production," all stakeholders should complete the work of reconciling their interests through communication and gaining a sense of mutual trust and satisfaction.

After that, stakeholders cooperate with each other to implement the project. This process proceeds in a flexible manner with repeated attempts and improvements. The reason is that social factors, such as interests, human relations, and financial problems among stakeholders, are usually unexpected and may impede or change the project plan. If a certain result is obtained while gradually improved, we can say that the "co-production" has been achieved (Stage 3).

However, this is not the end of the collaborative "co-design/co-production" process. "Co-production" rarely achieves complete problem resolution, and in many cases, it is necessary to repeat the "co-design/co-production" process. Therefore, at the stage where some kind of "co-production" outcome is obtained temporarily, internal evaluation or self-assessment will be carried out by the stakeholders who have jointly implemented the project thus far (Stage 4). Here, they evaluate whether the results of "co-production" are sufficient for the goal, if there was no problem in the "co-production" process. Then, such a temporal evaluation will be reflected in the next round of "co-production" in the form of a correction or improvement to the project. If they think that the result of "co-production" did not produce enough results, they may go back and again try the "co-design" process. In that case, it is not just a correction or improvement, but restarting the project from the "co-design" phase.

After a certain level of satisfactory results have been achieved while repeating internal evaluations, social evaluations by outsiders or non-stakeholder entities will be carried out (Stage 5). The internal evaluation in Stage 4 is self-evaluation by active stakeholders, and in some cases may fall into the category of "self-satisfaction." They may feel relieved that the project has been completed, and the assessment of whether the results actually contribute to problem-solving might be neglected. In addition, if the project was initiated with inappropriate "stakeholding," and those who should participate in the project were not able to, assessment from the perspective of excluded potential stakeholders will be very important. Likewise, it may be evaluated as imperfect because the problem should be dealt with on a larger or smaller scale. In that case, the appropriateness of "scaling" is reconsidered. In

addition, internal stakeholders are likely to remain interested in problem-solving in their own society and are not interested in whether the results of their project can be applied in other cases. Therefore, it will also be important to see how this project will be evaluated from an outsider's perspective.

Thus, in order to examine the possibility of falling into "self-satisfaction," the relevance of "stakeholding," "scaling," and applicability to other cases, the viewpoint of outsiders or non-stakeholder entities is critically important. Social evaluation is open to other potential stakeholders, mass media, residents in other local societies, and people on national or global level who are interested in the problem.

The project will become "legitimate" only after it is fully evaluated from these external viewpoints. If it fails to obtain legitimacy, it may need to be improved, revised, or restarted. It might be required to go back to "co-production" (Stage 2) or "co-design" (Stage 1), or further return to the very first phase of "stakeholding" (Stage 0). More importantly, it is natural to repeat this process of going back and forth. Only after the "co-design/co-production" is repeated, re-examined, and improved, and if it passes the legitimacy test in social evaluation, will there be a possibility of applying it in other places. This phase is called "co-delivery" in the Future Earth framework (Stage 6).

Depending on the nature of the problem, generality of the solution process, and legitimacy of the final result, the conditions, and requirements for a successful "co-design/co-production" demonstrated in a certain society may spread to other regions. If such "co-delivery" cases are accumulated, they may have an impact on problem-solving on a global scale. In other words, although local stakeholders are not necessarily aiming to "scale up," the results of "co-design/co-production" projects and their implications may eventually diffuse to the global scale.

If this is the case, those who are responsible for contributing to global sustainability through the Future Earth framework are not local stakeholders involved in "co-design/co-production," but external subjects or non-stakeholder entities who join in the social evaluation of local projects and consider their applicability to other areas.

6 Hypothetical Outline Map

Figure 2.2 shows a hypothetical outline map that reconstructs the timeline of the "co-design/co-production/co-delivery" process from the perspective of the relationship between each phase. This figure will provide a clearer understanding of what conditions and factors are required in each phase of the collaborative process.

As a brief summary of this chapter, we will point out the six most important matters related to the hypothetical indicators of the conditions or requirements for a successful "co-design/co-production/co-delivery" process and future research issues.

First, it is very natural that various "gaps" arise between stakeholders in the process. Therefore, the starting point of "co-design/co-production/co-delivery" is to

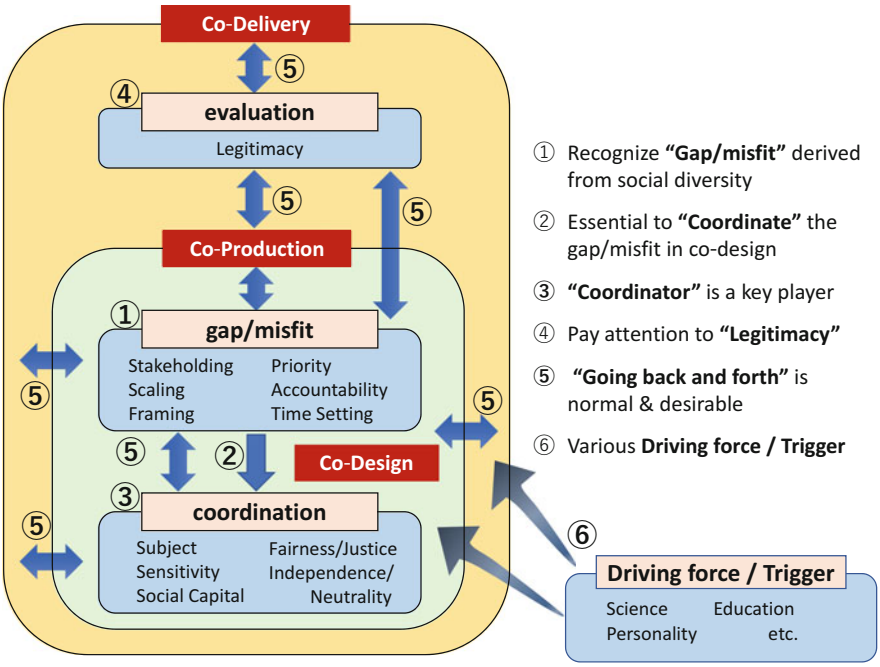


Fig. 2.2 Conditions and requirements for successful "co-design/co-production/co-delivery" in local society

recognize these "gaps" properly. This is a natural consequence of a diverse society, which is by no means monolithic; the problems proposed by scientists or researchers are not necessarily recognized in the same way by local stakeholders.

Second, it is important to fully understand the need to coordinate those "gaps" in all phases of the collaborative "co-design/co-production/co-delivery" process (especially in the phase of "co-design"). If you continue a collaborative project while leaving a "gap" as it is, it will result in the failure of "co-production," render social evaluation as illegitimate, and result in inapplicability to other areas or cases. This would be fatal to Future Earth, which aims to solve problems on a global scale.

Third, the role of a coordinator responsible for the mitigation of a "gap" is very important. The most important role of a coordinator is to build a relationship of mutual trust between stakeholders by keeping social sensitivity toward local interests. However, it is not yet clear what kind of characteristics, aptitudes, abilities, or attributes a coordinator should have, and this is a future issue. When scientists or researchers propose a collaborative "co-design/co-production/co-delivery" project, there are many cases where they will be responsible for coordination work by themselves. In that case, at the very least, we can say that scientists and researchers will be required to have human and social abilities to communicate with all stakeholders in addition to research capacity.

Fourth, in order to ensure the achievement of the "co-design/co-production/co-delivery" project and to secure the possibility of applying the results to other cases, social evaluation of legitimacy by non-stakeholder entities is important. Without the opportunity to test legitimacy, stakeholders may fall into "self-satisfaction" with internal evaluation that does not necessarily result in achieving their goals.

Fifth, the timeline of "co-design/co-production/co-delivery" is not a one-way process, and going back and forth is not only normal but also desirable. In "co-design/co-production/co-delivery" projects where the prospect of problem-solving is unpredictable and stakeholders with various interests are involved, it is quite rare for the original plan to proceed on schedule, and it is rather natural to repeat a continuous process of trial and error. By experiencing trial and error, it becomes possible to recognize and eliminate "gaps" between stakeholders and finally build a relationship of mutual trust. In other words, in the "co-design/co-production/co-delivery" process, we should aim for flexible management that allows for the possibility of modifying or reworking the project, rather than strictly setting a plan or goal.

Sixth, there are some factors that will function as a driving force or trigger for promoting successful "co-design/co-production/co-delivery." They include the role of science in informing local stakeholders about the existence of problems, the combination of academic research and educational programs, and the personality attributes of key stakeholders that will affect these projects for better or worse. However, future research topics remain to consider whether there are other elements and what kind of effects they may have on the process.

7 Conclusion

In this chapter, we introduced our perspectives on Future Earth research and our own problem setting. Then, we proposed hypothetical indicators for the conditions, requirements, and processes for successful "co-design/co-production/co-delivery." Although such indicators still remain to be explored further, each chapter of this part will introduce and analyze each case based on this hypothesis. Table 2.1 is a list showing an outline of the analyses carried out based on the hypothetical indicators. Subsequent chapters will show the difficult struggles in executing "co-design/co-production/co-delivery" in local societies.

Table 2.1 Outline of the case studies in part 2 based on the hypothetical indicators

① *Gap Analysis Indicators (GAI)*: Indicators to measure gaps between stakeholders					
	Yokota (India PHC)	**Sato (Indonesia Small hydropower)**	**Fujiwara・Onda (Indonesia Industrial tree plantation)**	**Hanamatsu・Tokunaga (Kami-tsushima high school)**	**Hanamatsu・Yamashita (Tsushima Abandoned land)**
Stakeholding	Multiple stakeholders with different project time phases since 2015. Stakeholders include Jaipur District Department of Medical, Health, and Family Welfare, Kalwar Village, Village Health Center, Saras Dairy, Lotus Dairy Company, Biyani Group of College, Grameen Communications, Kyushu University	Residents, Leader of traditional community, Involved, local government, researchers, NPOs and private companies. As the project progressed, the network of stakeholders gradually expanded. Active stakeholders change by phase.	Kyushu University, Company, NGOs, Residents, Government (there are conflicts within each stakeholder)	Stakeholders include Kami-Tsushima High School, Tsushima City, Tsushima Commerce & Industry Association, Local businessmen, Kyushu University. The scope of stakeholding was properly limited.	Stakeholders include Village A, Tsushima City, Kyushu University. However, the Tsushima City's temporary official staff as a good coordinator withdrew from the project halfway. On the other hand, Village A claimed a wider stakeholding.
Scaling	Kalwar Village (12,000 population) & Saras Dairy Manda Factory (500 employees)	Regional / district scale (Ciptagelar village), but similar problems can be seen in various places.	Industrial tree plantation (approximately 300,000 ha), scale depends on each problem (e.g., biodiversity conservation, land conflict, economic development)	Hitakatsu Area (900 population in 400 households) The geographical, societal scale were appropriate for the purpose of the project.	Village A (180 population in 100 households) There was a gap on the perception of scaling. Whereas Kyushu University group limited the scale into the village, Village A claimed a wider scale.
Framing	Framing is 「non-communicable disease prevention」. It was agreed with all stakeholders.	The problem of sustainable energy self-sufficiency in remote rural areas.	Biodiversity conservation, economic development, the rights and livelihoods of residents; the framing differs by company, NGO, residents, and scientists.	Two framing was successfully agreed with all stakeholders; changing consciousness of the local people & educating the local high school students about the local community.	There was a great gap on the perception of framing. Kyushu University group expected the reconversion of abandoned farmland with biodiversity and high profits by making use of external manpower. However, Village A thought that the problem of abandoning farmland was entirely caused by harmful wildlife damage.
Priority	Not yet discussed about [Priority] with local residents but with other stakeholders, it is agreed that our priority to a prevention of non-communicable diseases	・Residents: Stable electricity supply, Increase in cash income ・Customary community leader (Abah): Stable electricity supply, Conservation of traditional culture ・Researchers: Looking for ways to use renewable energy sustainably in remote areas ・Local government: Improvement of electrification rate	・Companies: maximizing profits and improving reputation in the international community ・NGO: emphasizing on human rights and environmental conservation ・Resident A: regaining land rights ・Resident B: expecting an increase in income ・Kyushu University: mediating between NGOs and company to promote collaboration; conserving biodiversity in protected areas of the company	All stakeholders agreed on the priority of changing consciousness of the local people and educating the local high school students about the local community by conducting continuous elaborate meetings. Based on such an agreement, each stakeholder pursued their own interest and role.	There was a great gap on the priority. Kyushu University group expected the reconversion of abandoned farmland. However, Village A gave priority to the resolution of harmful wildlife damage.
Accountability (Responsibility)	Shared cost and shared responsibilities were agreed among Kyushu University, Biyani College, Grameen Communications, and Lotus Dairy Company in 2019.	・Local government is responsible for improvement of electrification rate ・Local community is responsible for electricity supply to the residents ・Researchers support the sustainable electricity self-sufficiency	・Companies: responsibility for forest protection and land conflicts in industrial tree plantation areas ・Kyushu University: other stakeholders expressed concern about responsibility for taking part in greenwash.	All stakeholders agreed on the sharing of responsibility. High school wished to continue project and take responsibility byitself in collaboration with Tsushima City and Tsushima Commerce & Industry Association, even after the withdrawal of Kyushu University from the project.	Joint project and shared responsibilities were pursued, but village A hoped that Kyushu University group should have assumed the responsibility of the project.
Time Setting	No urgency for time setting but for long term time setting is more required to achieve our project objectives (reduce new cases of non-communicable diseases (NCDs), increase awareness, treatment, and control of NCDs)	Electricity supply is essential for modern life. The power outage problems should be immediately resolved.	・Company: making efforts to improve reputation as a priority issue. ・Kyushu University: hoping to start conservation activities as soon as possible because there are rare plant species in the protected areas of the company	The project was proposed in 2015, first tried in 2016 and developed in and after 2017. Trial and error was to some degree achieved. No urgency for time setting of the project. However, as the project is concerned with education and change of consciousness in local people, more long time setting is required to achieve the project objectives.	Village A recognized no urgency of the reconversion of abandoned farmland. However, it required an urgent resolution of harmful wildlife damage. Kyushu University group did not have much time left before the end of the research period and were urgent to start the project.
Transition Process	No major conflicts or gaps among stakeholders	No major conflicts or gaps among stakeholders	There is a conflict, but no time to resolve it. Kyushu University and the company collaborated in the biodiversity assessment, but it was not earned a reputation from other stakeholders.	No major conflicts or gaps among stakeholders (By conducting continuous elaborate meetings in co-design phase, each stakeholder's interests and intentions are mutually harmonized and coordinated.)	Great gaps on framing, scaling, stakeholding, priority, responsibility. There was no enough time for coordinating such gaps.

(continued)

Table 2.1 (continued)

② *Social Consideration Indicators (SCI)*: Indicators which coordinators should consider during the coordination process					
	Yokota (India PHC)	**Sato (Indonesia Small hydropower)**	**Fujiwara・Onda (Indonesia Industrial tree plantation)**	**Hanamatsu・Tokunaga (Kami-tsushima high school)**	**Hanamatsu・Yamashita (Tsushima Abandoned land)**
Coordination Subject	Biyani Group of Colleges	Kyushu University, AHB (Association of Hydro Bandung, just like NPO)	Kyushu University (However, it has not yet been coordinated within teams of Kyushu University. Kyushu University has a team that emphasizes collaboration with the company and a team that has a critical view of the company, and each team works with different stakeholders.)	The main coordinator is a municipal temporary official staff whereas this project was jointly coordinated by high school, Tsushima City and Kyushu University.	The coordinator is a municipal temporary official staff. However, Kyushu University group by itself tried to play the role of the coordinator after the municipal temporary official withdrew from the project.
Social Sensitivity	Consultation and communication with local, district, state level governments are already done but with target community residents are not yet done	Kyushu University, as a project organizer, tried to understand the local cultures, history, Socio-economic circumstances, and visit the site as much as possible using student training program. However, there was a limitation to visit overseas sites.	Insufficient although it is necessary to fully hear the opinions of each stakeholder and carefully present data while maintaining independence because there are severe conflicts among stakeholders	Consultation and communication with high school, local businessmen and residents were sufficiently done. Much attention has been paid to human relationship in local community.	Lack of social sensitivity to a local community as Kyushu University group did not carried out a detailed hearing investigation to the resident in the village. We did not fully understand the needs and priority of the community.
Social Capital	To develop and strengthen social capital, Kyushu Univ. team had multiple face to face meetings/discussions with Biyani Group of College (total of 12 times), with local, district, and state governments (2 times each), and other stakeholders.	By visiting the village as much as possible (3-4 times a year), talking and investigating together, human relations and trusting relationships were gradually nurtured.	Trusting relationships have not been developed among conflicting stakeholders so far.	Robust trust relationships between stakeholders was successfully built owing to a continuous elaborate meetings and communication between high school students and university group members.	Kyushu University group failed to build a trust relationship with the leader, main members and other residents of the village A. There was not enough time left for bringing about a relationship of trust with the village.
Fairness / Justice	All stakeholders agreed that "prevention of non-communicable diseases" and "improving an access to health services" are important and basic human right.	Because the power of the leader (Abah) was great, we took care to draw out the real intentions of the local residents as much as possible.	Kyushu University did not give appropriate consideration to conflicting company, NGOs, and residents while maintaining independence (e.g., publishing research results in the media of the company)	High school, Tsushima City and Kyushu University conducted continuous elaborate meetings on an equal status, and transmitted fully the result of meeting to Tsushima Commerce & Industry Association. Fair attention had been paid to all stakeholders.	No fairness and justice in that Kyushu University group did not carried out a detailed hearing investigation to the resident in the village and not fully understand the needs and priority of the community.
Independence / Neutrality	The project has certain independence and neutrality because we signed on mutual agreement to continue the project until 2020. But could be fragile when agreement is expired and research budgets completely exhausted.	Since there was no conflict composition, problems of independence and neutrality was not seen.	No independence and neutrality. It seems that the provision of data on biodiversity in response to a request by the company is neutral, but other stakeholders recognize as the behavior to justify the company.	Kyushu University group played as an active stakeholder, and did not remain independent nor neutral. However, it was no problem because a municipal temporary official staff played as a main neutral coordinator.	Kyushu University group played as an active stakeholder, and did not remain independent nor neutral. At first, a municipal temporary official staff played as a main neutral coordinator. However, he withdrew from the project halfway, and Kyushu University group also tried to become a neutral coordinator but failed to do it.

(continued)

Table 2.1 (continued)

③ *Social Evaluation Indicators (SEI)*: Indicators to be considered during social evaluation					
	Yokota (India PHC)	**Sato (Indonesia Small hydropower)**	**Fujiwara・Onda (Indonesia Industrial tree plantation)**	**Hanamatsu・Tokunaga (Kami-tsushima high school)**	**Hanamatsu・Yamashita (Tsushima Abandoned land)**
Legitimacy (**All project phases**)	Legitimacy for this project has not yet been discussed with local community residents but all stakeholders recognized our health project is legitimate since it contribute to increase people's access to healthcare services as basic human right.	Not yet evaluated.	None (although there was an agreement between Kyushu University and companies, social evaluation by other stakeholders including residents and NGOs, was not obtained.)	Legitimacy for this project has not yet been fully obtained through the external social evaluation, although it has already passed internal evaluation test among the active relevant stakeholders. As this project was taken up by the local media and became known to people in and outside the island to a certain extent, legitimacy will be proved in the future.	Legitimacy for this project has absolutely not been obtained through the external social evaluation as well as internal evaluation among the relevant stakeholders since Kyushu University group withdrew from the project without coordinating several gaps in the co-design phase.
How to decide?	We have consensus meetings with stakeholders for any important decisions on our project.	For local residents, Kyushu University proposed a method for solving problems and received approval from ethnic leader Abah and the other stakeholders.	・Biodiversity assessment: Kyushu University conducts the assessment, and companies use it as a reference for decisions. ・Coordination between expanding biodiversity conservation area of the company and appreciating the rights of residents: no progress	Joint decision by all stakeholders has been developed through continuous detailed meeting.	Unilateral decision process: Kyushu University group proposed a project plan and asked village A to accept it.
Who decide for whom to whom?	Biyani Colleges and Kyushu university usually make decisions on projects activities based on local target population's needs after consultations/discussions with stakeholders	For local residents, Kyushu University proposed a method for solving problems and received approval from ethnic leader Abah and the other stakeholders.	For the company, the research of Kyushu University is positioned as a tool to appeal the conservation activities.	Joint decision by all stakeholders for local high school students and local people.	Kyushu University group tried to make a joint decision with village A, but village A suspected that Kyushu University group would decide and carry out the project for their own sake.
Usefulness of Science	Our project is based on systematic research methods and social & behavioral theories which believed to be useful for the implementation.	Useful. The lack of scientific and technical evaluation is a part of the problem.	Use of science for the basis of corporate profits and CSR.	Scientific technics or tools have not been used except for a questionnaire survey. However, there was some possibility that the reliance on the scientific and educational knowledge of Kyushu University enabled other stakeholders to try this project.	Neither trust nor doubt were heard among residents of the village about scientific knowledge on biodiversity and technology for improving productivity. The fact that the project was to be based on scientific knowledge and technology did not seem to have a direct influence on the judgment of the residents.
Social Sensitivity	Sensitivity to local community residents is not sufficient since no consultations or discussions are made, but sensitivity to other stakeholders are considered to be sufficient since number of face-to-face meetings and site visits were made.	Ciptagelar is a village where traditional culture remains, so that the consideration was made not to inadvertently damage the natural environment or culture.	Careful consideration to conduct research was not adequate in intense conflicts among stakeholders.	Consultation and communication with high school, local businessmen and residents were sufficiently done. Much attention has been paid to human relationship in local community.	Lack of social sensitivity to a local community as Kyushu University group did not carried out a detailed hearing investigation to the resident in the village. We did not fully understand the needs and priority of the community.

(continued)

Table 2.1 (continued)

④ *Additional Factors (AF)*					
	Yokota (India PHC)	**Sato (Indonesia Small hydropower)**	**Fujiwara・Onda (Indonesia Industrial tree plantation)**	**Hanamatsu・Tokunaga (Kami-tsushima high school)**	**Hanamatsu・Yamashita (Tsushima Abandoned land)**
Personality	Most stakeholder leaders are supportive, positive, open-minded, and willing to make social impacts.	The ethnic leader Abah has two opposite aspects: A young man who love the latest electronic technology and crafts./ A shaman who is a spiritual pillar of local traditional culture.	The influence of business judgment by the company is considerable. The pressure from NGOs affects business judgment in many cases.	This project was highly dependent on the personality of the temporary municipal officials, but the adverse effects of the change of particular stakeholders were overcome by the relationship of trust and communication among other stakeholders.	Personality of the village leader had a great impact. Change of leader caused a reversal of the project. On the other hand, this project was highly dependent on the personality of the temporary municipal official. His withdrawal had a great adverse influence on the project.
Integration of scientific research & education	Currently only research not educational activities yet.	Integration of scientific research & education was useful. Student educational activities consisting of various specialized students helped to understand the community.	Research-only stage	This research project was closely connected with educational programs such as "citizenship education" of local high school students and fieldwork activities by graduate students of Kyushu University.	Only research (This project was expected to connect with educational programs in high school and university in the future, but finally given up before discussing a detailed plan.)
others	Frequent and continuous dialogues, meetings, and discussions are necessary to maintain the project to be sustainable. Long term official written agreements are also necessary to keep stakeholders to be accountable.	Characteristic of local culture was important. The village has a idea of pair (Male & Female, Sky & earth etc.) Due to the idea, modern technology is easily accepted, without contradicting with the conservation of the traditional cultures.	There was a consultation from the company. It has difficulty making collaboration in social aspects due to the lack of information provided by the company.	Coordination by municipal temporary official staffs were excellent. Success of this project was due mainly to the work of such coordinators.	Withdrawal of the municipal temporary official staff from the project had a great adverse influence on the project. Failure of this project was mainly caused by the subsequent absence of a neutral coordinator.

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs, and JSPS Grants-in-Aid for Scientific Research Grant Number 17H02491 and 17K18531.

References

Asayama S, Emor S, Masuda K (2017) Toward reflective advocacy in climate controversy: complex boundaries between science and policy. Sociotechnica 14:21–37

Bache I, Flinders M (2004) Multi-level governance. Oxford University Press, Oxford

Brown VA, Harris JA, eds RJY (2010) Tackling wicked problems: through the transdisciplinary imagination. Routledge, London

Coicaud JM (2002) Legitimacy and politics: a contribution to the study of political right and political responsibility. Cambridge University Press, Cambridge

Edwards M (2014) Civil society, 3rd edn. Polity Press, Cambridge

Ehrenberg JR (2017) Civil society: the critical history of an idea, 2nd edn. New York University Press, New York

Freeman RE, Harrison JS, Wicks AC, Parmar BL, de Colle S (2010) Stakeholder theory: the state of the art. Cambridge University Press, Cambridge

Funtowicz SO, Ravetz JR (1993) Science for the post-normal age. Futures 25:739–755

Future Earth (2013) Future earth initial science report. International Council for Science, Paris

Future Earth (2014) Strategic research agenda 2014: priorities for a global sustainability research strategy. International Council for Science, Paris

Hanamatsu Y (2012) National boundaries and the fragmentation of governance systems: Amur-Okhotsk ecosystem from the legal and political perspective. In: Taniguchi M, Shiraiwa T (eds) The dilemma of boundaries: toward a new concept of catchment. Springer, New York, pp 123–143

Herod A (2011) Scale. Routledge, London
Jasanoff S (2010) A new climate for society. Theory Culture Soc 27:233–253
Jonas AEG (2015) Scale. In: Agnew J, Mamadouh V, Secor A, Sharp J (eds) The Wiley Blackwell companion to political geography. Wiley-Blackwell, Chichester, pp 26–34
Kurtz HE (2003) Scale frames and counter-scale frames: constructing the problem of environmental injustice. Polit Geogr 22:887–916
Latham A (2002) Retheorizing scale of globalization: topologies, actor-networks and cosmopolitanism. In: Herod A, Wright MW (eds) Geographies of power: placing scale. Blackwell Publishing, Hoboken, pp 115–144
Lövbrand E, Beck S, Chilvers J, Forsyth T, Hedrén J, Hulme M, Lidskog R, Vasileiadou E (2015) Who speaks for the future of earth?: How critical social science can extend the conversation on the anthropocene. Glob Environ Chang 32:211–218
Mitchell RK, Agle BR, Wood DJ (1997) Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. Acad Manag Rev 22:853–886
Moser SC (2016) Can science on transformation transform science? Lessons from co-design. Curr Opin Environ Sustain 20:106–115
O'Brien K, Barnett J (2013) Global environmental change and human security. Annu Rev Environ Resour 38:373–391
Pielke RA (2007) The honest broker: making sense of science in policy and politics. Cambridge University Press, Cambridge
Putnam RD (1993) Making democracy work: civic traditions in modern Italy. Princeton University Press, Princeton
Putnam RD (2000) Bowling alone: the collapse and revival of American community. Simon & Schuster, New York
Smith N (1992) Geography, difference, and the politics of scale. In: Doherty J, Graham E, Malek M (eds) Postmodernism and the social sciences. MacMillan, Basingstoke, pp 55–79
Stafford-Smith M, Gaffney O, Brito L, Ostrom E, Seitzinger S (2012) Interconnected risks and solutions for a planet under pressure—overview and introduction. Curr Opin Environ Sustain 4:3–6
Swyngedouw E (1997) Excluding the other: the production of scale and scaled politics. In: Lee R, Wills J (eds) Geographies of economies. Routledge, London, pp 167–176
Swyngedouw E (2004) Scaled geographies: nature, place, and the politics of scale. In: Sheppard E, McMaster RB (eds) Scale and geographic inquiry: nature, society and method. Blackwell Publishers, Hoboken, pp 129–153
Swyngedouw E (2011) The non-political politics of climate change. ACME 12:1–8
Swyngedouw E (2014) Anthropocenic politicization: from the politics of the environment to politicizing environments. In: Bradley K, Hedrén J (eds) Green Utopianism: perspectives, politics and micro-practices. Routledge, London, pp 23–37
Turnhout E, Boonman-person S (2012) Databases, scaling practices, and the globalization of biodiversity. Ecol Soc 16:35–48
Van der Hel S (2016) New science for global sustainability? The institutionalization of knowledge co-production in future earth. Environ Sci Pol 61:165–175
Weinberg AM (1972) Science and trans-science. Minerva 10:209–222
Werlen B (2015) Global sustainability, cultural perspectives and challenges for transdisciplinary integrated research. Springer, New York
Yohannan F, Obinna P, Polman N, Termeer C (2014) Scale-sensitive governance of the environment. Wiley-Blackwell, Hoboken
Yokota F, Biyanic M, Islam R, Ashir A, Nishikitani M, KikuchKi NY, Nakashima N (2018) Lessons learned from co-design and co-production in a portable health clinic research project in Jaipur District, India (2016–2018). Sustainability 10:4148
Zalasiewicz J, Williams M, Steffen W, Crutzen P (2010) The new world of the anthropocene. Environ Sci Technol 44:2228–2231

Chapter 3
Co-design, Co-production, and Co-evaluation Processes for a Mobile Health Check-Up Research Project in Jaipur, India: A Case Study of the Portable Health Clinic, 2016–2020

Fumihiko Yokota, Manish Biyani, Rafiqul Islam, Ashir Ahmed, Mariko Nishikitani, Kimiyo Kikuchi, Rieko Izukura, Yasunobu Nohara, and Naoki Nakashima

Abstract This chapter summarizes the co-design, co-production, and co-evaluation processes of a mobile health check-up research project in Jaipur, India, from March 2016 to June 2020. It is the continuation of our previous paper which was published in November 2018 at *Sustainability*. The main focus of this chapter is to describe the processes of co-production, co-implementation, and co-evaluation research activities after November 2018. To accomplish this, all documents and materials related to the research processes of co-design, co-production, and co-evaluation were thoroughly reviewed, including minutes from meetings, consultations, workshops, trainings, presentation slides, pictures, and reports. After reviewing the past 4 year's research process, the road map of a sustainable mobile health check-up project in India was proposed.

Keywords Healthcare services · Disease prevention · Transdisciplinary research · Co-design · Co-implementation · Co-evaluation · India

F. Yokota (✉) · M. Nishikitani · K. Kikuchi · N. Nakashima
Institute of Decision Science for Sustainable Society, Kyushu University, Fukuoka, Japan

M. Biyani
Biyani Group of Colleges, Jaipur, Rajasthan, India

School of Materials Science, Japan Advanced Institute of Science and Technology, Ishikawa, Japan

R. Islam · R. Izukura · Y. Nohara
Medical Information Center, Kyushu University Hospital, Fukuoka, Japan

A. Ahmed
Graduate School of Information Science and Electrical Engineering, Kyushu University, Fukuoka, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_3

1 Introduction

Future Earth research incorporates both natural and social sciences to solve global environmental issues (Lovbrand et al. 2015) and has "pioneered approaches to co-design and co-production of solutions-oriented transdisciplinary research for global sustainable development" (Future Earth 2014). However, transdisciplinary research is still hampered by a number of issues. First, the most recent reviews of transdisciplinary case studies concluded that in the co-design and co-production, processes of transdisciplinary research, methods, and concepts are still not clearly framed (Moser 2016; Brandt et al. 2013; Leemans 2016; Zscheischler et al. 2017). Second, most previous literature pertaining to transdisciplinary research only describe an early stage of "co-design" rather than actual implementation, application, and evaluation stages (Brandt et al. 2013; Page et al. 2016). Previous research includes the key components of early co-design phases such as "framing of problems" (Leemans 2016; Zscheischler et al. 2017; Adler et al. 2018), "social capital," "partnership with mutual trust" (Mckee et al. 2015; Emmons et al. 2008; Ruddy and Rhee 2005), "scaling" (Fraser et al. 2006), "accountability" (Van Del Hel 2016; Lang et al. 2012), "ownership" (Lang et al. 2012), and "priorities and needs" (Rhodes et al. 2012). However, a few previous transdisciplinary research have reported on participatory case studies including "co-design," "co-production," and "co-evaluation" together in a comprehensive, bottom-up manner (Leemans 2016). Finally, fewer transdisciplinary case studies, particularly on health issues, have been conducted in low- and middle-income countries in Asia, compared to Europe and North America (Leemans 2016). Therefore, the whole processes of co-design, co-production, and co-evaluation in health-related transdisciplinary research in Asia are still vague and largely unknown.

To fill these knowledge gaps, a community-based mobile health check-up research project called "Portable Health Clinic (PHC)" was introduced in Jaipur, India, in March 2016 as part of a collaborative Future Earth research project among Kyushu University (KU), Biyani Group of Colleges (BGC), and Grameen Communications (GC) (Yokota et al. 2018) (Fig. 3.1). This paper is the continuation of our previous paper which was published in November 2018 at *Sustainability* and aims to update and describe the processes of this health-focused transdisciplinary research that are still taking place as of June 2020. Based on the reviews of the past 4 year's research process, the road map of a sustainable business model in the mobile health check-up project was proposed. As an initial step, we hope to contribute to developing a methodological and conceptual framework for health-focused transdisciplinary research, as well as a new model for collaborative processes in the Asian context.

Fig. 3.1 Portable health clinic box, healthcare entrepreneur, and health check-up result

2 Portable Health Clinic (PHC) Research Project

A remote healthcare system called PHC was originally developed and implemented in Bangladesh in 2010 under a research collaboration agreement between GC and KU in 2007. GC is one of the Grameen family organizations established by Dr. Muhammad Yunus, the Nobel Peace Prize-winning founder of Grameen Bank. It is a non-profit information technology company in Bangladesh that provides software products and services, Internet services, hardware and networking services, and IT education (Wikipedia 2018). PHC is an e-health service system that includes a set of medical sensor devices in a briefcase allowing mobile health check-ups and telemedicine services in remote rural areas using Skype (Nohara et al. 2015; Ahmed et al. 2014; Nakashima et al. 2013) (Fig. 3.1). After Kyushu University Hospital joined the PHC project in 2012, PHC focused on the prevention and management of noncommunicable diseases (NCDs) such as diabetes, hypertension, and obesity. At the beginning of 2019, PHC services had been used by more than 42,000 people at 32 locations in Bangladesh (Grameen Communications 2020).

2.1 Data Sources

Data sources for this paper were all the research reports, activity logbooks, presentation slides, and the research plan/protocol including research timelines, activity schedules, and budgets. These documents produced during the period between March 2016 and June 2020 were thoroughly reviewed.

2.1.1 Co-design and Co-production Processes Among KU, GC, and BGC in Phase 1 (Photo 3.1)

In India, the PHC research project started in March 2016 as a community-based health check-up service as a collaboration between KU, GC, and BGC as part of the Future Earth Research Project funded for the Institute of Decision Science for Sustainable Society, KU (Fig. 3.2). For more detailed information on the processes in phase 1, please refer to Yokota et al. (2018).

Photo 3.1 Initial meeting, staff training, and pilot implementation jointly conducted by KU, GC, and BGC in phase 1 (March 2016 to April 2017)

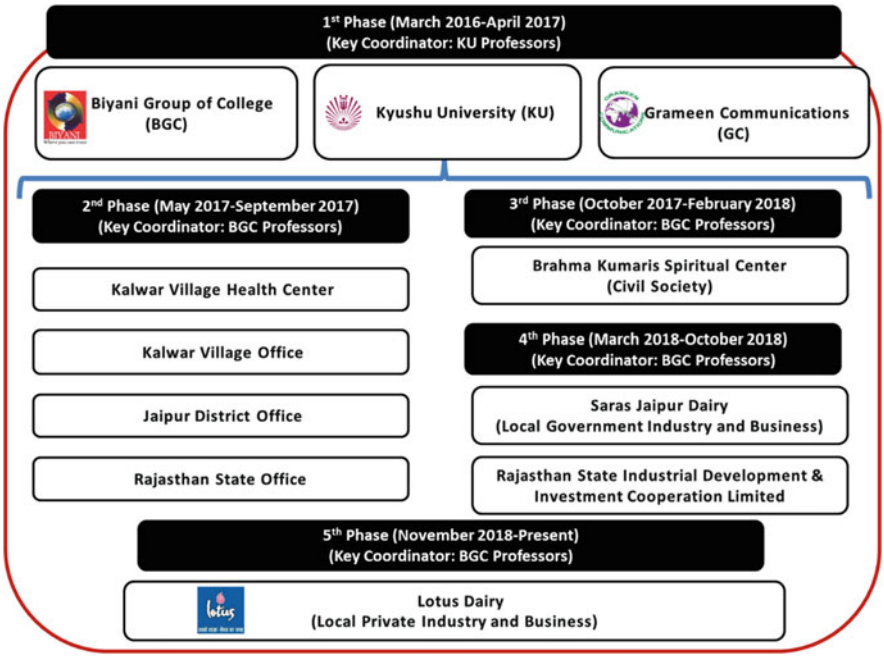


Fig. 3.2 Stakeholders and key coordinators for the PHC research project in Jaipur in five phases (March 2016 to September 2019)

Photo 3.2 Courtesy visits including meetings and discussions held among government stakeholders (from left: Rajasthan state, Jaipur district, Kalwar village government office, and Kalwar Health Center) in phase 2 (May 2017 to September 2017)

Map 3.1 Location of Rajasthan state and Jaipur city

2.1.2 Co-design Process with Local Government Agencies in Phase 2 (Photo 3.2)

After going through the pilot phase 1, KU and BGC realized that permission and agreement from local government agencies were necessary for officially implementing the PHC research project in Rajasthan (Map 3.1). In May 2017, the research team visited the following agencies: Rajasthan state and Jaipur district department of medical, health, and family welfare; Kalwar village office; and Kalwar

health center (Fig. 3.2). For more detailed information on the processes in phase 2, please refer to Yokota et al. (2018).

2.1.3 Co-design, Co-production, and Co-evaluation Processes with a Civil Society Organization in Phase 3 (Photo 3.3)

In phase 3, starting from October 2017, KU and BGC had signed the official academic collaboration agreement. Based on the revised research plan and protocol, we decided to investigate the health needs, priorities, and longitudinal effects of our PHC health check-up services among different population cohort groups in various Jaipur districts. To achieve these objectives, we needed to follow up with the same individuals over time to monitor changes in their health status, behaviors, needs, and priorities. In this aspect, members of civil society organizations were much easier to follow up with than general community residents over the years. Thus, BGC first contacted the Brahma Kumaris World Spiritual University (BK) to be a stakeholder and target research population group (Fig. 3.2). For more detailed information on the processes in phase 3, please refer to Yokota et al. (2018).

2.1.4 Co-design, Co-production, and Co-evaluation Processes with Local Government Industry in Phase 4 (Photo 3.4)

In phase 4, starting January 2018, the core research objective was the same as in phase 3, to understand the health status, behaviors, and needs of local people as well

Photo 3.3 Seminars, workshop trainings, and pilot implementation jointly conducted by KU, BGC, and BK Center in phase 3 (October 2017 to February 2018)

Photo 3.4 Seminars, workshop trainings, pilot implementation jointly conducted by KU and BGC, at Saras Dairy and BGC sites in phase 4 (March 2018 to October 2018)

as determining the effectiveness and acceptability of our project in a Jaipur district. However, in phase 4, the research target population was industry employees rather than general community residents or civil society members. Our aim was to identify the high-risk population groups which are most in need of health check-up services for NCD prevention. Thus, the study in phase 4 enables the comparison of health needs, health status, and health behaviors among civil society organization members, industry employees, and the general community members in Rajasthan. For more detailed information on the processes in phase 4, please refer to Yokota et al. (2018).

2.1.5 Co-design, Co-production, and Co-evaluation Processes with Local Private Industry in Phase 5 (Photo 3.5)

In phase 4, PHC services could not continue as a sustainable business model nor health insurance scheme in a sustainable manner. From the previous phrases, we learned that there are needs for eye check-up and traditional Indian doctors (Ayurveda) among factory employees in Jaipur district, India. In addition, factory employees need more detailed blood tests including HbA1c for diabetes and HDL/LDL cholesterol. Therefore, the Indian PHC services were customized according to specific population's needs. We also learned that it was very difficult to implement long-term sustainable health check-up services for government factory employees due to the following reasons: (1) government system is very slow and difficult such that it has many approval steps and paper works to proceed a new health check-up scheme, (2) government factory managers (leaders) do not want to have additional tasks or extra works to start new sustainable health check-up system, and (3) government leaders request many things but not take initiatives to start a new sustainable health check-up system. In phase 5, therefore, we changed our collaborative partners from government companies to private companies because private companies do not have such obstacles (1)–(3) that government companies have. From September to October 2018, we have searched for any potential private companies who are interested in implementing health check-up services for their employees in a long term as a health insurance scheme or social business. From BGC's principle's network, we found that Lotus Dairy (LD) Milk Company is interested in the PHC health check-up services for their employees and they were willing to provide their own factory's facility room as a PHC clinic and also willing

Photo 3.5 Newly customized PHC provided for factory employees by KU, GC, and BGC, at Lotus Dairy and Lotus Manda factory clinic in phase 5 (November 2018 to Present)

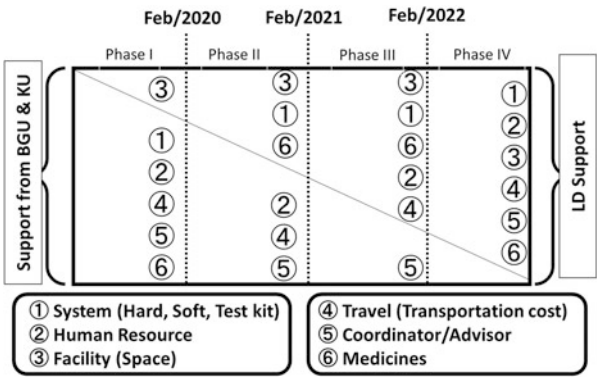


Fig. 3.3 Road map of the proposed LD company's health insurance business model of PHC project, India

to pay for a cost for medicines. KU, GC, BGC, and LD had several meetings to discuss "how can we continue to implement PHC health check-up services for LD's employees even after research funds finish?". Based on the discussions, all four (KU, GC, BGC, and LD) could have an official agreement on implementing sustainable PHC health check-up services for LD's factory employees in Jaipur district, India (Fig. 3.2). However, due to the closure of KU, Institute of Decision Science for Sustainable Society, this agreement had to be ended by the end of March 2020. Although the official joint research agreement was ended in March 2020, KU, BGC, GC, and LD tried to continue the project by developing the cost-sharing scheme as below:

- LD is to provide a cost for their factory clinic, electricity, water, and other clinic maintenance cost as well as the cost for medical drugs.
- BGC is to provide a cost for human resources (coordinator, Ayurveda doctor, health workers, IT technicians).
- GC is to provide technical assistance on data management and software for PHC system.
- KU is to provide scientific knowledge and evidence on the effects and impacts of health check-up and tele-consultation services (data collection, data analysis, publish academic papers, etc.) and provide consumables for health check-up for the first 1 or 2 years.

In addition, KU and BGC developed a road map of the proposed business model for LD to be self-sustained in this PHC project (Fig. 3.3). In February 2020, KU, BGC, and LD had a face-to-face meeting at the LD headquarter office at Jaipur, India, to discuss the possibility of continuing the PHD project as the proposed business model. LD made two requests:

1. More detailed evaluation results collected from company employees who received the PHC services including their satisfaction levels
2. More robust supports and promotion from local government agencies such as the Ministry of Health, Medicine, and Family Welfare in India

KU and BGC agreed to have the evaluation interview survey for those who received PHC services and request LD for jointly implementing the second time PHC services and evaluation surveys targeting those who received PHC services once before. Unfortunately, due to the COVID-19 situations in India and Japan, our joint PHC project has been pending as of June 2020.

2.1.6 Summary of Co-design and Co-production Processes in All Five Phases

In all phases that we described in this section, we utilized the following co-design, co-production, and co-evaluation process steps (Fig. 3.4): (1) jointly develop and revise a research plan and protocol which includes research objectives, methods, timelines, activity schedules, and budgets; (2) reach collaborative agreement and consensus on the research plan and protocol with both academic and nonacademic stakeholders through meetings, consultations, and workshops; (3) conduct local research staff training workshops based on the protocol in order to improve the quality of services and quality of data jointly with stakeholders; (4) implement the pilot PHC health check-up research involving all stakeholders; (5) analyze, disseminate, and provide feedback on the results with all stakeholders through presentations, seminars, workshops, and conferences; (6) revise the research plan and protocol based on feedback such as local needs, priorities, and requests from stakeholders; and (7) develop and implement sustainable PHC social business model (business partners, staff, customers, business services and products, service delivery process and activities, business resources, cost structures, time frame, target locations, marketing plan). We should have engaged with all of our government, industry, and community stakeholders at an earlier stage of the co-design process, so that we did not need to go and back again between co-design and co-production. Van der Hel et al. (2016) indicated that engaging more stakeholders throughout the research process will increase legitimacy and reduce skepticism. Some key factors, such as effective local coordinators, personality types of stakeholder leaders, and continuous involvement and engagement with stakeholders, particularly both government and nongovernment stakeholders helped mitigate such difficult situations in our research in India.

Acknowledgments I would like to thank the following stakeholders and the individuals who provided support for the project: Biyani Group of Colleges; Grameen Communications; Kalwar village office; Kalwar health center; Jaipur district and Rajasthan state department of medical, health, and family welfare; Brahma Kumaris Spiritual Centers; Saras Dairy; and Lotus Dairy. This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

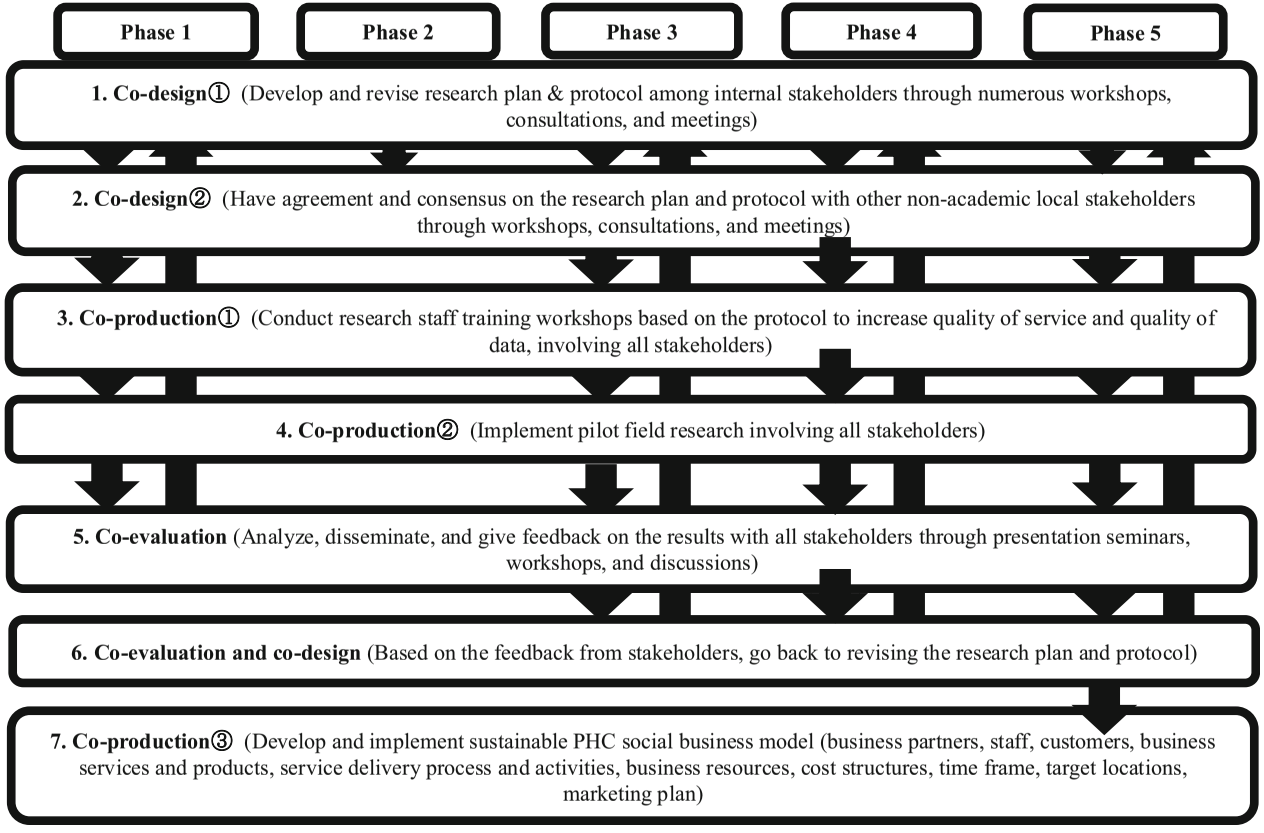


Fig. 3.4 Co-design, co-production, and co-evaluation process of India PHC project

References

Adler C, Hadorn GH, Breu T, Wiesmann U, Pohl C (2018) Conceptualizing the transfer of knowledge across case in transdisciplinary research. Sustain Sci 13:179–190

Ahmed A, Rebeiro-Hargrave A, Nohara Y, Kai E, Hossein Ripon Z, Nakashima N (2014) Targeting morbidity in unreached communities using portable health clinic system. IEICE Trans Commun 3:97

Brandt R, Ernst A, Gralla F, Luederitz C, Lang DJ, Newig J, Reinert F, Abson DJ, von Wehrden H (2013) A review of transdisciplinary research in sustainability science. Ecol Econ 92:1–15

Emmons KM, Viswanath K, Colitz GA (2008) The role of transdisciplinary collaboration in translating and disseminating health research. Am J Prev Med 35(2):S204–S210

Fraser EDG, Dougill AJ, Mabee WE, Reed M, McAlpine P (2006) Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. J Environ Manag 78 (2):114–127

Future Earth (2014) Future earth 2025 vision. http://www.futureearth.org/sites/default/files/future-earth_10-year-vision_web.pdf. Accessed on 3 May 2018.

Grameen Communications (2020) Global Communication Center. Portable Health Clinic. http://ghealth.gramweb.net/. Accessed on 6 May 2020

Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci 7(Suppl. 1):25–43

Leemans R (2016) The lessons learned from shifting from global-change research programmes to transdisciplinary sustainability science. Curr Opin Environ Sustain 19:103–110

Lovbrand E, Beck S, Chilvers J, Forsyth E, Hedren J, Hulme M, Lidskog R, Vasileidou E (2015) Who speaks for the future of earth? How critical social science can extend the conversation on the Anthropocene. Glob Environ Chang 32:211–218

Mckee A, Guimaraes MH, Pinto-Correia T (2015) Social capital accumulation and the role of the searcher: an example of a transdisciplinary visioning process for the future of agriculture in Europe. Environ Sci Policy 2015:88–99

Moser SC (2016) Can science on transformation transform science? Lessons from co-design. Curr Opin Environ Sustain 20:106–115

Nakashim N, Hiramatsu T, Ghosh PP, Islam R, Kobayashi K, Inoguchi T (2013) Evaluation of "Portable Health Clinic" with BAN standard for 10K subjects in Bangladesh. In: Conference Proceedings of the IEEE Engineering in Medicine and Biology Society. pp 1672–1675

Nakashima N, Nohara Y, Ahmed A, Kuroda M, Inoue S, Ghosh PP, Islam R, Hiramatsu T, Kobayashi K, Inoguchi T, Kitsuregawa M (2013) An affordable, usable and sustainable preventive healthcare system for unreached people in Bangladesh. Stud Health Technol Inform 192:1051

Nohara Y, Kai E, Ghosh PP, Islam R, Ahmed A, Kuroda M, Inoue S, Hiramatsu T, Kimura M, Shimizu S, Kobayashi K, Baba Y, Kashima H, Tsuda K, Sugiyama M, Nakashima N (2015) Health checkup and telemedical intervention program for preventive medicine in developing countries: verification study. J Med Internet Res 17(1):e2

Page GG, Wise RM, Lindenfeld L, Moug P, Hodgson A, Wyborn C, Fazey L (2016) Co-designing transformation research: lessons learned from research on deliberate practices for transformation. Curr Opin Environ Sustain 20:86–92

Rhodes SD, Kelley C, Siman F, Cashman R, Alonzo J, McGuire J, Wellendorf T, Hinshaw K, Allen AB, Downs M, Brown M, Martinez M, Duck S, Reboussin B (2012) Using community-based participatory research (CBPR) to develop a community –level HIV prevention Intervention for Latinas: a local response to a global challenge. Women's Health Issues 22(3):e293–e301

Ruddy G, Rhee K (2005) Transdisciplinary teams in primary care for the underserved: a literature review. J Health Care Poor Underserved 16(2):248–256

Van Del Hel S (2016) New science for global sustainability? The institutionalization of knowledge co-production in Future Earth. Environ Sci Pol 61:165–175

Wikipedia (2018) Grameen family of organizations. https://en.wikipedia.org/wiki/Grameen_family_of_organizations. Accessed on 29 May 2018

Yokota F, Biyani M, Islam R, Ahmed A, Nishikitani M, Kikuchi K, Nohara Y, Nakashima N (2018) Lessons learned from co-design and co-production in a portable health clinic research project in Jaipur District, India (2016-2018). Sustainability 10(11):4148

Zscheischler J, Rogga S, Bussse M (2017) The adoption and implementation of transdisciplinary research in the field of land-use science – a comparative case study. Sustainability 9:1926

Chapter 4
Sustainability of Micro Hydropower Generation in a Traditional Community of Indonesia

Tatsuro Sato and Jun'ichiro Ide

Abstract Over 3 years, we undertook a micro hydropower (MHP) project in the Ciptagelar village, West Java, to improve the understanding and implementation of sustainable operations and management of MHP generation in remote rural areas, where the primary industry is farming and thus monetary incomes are low. First, we describe in this paper the history of setting up the research agenda to be tackled with the cooperation of governmental and nongovernmental stakeholders. Second, we report the current status of MHP plants and the related issues obtained through fieldwork and model simulations, in the context of culture, traditions, and society in the village. Finally, we propose guidelines to solve the issues and present the lessons learned and things scientists should pay attention to when proceeding with transdisciplinary research projects in remote rural areas. Through fieldwork and model simulations, we revealed issues related to budgeting and techniques for maintaining and operating MHP plants. We found that the village had difficulty in securing funds for repairing broken intake weirs, though it had funds to cover the general maintenance of the MHP plants. We also found that the intake weirs were vulnerable to large floods and that no accomplished technicians were available to operate MHP plants in the village properly. To solve these issues, we need to find ways to reinforce the intake weirs using local materials and increase monetary incomes by creating new industries based on the MHP generation while considering the cultural and traditional backgrounds of the remote rural areas.

Keywords Mountainous area · Off-grid power · Renewable energy · Rice paddy · Sustainable infrastructure

T. Sato (✉)
Disaster Risk Reduction Research Center, Graduate School of Engineering, Kyushu University, Fukuoka, Japan

J. Ide
Department of Applied Chemistry and Bioscience, Chitose Institute of Science and Technology, Chitose, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_4

1 Introduction

Global energy demand nearly doubled from 1970 to 2003, increasing with population and economic growth. By 2040, it is expected to increase by ~30% over current levels (International Energy Agency 2016). Developing countries are expected to account for ~60% of the increase in energy demands as of 2030. However, meeting these energy demands may be difficult because of continued dependence on finite fossil fuels. In addition, the use of fossil fuels emits large amounts of greenhouse gases into the atmosphere, resulting in severe climate change. The Paris climate agreement, an international framework for reducing greenhouse gas emissions starting in the year 2020, was signed on November 4, 2016. Nearly all countries, including major greenhouse-gas-emitting countries, participated in the agreement to stipulate efforts toward achieving the global, long-term goal of keeping the average temperature rise sufficiently below 2°C, with each country submitting and updating emissions reduction targets as well as examining the global implementation status every 5 years. The first key to achieving the ambitious goal is to promote an energy mix that emphasizes renewable energy, in addition to energy saving and increased energy efficiency.

The introduction of distributed renewable energy production is essential for various reasons. First, geographically dispersed renewable energy promotes regional economic development. Local renewable energy is a sustainable regional resource and is an inexpensive form of energy for future use. Shifting from energy dependence on external sources to locally procured energy leads to the increase of fund circulation within the region, activation of the regional economy, and increased employment opportunities in the newly developed energy industry. Besides, renewable energies are more resilient against disasters compared with their nonrenewable counterparts. On March 11, 2011, the Great East Japan Earthquake and subsequent Fukushima Daiichi nuclear disaster shed light on the significant weaknesses of the existing electricity infrastructure. The damage to lifelines and power outages significantly affected the Japanese citizens; medical care, transportation, and industrial activity were all restricted. These experiences exposed the limitations of large-scale centralized power systems. Conversely, when the 2016 Kumamoto earthquake occurred, homes wherein photovoltaic power generators were installed received uninterrupted electricity supply, even during power grid failures.

Comprehensively considering these diverse positive impacts encourages the creation of sustainable energy systems. The policy framework that directly addresses these positive impacts is the 2030 Agenda for Sustainable Development, which lays out Sustainable Development Goals (SDGs), adopted by the UN Sustainable Development Summit held in September 2015. Of the 17 goals and 169 targets, Goal 7 relates specifically to energy, aiming at "ensuring access to affordable, reliable, sustainable, and modern energy for all" (United Nations 2019). As population increases and lifestyles change in developing countries, energy demands continue to increase. Sustainable energy supply is vital for eradicating poverty, establishing a stable environment that is resilient against disasters, and providing a culturally rich

lifestyle. Discussions on a national level regarding power supply and energy mix have gradually accelerated; however, vested interests in the energy sector are great, and current political conditions pose difficulties in introducing significant top-down changes. On the other hand, at the Institute of Decision Science for a Sustainable Society (IDS3) in Kyushu University, we have collaborated with local communities to develop bottom-up sustainable social reforms. We hope that such individual challenges (learnings) encountered at the local level will be shared via the global network, leading to a big wave of support for a sustainable society.

Herein, the micro hydropower (MHP) project, which is an essential renewable energy source in the farming villages of Indonesia, is introduced. In this project, we aimed to answer the question, "how do we realize sustainable MHP generation in remote rural areas?". For this, we have investigated the current status of energy self-sufficiency in a traditional farming village located in the mountainous area in West Java, Indonesia, over 3 years. We describe the contents of our investigations and efforts in Indonesia in chronological order. We would also like to share crucial points to help conduct Future Earth research that orients the cooperation between scientists and social stakeholders.

2 Case History

2.1 Phase I (2015): Setting Up the Research Agenda to be Tackled (Co-design)

The Republic of Indonesia is located in East Asia and has the fourth largest population in the world. In recent years, its economic growth rate and consequently, energy demand has been rapidly increasing. On the other hand, it has many remote regional areas that are not electrified. This is because Indonesia is the world's largest archipelago state, which consists of more than 17,000 islands, and thus it is unfeasible to construct centralized power grids all over the country. Therefore, activities to electrify the remote off-grid areas are being promoted by using inexpensive techniques of MHP generation that have been developed in Indonesia.

MHP is one of the most widely introduced renewable energies in Indonesia (Sukarna 2012), because Indonesia has steep terrain and thereby has enormous potential for MHP generation, and because MHP does not need massive constructions like dams. The electrification rate in villages in Indonesia increased from 5% in 1978 to 62% in 1995 and reached approximately 82% in 2000 (Nagai 1999; JICA 2005). In recent years, the introduction of feed-in tariff has accelerated the spread of renewable energy, such as MHP, in remote regional areas. However, during the rainy season, flood disasters frequently occur in the areas suitable for MHP and sometimes destroy the MHP generation facilities. Additionally, there are many cases where MHP is operated mainly by residents, and the destroyed MHP facility remains unrepaired because of insufficient budgeting (Ranzanici 2013).

To narrow down the research topics for sustainable regional MHP generation, we contacted Bandung Hydro Association (Asosiasi Hidro Bandung: AHB), the central organization for MHP generation in Indonesia. Moreover, Kyushu University already had a cooperative relationship with AHB because of technology exchange. Initially, we tried to grasp the current status of MHP generation in remote areas in Indonesia. We conducted face-to-face interviews and discussions with several stakeholders: The Agency of Energy and Mineral Resources of West Java Province (Dinas Energi dan Sumber Daya Mineral Provinsi Jawa Barat: ESDM), Bandung Institute of Technology (Institut Teknologi Bandung: ITB), and local village leaders, operators, and managers who face the issues on MHP. It was found that in approximately half of the MHP facilities introduced in remote areas in Java, intake weirs, headrace channels, and penstocks were broken by flood and sediment disasters, and consequently, the MHP generation stopped (Rahadian 2016, personal communication). This rate of the stopped MHP facilities was consistent with Peters and Sievert (2014), who found that more than 20% of the MHP facilities they visited were out of order.

Several economic, social, and environmental issues affect sustained operations of MHP generation in economically developing countries (Purwanto and Afifah 2016). However, few studies have conducted field investigations to clarify practical issues that MHP stakeholders face or have proposed ways of resolving such issues. We have co-designed the content of the transdisciplinary (TD) study on the issues that challenge sustainable MHP operations while closely cooperating with the stakeholders. We set a goal to make protocols for the rehabilitation of stopped MHP facilities and sustainable operations and management of MHP in remote areas. Next, we decided on the target field. ESDM introduced us to a remote mountainous village, Ciptagelar village, where residents conserve a traditional lifestyle and are self-sufficient in electricity supply from MHP generation. However, the village had some problems with the MHP system. We selected this village as the TD study area.

2.2 Phase II (2016): Research Framework in the Ciptagelar Village (Co-design)

Ciptagelar village is located in the mountainous area of Sukabumi District, West Java Province, Indonesia (6°48′S, 106°30′E; 1122 m a.s.l.; Fig. 4.1), and is difficult to access especially during the rainy season. There are approximately 750 households (receiving electricity from four MHP plants) in the village, and it is the heart of the Sundanese ethnic group, the Kasepuhan adat community. It is estimated that approximately 16,000 people belong to that community and are distributed in the West Java and Banten Provinces (Suganda 2009). The highest leader of the Kasepuhan adat community, Abah Ugi (Abah means “a father” and plays the role of a king), lives in Ciptagelar village.

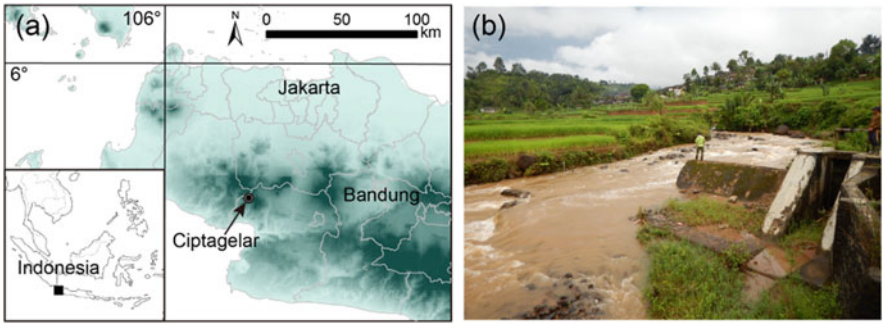


Fig. 4.1 (**a**) Location of the Ciptagelar village, Sukabumi, West Java Province, Indonesia. (**b**) Broken intake weir of the Situmurni No. 1 MHP (as of Mar. 2016)

Table 4.1 Properties of four MHP plants in Ciptagelar village

Name of MHP plant	Year of construction	Max. output (kW)	Broken parts (times)[a]	Funders (at construction)
Cicemet	1997	60	Turbine (2) Generator (2) Controller (1) Intake weir (1)	JICA (Japan)
Situmurni No. 1	2001	40	Turbine (1) Bearing (?) Belt (?) Intake weir (?)	West Java Province
Cibadak	2012	60	Turbine (1) Transformer (2)	Local bank
Situmurni No. 2	2013	45	Headrace channel (1)	KOMIPO, KOIKA, (Korea), IBEKA

[a]Number of times that an issue with the part has caused the MHP plant to be out of operation

As the village is located along the boundary of Gunung Halimun National Park, in a steep mountainous area and difficult to access because of steep unpaved roads, power supply from the Indonesian government-owned power company (Perusahaan Listrik Negarandonesian: PLN) has been restricted. To compensate for the insufficient power supply in the village, four MHP facilities (Table 4.1) have been installed in sequential order since 1997 through the support of international donors, the local government, NGOs, and a local bank. The generated electricity is used for basic modern human needs, mainly electric lighting (Ide et al. 2018), which has replaced oil lamps. Other uses of electricity are watching television and using smartphones (i.e., charging their batteries), which provide residents information from outside of the village. However, as of March 2016, two of the four facilities (Situmurni No.1 and Cibadak) were out of operation because of disasters, such as massive floods, landslides, and thunderstorms caused by extreme weather conditions.

In March 2016, we conducted a stakeholder meeting including the village residents, Abah, who is a proprietor of MHP in the village, and staff of the ESDM of West Java and AHB. Then we co-designed the framework of transdisciplinary research in this village, which aims to assess the vulnerability of MHP plants to disasters scientifically. We planned to make an actual rehabilitation plan for a stopped MHP plant (Situmurni No. 1) in collaboration with all the stakeholders, considering the village's history, characteristics, beliefs, and economic conditions.

However, early in the project, our research framework was forced to change. As soon as the investigation started toward the rehabilitation of the broken intake weir, the intake weir was reconstructed by a coal mining company, as a corporate social responsibility activity under the permission of Abah. This is because it had been 7 months since the intake weir was broken and the power supply to households stopped, and residents were demanding that electricity be restored to resume their normal lives. This suggests that electricity has already become an essential part of residents' lives. At that time, we had not built a trusting relationship with the community and the leader, Abah, and so we were not able to be involved in the rehabilitation efforts of the intake weir. The real world could not afford to wait for research results. The reconstruction of the intake weir was good news for the village. However, we were concerned about the fact that the structure and location of the reconstructed intake weir were the same as those of the previous one, which was vulnerable to massive floods. Risks remain that the intake weir will be broken again by floods.

We changed our research framework (re-co-design). We decided not to rehabilitate the intake weir with the stakeholders specifically but to present management methods for sustainable MHP plants from both sociological and engineering approaches.

2.3 Phase III (2017): Learning the Context of the Ciptagelar Community (Co-production)

To evaluate the vulnerability of MHP plants to disasters and build the countermeasures scientifically, we investigated the structure of the broken intake weir of an MHP plant. We additionally collected hydrological data such as rainfall and river flow data in 2017. Such research activities were conducted in collaboration with several stakeholders, including ESDM, ITB, AHB, and the local residents.

We also had repeated dialogue with residents and leaders in order to understand the culture, traditions, thought, industries, and economic conditions of the Ciptagelar community. This understanding is the foundation of sustainable MHP management and essential to building trust with the community (Fig. 4.2). We visited the village many times and sometimes participated in some critical traditional ceremonies relating to rice farming and Abah's birthday parties.

Fig. 4.2 Rice farming and the barns "Leuit" in Ciptagelar

Through the repeated dialogs, we could touch the deep traditional culture and understand the current socio-economic situation of the Ciptagelar community. The birth of the Kasephan ethnic group, to which the Ciptagelar village belongs, dates to 1368. Since then, the "Abah" has continued via a male patriarchy system. He administers religious services and magic rituals like a shaman in the community. He is the spiritual pillar of the community, and the community members have deep trust in him. Rice farming conducted cooperatively between residents is essential for the traditional livelihoods of the residents in Ciptagelar village (Fig. 4.2). The residents believe that rice is part of the sacred life, and they plant it for subsistence, but not for commercial use. They are not allowed to buy and sell the harvested rice, because selling rice is comparable to selling life for them. They plant and harvest rice only once a year, according to the natural rhythm, though it is possible to plant rice two or three times per year in the West Java Province. In Ciptagelar village, human beings are recognized as a part of nature and nature as "Mother Earth" (Sato et al. 2017). Thus, residents do not use pesticides that kill living organisms in rice farming. Ten percent of the harvested rice is stored every year in unique barns called "Leuit," which is a symbol of the village (Fig. 4.2), to provide food in case of a poor harvest year. Leuit is also a sacred place, and it exists under the thought that the paddy must not be eradicated but be kept alive with the same importance as that of human life. Residents in Ciptagelar village have the "thought of pair," which is a philosophy that objects or things are a pair or have two poles, such as man and woman or the sun and the moon. Based on this thought, they introduce modern techniques, that is, electricity, while also recognizing the importance of the traditional livelihood.

Thus, the main livelihood in the Ciptagelar village is rice cultivation, but the sale of rice is prohibited. As a result, the source of cash income in the village is limited to the sale of agricultural products, such as Java sugar made from the sap of sugar palm, and construction labor. For this reason, many village residents migrate to the Banten Province to work as gold miners or to large cities such as Jakarta to work as construction laborers or housekeepers.

2.4 *Phase IV (2018): Scientific Outcomes Revealing the Sustainability Issues of MHP Plants in Ciptagelar (Co-production)*

Accurate assessment of flood risk is essential for the sustainability of MHP plants in Ciptagelar. Several studies on flood risk assessments have valued the importance of technical and scientific approaches (Merz et al. 2014; Kellermann et al. 2015). In general, the risk assessment and the choice of preventive actions are based on several methods such as flood mapping, which is a crucial element of flood risk management. In order to help the stakeholders who were not familiar with technology and science understand the issues more clearly, flood mapping was selected to show the flood risk visually.

Based on the collected hydrological data, we constructed a runoff model on the relationship between rainfall and river flow, and the 2D flood simulation model (using Nays2Dflood solver in the iRIC software, https://i-ric.org/en/) that shows the spatial flood risk (Fig. 4.3). At first, the 2D flood model was developed only for one MHP plant (Situmurni No. 1 power plant), which had been out of operation because of damage to the intake weir at the start of this project. According to the request from stakeholders including the residents, we expanded the model to all four MHP plants in Ciptagelar village. In the development of the 2D flood model, drone photogrammetry for making high-resolution digital elevation data was conducted with stakeholders. Combining the frequency analysis using long-term public observation data

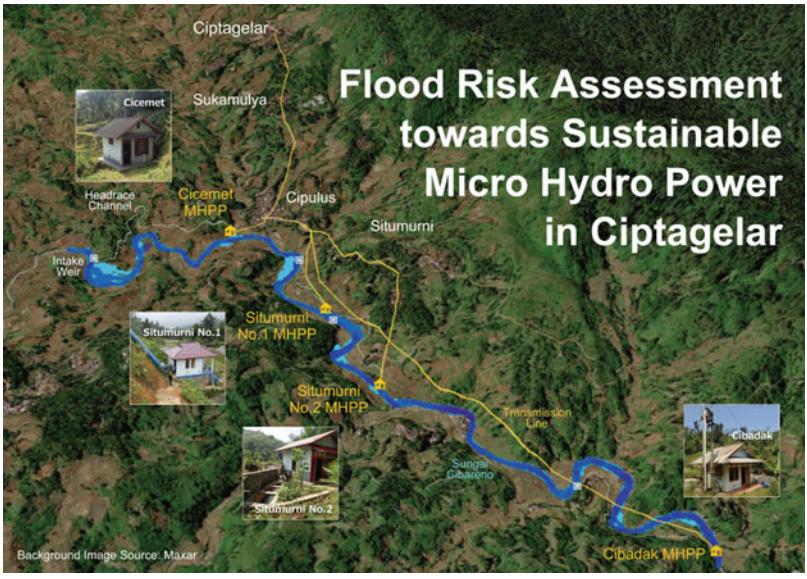


Fig. 4.3 Scientifically analyzed flood risk map in Ciptagelar, shared by stakeholders. Background image from © Maxar

on rainfall, we could make the flood risk map in return periods covering all MHP plants. This map indicated that some MHP plants were vulnerable to floods.

Also, our investigations on the socio-economic issues underscored the difficulty for the village to secure budgets to repair and maintain the MHP facilities. The operators and Abah told us that some part of the facilities in all four MHP plants had been broken because of disasters, operation mistakes, and other causes and were replaced with a new one by Abah's borrowing money from banks and other companies. Previous studies pointed out that most of the village communities in remote areas have difficulty in permanently securing budgets for repairing and replacing parts of MHP facilities and generators because their primary industry is agriculture, which provides little monetary income (Yasunaga and Nishio 2001; Ranzanici 2013; Purwanto and Afifah 2016). Therefore, the community has no choice but to rely on external grants and donors to determine whether they can repair the broken facilities, as is the case in other developing countries (e.g., Palit and Chaurey 2011). These facts are true in the case of Ciptagelar village. On the other hand, it was hard for the donors to cover the cost of repairing the broken or damaged facility, though they support the construction cost as a startup of the MHP project because of the issue of equity and unclear ownership (West Java Province government has started to subsidize the repair of broken MHP plants).

In many MHP projects in developing countries, donors tend to focus on the construction of new power plants in places that have never had electricity (Urmee and Md 2016). However, once an MHP facility is installed, the responsibility of its operation and maintenance are often handed over to the community. Eventually, the project fails because the community does not have a sufficient maintenance budget. Our detailed survey clarified the electricity bill payments received from all households for the electricity supplied from the four MHP plants and the cost of maintenance including labor costs. It indicates that minimum maintenance can be performed based on the current electricity bill collection amount. However, this amount is not sufficient to cope with severe damage caused by large-scale failure or disaster.

3 Exploring Measures to Solve the Issues

From the issues as mentioned above related to operations and management of MHP in Ciptagelar village, we aimed to rehabilitate the stopped MHP facility, in consideration of the sustainability of MHP and the regional development. Specifically, we tried to support residents in starting new industries based on the MHP generation and thereby increase monetary income for maintaining MHP. Furthermore, we intended to increase job opportunities by creating new industries and thereby activate the regional economy and development. This rehabilitation should be operated mainly by the residents in the village and therefore should be conducted based on the

combination of traditional and cutting-edge technologies, while respecting backgrounds, such as culture, tradition, and society of all stakeholders.

To reduce the risks and prepare for repairing the MHP facility in the future, we need to find ways of securing the budgets for the maintenance of MHP. Saito and Takahata (2004) proposed that part of electricity charges from residents should be accumulated as budgets for repairing the MHP facility. However, residents' income is generally much lower in the remote areas where the off-grid electrification was applied, and there are few sources of monetary income (e.g., Nagai 1999). In Ciptagelar village, there are limited sources of monetary income, that is, sales of agricultural productions, such as palm sugar and coffee beans. Therefore, if a high price is set for the electricity charges to secure the funds for repairs and it exceeds the residents' capability to pay, it cannot be adequately collected (Yasunaga and Nishio 2001).

We described earlier a way of securing the budgets by creating new industries based on MHP. This was also proposed by other previous studies (Saito and Takahata 2004; Ranzanici 2013). However, there is a deeply penetrated philosophy, "thought of a pair," in Ciptagelar village. Abah and residents think that they have to conserve their traditional livelihood as they integrate new technologies into their lives. The generated electricity is applied to the process of coffee beans, which is a main agricultural product in the village, and the monetary income generated through their sale is used for maintaining MHP facilities. However, this monetary amount is not sufficient because the production of coffee beans is limited. On the other hand, residents do not conduct a single plantation of coffee trees for increasing monetary income because of their philosophy (Sato et al. 2017). The industrial structure in the village should be changed to generate sufficient monetary income to cover the maintenance expenses of the MHP facilities. However, this is unfeasible in the village because it would change the unique traditions and livelihood, which would lead to the destruction of the psychological culture.

4 Concluding Remarks and Perspectives

In order to use and operate MHP generation in the local communities in a sustainable manner, both technical and financial aspects need to be addressed. As a result of a detailed investigation of the operation and maintenance status of MHP plants, it was found that the necessary maintenance costs can be derived from the residents through electricity bill payments. On the other hand, it was also found that once the plant was destroyed by natural disasters such as floods, funds could not be secured to restore or recover it. Therefore, in hydrological observations at the planning stage of MHP plants, it is necessary to precisely estimate not only low flow conditions, which strongly affect the amount of power generation, but also high flow conditions, which can damage or destroy the MHP plant. Also, it is necessary to create a countermeasure plan for flood risks, such as reinforcement of the intake

weir. We are working closely with the West Java Provincial Government and are planning a budgetary backup for the countermeasures.

It turned out that errors in operation could often damage the MHP plant. The improvement of the skills of the operators in remote rural communities is the key to the sustainability of MHP generation. It is vital to build a cooperative relationship between NPOs in urban areas, such as AHB, Japanese engineers, and residents, and thereby share knowledge and technology over a long period.

5 Lessons Learned

1. Work together, learn together:
   - Researchers tend to replace practical issues with the issues related to their fields of expertise, but they should think deeply about the true nature of the issues with local people. In other words, researchers should sincerely face the issues in which local people take a deep interest.
   - To understand the true nature of the issues, researchers should frequently visit the site and thereby build a trusting relationship with local people.
2. Building a network flexibly:
   - To grasp the true nature of practical issues and explore measures to solve them under changing social conditions, transdisciplinary approaches are needed; researchers need cooperation from several stakeholders. On the other hand, the relationships between stakeholders change with time, and stakeholders themselves change according to the stages of solving issues. Thus, researchers need to respond flexibly to their changes.
3. Practical wisdom:
   - Problem-based research projects are not necessarily generalized; a case-by-case problem resolution is needed according to local and/or social situations.
   - An accumulation of case studies is required so that everyone can access them for reference.

Acknowledgments This work was supported in part by the Program for Leading Graduate Schools from the JSPS (Graduate Education and Research Training Program in Decision Science for a Sustainable Society), a grant for Future Earth Study from the JST-RISTEX (JPMJRX16F1), the Grant-in-Aid for Scientific Research from the JSPS (#JP15K16115; #JP18K11623), and a research grant from the Mitsui & Co. Environment Fund (#R19-0026). We would like to acknowledge Dr. Nariaki Onda, Mr. M. Alhaqurahman Isa, Ms. Asari Takada, and other students in the Institute of Decision Science for a Sustainable Society, Kyushu University, for helping us with our field survey, and members of the Dinas ESDM-Jabar and AHB for their kind cooperation during the field survey. We also extend sincere thanks to the Ciptagelar community.

References

Ide J, Sato T, Fujiwara T, Fuse K, Kikuchi A, Yokota F, Isa MA, Rahadian F, Tjia YF, Shimatani Y (2018) Current status and issues on sustained management and operations of micro hydropower generation in the remote area in Indonesia: a case study in the Ciptagelar village. J Jpn Soc Hydrol Water Res 31:262–269

International Energy Agency (2016) World energy outlook 2016. France, p 684

JICA (2005) Prior assessment report of regional electrification in Indonesia, p 50

Kellermann P, Schöbel A, Kundela G, Thieken AH (2015) Estimating flood damage to railway infrastructure – the case study of the March River flood in 2006 at the Austrian Northern Railway. Nat Hazards Earth Syst Sci 15:2485–2496

Merz B, Aerts J, Arnbjerg-Nielsen K, Baldi M, Becker A, Bichet A, Blöschl G, Bouwer LM, Brauer A, Cioffi F et al (2014) Floods and climate: emerging perspectives for flood risk assessment and management. Nat Hazards Earth Syst Sci 14:1921–1942

Nagai M (1999) Efforts toward regional electrification in Indonesia. Elect Power Civil Eng 279:134–136

Palit D, Chaurey A (2011) Off-grid rural electrification experiences from South Asia: status and best practices. Energy Sustain Dev 15:266–276

Peters J, Sievert M (2014) Impact evaluation of Netherlands supported programmes in the area of Energy and Development Cooperation in Indonesia the provision of electricity to rural communities through micro-hydro power. International Institute of Social Studies, p 76

Purwanto WW, Afifah N (2016) Assessing the impact of techno socioeconomic factors on sustainability indicators of microhydro power projects in Indonesia: a comparative study. Renew Energy 93:312–322

Ranzanici A (2013) Sustainability comparison between EnDev and non-EnDev micro-hydro power (MHP) in Indonesia. Universidad Politecnica de Madrid, p 101

Saito Y, Takahata M (2004) Residents-participatory regional electrification projects of micro-hydropower in Indonesia. Elect Power Civil Eng 313:123–125

Sato T, Ide J, Isa MA, Rahadian F, Fujimoto T, Shimatani Y (2017) A challenge for sustainable electrification, respecting the local tradition in Ciptagelar Village, West Java, Indonesia: Complementary Approach with a Private Company. Energy Procedia 141:368–372

Suganda KU (2009) The Ciptagelar Kasepuhan indigenous community, West Java: developing a bargaining position over customary forest. In: Forests for the future: indigenous forest management in a changing world. AMAN-DTE, Jakarta, pp 27–62

Sukarna ID (2012) Energy efficiency and renewable energy in Indonesia. Available at http://energy-indonesia.com/03dge/0120720. Accessed 6 December 2017

United Nations (2019) Report of the secretary-general on the work of the Organization. United Nations Publications, New York, p 120

Urmee T, Md A (2016) Social, cultural and political dimensions of off-grid renewable energy programs in developing countries. Renew Energy 93:159–167

Yasunaga R, Nishio F (2001) A consideration on ways of setting electricity charges in regional electrification - a case study of small hydropower electrification in the regional village in Indonesia. Elect Power Civil Eng 296:170–175

Chapter 5
Conflict of Legitimacy Over Tropical Forest Lands: Lessons for Collaboration from the Case of Industrial Tree Plantation in Indonesia

Takahiro Fujiwara and Nariaki Onda

Abstract Industrial Tree Plantation (ITP) in Indonesia has been controversial due to its significant environmental, economic, and social impacts and the severe conflicts among stakeholders. Therefore, it is crucially important to discuss the fundamental structure of the conflicts to promote going forward. We introduce the concept of "legitimacy" and discuss the (1) inequality of the landholding structure and (2) legal pluralism established by historical circumstances as the fundamental structure of the conflicts. Our discussions present some key lessons in promoting collaboration among stakeholders. The first lesson is that the degree of interest and priority for problems differs among stakeholders. Therefore, an understanding of these differences is the first step toward collaboration. The second lesson is about the importance of considering history. Awareness of the problem, interpretation of the historical facts, and evaluation of other stakeholders by a certain stakeholder change over time. Therefore, to start a collaboration, it is necessary to build a consensus among stakeholders as a time point to go back to in order to discuss the problem. The third lesson is that a procedure for data presentation agreeable among stakeholders as independent, neutral, and fair is essential for their collaborations. Especially in cases where conflicts among stakeholders are intensive, it appears that confidence in and interpretation of presented data are different for each stakeholder. Therefore, data presentation agreeable to all stakeholders is essential to promote their collaborations. Unlike conventional scientific research, scientists are required to uphold various values existing in society to collaborate with stakeholders in transdisciplinary research of Future Earth.

Keywords Multiple functions of forests · Wealth inequality · Legal pluralism · Various values · Fairness

T. Fujiwara (✉)
Faculty of Agriculture, Kyushu University, Fukuoka, Japan
e-mail: takaf217@gmail.com

N. Onda
Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_5

1 Introduction

A tropical virgin forest is a biocenosis where biodiversity is the highest on earth; as many as 44% of all species of vascular plants and 35% of all species in four vertebrate groups are confined to 25 hotspots (Myers et al. 2000). Indonesia has extensive tropical forests, next only to Brazil and the Democratic Republic of the Congo, which include 2 of the 25 hotspots: Sundaland and Wallacea. Indonesia is therefore called a "mega-diversity country" because it contains so many species, while only covering approximately 1.3% of the land area of the world (Kawamoto 2011).

Approximately 70% of the national territory of Indonesia (approximately 130 million ha) is "state forest area (*kawasan hutan*)"; it is classified into three categories: (1) conservation forest (*hutan konservasi*), (2) protected forest (*hutan lindung*), and (3) production forest (*hutan produksi*). The proportion of each area is as follows: the conservation forest is 16.2% (approximately 21 million ha), the protected forest is 24.5% (approximately 32 million ha), and the production forest is 59.3% (approximately 78 million ha) of the total forest area (Kementerian Kehutanan 2012a).

To utilize the state forest area, there are six types of forest and wood product utilization licenses (IUPHHK: *Izin Usaha Pemanfaatan Hasil Hutan Kayu*): (1) natural forests (HA: *Hutan Alam*) (hereafter, NF/HA), (2) industrial tree plantation (HTI: *Hutan Tanaman Industri*) (hereafter, ITP/HTI), (3) ecosystem restoration (RE: *Restorasi Ekosistem*), (4) community tree plantation (HTR: *Hutan Tanaman Rakyat*), (5) community forestry (HKm: *Hutan Kemasyarakatan*), and (6) village forest (HD: *Hutan Desa*). The community tree plantation (HTR), the community forestry (HKm), and the village forest (HD) are aspects of social forestry that aim to improve the welfare of local communities and customary law communities, while balancing the environment and sociocultural dynamics (the regulation of Minister of Environment and Forestry No. 83 in 2016 regarding social forestry).

Companies carry out their businesses with these licenses. In the last 20 years, the ITP/HTI was increasingly used in Indonesia (Fig. 5.1). Therefore, ITP/HTI is becoming increasingly important when considering forest conservation in Indonesia. In terms of mandatory and voluntary systems for forest conservation in the ITP/HTI area in Indonesia, the Ministry of Environment and Forestry (MoEF) obliges ITP/HTI companies to allocate more than 10% of the operation area as a protected area (the regulation of Minister of Environment and Forestry No. 12 in 2015 regarding the development of industrial tree plantation). In addition to this mandatory obligation, some pulp and paper companies have voluntarily declared a zero-deforestation policy to carry out production activities using only planted trees procured from ITP/HTI area without cutting down natural forests.

ITP/HTI has attracted many stakeholders. However, ITP/HTI has been controversial due to its large impact on environmental, economic, and social aspects. Some stakeholders expect ITP/HTI to meet growing timber demand, create employment opportunities, and contribute to national economic development. In contrast, other stakeholders, such as environmental and human rights nongovernmental

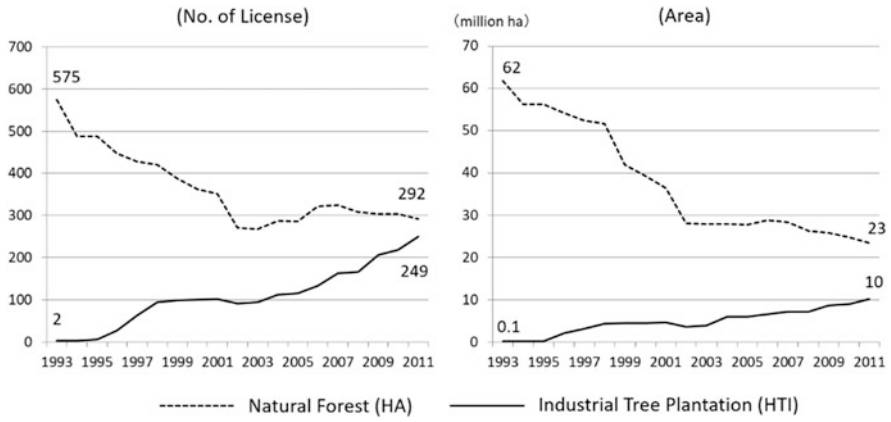


Fig. 5.1 The transition of natural forest (HA) and industrial tree plantation (HTI) licenses between 1993 and 2011 (source: translated Fujiwara et al. (2015) from Japanese to English by authors. Original date came from Kementerian Kehutanan (2012a))

organizations (NGOs), strongly criticize ITP/HTI for biodiversity loss caused by converting natural forests (including past conversion), forest and peatland fire owing to inappropriate peatland management, and land disputes due to violation of local people's rights. To promote collaborations among stakeholders (i.e., co-design, co-production, and co-delivery) for forest conservation in ITP/HTI, it is therefore crucially important to discuss the fundamental structure of these conflicts. Here we introduce the concept of "legitimacy." Miyauchi (2006) defines legitimacy as a situation where social recognition and/or approval is established about who should engage and manage a certain environment and under what value or what kind of mechanism (or the manner of recognition and/or approval). Abe (2006) characterizes present forest issues in Indonesia as an interactive process in which multiple legitimacies have different levels that need to be followed and/or competed.

In the following sections, we discuss (1) inequality of landholding structure and (2) legal pluralism established by historical circumstances as the fundamental structure for conflicts of legitimacy over the land of ITP/HTI in Indonesia.

2 Inequality of Landholding Structure

The Sustainable Development Goals (SDGs) contains 17 goals. Among these, Goal 1, "No Poverty," aims to end poverty in all its forms everywhere, and Goal 10, "Reduced Inequalities," aims to reduce inequality within and among countries.

In recent years, the economy of Indonesia has grown rapidly. Consequently, the percentage of people living under the international poverty line ($1.90/day) declined significantly from 39.3% in 2000 to 6.5% in 2016, despite the fact that 31.0% of Indonesian people still live under the lower- and middle-income poverty line ($3.20/

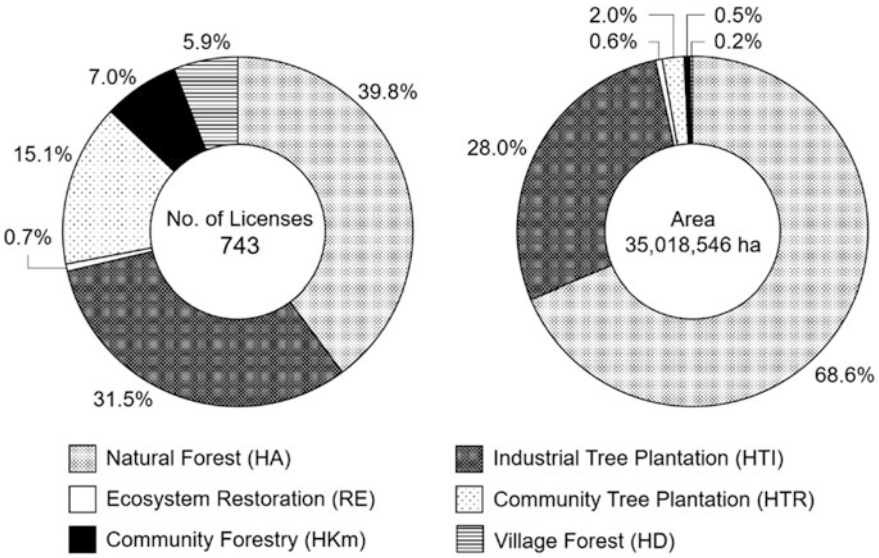


Fig. 5.2 Percentage of forest and wood product utilization license (IUPHHK) area (source: translated Fujiwara et al. (2015) from Japanese to English by authors. Original date came from Kementerian Kehutanan 2012b)

day) (World Bank 2018a). In contrast, economic disparities have tended to expand in Indonesia, and the Gini index reached 38.4 in 2016 (World Bank 2018b). According to the Oxfam briefing paper by Gibson (2017), Indonesia is the sixth-worst country for inequality of wealth in the world; in other words, the four richest billionaires had more wealth than the poorest 100 million people combined in 2016. This inequality of wealth leads to the inequality of opportunity to access health and education services as well as inequality of power with regard to who decides rules, who controls capital and resources, and who can challenge the status quo (Gibson 2017).

Although the drivers of wealth inequality in Indonesia are complex and multi-layered, one of them is a concentration of land ownership in the hands of a few companies and wealthy individuals (Gibson 2017). According to Kementerian Kehutanan (2012b), as of November 2012, 743 forest and wood product utilization licenses (IUPHHK) were issued for approximately 35 million hectares of state forest area. Of these areas, 68.6% were for NF/HA, and 28.0% were for ITP/HTI (Fig. 5.2). Therefore, almost all the issued licenses (i.e., 96.6%) were for NF/HA and ITP/HTI operated by companies. The area designated for improving the welfare of local communities and customary law communities by social forestry (i.e., the sum of community tree plantation (HTR), community forestry (HKm), and village forest (HD)) accounted for only 2.7%.

Furthermore, there is a concentration of land ownership by some NF/HA and ITP/HTI companies. Seventy-nine percent of NF/HA licenses (234 licenses) and 89.8% of ITP/HTI licenses (210 licenses) were for areas of less than 100,000

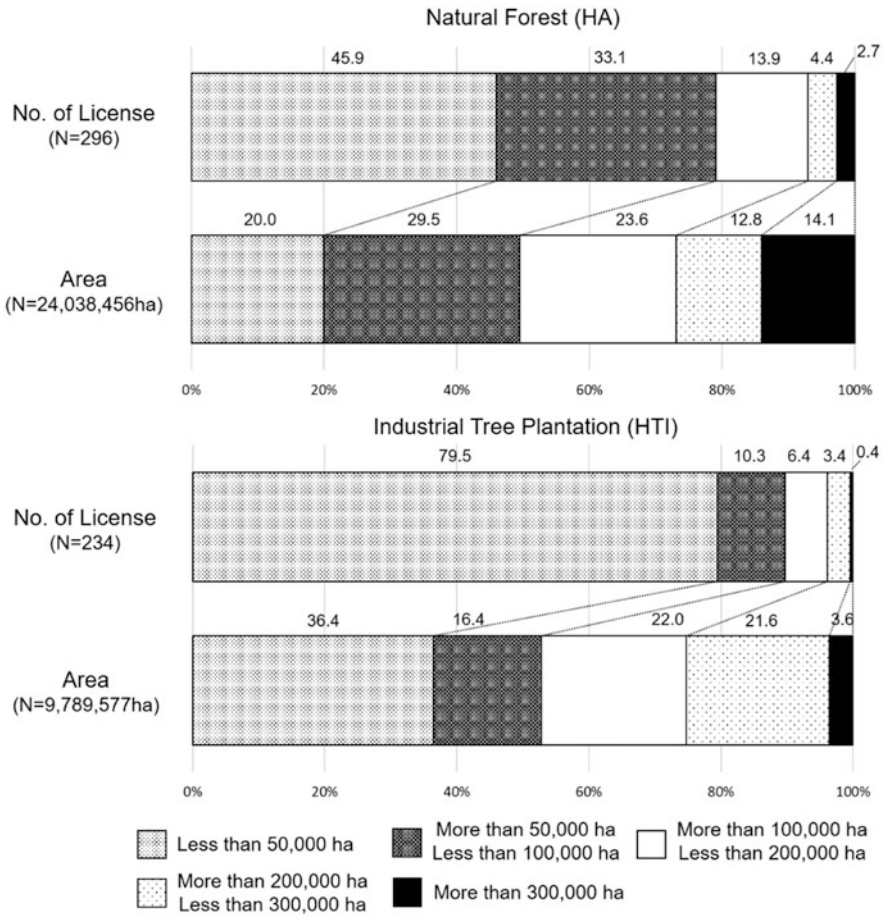


Fig. 5.3 Holding situation of natural forest (HA) and industrial tree plantation (HTI) licenses based on classification by area (source: translated Fujiwara et al. (2015) from Japanese to English by authors. Original date came from Kementerian Kehutanan (2012b))

hectares. Only 7.1% of NF/HA licenses (21 licenses) and 3.8% of ITP/HTI licenses (9 licenses) were for areas of more than 200,000 hectares. However, 7.1% of NF/HA license holders for areas of more than 200,000 hectares held 26.9% of the total area (approximately 6.5 million ha). Similarly, 3.8% of ITP/HTI license holders held 25.2% of the total area (approximately 2.5 million ha) (Fig. 5.3). Therefore, few companies held large-scale forestlands. Furthermore, some companies held plural licenses as a group. As of 2010, 28.6% of the total NF/HA area (approximately 7.07 million ha) was accumulated by only ten company groups, and 39.0% of the total ITP/HTI area (3.5 million ha) was accumulated by only two company groups (Kementerian Kehutanan 2010).

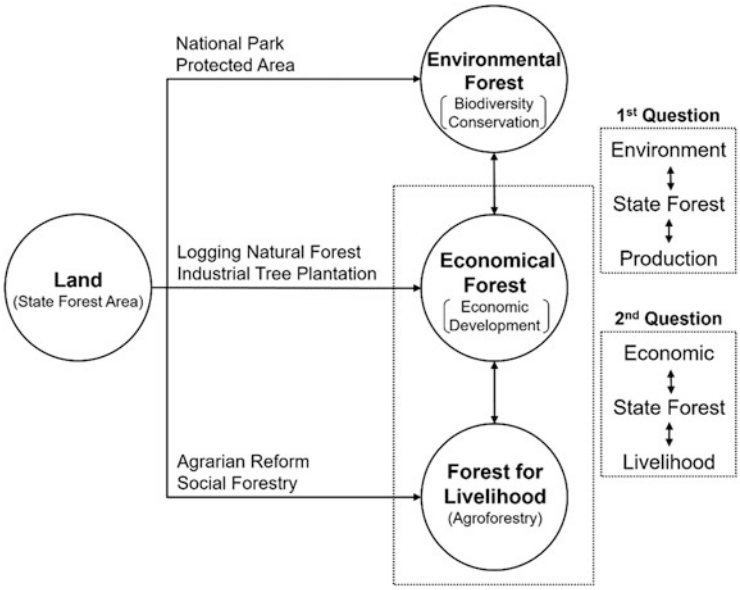


Fig. 5.4 Multilayered controversies on the land allocation and zoning of state forest area

In other words, there are companies with several millions of hectares of land, whereas there are many people who do not have 1 hectare of land in Indonesia. Thus, the correction of the largely distorted landholding structure has been an important policy issue in Indonesia. For this reason, the Government of Indonesia has set a goal to redistribute 9 million hectares of state land, including 4.9 million hectares of state forest area (TORA: *Tanah Obyek Reforma Agraria*) and 12.7 million hectares of social forestry (PS: *Perhutanan Sosial*), in its National Medium-Term Development Plan (RPJMN: *Rencana Pembangunan Jangka Menengah Nasional*) 2015–2019.

As we have seen so far, the problem with ITP/HTI is one concerning land allocation and zoning in the state forest area. There are multiple interests and multilayered controversies on land allocation and zoning of state forest area (Fig. 5.4). The first question in meeting this goal is deciding which parts of the state forest area should be designated for conservation and production. The second question is which part of the production forest should be designated for economic development by companies (i.e., NF/HA and ITP/HTI) or livelihood by local people (i.e., state land redistribution and social forestry). The degree of interest and priority for problems differs among stakeholders ranging from local to international.

3 Legal Pluralism Formed by Historical Circumstances

The Forestry Law (Law No. 41 in 1999) of Indonesia defines the "state forest area (*kawasan hutan*)" as follows: a specific territory designated by the government as permanent forests. The state forest area is also called "political forest," which is defined as *political land-use zones meant to remain in permanent forest* (Vandergeest and Peluso 2015, p. 162).

After the independence of Indonesia, the government violently enclosed the state forest area by the Basic Forestry Law (Law No. 5 in 1967) and the following forest zoning (TGHK: *Tata Guna Hutan Kesepakatan*) in the early 1980s (Resosudarmo 2004; Wollenberg et al. 2009). This enabled the government and companies to accumulate huge profits (Peluso 2011). In contrast, it caused many land conflicts among the government, companies, and local people, which carry through to the present day. One area of contention was that these enclosures incorporated a large part of the Outer Islands (islands excluding Java Island and Madura Island) into the state forest area and overrode the customary rights of local people, despite the fact that many people lived in those areas (Fay and Sirait 2002).

Looking further back into history, the Agrarian Law (*Agrarisch Besluit*), enacted by the Dutch colonial government, declared that all land, which could not be proven to be owned (individually or communally) by villagers, was the state land (Peluso 1992). This Agrarian Law made the basis for scientific forestry, which was governed by a systematic adherence to working plans for logging and replanting (Peluso 1992). The Mizuno and Kusumaningtyas (2016, p. 41) interpret this Agrarian Law as stating that *the domain declaration was issued for this vast territory that is extremely diverse in terms of biology, society, topography, and soil, precisely in order to enable large-scale investment by plantation companies while turning a blind eye to this diversity*.

The state lands were further classified into two subsets: (1) unfree state domains (*onvrij landsdomein*), which were subject to the hereditary right for individual use (*erfelijk individueel gebruik*) or the right to possession by indigenous people (*inlanders bezitrecht*), such as proactively cultivated wet-rice fields and other lands by indigenous people, and (2) free state domains (*vrij landsdomein*), which were subject to customary disposal right (*beschikkingsrecht*), such as shifting cultivation lands (Mizuno 1997; Mizuno and Kusumaningtyas 2016). Long-term concessions (*hak guna usaha*) for Westerners were issued for the free state domains (Mizuno 1997; Mizuno and Kusumaningtyas 2016). Additionally, there was an ideology of state forest management in the colonial era that was characterized as the utilitarian view (i.e., the greatest goods of the greatest number of people) and scientific forestry, and those looked down on the ecological knowledge of local people (Peluso 1992; Vandergeest and Peluso 2006a, b).

After the independence of Indonesia, the Basic Agrarian Law (Law No. 5 in 1960) was enacted in 1960. This law aimed at a legal unification of the dual structures of Western European law and customary law, and it recognized the existence of "customary communal right of disposal (*hak ulayat*)" (Mizuno 1997;

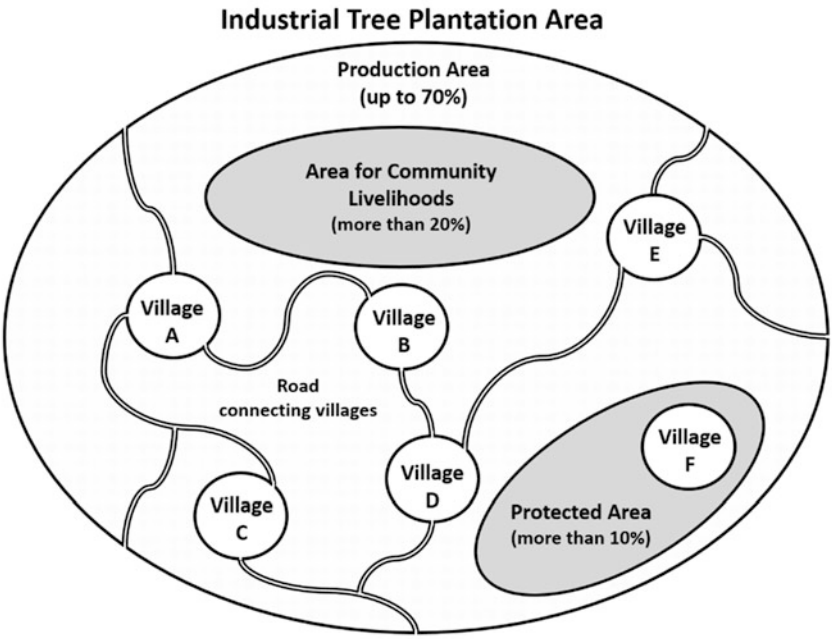
Mizuno and Kusumaningtyas 2016). Additionally, it is acknowledged that land rights were based on customary laws' land rights (i.e., it recognized customary land rights of local people for lands that were not proactively cultivated, such as fallow lands of shifting cultivations, as long as customary land rights had existed previously) (Mizuno 1997; Mizuno and Kusumaningtyas 2016). However, the methods for proving the existence of customary land rights varied according to the times, and it was very difficult for local people to claim their customary land rights positively in the era of a developmental dictatorship government of the New Order regime led by President Soeharto (Mizuno 1997; Mizuno and Kusumaningtyas 2016).

After the New Order regime reached its end, land claims by local people and the movement of land reforms have become very active again (Lucas and Warren 2003). For example, the article 4 (j) of the Parliamentary Decree IX on Agrarian Reform and Management of Natural Resources (Tap MPR IX/2001) in 2001 specified the necessity to recognize, respect, and protect the rights of customary communities and cultural diversity of the nation on lands and natural resources as the principles of agrarian reform and natural resource management. More recently, the constitutional court's decision, which was finalized in May 2013 (35/PUU-X/2012), declared that the "customary forest (*hutan adat*)," previously prescribed as "*state forest* to be in the area of the customary law community (*masyarakat hokum adat*)," by the Forestry Law (Law No. 41 in 1999) was "*forest* to be in the area of the customary law community." Along with this decision, the MoEF reclassified forests of Indonesia from two categories (i.e., (1) state forest [*hutan negara*] and (2) privately owned forest [*hutan hak*]) to three categories (i.e., (1) state forest [*hutan negara*], (2) customary forest [*hutan adat*], and (3) privately owned forest/[*hutan hak*]) (the regulation of Minister of Environment and Forestry No. 32 in 2015 regarding right forest).

From the above discussion, it appears that there is legal pluralism established by historical circumstances in ITP/HTI area and the legality, which companies and local people rely on, as well as the forms of forestry used, often differ. In other words, ITP/HTI companies are conducting scientific forestry to maximize raw material production for pulp and paper productive activities with the forest and wood utilization license (IUPHHK) based on the modern land system formed by ex-Western European Law. In contrast, local people are conducting forestry for livelihood, such as agroforestry, including traditional shifting cultivation, with customary communities' disposal rights (*hak ulayat*) based on a customary land system derived from traditional customary law (Fig. 5.5).

4 Discussion

The tropical forests of Indonesia have attracted many stakeholders because of their high biodiversity, and their conservation is essential to achieve SDGs. In the last 20 years, there has been a trend towards increasing the use of ITP/HTI in Indonesia.



	Company	Local People
Holding Land Right	• Forest and Wood Products Utilization License (IUPHHK)	• customary communities' disposal right (*hak ulayat*)
Grounds for Legality	• modern land system formed by ex-Western European Law	• customary land system formed by customary law
Form of Forestry	• scientific forestry • monoculture forestry	• agroforestry • shifting cultivation
Main Purpose of Forestry	• to maximize raw material production for pulp and paper production	• to stable livelihood

Fig. 5.5 A model of industrial tree plantation (HTI)

Therefore, ITP/HTI is becoming increasingly important when considering forest conservation in Indonesia. However, ITP/HTI has been controversial as they have big impacts on environmental, economic, and social aspects, and there are severe conflicts among stakeholders (e.g., government, companies, NGOs, and local people). To promote collaborations among stakeholders (i.e., co-design, co-production, and co-delivery) for ITP/HTI problems, it is therefore crucially important to discuss the fundamental structure of the conflicts. For this reason, we introduced the concept of "legitimacy" and discussed (1) inequality of landholding structures and (2) legal pluralism formed by historical circumstances as the fundamental structure for conflicts of legitimacy over the land of ITP/HTI in Indonesia. The discussions

regarding ITP/HTI in Indonesia shows some key lessons in considering promoting collaborations among stakeholders in Future Earth.

The first lesson is that the degree of interest in and priority for problems differs among stakeholders ranging from local to international. In the case of ITP/HTI, the problem concerns land allocation and zoning of the state forest area, and there are at least three different interests among stakeholders: biodiversity conservation, economic development, and livelihoods of local people. Additionally, these interests are often in a trade-off relationship. Recently, it appears that attention to the conservation of tropical forests and their biodiversity is steadily increasing. In contrast, some scholars express deep concern over community displacements in the name of environmental conservation (also called Green Grab) (Harada 2018). Therefore, understanding that stakeholders have different priorities and perceptions of problems is the first step in collaboration, and coordination of conflicting interests among stakeholders is crucial to create legitimacy for the collaboration. Regarding the ITP/HTI problems of Indonesia, the correction of the largely distorted landholding structure is extremely important to create legitimacy for collaboration among stakeholders. Conservation and production activities should be based on fair use and equitable allocation of forestlands.

The second lesson is the importance of considering history. There was legal pluralism formed by historical circumstances in the ITP/HTI area. It appears that stakeholders claim their legitimacy based on different legalities formed by historical circumstances. In other words, the problem differs depending on the time point considered when discussing the problem. For example, recently, some pulp and paper companies in Indonesia have voluntarily declared a zero-deforestation policy to carry out production activities using only planted trees derived from ITP/HTI without cutting down natural forests. For the production activities based on the zero-deforestation policy of pulp and paper companies in Indonesia, some stakeholders highly appreciate their policy as significantly contributing to conserving tropical forests and biodiversity. In contrast, some stakeholders such as environmental and human rights NGOs strongly criticize companies based on the historical facts that immense forest land enclosed by companies to realize production with zero-deforestation may contain lands converted from natural forests as well as lands enclosed by violence and by ignoring the customary land rights of local people.

Looking further back on the history, some pulp and paper companies in developed countries also received international criticism for converting tropical forests on a large scale and for violating the rights of local people in days past, just like what is being currently done by Indonesian pulp and paper companies. However, those are now regarded as environmentally friendly companies, and some of them have become cooperative members of NGOs. Therefore, awareness of the problem, interpretation of the historical facts, and evaluation of other stakeholders by certain stakeholders change over time. In other words, in order to start a collaboration, it is necessary to build a consensus among stakeholders as to which time point should be considered when discussing the problem.

The third lesson is that a procedure/method of data presentation agreeable among stakeholders as independent, neutral, and fair is very important for their

collaboration. In cases in which conflicts among stakeholders are intensive such as for ITP/HTI in Indonesia, it appears that confidence in and interpretation of presented data are different for each stakeholder. For example, it is supposed that high biodiversity is found in a protected area of the ITP/HTI area managed by a company through a scientific survey. Some stakeholders, who achieve a friendly relationship with the company, can receive the survey results positively and interpret it as a company changing their business attitude and making an effort for forest conservation. In contrast, some stakeholders, who take a critical and confrontational attitude, may receive the same survey result negatively and interpret it as a company destroying extensive natural forests with high biodiversity and then implementing conservation efforts, which are insufficient and for public relations only (also called greenwashing). Data and information provided by opponent stakeholders may be unreliable (i.e., is it a fact or an advertisement?). Therefore, data presentation agreeable among stakeholders is essential to promote their collaborations.

Stakeholders have varying sets of values, and they rely on different legitimacy. In other words, stakeholders have different perceptions and priorities for the *problem* (e.g., biodiversity conservation, economic development, the livelihood of local people). Additionally, they have different historical awareness of the *problem* (e.g., which time point do we go back to, to discuss the land tenure *problem*?). Unlike conventional scientific research, scientists are required to adhere to various values existing in society to collaborate with stakeholders to facilitate transdisciplinary research of Future Earth.

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs, the Environment Research and Technology Development Fund (4-1601) of the Environmental Restoration and Conservation Agency of Japan, and JSPS KAKENHI Grant Number JP17K15340.

References

Abe R (2006) Competing legitimacy for forest resource management in a developing country: the case of Marga vs. the industrial reforestation project in South Sumatra, Indonesia. J Environ Sociol 12:86–103

Fay C, Sirait M (2002) Reforming the reformists in post-Soeharto Indonesia. In: Colfer CJ, Resosudarmo IA (eds) Which way forward? People, forests, and policymaking in Indonesia. Resource for the Future, Washington, DC

Fujiwara T, Awang SA, Sato N (2015) Current situation of land grab in state forest area in Indonesia: analysis of forest and wood products utilization license. J For Econ 61(1):63–74

Gibson L (2017) Towards a more equal Indonesia. https://d1tn3vj7xz9fdh.cloudfront.net/s3fs-public/bp-towards-more-equal-indonesia-230217-en_0.pdf. Accessed 10 December 2018

Harada A (2018) Green grabs: community displacements in the name of environmental conservation. J Azabu Univ 29:45–57

Kawamoto A (2011) Current situation and conservation policy of biodiversity in Indonesia. Jpn J Int Forest Forest 82:22–27

Kementerian Kehutanan (2010) Laporan Perkembangan Pemanfaatan dan Penggunaan Hutan Produksi Triwulan IV [Oktober – Desember 2010] (Report on development of utilization and use of production forest progress quarterly [October–December 2010]). Kementerian Kehutanan, Jakarta

Kementerian Kehutanan (2012a) Statistik kehutanan Indonesia 2011 (forestry statistics of Indonesia 2011). Kementerian Kehutanan, Jakarta

Kementerian Kehutanan (2012b) Data dan informasi pemanfaatan hutan tahun 2012 (data and information on forest utilization 2012). Kementerian Kehutanan, Jakarta

Lucas A, Warren C (2003) The state, the people, and their mediators: the struggle over agrarian law reform in post-new order Indonesia. Indonesia 76:87–126

Miyauchi T (2006) Legitimacy no shakaigaku he: commons ni okeru shounin no shikumi (toward legitimacy in sociology: approval mechanism in commons). In: Miyauchi T (ed) Commons wo sasaeru shikumi: legitimacy no kankyou shakaigaku (mechanism to support commons: legitimacy in environmental sociology). Shinyosha, Tokyo, pp 1–32

Mizuno K (1997) Indonesia ni okeru tochiken tenkan mondai: shokuminchiki no kindaihou tochiken no tenkan mondai wo chuushin ni (land rights conversion problem in Indonesia: focusing on conversion problem of modern law's land rights in the colonial period). In: Mizuno K, Shigetomi S (eds) Tounan Asia no keizai kaihatsu to tochi seido (economic development and land system in Southeast Asia). Institute of Developing Economies, Chiba, pp 115–154

Mizuno K, Kusumaningtyas R (2016) Land and forest policy in Southeast Asia. In: Mizuno K, Fujita S, Kawai S (eds) Catastrophe and regeneration in Indonesia's peatlands: ecology, economy and society. NUS Press, Singapore, pp 19–68

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403:853–858

Peluso NL (1992) Rich forests, poor people: resource control and resistance in Java. University of California Press, Berkeley

Peluso NL (2011) Emergent forest and private land regimes in Java. J Peasant Stud 38(4):811–836

Resosudarmo IAP (2004) Closer people and trees: will decentralization work for the people and the forests of Indonesia? Eur J Dev Res 16(1):110–132

Vandergeest P, Peluso NL (2006a) Empires of forestry: professional forestry and state power in Southeast Asia, part 1. Environ Hist 12:31–64

Vandergeest P, Peluso NL (2006b) Empires of forestry: professional forestry and state power in Southeast Asia, part 2. Environ Hist 12:359–393

Vandergeest P, Peluso NL (2015) Political forest. In: Bryant RL (ed) The international handbook of political ecology. Edward Elgar Publishing, London, pp 162–175

Wollenberg E, Moeliono M, Limberg G (2009) Between state and society: decentralization in Indonesia. In: Moeliono M, Wollenberg E, Limberg G (eds) The decentralization of forest governance: politics, economics and the fight for control of forests in Indonesian Borneo. Earthscan, London, pp 3–23

World Bank (2018a) Poverty & equity data portal: Indonesia. http://povertydata.worldbank.org/poverty/country/IDN. Accessed 10 December 2018

World Bank (2018b) Poverty & equity brief: Indonesia. http://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_IDN.pdf. Accessed 10 December 2018

Chapter 6
Sustainable Community Co-development Through Collaboration of Science and Society: Comparison of Success and Failure Cases on Tsushima Island

Yasunori Hanamatsu, Tomomi Yamashita, and Shota Tokunaga

Abstract This chapter examines how science can co-produce with local communities and what kind of roles it can play for local revitalization in one of the border islands of Japan, Tsushima (Nagasaki Prefecture). Currently, depopulation, declining birthrate, and aging population are accelerating in local regions all over Japan, and the management and survival of local communities is becoming "unsustainable." Therefore, it has become a major issue on how to build a sustainable local community around Japan, and various efforts have already been made everywhere. Under these circumstances, the case of Tsushima is a practical case study of transdisciplinary research to develop a sustainable local community. This is also one of the Future Earth research which is based on the "co-design, co-production, and co-delivery between science and society." This chapter will introduce two cases in Tsushima islands, and then, from the perspective of TD research, emphasize the importance of the role of coordinator, social sensitivity to local needs and realities, priority, problem framing, and scale setting.

Keywords Tsushima · Social capital · Coordinator · Personality · Social sensitivity

Y. Hanamatsu (✉)
Faculty of Law, Kyushu International University, Kitakyushu, Japan
e-mail: hanamatsu@law.kiu.ac.jp

T. Yamashita
Academic Research and Industrial Collaboration Management Office, Kyushu University, Fukuoka, Japan

S. Tokunaga
Division of Marketing Data Bank, JMA Research Institute Inc., Tokyo, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_6

1 Introduction

In this chapter, we examine how science (scientists, scientific knowledge, universities, and other research institutes) can co-produce with local communities (local society) and what kind of roles it can play for local revitalization in one of the Japan border islands, Tsushima (Nagasaki Prefecture). Currently, depopulation, declining birthrate, and aging population are accelerating in local regions all over Japan, and the management and survival of local communities is becoming "unsustainable." Therefore, it has become a major issue on how to build a sustainable local community around Japan, and various efforts have already been made everywhere.

Under these circumstances, the case of Tsushima, which is introduced in this chapter, is a practical case study of transdisciplinary research (hereinafter, TD) to develop a sustainable local community. This is also one of the Future Earth research which is based on the "co-design, co-production, and co-delivery between science and society," conducted by the interdisciplinary research team from the Institute of Decision Science for a Sustainable Society, Kyushu University (IDS3). In other words, this is one of the TD case studies from a local perspective, which tries to answer the theme of this part of "how can we co-design, co-produce, and co-deliver with local society toward a sustainable local community?"

Specifically, this chapter will introduce two cases in Tsushima islands: (1) project which aims to find and resolve local issues with local high school students and (2) project to revitalize local communities by regenerating abandoned farmland. The aim of the former project is that local children will grow as local leaders in the future in a local community that is struggling with population decline, by trying to discover local resources (including resources of the natural environment as well as the distinctive history, culture, stories, places, and people in the region) and raising awareness of local residents. And, the aim of the latter is that local residents are reusing abandoned farmlands in consideration of biodiversity, to commercialize high-value-added crops and develop experiential tourism.

In these two projects, the focus is on whether it is possible to achieve "co-design/co-production/ co-delivery" between science and local societies, and what kind of implication does "co-design/co-production/co-delivery" have in the planning and implementation of the project. Then, from the perspective of TD research, the importance of social capital (face-to-face relationship), the role of coordinator, social sensitivity to local needs and realities, priority, problem framing, scale setting will be emphasized.

2 Definition of Local Society and Local Community

First of all, we want to make a simple definition of the concept of "local society" and "local community" used in this article. The meaning of these words is likely to differ greatly by country or scholars. The word "local" is very ambiguous (Herod 2011).

The general Japanese word corresponding to "local" is "Chiiki," but the meaning or content is similarly diverse (Tonooka 2004). This term may be used in the meaning of a "prefecture" or "municipality," or a smaller area where dozens of people live within relatively small blocks enclosed by several roads or rivers. In addition, other concepts similar to "local" in English include "region," "rural," "municipality," "province," "area," "village," "settlement," "town," "city," "field," "zone," "district," and "block." Although the definition of these concepts has been discussed in each discipline such as political science, geography, sociology, cultural anthropology, and urban planning (Sakamoto 1966; Mitsuhashi 2007), the difference is not clearly defined or understood. It is not the purpose of this chapter to closely follow these discussions on the definition of "local" (Yohannan et al. 2014; Hooghe and Marks 2016). However, for the moment, it is necessary to define the concepts of "local society" and "local community" in this chapter, because comparisons with other local cases are meaningless if the geographical scale, spatial range, scope of the targeted local people, and limits of jurisdiction are not clear and do differ from case to case (Ihara 1983).

The "local society" used in this chapter refers to all types of societies that are established at a lower level than the national level. It may mean an area of local government such as prefecture or municipality in Japanese administrative division, or an area of smaller unit, scale, community, or neighborhood. Therefore, it is to be regarded in the broad sense of the word without limitation as far as it is located within the national territorial jurisdiction. In connection with such a geographical scope, the term "local people," "locals," and "local resources" are used without limiting the scope.

On the other hand, the term "local community" is used in the sense of more restrictive, limited scope. It is usually regarded as a smaller unit than the municipality that Japanese people often imagine in the word "Chiiki" (local). In addition, it should also be a "community" where some material is shared by a group of people. Specifically, it is a communal unit that is composed of several or thousands of households with a certain geographical range. Because there is a variation in the scale, it is called "town" when the number of members is large, or is called "village" or "settlement" when it is small. When the geographical area is relatively broad, it is sometimes referred to as "district." However, the common feature is that a certain level of resident's self-governance or autonomy exists. Of course, there is a possibility that all residents share something even on the prefecture or municipal level. However, in Japan where the scope and scale of municipality is too large in the world, the resident's autonomy at the level of daily life is usually implemented in a smaller scale than municipality. Such a smaller scale is called a "local community" in this chapter, and it is likely to be referred to as "rural community" in other cases.

The above definition is likely to be criticized from various disciplines, but is to be set up just only for convenience to clarify the range of this chapter in accordance with the purpose of this part. It must be emphasized repeatedly that our case of "co-design/co-production/co-delivery" especially focuses on the "local community" that is a unit smaller than municipality and has something shared by a group of people as self-governance.

Finally, we would like to briefly explain why local community in such a small scale should be focused on. First, municipality which is often imagined in the word "Chiiki" (local) by Japanese people has a very large geographical range or population size, and has a wide variety of culture, history, industry, lifestyle, and interests. Therefore, it is very difficult to think of municipality as a single unit or a bundle of community. In other words, Japanese municipality on a large scale will always have difficulty in promoting the collaborative "co-design/co-production/co-delivery" with various stakeholders living in the society that is demanded in Future Earth research.

Hence, in order to achieve "co-design/co-production/co-delivery" within a local society, it is necessary to "scale down" to a small "local community" level where local people can share something in a substantial form.

Second, as mentioned earlier, the municipalities in Japan are losing their financial and governance capabilities for tackling the problem of declining population and birthrate. As a result, it is becoming difficult for municipalities to provide an adequate quality of public services to all areas of jurisdiction, or to solve the problems in the entire region. Under the circumstances, some of new approaches in local governance have already started. For example, an entire area of municipality is subdivided into small areas of tens to thousands of households. Then, local people in such a small unit establish a "resident's organization" ("resident's self-governance unit"), while municipalities provide financial and human support. The "resident's organization" is administered and managed by local people themselves, and also responsible for providing a part of the public service such as water supply, childcare service, and local event on behalf of the municipal organization. Unnan City in Shimane Prefecture is the pioneer region where 30 resident's organizations in the city are actively engaged in the operation of public service. On the other hand, on the nationwide scale in Japan, more than 3000 resident's organizations were already established, and it is usually called "self-governance organization of small scale and multi-function" with much attention.

It can be pointed out that, in recent years, local autonomy or self-governance in a smaller scale of community is demanded more and more in Japan, as public governance and problem solving at the national or municipality level have become unsustainable gradually. In light of the viewpoint of this chapter, this trend indicates that, in order to "co-design/co-produce" a sustainable local society, it is necessary to consider at the level or scale of smaller "local community" rather than the municipality level.

3 Tsushima Island

We would like to briefly introduce the outline of the subject of case studies presented in this chapter and the current situation in Tsushima island in Nagasaki Prefecture.

Tsushima island is a border island located at the north westernmost end of Japan. It is the tenth largest island in Japan, and the current population is about 30,000 people. About 90% of the area is covered with forest and mountain, and because

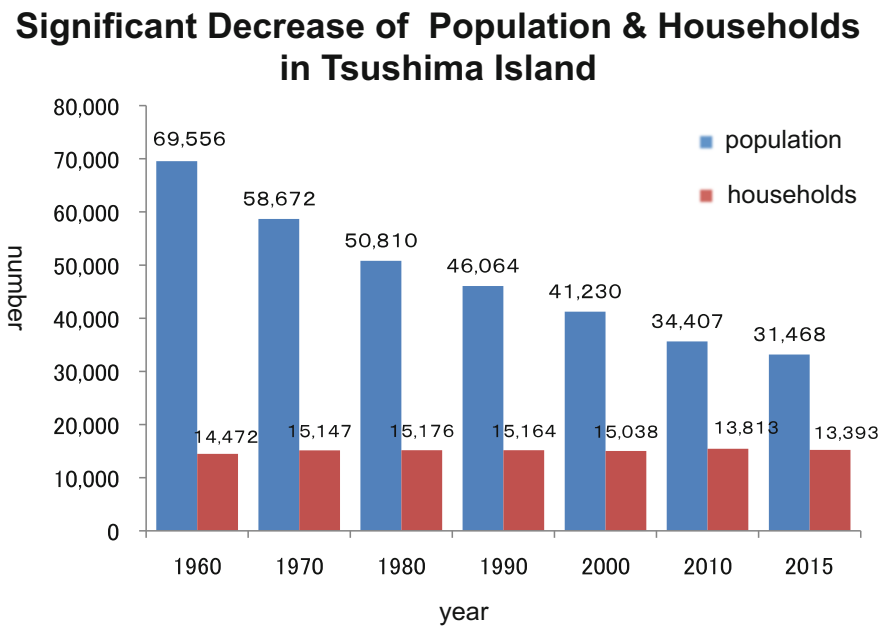


Fig. 6.1 Change in population and households in Tsushima Island

there is little land suitable for cultivation, people's lives have been managed by the exchange and trade with Korean peninsula which is 49.5 km away from the island since ancient times. Moreover, because it is a border remote island, the island as a whole functioned in the past as a military fortress, and development such as construction of the road has been restrained for many years. Therefore, Tsushima was one of the most "undeveloped" regions in Japan, as the folklore scholar Tsuneichi Miyamoto said in 1960 that "the Middle Ages still remain in Tsushima" (Miyamoto 1984). Since the modern era, fishery has become a key industry, but with the decline in fishery resources in recent years, the population has already fallen down to less than the half of the 1960s (Fig. 6.1).

In line with the population decline, one of the most serious problems is the declining birthrate and aging population. The average of total special fertility rate in Tsushima City from 2008 to 2012 is 2.18, and this is the fifth highest in all municipalities in Japan. However, the total number of children continues to decrease every year due to the population decline of the parent generation, and in recent years, elementary and junior high schools have been forced to close. A lot of children go out of the island after graduating high school for getting a job or going on to a university, and most of them do not return to the islands afterward. On the other hand, the aging rate, which shows the percentage of people of 65 years or over in the total population, is 33.9% in Tsushima City in 2015 (Fig. 6.2). This rate is said to be the same as that of the entire country of Japan after 20 years. In addition, there are

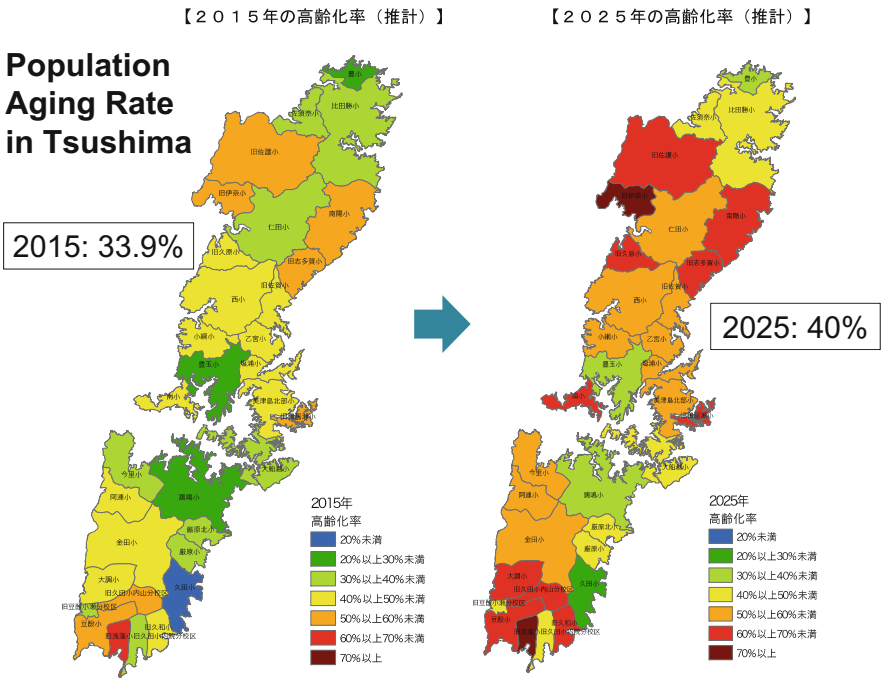


Fig. 6.2 Population aging rate in Tsushima (Source: Tsushima City, *2nd Comprehensive City Planning*, 2016)

some areas in the island where the aging rate has already exceeded 60%. It indicated that the number of local people who can accept the responsibility for supporting a senior citizen in the island has been extremely declining.

As an approach to this problem, Tsushima City has been working on the project "collaboration between university and local society" (Tsushima City 2020) since 2014. This is the national project in Japan from 2012 in which university students and teachers work with local people together to promote "activities that contribute to the revitalization of local communities and the development of local human resources" (Japan Ministry of Internal Affairs and Communication 2012). Tsushima City has been attracting attention as one of the pilot model cases. More than 500 university students and graduate students visit Tsushima from all over the country every year, and they collaborate with local people in various fields of natural science, social science, and humanities. Many of them are continually tackled and there are also successful cases that have a positive effect on the region, but there is also the challenge that this kind of collaborative approach is not necessarily being implemented in all areas and problems in the island.

On the other hand, so many Korean tourists have visited from Busan on the opposite bank of the strait to Tsushima island. Since the opening of the international sea route between Tsushima and Busan in 1999, the number of tourists from

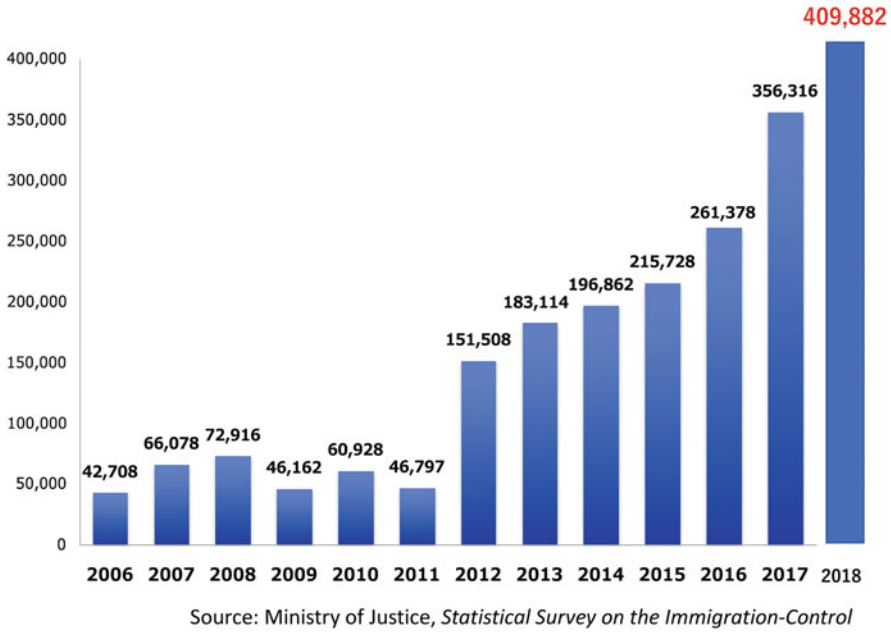


Fig. 6.3 Increasing number of foreigners entering Tsushima

Korea has increased every year, and in 2018, the number of foreign immigrants has exceeded 400,000 (Fig. 6.3). Most of them are Koreans and have reached about thirteen times the population of Tsushima City. The tourism consumption by Korean tourists has increased by 2.4 times in the last 5 years, and the two port cities in Tsushima where regular vessels arrive are undergoing remarkable development in recent years. However, it is said that the recipient of the profit is limited to a part of tourist companies and construction contractors doing business activities around the port city, and the feeling of doing good business in tourism is hardly felt in other areas with small population size. On the other hand, the tourist needs for Koreans in Tsushima are diversified, and the development of the tourism service and tourist attractions is demanded firmly. Nevertheless, regarding the promotion of tourism, efforts made by local residents themselves as well as cooperative joint projects through the aforementioned municipality project of "collaboration between university and local society" have been rarely observed.

Based on the current situation in Tsushima, our team was aware of the following issues: (1) Is it possible to take an interdisciplinary approach of "co-design/co-production" for improving the sustainability of the local areas that have not been tackled in the past, based on the framework of the municipality project of "collaboration between university and local society"? (2) Is it possible to "co-produce" a sustainable community in cooperation with local residents or universities, by organizing both university students and Korean tourists as not guests (objects) but players (subjects) for supporting local communities? (3) Is it possible to make an

opportunity for children who were born and bred in the island and then go out of the island, to return to the island in the future and play an active part as a supporter of the community without relying too much on the power of "Yosomono" (people coming from outside)? (4) What conditions or requirements will be necessary for tackling the abovementioned issues at the level of the local community which is a smaller unit than municipality?

4 Project "Looking for Island Treasures" by Local High School Students

The first case is an attempt to "co-produce" a sustainable local community with local people and local high school students by rediscovering local resources. One of the purposes of the project is that the local high school students are expected to learn afresh about the local community where they live in, try to find the local resources, and to resolve the problems in local community by "co-designing/co-producing" with local residents and university students. Second, they are also expected to have a feeling of attachment or a sense of mission to their home island by knowing well the local community and finally become the supporter of the community after returning to the island in the future. Third, local people are expected to take a look at the hard struggle by local high school students and have an awareness of the social issues and their own role or responsibility to contribute to the establishment of the sustainable local community. In this project, for the purposes mentioned above, it must be examined what kind of function science or university can perform in such a "co-design/co-production," and on what conditions or requirements local community and university can "co-design/co-produce" a sustainable local society.

4.1 Background of the Project Starting

In the winter of 2015, we were talking with the president of the local construction company, the head of the Commerce and Industry Association, and municipal officials (Tsushima City officials) in Kamitsushima town located in the northernmost part of Tsushima. This was the first time to talk together with the counterpart of the industry, local government, and academia on the future of Kamitsushima town, although we had connected with various parties in this area through the educational program in the university or the fieldwork research on borders.

One of the municipal officials in the meeting was Mr. K who was working in Tsushima City as a temporary staff. He came to Tsushima from Tokyo with a 3-year term as a new supporter of the local community, by the fiscal backup of the Japan Ministry of Internal Affairs and commissioned by Tsushima City. He was an excellent talent who penetrated deeply into and understood the realities of the

local community by using his delicate standing position of "half-inhabitant" and "semi-outsider." He also played an important role in connecting local islanders with "outsiders," or "guests" coming from outside the island such as university researchers.

In Kamitsushima, the municipality so far had been taking various initiatives aiming at the revitalization of the local community, and it did not go quite well. A good idea had not occurred to the local people, and it was expected to have good wisdom from outside. While the number of Korean tourists increases every year, the improvement of tourism service, attraction, and hospitality remained to be discussed for many years. Moreover, the shopping street which is the symbol of the community was deserted without traffic, and the decline of the community had progressed in the visible form. The sense of urgency that we had to respond as soon as possible was shared by all concerned.

Then, Mr. K raised the topic of Kamitsushima high school which is one of three high schools in Tsushima City. The number of students in this high school has decreased rapidly as the area declines, and it is now facing a crisis of "closing down." The existence of the school is vital for the survival of the local community, and the close-down of the high school will have an adverse effect on the local community. Mr. K proposed to launch a special educational program in order to overcome the close-down crisis. His proposal is that students are expected to learn something interesting in the field outside the classroom altogether with local people, municipality, and university students coming from outside.

Then, we hit on a plan that the local high school student will learn the realities or problems in the local community by interviewing various local residents while walking in the shopping street. In addition, the plan expected them to try to resolve the problem in the community and then make a presentation of an idea for revitalizing the local community toward local businessmen. The president of the local construction company and the head of the Commerce and Industry Association agreed to this proposal, hoping that the young high school students would consider the idea of revitalizing the area while wishing for the continuation of a local high school, a source of vitality in the local area. We also agreed that it would be an interesting initiative to stimulate the local people by involving local high schools.

What we had to consider for starting the project was who will plan, organize, and implement such an extracurricular class. Even if the municipality or businessmen are familiar with the actual situation of the area, they do not have know-how and enough time to teach high school students. On the other hand, high school teachers have professional skills of teaching in classroom, but in fact they do not have much contact with the area outside the school, and it is difficult to say that they understand fully the situation and the problem of the local area. Most teachers are actually "strangers" to the local area, and not "local people" because the teacher of the prefectural high school has the practice of repeatedly transferring to another high school in Nagasaki every few years.

Then, we thought that the researchers and graduate students of the university can accept the work of teaching the realities of the local area to the local high school student. We are certainly "strangers" coming from outside of the island, but we are

slightly familiar with local people in Kamitsushima because we had been engaged with the education practice there many times. We researchers have some experience and knowledge about resolving local problems and have enough know-how to teach students. On the other hand, the graduate students who have participated in the educational practice in various regions have the experience of finding and solving problems in local areas. In addition, it was preferable, from the viewpoint of the educational effect on graduate students, that the graduate students themselves carried out the joint fieldwork for finding and solving problems with the high school students who were comparatively close in age to them.

Therefore, we can summarize the roles and interests of each of the stakeholders as follows. First, the university including researchers and graduate students is responsible for planning the education programs of local high school students and actual classroom management of the joint fieldwork. In doing so, the graduate students have the advantage of being facilitators and deepening their involvement in resolving local problems, which will promote a study on community for graduate students. Next, the high school will be able to show the appeal to avoid the close-down crisis by implementing a unique, distinctive education program. In addition, the local businessmen and Commerce and Industry Association will give advice on the selection of interviewed persons and arrange a presentation meeting directed at local people scheduled at the end of the year. By obtaining ideas from a fresh viewpoint of the local high school students, they will be able to propose a project that will stop the decline of the area. Finally, the municipality will coordinate the entire stakeholders, standing between the high school, the university, the business operators, and the Commerce and Industry Association. By undertaking such a coordination work, it can produce a satisfactory result on the municipal project "collaboration between university and local society" and another project "collaboration between high school and university" which are also progressing nationwide in recent years.

The first challenge was whether the high school, the most important stakeholder, would accept this project. At this point, high school officials did not participate in the process of the planning discussion. Therefore, it would be a complete surprise for the high school side. At first, we thought that Mr. K and our university researchers would submit the petition to the high school. However, the president of the local construction company who was a co-planner of the project suddenly visited the high school and persuaded the principal to accept the project. It was also a complete surprise for us that the project was decided to start in such a way.

Then, we university team would be in charge of the extracurricular class for the 26 high school students. They would find attractions and problem in the area, try to solve the problem, and finally make a presentation to local people. The project is named "Looking for Island Treasures" project for the purpose of exploring the challenges and possibilities of the local community while rediscovering the attractions of the island.

It is true that the high school side wished to have a distinctive educational program to avoid the close-down crisis, but it is presumed that the most influential driving force for reaching that decision is the specific interpersonal relationship between the president of the local construction company and the principal of the

high school. In other words, we have to emphasize that research and education ability and scientific knowledge of our university have not had a big influence on the start of the project.

4.2 Trial Experiment in the First Year

Since the project has started suddenly, we did not necessarily share a clear understanding or image of a goal setting, a definite division of roles, and a feasible outcome from the beginning among all the stakeholders. Rather, it proceeded through trial and error approach, while we "try for the time being, and then re-examine or revise if there occurs a problem." The reason is that such an approach of repeated trial and error (the so-called adaptive governance) is suitable according to circumstances of the community and the change of the interests of each stakeholder (Folke et al. 2005; Brunner et al. 2005).

In 2016, which was the first year, all the stakeholders felt in the dark about the project. Even our university group, who were supposed to lead the fieldwork and group work of high school students, had to go through the confusion occasionally because it was the first experience of the "co-design/co-production" project. The involvement of our university group in the management of the class was limited because we were afraid of confusing the high school teachers. Due to the circumstances of the university group, it was not possible to get enough students to participate in the class, so the members of university students in charge of each high school student group changed every time. As a result, the mutual trust relationship between high school students and our university group was not able to develop well. It was also the first time for high school teachers to get students out of school and to interview local people, so it was a very confusing experience. It was supposed that there were a lot of high school teachers who were attending the joint fieldwork and group work with the question "what is the meaning of such a hard extracurricular activity?"

Still, the students who were divided into five groups continued the interview investigation in their own ways. They investigated the attractiveness and problems about the local food culture, natural resources, history, the annual "border marathon" events, and hosting Korean visitors in the community. Finally, they showed the results of the group investigation at a town meeting where local residents and business operators participated (Picture 6.1).

It actually has become a great stimulus for the people of the community, as the participants of 20 local residents and business owners asked sharp questions about the students' presentations. In the questionnaire survey toward the high school students after the presentation, there were several positive comments such as "It was pleasant," "It was stimulated," and "it was good to know a lot about the local community where I lived." In addition, the high school teacher also seemed to have obtained a feeling of satisfaction and accomplishment.

Picture 6.1 Presentation of the students group investigation at a town meeting

On the other hand, in the opinion of students and teachers, there were many comments indicating that they wanted our university group to be involved more actively in their work. "We want them to go to the fieldwork with us every time," "we wished the same university group member to take charge of each group every time by communicating with each other," and "we want to have a more friendly chat with university group members." A lot of comments asked for the enhancement of communication and trust between high school and university. In fact, we university group members were not able to carry out the work with a well-organized plan. Therefore, they indicated dissatisfaction and regret that the project was not able to achieve complete presentation and practice of the solution, even if they were able to point out the problem in the local community. In addition, we also received many expectations and requests for the intellectual resources of the university. "We wanted them to show a model of interview to us", "we want them to teach us more and more about how to make a good questionnaire survey," "we want them to give more guidance and advice of presentation by PowerPoint," and so on.

As described above, even if there is plenty of scope for improvement, the results of trial experiments in the first year gave a positive impression to each stakeholder. We also received a nice request from the high school side that "we want you to continue this project not only this time but also next year." On the other hand, a variety of problems were also highlighted. Therefore, it was the key to the project success to overcome and improve these problems next year.

4.3 Development Phase in Second Year

In response to the reflection of the first year, the second year of the 2017 project focused on communication between stakeholders and started in a way that greatly strengthened the commitment of university members.

Mr. K, who has been a key coordinator among the stakeholders, left the island with the termination of his term, and a successor Mr. S was to play a similar role as a new temporary municipal official. Therefore, it is important to carry out the succession of tasks from Mr. K to Mr. S, and to conduct a thorough meeting between stakeholders in order to aim for further development while taking into account the circumstances to the point. In the first year, the project was started without sufficient planning, but the second year began with a meeting from four months before the start of the class, and a total of 20 meetings were held between the stakeholders throughout the year (Picture 6.2). In addition, the role sharing between stakeholders has become clear through the previous year trial. It was agreed that the university members would be more actively involved in the planning and management of educational programs (Fig. 6.4). In addition, it seems that the high school teacher tried to get involved in this project more proactively, as a result of a thorough meeting beforehand and continuously exchanging opinions about the aim and contents of the project many times. As described later, the accumulation of such

Picture 6.2 Continuous meetings among stakeholders

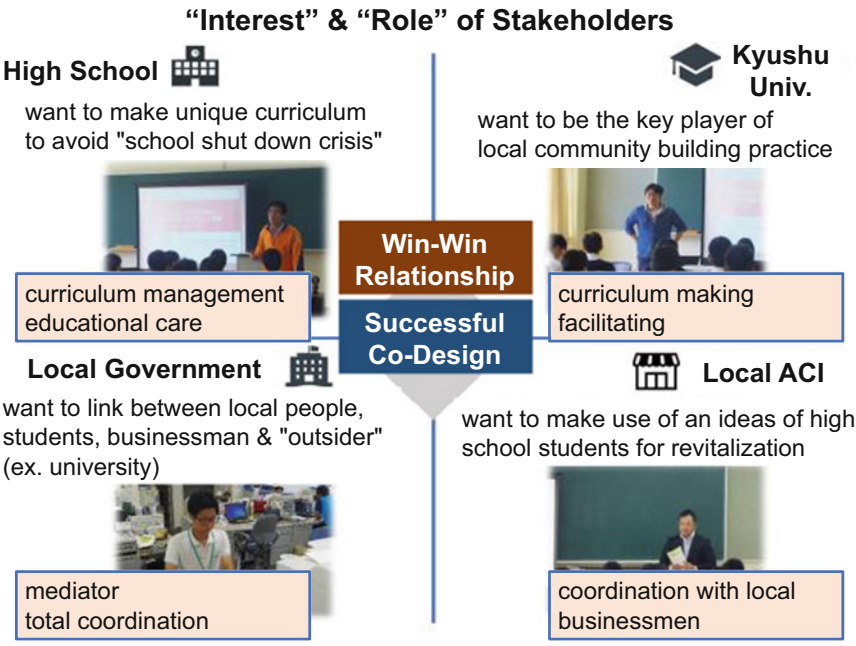


Fig. 6.4 Interest and role of each stakeholder in the project

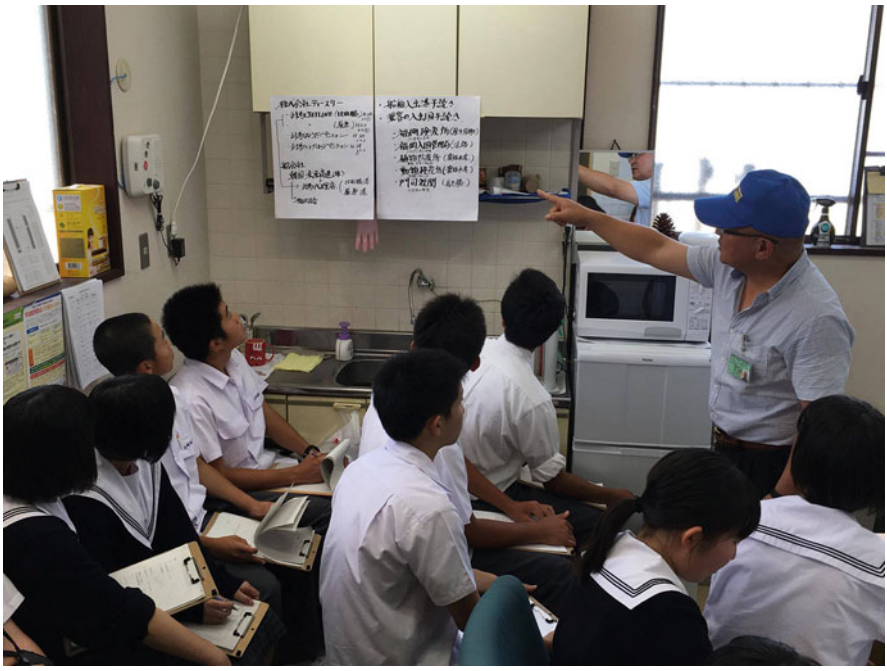
in-depth meetings and face-to-face communication led to the success of the project by building a strong trust relationship between stakeholders.

The number of students in the second year has increased by 36. On the other hand, it has greatly increased the attendance and participation frequency of the university members to ensure sufficient communication and trust with all students. The organizing staff was 10 members composed of university teachers and graduate students, approximately twice as many as the previous year. Although the frequency of our participation was about five times in the previous year, the second year was approximately 15 times. We supported not only extracurricular fieldwork, but also the facilitation of group work for setting up and analyzing tasks in the classroom (Picture 6.3), and the preparations for their presentation in a meeting with local residents. In addition, prior to the full-fledged start of the class, preparative lectures and group works were carried out twice beforehand (Picture 6.4). By giving high school students sufficient preparation time, students were able to set up their own problems without being swayed by instructions from high school teachers and university members. As a result, the friendship between the university and the high school students was significantly improved, and the students' willingness to participate in the project was clearly increased.

With the involvement of our university members in almost every class and fieldwork, the quality of the surveys by high school students has risen significantly. One of the groups discussed a concrete proposal about the strategy to increase jobs in local society based on the result of the interview investigation (Picture 6.5). There

Picture 6.3 Facilitating a student group work by a university group member

Picture 6.4 Preparative lecture by a university graduate student



Picture 6.5 Interview research with local people and businessmen

was a group who carefully examined a sensitive problem of whether the local community in Tsushima island ought to receive Korean tourists or not, and finally tried themselves to guide Korean tourists in the street. In addition, another group conducted a questionnaire survey both to Korean tourists and to Japanese tourists, and came up with a concrete proposal to improve tourism hospitality by receiving more than 500 answers from tourists. The findings of the latter group won the best prize at a poster session of the academic research event sponsored by Tsushima City at a later date. We also tried to maintain a good relationship with local residents by exchanging frequent greetings with the local businessmen and people who supported the high school students' interviews and questionnaires survey.

The second year of project activity was also widely featured in the local newspaper, and it became well known to local residents (Picture 6.6). In addition to having the opportunity to talk about the project in the high school cultural festival, we also held the same presentation event for local residents as the previous year, and high school students fruitfully exchanged views with about 20 local people. This project has become more and more popular among local residents, and high schools students and teachers have been able to fully realize the impact of the project on the local society.

The results of the questionnaire survey to high school students after the end of the class showed that the high school students changed their minds about the local society. As shown in Fig. 6.5, the students commented that "I was able to think

Picture 6.6 Reported in local newspapers

Fig. 6.5 Comments from high school students after the project

- I was able to think deeply about Tsushima.
- I have noticed the attractiveness of the community.
- I was surprised to know that population will decrease dramatically in Tsushima.
- I want to participate more frequently in local events.
- I want to come back to Tsushima after university graduation.
- I came to think of what I can contribute to Tsushima.
- I have to make me responsible for the Future of Tsushima.
- I want to become a local community leader in the future.
- I found this island is so attractive to outsiders and foreign tourists.
- I have never thought about Tsushima much deeper before.

deeply about Tsushima," and "I have noticed the attractiveness of the community" in the same way as in the previous fiscal year. Moreover, there were positive comments such as "I want to participate in local events more and more," "I want to return back to Tsushima in the future," "I came to think about what I could do for Tsushima," and "I want to become a local leader in the community in the future." This shows that they did not only capture the attractiveness and problems of their island from an

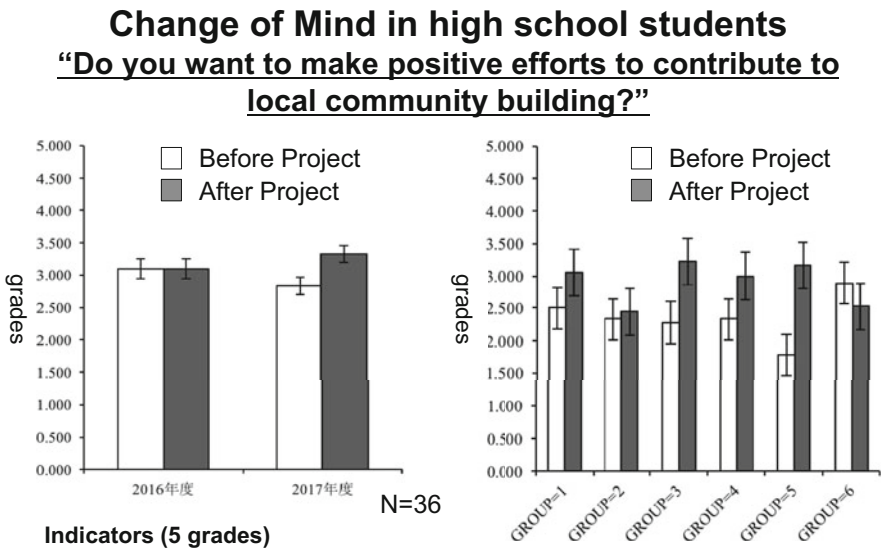


Fig. 6.6 Change of mind in high school students before and after the project

objective point of view, but also seemed to have the intention to be deeply involved in the future of the island or community. These comments also show that this project may actually contribute to the purpose that local children will have a sense of attachment to the local community where they were born and raised, and a sense of responsibility to become a local community leader after returning to the island in the future" as expected from the project designing phase.

This conclusion was also backed up by a questionnaire to the high school students that shows how the student's consciousness changed before and after the project. Figure 6.6 shows the result of the question to all 36 students, "Do you want to make positive efforts to contribute to local community building?" They self-evaluated in five grades for four indicators before and after the project. The result shows that their willingness to contribute to the community is greatly increased after the project than before.

4.4 Examining from the Perspective of "Co-design/Co-production/Co-delivery"

Based on the achievements and results of the "Looking for Island Treasure" project conducted over 2 years, what can be said from the perspective of "co-design/co-

production/co-delivery" in Future Earth studies and TD research? Finally, we will summarize from our own six perspectives.

First, the geographical, societal scale, and scope of the project were appropriate for the purpose. Although the target area should be the whole town of Kamitsushima with about 3800 people given the range of a school district where students attend the school, but the 26 students who participated in the project actually performed fieldwork at the Hitakatsu area, a central part of Kamitsushima town, where about 800 people in 400 households lived in. The quality of the project and the impact on a community seem to have been secured by limiting the geographical scale to the small local community of 800 people, instead of expanding to the large scale of the entire Tsushima City or Kamitsushima town. In this sense, scaling of geographical and human ranges was appropriate in light of one of the TD indicators ("scaling") shown in this part. It was also important to limit stakeholders to high school, university, commerce associations, local businesses, and municipality in order to carry out projects on such a small scale. There were many other individuals and organizations in the community, and it was not impossible to get them involved with the project for the purpose of it. However, it was likely that the uncertainty of the interest adjustment would increase, and the achievement of the goal would be difficult if we involved in the project other local individuals, organizations, and larger administrative bodies such as prefecture, central government, and international organizations (even if it is actually impossible). All individuals and organizations involved in collaborative work would usually have and wish to achieve their own intentions and interests. In that sense, it can be said that the "stakeholding" which is the selection of the interested party according to "scaling" was also appropriate.

The second is the success of building trust relationships between stakeholders. In the first year, sufficient planning and staffing were difficult and impossible, but in the second year, a sufficient good relationship was established between the stakeholders by conducting continuous elaborate meetings and emphasizing communication with high school students. As a result, consensus was formed between stakeholders almost perfectly about the policy, aim, and content of the project, and finally the "co-design" was successfully achieved. This means the fulfillment of "social capital" as a building of trust between stakeholders (TD indicators shown in this part), but in more detail the following can be said. First is that the agreement on the "framing" (TD indicators shown in this part) of changing minds of the local populace while educating the local high school student as future supporters of the local community has been successfully achieved. Second, the consensus on "priority" (TD indicator shown in this part) has been achieved in that each stakeholder's interests and intentions are mutually harmonized complementarily. On the other side, "transition process" (TD indicators shown in this part) to reconcile conflicts and gaps between stakeholders was not generated. These points seem to be a major factor for going further to the "co-production" without stopping at the "co-design" stage.

Third, Mr. K and Mr. S, who were temporary municipal officials, successsfully played a major role as coordinator for the entire project. Because they were in a position to stay in Tsushima only for the term of three years, they could have a "halfway" standpoint, so to speak, neither a complete outsider nor a

complete resident. However, on the contrary, their halfway position enabled them to pay fair attention to each stakeholder while taking the distance moderately with all stakeholders ("sensitivity" and "fairness" as TD indicators shown in this part), and build the trust relation with each other. In the case of TD research, there are cases where scientists and university members are working as coordinators. However, since Mr. K and Mr. S played the role of coordinator in this project, we university members were able to be released from a neutral role of the coordinator ("independent/ neutral" as TD indicators shown in this part). This enabled our university members to act independently as one of the active stakeholders rather than the entire coordinator. In summary, it can be said that the role of coordinator should not necessarily be taken on by scientists or university. In other words, other subject actors might be suitable for coordinator in order to achieve a successful co-design and co-production.

Fourth, the credibility of the university's scientific knowledge and research technology might have influenced the success of the project. Although whether or not the methodology of interviews and questionnaires can be said to be "scientific" in a strict sense seems to be debatable, expectations from high school teachers and students for these methods were so large at the end of the first year. In fact, it is also true that in the second year, the quality of research has been improved owing to these techniques provided by our university members. On the other hand, "citizenship education" that has its origin in the UK (Crick 2000), which raises the consciousness of political participation of citizens and people, has been attracting attention in the discipline of political science. If we can regard this project as one of such "citizenship education" (Tokunaga and Akiho 2018), we can also see that in this project a method of "citizenship education" has been accepted as a scientific and technical tool. This shows the possibility of "usefulness of science" in TD research (TD indicator shown in this part), and such method can be applied to other locals and cases. In this sense, this project can also be regarded as a case that indicates the potential of "co-delivery." On the other hand, the usefulness of scientific knowledge and reliance on it were based on a strong relationship between stakeholders and the hard work of Mr. K and Mr. S as coordinators. Therefore, merely adopting such method would not necessarily have been able to lead to the success of this project.

Fifth, it is about the factor of "personality" (TD indicator shown in this part) that depends on the standpoint and ability of a particular stakeholder. In particular, this project was highly dependent on the temporary municipal officials Mr. K and Mr. S, but, on the other hand, the adverse effects of the substitution of a coordinator from Mr. K to Mr. S were mitigated by the relationship of trust and communication among other stakeholders. Therefore, it can be said that the influence of personality was able to be overcome by other such factors.

Finally, the sixth is about time setting. This chapter introduced the process of the project until the end of the second year, but from that time it is likely to take a long time for the results of the project to appear in a tangible way. It is not yet clear whether the high school students who actually performed fieldwork will return to the island in the future and become a local leader of the community. In addition, this project was also taken up by the local media, and became known to a certain extent

in Tsushima island, but it has not yet come to the next stage where the external social evaluation ("legitimacy" as a TD indicator shown in this part) has been obtained apart from the internal evaluation among the relevant stakeholders. In that sense, it will take much longer to confirm the final success of this project. On the other hand, the financial support of JST for Future Earth research is in only five years, including two years of feasibility study and further three years as a full research period. Here, we would like to emphasize that there is a significant gap between the amount of time it actually takes to get results in the field site and that of time that can be supported as a Future Earth TD research. Strictly speaking, it is virtually impossible for science and universities to "co-design/co-produce" a successful result with society in a short period of five years. Therefore, from the beginning of the project, we have been preparing for achieving the phase of "self-propelled" by local stakeholders alone to continue this project, on the premise that we university would "withdraw" from the project as a stakeholder after the three years full-scale research period has passed. For that purpose, we prompted the high school teachers to understand completely the significance of this project, and continue the project as an annual educational program. In addition, the know-how of fieldwork research, facilitation, and presentation should be accumulated by the high school, and taken over among teachers who transfer from and to the high school. This project should also be a regular local event supported by the local Chamber of Commerce, businessmen, and municipality. If it will be taken over well, it is possible to be arranged and organized only by the local stakeholders continuously even after the university leaves. In fact, it is expected to be carried out only by local stakeholders from 2019. Whether this project will continue in the future is not yet known, but given the limited role that scientists and universities can play in the local society in a limited period of time, we university are required to start the process of "co-design/co-production" while keeping in mind a future image of phase "self-propelled" by local stakeholders.

5 Project "Reconversion of Abandoned Farmland" in Consideration of Biodiversity

The second case is a project aimed at rebuilding a sustainable local community by reconverting an abandoned farmland straggling all over the island of Tsushima. As mentioned above, Tsushima has accelerated the population and birthrate decline in recent years, and the population of the elderly is increasing and simultaneously the number of young people is decreasing in local communities. As a supporter and manpower of agriculture becomes insufficient, agriculture that has been managed until then in local communities is becoming "unsustainable." As a result, agricultural farmland is abandoned as it is, and "abandoned farmland" which is left uncultivated is now increasing rapidly. There is no objective statistical data, but according to Tsushima City, the percentage of abandoned farmland in the entire cultivatable land

area is more than 50%. This phenomenon is seen in the whole country of Japan in recent years (Japan Ministry of Agriculture, Forestry and Fisheries 2017), but it is especially remarkable in Tsushima island. And with the decline in population, birthrate, and agricultural industry, the transformation of a local community toward "marginal settlements" (Yamashita 2012) is further accelerating. Therefore, we thought of the plan to restore such abandoned land to a richly cultivated land with high biodiversity, and to raise value-added crops which conserve rare organisms, while mobilizing inbound tourists such as Korean and university students coming from outside the island as the manpower for agricultural work. We also expected that it is to give vitality to a local community by securing a high profit.

In doing so, it must be questioned what kind of role does science and university play, and on what conditions are science and university able to "co-design/co-produce" with the local community?

5.1 Background of the Project Planning

The project was born from the idea of our researchers' group in IDS3. We have originally been interested in the unique natural environment of Tsushima and the problem of the community degradation. As we have visited Tsushima many times and drove around the island, we were very surprised to see too much abandoned farmland. At that time, a project idea has suddenly occurred to us to restore abandoned farmland in order to promote the community revitalization. What should be noted here is that the project plan has not been studied based on local needs and data obtained from local interviews, but has actually been started from a pure idea of our scientists and researchers.

The contents of the plan are as follows (Fig. 6.7). It is difficult to simply restore abandoned land to the original farmland. Of course, it takes a lot of effort and labor, but the most important point is that the crops produced on farmland restored in the conventional form are low in profitability and are "not worth the candle." This is a common problem that farmers working all over the country are facing. Therefore, we thought of changing such an abandoned land to a high-biodiversity farmland. It was expected that the reconversion of abandoned farmland into eco-friendly farmland enables to produce highly value-added crops with high price, because the survival of rare animals may be ensured in such an ecological farmland.

A rare animal, the Tsushima Leopard Cat inhabits in Tsushima (Picture 6.7). It is the cat that does not live in Japan except in Tsushima, and is designated as a "Natural Monument of Japan," and listed as "Critically Endangered Species (IA)" in the Red Data Book edited by the Ministry of Environment of Japan. It is a subspecies of the Bengal cat which has originally crossed from the Korean peninsula, and is a unique animal living only in Tsushima island in Japan. Its scarcity and appearance enjoys huge nationwide popularity.

The number and range of the Tsushima leopard cat are recently decreasing in the island. It is said that one of the major causes is a decrease in cultivated land. The

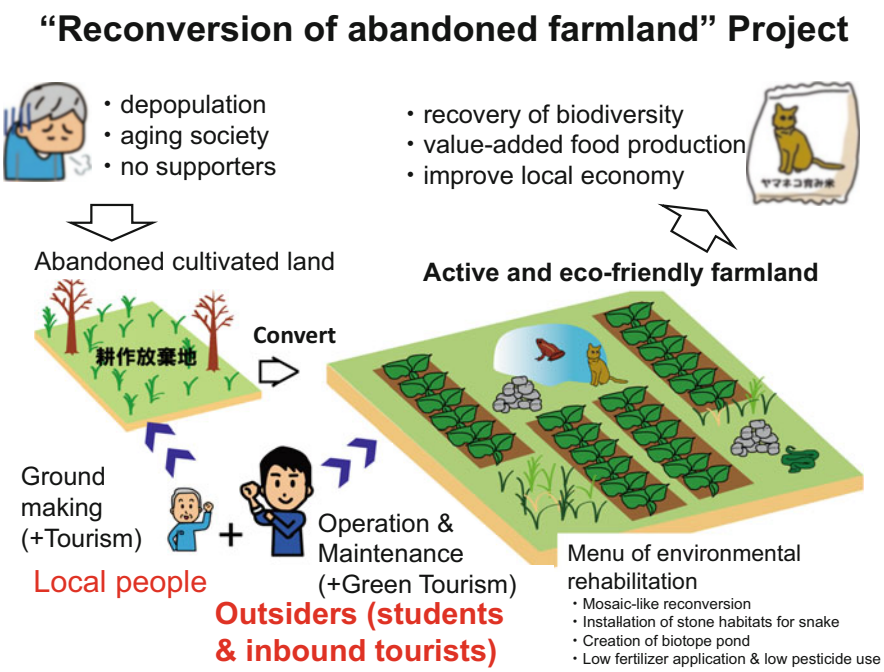


Fig. 6.7 Outline of the "reconversion of abandoned farmland" project

Tsushima leopard cat usually feeds on rats and aquatic insects which live in the cultivated land such as rice fields. However, as the cultivated land disappears, such food for the Tsushima leopard cat is decreasing. Therefore, by transforming an abandoned land into a high-biodiversity ecosystem environment and making it a habitat and feeding area for the Tsushima Leopard Cat, it is possible to contribute to the preservation of the Tsushima leopard cat. And, the crops made on such a high-biodiversity farmland are added value and regarded as "crops to preserve the Tsushima leopard cat." They are to be sold at a high price, and it may become a source of income for a local community. This could make a community even more lively. In addition, if such a reconversion project is successfully implemented in Tsushima island, it may lead to a new job creation, and put the brakes on the trend of "marginal settlements" in local communities in Japan.

The scientific and practical knowledge of the university on natural regeneration is useful for the creation of high-biodiversity farmland. Scientists in our group will conduct scientific examination into the applicability of natural regeneration technology and the effect of re-cultivation of land.

On the other hand, the manpower for agriculture in Tsushima, which decreased with aging trend and declining birthrate, might be partly provided by a lot of Japanese university students who come to Tsushima for research and educational purposes in the municipal framework of "collaboration between university and local

Picture 6.7 Tsushima Leopard Cat

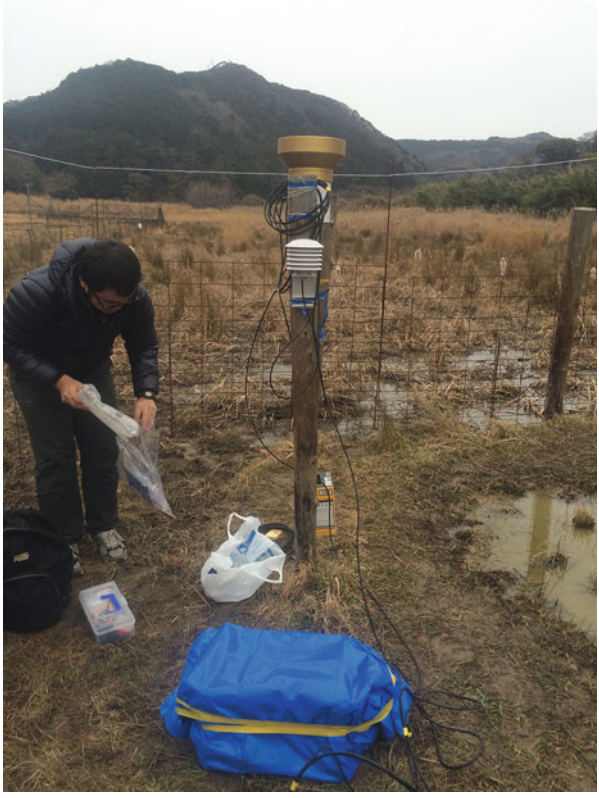
society," and also Korean tourists coming to Tsushima. We thought of providing Korean tourists with the experience of farmwork in a highly biodiversity ecosystem as green tourism. Each different tourist might be engaged in separate farmworks as green tourism during their stays only for a few days. This was also conceived from the results of our hearing survey on Korean travel agencies. According to one of the travel agencies, the tourism attraction in Tsushima is scarce, and it is still confusing where to take Korean tourists in Tsushima. Then, we thought that the experience of such green tourism might be accepted as one of the sightseeing menu for the Korean tourist who tends to be attracted by rich nature that does not exist in Korea.

5.2 Project Start

In the starting phase of this project, there was no specific prospect of local community in the island as an object of investigation. Moreover, it is necessary to find a candidate site which must meet various geographical requirements: it has to be near the place where (1) it seems to be the habitat of the Tsushima leopard cat, (2) sufficient water can be supplied because we originally assumed the cultivation of rice

(however, rice was finally rejected and we changed to buckwheat later because rice production will take a great deal of time to care for cultivation and farmland), (3) there is a local community which agrees to provide an abandoned land for joint cultivation, (4) Korean visitor can easily access to. For this reason, we have traveled many times from 2014 and went around the entire island to explore the surrounding environment and ecosystem while investigating a candidate site (Picture 6.8). In addition, we talked to the residents of the area where environmental conditions seemed to be appropriate, and tried to negotiate with them on whether we could ask them to take charge of actual farmwork to a certain extent (Picture 6.9). We have looked for a candidate site for two years, but were not able to find out a suitable research site. Our research group was actually puzzled as to what we should do.

Meanwhile, the temporary municipal official Mr. K, who was playing an important role in the early stages of the project "Looking for Island Treasures" mentioned earlier, suddenly introduced us to a village in late 2016. Because residents of village A in the northern part of Tsushima were cultivating sweet potato for revitalizing the local community, he proposed that our research group might be able to start the project by collaborating with village A. The village A of about 60 households had a sense of crisis in the declining population and birthrate and voluntarily tried to start a



Picture 6.8 Investigating a candidate site (2014)

Picture 6.9 Negotiation with local residents on the operation of farmwork (2015)

local community business by cultivating sweet potato. The motivation of the residents in the village A was very high, and Mr. K had a good relationship with them, so we thought that it might be possible to start the project if we could ask Mr. K to take on the responsibility of acting as coordinator.

In addition, we received an invitation from Mr. K to explain the outline of the project in the village meeting to be held several weeks later. As we were actually at a loss how to find a research field, there was no reason for refusing the invitation. After observing a field where the residents of village A were actually making sweet potato (Picture 6.10), in February 2017 we explained the project in front of the leader and other 10 members of village A (Picture 6.11). We received various opinions and comments there. For example, "Is it ok for you to make sweet potato rather than rice?" "I think buckwheat cultivation will be better considering the troublesome work of care," "how much manpower is necessary for the project implementation?" "It is necessary to cooperate with a farm corporation for selling the farm products with added value. What do you think about that plan?" All of these comments and questions were very important, but we honestly told them that we did not have any clear answer and that we would rather want to "co-design" the project together with them and continue to think ahead. We generally got a positive reaction, not a negative or critical opinion, and finally they told us that it was possible to offer a farmland for the project. On the other hand, the deadline for applying for the subsidy in Tsushima City was approaching in May 2017, and there was not much time left before the end of the research period in IDS3. Therefore, after discussing with the members of the village A, we decided to start the project there as early as possible, especially within three months or less.

Picture 6.10 A new candidate site for the project (2016)

Picture 6.11 Presentation on the project to members of the village (2017)

5.3 Project Development

It seemed that the project would start smoothly, but two major changes occurred here. First, the village leader was replaced at the turn of the fiscal year. The former leader was active and cooperative in our project, but the new leader was rather

negative about the project. We tried to persuade the new leader several times, but there was no change in his cautious stance, and frustration began to show in our communication with him. After that, he proposed to change the course of action about our project in the community meeting where all households in the village participated in. The main member of the village used to make a positive comment before, but most of the residents who participated in the meeting agreed on a negative policy proposed by the new leader. Frankly speaking, this was an unexpected happening for us. The cause of such a change was not certain, but it seemed that the human relations and the power of the new leader in the village probably influenced their decision.

Second, as mentioned earlier in the description of the "Looking for Island Treasures" project, the Tsushima City's temporary staff Mr. K left the island due to the expiration of his term. The succeeding new staff, Mr. S who took over the mission of Mr. K in the "Looking for Island Treasures" project, were not yet in a good relationship with the residents of the village and not able to cooperate well in this project, because it has not been long since he came to the island. Owing to the fact that Mr. K who had played the role of the great coordinator and connected village A with our university group was gone, the mediator and the connecting post were lost. The impact of the absence of a coordinator was greater than expected. Until then, we could not say that we had been able to build a robust one-to-one relationship of trust with the village A. Finally, it became much difficult for us to reconcile our opinions with village A.

Both our research group and the members of the village were being beset by doubts and fears with each other and we began to think that it would be difficult to start the project. However, a chance of turning the tables in our favor was suddenly given from village A. In the end of April 2017, we were asked to explain once again the contents and prospects of the project to all the residents of village A in the community meeting.

The deadline for the project to start was approaching and we were impatient, but one of us decided to visit there and explained our project carefully. However, most of the reactions from the resident were negative. Figure 6.8 is an extract of the comments received from the resident at that time.

The details and implication of each comment will be described later, but we can simply conclude that it was not possible to fill the gap of the idea with the residents of village A. As mentioned in the last comment from the residents, there was an opinion that they wanted to spend more time talking about the project because they were still not able to understand and discuss each other sufficiently. At the end of the meeting, our university group and village A formally concluded that we would continue the discussion. But our group had no time left. The deadline to start the project is approaching in May 2017, taking into consideration a necessary period of time for developing and selling high-value-added products by cultivating some crops and for verifying the effect on the local community revitalization. Therefore, we discussed carefully and ultimately decided to give up the start of this project.

- I cannot understand why we should bear physical and monetary burden.
- We are all very busy, and cannot cooperate in any farm work.
- How long will Kyushu University go on contributing to our village?
- How much money will Kyushu University provide for us?
- Agricultural damage caused by wild animal such as deer and boar is much more critical for us than biodiversity, conservation of Tsushima Leopard Cat. Can you cooperate in the extermination of harmful wild animals?
- We suspect that Kyushu University will make use of our village for scientific research on the conservation of Tsushima Leopard Cat.
- We need much more time for talking with each other. This project plan is complete surprise for us. We cannot still understand your explanation.

Fig. 6.8 Comments from village residents at the presentation meeting

5.4 Lesson Learned from the Project "Reconversion of Abandoned Farmland"

This project ultimately ended in "failure," but what can be learned from the perspective of Future Earth research, and "co-design/co-production/co-delivery" in TD research? We will summarize from our own seven points of view in short.

First, it is necessary to build a strong trust relationship with the local community for scientists and universities to "co-design/co-produce" with it on an equal status. For that purpose, a lot of time and labor for confidence building is essential. In fact, the project had difficulty in finding an appropriate research site at the stage of feasibility study, and began negotiations with village A for the first time in the stage where there was not enough time left. However, due to the lack of time, we rushed ahead and tried to start the project without being able to communicate adequately with the residents of village A and building a trust relationship. As a result, as shown in Fig. 6.8, the residents showed their refusal to devote money and labor and had the misunderstanding that our university group tried to make use of village A for another purpose such as scientific research on the preservation of Tsushima leopard cat. This shows the failure in building "social capital" as the TD indicator shown in this part. In other words, "co-design/co-production" does not succeed without bringing about a relationship of trust with the local community, even if scientific researchers or universities have enough scientific knowledge and technics for contributing to the sustainability of a local community. We also had difficulty in "time setting" (TD indicator shown in this part) in that it was not allowed to have enough time to build trust relationships with the local community.

On the other hand, second, in the co-design phase of this project, the voice of both trust and doubt was not heard among residents of the village about scientific knowledge on biodiversity and technology for improving productivity which our university group could offer to them. The fact that the project was to be based on scientific knowledge and technology did not seem to have a direct influence on the

judgment of the resident. Of course, in fact, the residents of the local community do not have the ability to judge the validity of scientific knowledge. Moreover, there is a possibility that the resident's understanding and reliance on the scientific knowledge and technology were not enough and that might have been a chief cause for a negative reaction by the residents. However, as a result, it is true that the residents valued building the trust relation, agreeing on the purpose and direction of the project with our university group rather than questioning the validity of the scientific knowledge. Therefore, it can be said that the validity and usefulness of scientific knowledge are not sufficient conditions even if it is a necessary condition, for the successful achievement of "co-design/co-production" with the local community. On the other hand, one of our group members thinks that the primary cause of failure in the project is that we did not show a fully satisfactory scientific basis and data to the local community, rather than a failure in building a human trust relationship with each other. However, the problem is that, in case of failure in the collaborative work, it is so difficult to examine why we failed by, for example, talking with the other stakeholders after the event. As a sensitive human relationship between our group member and the residents of the village or among residents of the community may matter, it is difficult to do an ex post interview survey with the stakeholders.

Third point is that a neutral "coordinator" (TD indicator shown in this part) was indispensable. The withdrawal of the municipal temporary official staff Mr. K from the project had a great influence, and we lost the mechanism which coordinated the disagreement of the opinion between our university group and village A. If scientists or university members cannot play the role of a neutral coordinator, it would be a prerequisite for some other entity to play such a role.

Fourth, the "personality" of the stakeholders (TD indicator shown in this part) had a significant impact on the project because the atmosphere of the residents changed greatly by the alternation of the leader of village A. This is not something that can be controlled by ourselves, and we cannot expect what kind of person becomes the head of the village, so it can be said that it is a problem which depends on luck. However, such a personal human nature as a standpoint, character, and bias of a particular stakeholder usually influences the project at any time. Supposing that factor, it should be noted that the influence by the personality of the specific stakeholder might have been somewhat eased if it was possible to have enough trust relations with other stakeholders of residents in the village.

Fifth, there was a critical problem in the way that our university group unilaterally designed a project, created the plan, and proposed it to the local community and asked for consent and cooperation. Undoubtedly, we had a stance that we wanted to discuss with the member of the community the details of the project, the specific goals, and the process on how to proceed. However, the blueprint for the entire project was produced only by our university group. We did not fully understand the needs of the community by doing a detailed hearing investigation of the resident in village A, even if there was not enough time left for "co-designing" at the early stage of the project planning while we were suddenly introduced to the village A by Mr. K. In this sense, it must be said that we failed to meet the requirement of "sensitivity" to the local community as a TD indicator shown in this part.

Sixth, there was a huge gap in the "framing" and "priority" between the residents of village A and our university group. We thought that, for the revitalization of the local community, it was necessary to make the farm products which made high profits by reconverting abandoned farmland and making use of external manpower. However, as shown in Fig. 6.8, the residents of village A thought that the problem of abandoning farmland and unsustainable local community was caused by damages of increasing harmful wildlife such as deer and boar. In a word, they assigned high priority to the resolution and reduction of such a harmful wildlife damage rather than the reconversion of abandoned farmland. Unless the harmful wildlife damage problem is resolved, the surrounding mountain and field will be left to run wild and there will be no rat which Tsushima leopard cat usually feeds on.

Seventh, the gap in "framing" and "priority" also leads to the gap in the perception of "scaling" and "stakeholding" between our university and village A at the same time. Harmful wildlife damage caused by drastically increasing deer and boar is extending through the whole area of the island. Because animals move freely in disregard of human boundaries (borders) such as settlements and communities, it is not a problem that can be managed only within a particular village. Rather, it is a problem that must be managed in a larger area by involving the entire scope of the Tsushima City or at least a neighboring local community. In this sense, we can say that there was a gap in the perception of "scaling" of the problem between our university and the residents of the village. There are various different types of scale, for example, local community scale such as village A, local area scale including surrounding local communities around Tsushima City, and even larger scale such as prefectures and Japan nationwide with similar problems. So, it is understood that it should have been taken as a problem of a "layered scale." Also, as the perception of "scaling" is different, of course, the scope of stakeholders corresponding to each scaling also changes. In other words, it could be said that we consequently failed to decide the appropriate "stakeholding".

On the other hand, even if these gaps are recognized, adjusting and correcting over time may eventually eliminate the gap. It might be usual that there occurs a "gap" in various respects between scientists and the people who live in the local community in TD research. What is important there is we should establish a process of coordinating such gaps, and if this process succeeds, it will lead to a strong trust relationship. However, in the case of this project, unfortunately it was not possible to secure sufficient time for "transition process" (TD indicator shown in this part) which adjusts such various "gaps."

Finally, as we mentioned repeatedly, the research term of three or five years in Future Earth research is too short for successfully achieving the "co-design/co-production" of a sustainable local society with a local community and further to verify the effect. In particular, unlike "Looking for Island Treasures" project, if geographical and natural environmental requirements are imposed on the selection of research sites, it will take a considerable amount of time to pre-examine the candidate sites. Then, the various social activities (understanding the needs and priority of the community by hearing investigation, setting an appropriate scaling and stakeholding, and establishing a trust relationship with the local community)

which are necessary after the investigation and decision of the research site will obviously be constrained in time.

6 Conclusion

It is difficult to make an assertive conclusion to the question "how can we achieve the "co-design/co-produce/co-delivery" between science and (local) society toward a sustainable local community?" shown at the beginning of this chapter only from the examination of these two cases in Tsushima island. Society is inherently diverse, complex, and dynamic (Miyauchi 2018). Therefore, it may be impossible to provide a "manual" or "recipe" for promoting the "co-design/co-production/co-delivery" between science and society.

However, when comparing the two cases in this chapter from the perspective of the hypothetical TD indicators presented in this part, there are some important points in common.

One is that it is important to develop social "sensitivity" and build "social capital" or trust relationship with a local community. In other words, "co-design/co-production/co-delivery" will not be approved only by the validity of the scientific knowledge and technology. Second, the presence of a neutral coordinator is a prerequisite. If scientists or university cannot play that role, some other stakeholders should take it. Third, a consensus of opinion on scaling, stakeholding, framing, and priority with a local community must be reached through sufficient pre-investigation and continuous face-to-face communication. If these "gaps" occur, the process of coordinating the gap will always be necessary. Finally, the fourth is to properly perform the "time setting" required for "co-design/co-production." If the "co-design/co-production" process ends halfway when time expires, social responsibility or "accountability" (TD indicator shown in this part) of scientists and university to society will always occur. Then, unless we make ourselves responsible and accountable for that failure, the trust in science in the society will be lost more and more.

The "co-design/co-production/co-delivery" between science and society would not be achieved only if scientists and university install scientific knowledge on the social field. If we are collaborating with any kind of society or community with various interests, effortful social activities that have nothing to do with scientific research will be very important. In this sense, the efforts to pursue science–society collaboration ("co-design/co-production/co-delivery") will absolutely require scientists and university not only to have academic research skills, but also to have human and social ability to talk, communicate, and discuss face-to-face with a society.

Acknowledgments We would like to express my deep gratitude to the following organizations and individuals who provided support for the project: Tsushima Local Government, Kamitsushima high school, Tsushima Local Promotion Association, Tsushima Commerce and Industry Association, MIT Co., FlatHour Co., Toru Nakagami, Yuki Kusunoki, Tomohiro Shirota, Yoshito Takesue, Hirokazu Kusu, and Tsuyoshi Maeda. This work was also supported by a grant JPMJRX16F1

from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST), and JSPS Grants-in-Aid for Scientific Research Grant Number 17H02491 and 17K18531.

References

Brunner RD, Steelman TA, Coe-Juell L, Crowley CM, Edwards CM, Tucker DW (2005) Adaptive governance: integrating science, policy, and decision making. Columbia University Press, Columbia

Crick B (2000) Essays on citizenship. Continuum, Boston

Folke C, Hahn T, Olsson P, Norberg J (2005) Adaptive governance of social-ecological systems. Annu Rev Environ Resour 30:441–473

Herod A (2011) Scale. Routledge, London

Hooghe L, Marks G (2016) Community, scale, and regional governance: a postfunctionalist theory of governance. Oxford University Press, Oxford

Ihara T (1983) Consideration of the concept of "local" in local analysis. Kagawa Univ Econ Rev 56 (1):245–257

Japan Ministry of Agriculture, Forestry and Fisheries (2017) Summary of the annual report on food, agriculture and rural areas in Japan (FY2016). https://www.maff.go.jp/e/data/publish/attach/pdf/index-57.pdf. Accessed 30 June, 2020

Japan Ministry of Internal Affairs and Communication (2012) Model project on "Ikigaku-renkei". https://www.soumu.go.jp/main_content/000208378.pdf. Accessed 30 June, 2020

Mitsuhashi H (2007) In regional industrial policy, change of "regional concept": case study of cluster policy. Stud Regional Policy 9:229–239

Miyamoto T (1984) Wasurerareta nihonjin (the forgotten Japanese). Iwanami Shoten Publishers, Tokyo

Miyauchi T (2018) Adaptive process management: dynamic actions toward sustainable societies. In: Sato T, Chabay I, Helgeson J (eds) Transformations of social-ecological systems: studies in co-creating integrated knowledge toward sustainable futures. Springer, New York, pp 159–168

Sakamoto H (1966) The regional concepts in agricultural geography: the classification of agricultural region and the functional study. Jpn J Hum Geogr 18:35–53

Tokunaga S, Akiho R (2018) Considering a way of community-based citizenship education: the case of "island's treasure project" of Kamitsushima High School in Tsushima. Decis Sci 4:5–32

Tonooka T (2004) A reconsideration of the concept of "region" in sociology of education: from the view of "socio-spatial theory". Bull Grad Sch Educ 44:141–148

Tsushima City (2020) Field Campus Tsushima Gakusha. http://fieldcampus.city.tsushima.nagasaki.jp. Accessed 30 June, 2020

Yamashita Y (2012) Truth on marginal settlements. Chikuma

Yohannan F, Obinna P, Polman N, Termeer C (2014) Scale-sensitive governance of the environment. Wiley-Blackwell, Hoboken

Part III
Sustainable Natural Resource Management: Theory and Practice

Chapter 7
Theoretical Models as a Tool to Derive Management Strategies for Sustainable Natural Resource Management

Joung-Hun Lee

Abstract Biodiversity hot spots cannot be preserved successfully unless human activities such as illegal logging and grazing are properly controlled and cooperation is achieved among resource users to reduce anthropogenic impacts. We explore strategies for sustainable use of common resources by studying resource users' behaviors together with resource dynamics, because ecological and social factors are known to interact strongly. By showing three systems dealing with the risk of illegal logging, grazing pressure, and increasing catching effort respectively, we show the advantages of a mathematical model as a management tool.

Keywords Biodiversity · Natural resource management · Sustainable use · Social-ecological dynamics · Mathematical modeling · Sustainable use

1 Introduction

Many of the ecosystems are maintained under the strong influence of human activities. Without proper control of prevalent illegal logging, hunting, and resource overuse and also with lack of cooperation of local inhabitants, we cannot achieve our goals: successful conservation of biodiversity and ecosystem management, in other words, sustainable resource management.

To resolve such problems, an interdisciplinary approach embracing natural sciences and social sciences is required. Natural sciences are for understanding the biological mechanisms under which natural resource behaves. Social sciences help us understand how individual resource users behave and make decisions which may make a tremendously huge impact on the resource and ecosystem.

In addition to the traditional academic fields, we also actively embrace new approaches to facilitate our understanding on human behaviors or dynamics of

J.-H. Lee (✉)
The Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan
Department of Biology, Faculty of Sciences, Kyushu University, Fukuoka, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_7

interactions among decision-makers. As an example, we would like to introduce theoretical biology as a tool to enhance such roles toward sustainable society: to test/derive strategies which promote cooperative behavior for public goods, to couple social/ecological aspects for comprehensive ecosystem management, and to support decision makings through testing possible scenarios. In the following sections, we provide three examples which handle different ecosystems and sustainable use of the resource in the ecosystem and show how a theoretical modeling approach can contribute to our shared goal of a sustainable society.

2 Connecting the Understanding of Mechanism for Human Cooperation to Strategies for Cooperation in Real Setting

As we briefly mentioned in Chap. 1, theoretical biology has been accumulated understanding on the mechanism of cooperation building or maintenance among people such as direct/indirect reciprocity, reputation, and punishment. By specifying the strategies of agents who apply those mechanisms to games, especially the public or common goods game, theoretical models help us understand in which conditions cooperative behavior (leading to good results for whole participants) can stay and defective behavior (exploit cooperative player) can be suppressed. Besides deepening our understanding on the fundamental questions on human cooperation, the explorational feature of the theoretical approach can be used for more field-related tests such as policy making or rule application to the common good managements. Models for the tests need not be fully realistic; we can have reasonable expectations about how the idea or thoughts will work by the test.

2.1 Illegal Logging Suppression

As an example, we would like to provide a game theoretical model of a self-regulating community in which rules are invented to suppress illegal logging in their communal forest (Lee and Iwasa 2011). Illegal logging is a serious problem for some countries, such as Cambodia, Indonesia, and Bolivia. Indicative estimates of illegal logging even exceed 80% (Food and Agriculture Organization (FAO) 2005; European Forest Institute 2005), and illegal logging occurs widely and persistently, at both state and community levels (World Bank Group 2006). In this model, we focus on the community-level illegal logging considering these countries usually suffer from the lack of administrative power so that if the community can regulate autonomously, it would be more effective prevention for smaller-scale illegal logging.

Illegal logging is a typical example of a crisis of management of a common good threatened by the tragedy of the commons. Each individual resource user (tree

harvester) gains from harvesting more trees or resources from the forest than other users. Thus, preventing the overuse of the forest requires establishing standards for sustainable level of harvesting. The standard requires the tasks of monitoring and sanctioning harvesters who break rules. However, those tasks cannot be always implemented by community members, so if the tasks are delegated to the third party who is relatively free from social pressure inside the community, corruption may arise. As corruption is known to be positively correlated with illegal logging in many places around the world (Seneca Creek Associates and Wood Resources International 2004), we believe that the model could give us important insights on how to reign corruption and eventually illegal logging.

2.2 Model

To reflect the autonomous community management setting, we consider a situation in which a group of harvesters establish a rule to restrain the harvesting amount. Hired enforcers monitor the harvesters who comply to the rule and fine defectors who harvest trees excessively. We assume that rule enforcers are paid by the harvesters, rather than being funded through an external source or organization. To investigate whether this rule enforcement system can emerge as a social institution in the modeled community, we use replicator dynamics describing social learning occurring through the imitation of successful role models (e.g., Sigmund 2010).

We specify three types of tree harvesters and two types of hired enforcers involved in this forest management: conditional cooperator, committing defector, non-committing defector, corrupt enforcer, and honest enforcer. A harvester is assumed to be a member of the community and free to choose either to hire an enforcer or not. A rule complier to the harvest amount is called a conditional cooperator who hires an enforcer (pay for hired enforcer). The conditional cooperator won't cooperate with the player who doesn't pay for the enforcement system. A committing defector is one that does not comply to the harvest rule but pay for the hired enforcer to exploit conditional cooperator. This type of harvester can be successful when he meets corrupt enforcers by bribing them otherwise punished harshly by an honest enforcer. By being hired by a pair of harvesters given that both are committing harvesters, enforcers may earn their salary. By setting the parameters such as benefit from cooperative behavior (b), cost of the cooperation (c), salary of hired enforcer (s), bribery from excessively harvesting defector to corrupt enforcer (B), and punishment to the defector (A), we can summarize the payoff for each type of player of the game as shown in Table 7.1. On this basis, we investigate conditions sustaining cooperative behaviors of harvesters and suppressing corrupt enforcers.

Table 7.1 Payoffs for harvesters and enforcers

	Conditional cooperator	Committing defector	Non-committing defector
a. Payoffs for harvesters accompanied by an honest enforcer			
Conditional cooperator	*b-c-s*	*-c-s*	0
Committing defector	*b-s-A*	*-s-A*	0
Non-committing defector	0	0	0
b. Payoffs for harvesters accompanied by a corrupt enforcer			
Conditional cooperator	*b-c-s*	*-c-s*	0
Committing defector	*b-s-B*	*-s-B*	0
Non-committing defector	0	0	0
c. Payoffs for an honest enforcer			
Conditional cooperator	*2s*	*2s*	0
Committing defector	*2s*	*2s*	0
Non-committing defector	0	0	0
d. Payoffs for a corrupt enforcer			
Conditional cooperator	*2s*	*2s+B*	0
Committing defector	*2s+B*	*2s+2B*	0
Non-committing defector	0	0	0

2.3 Findings

With the help of replicator dynamics based on the payoff (Table 7.1), we find the system may be faced with very different outcomes: full of cooperators leading to a very well-managed forest or full of illegal loggers leading to a devastated communal forest. It depends on whether the system retains a critical fraction of honest enforcers in the first beginning. With the fraction of honest enforcers higher than the critical fraction, the communal forest can be sustainably managed. If not, even with almost all cooperative harvesters, the forest finally ends up with deforestation by illegal loggers. This result implies that it is most important to ensure the quality of enforcers and also keep the quality by a sound educational system. Figure 7.1 shows how important the critical fraction is to maintain the forest sustainable. If the critical fraction of honest enforcers is larger, then the fraction of undesirable resultant outcomes is increased.

We also find that the critical fraction is denoted by the model parameters as a formula, $(c\text{-}B)/(A\text{-}B)$. This formula says that with the same level of bribe (B) if the punishment to rule breaker (A) is larger or the cost of cooperative behavior (c) is small, the system requires smaller fraction of honest enforcers in the beginning than the opposite cases.

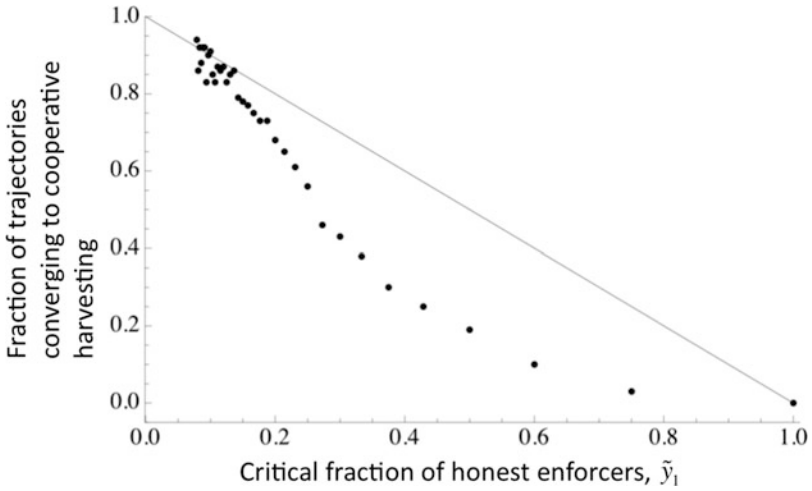


Fig. 7.1 Importance of an initial fraction of honest enforcers. A total of 100 different initial conditions consisting of different fractions of harvesters and enforcers are tested. Each condition converges to either cooperative harvesting or devastating harvesting. Larger critical fraction of honest enforcers means smaller cooperative harvesting in that any initial condition less that the fraction goes to the defective harvesting. The figure is adapted from Lee et al. (2015b)

3 Incorporating Social and Ecological Knowledge: Coupled Dynamics for Sustainable Resource Management

Hot spots or areas worthy of preservation identified by ecologists and evolutionary biologists cannot be properly preserved without proper management of anthropogenic impacts. Needless to say, biodiversity will be in danger under the presence of prevalent overuse of resources and lack of managing strategy in achieving the cooperation of local inhabitants. In this respect, it is important to incorporate the way to manage these aspects and to plug it into the ecosystem management that should be also based on ecology too. This is a point where we need the concept of social-ecological systems or human-environmental systems for successful conservation. Here we provide an example of the coupled dynamics of social-ecological systems (Lee et al. 2015b).

3.1 Mongolian Rangeland Management

The Mongolian rangeland is one of the terrestrial ecosystems affected by intensive human activities, cattle grazing. Precipitation here fluctuates greatly year to year, herders should cope with environmental uncertainty caused by such fluctuation (Smith et al. 2007). Herders, who are especially based on the southern part of Mongolia and have limited access to the northern area due to the traveling cost

suffer from environmental uncertainty than herders in the northern area with more abundant, stable precipitation. During drought, the rangeland grasses disappear except in small areas called "key resource," and those provide refuge and forage for the herders and their animals in the very dry season (Kakinuma et al. 2013). Thus it is essential to keep key resource areas and to understand how it could be maintained for the herders in southern herders.

3.2 Model

To understand how herders' choice interacts with plant dynamics in key resource areas, we study the coupled dynamics of grasses of key resource areas and herders who choose between staying at the same site and moving to an alternative rangeland during drought. With strong grazing pressure, grass biomass in the focal rangeland is decreased, and then more herders move to an alternative rangeland rather than staying in the focal rangeland. Thus, plant biomass is influenced by its intrinsic growth rate, caring capacity, and grazing pressure from the animals in the site (Fig. 7.2).

Herders are assumed to choose the foraging site giving the higher payoff. We assume that the payoff in the southern area (U_{stay}) depends on the level of grass biomass (consumed by animals) and the payoff in the northern area (U_{move}) is constant reflecting that it has a more stable environment. Herders choose to either stay or move considering each payoff and are assumed to do it in accordance with stochastic best-response dynamics. Besides stochastic best-response dynamics, we incorporate the aspect of inertia or delay of human decision-making in herder's choice which reflects that people could maintain their current choice with many

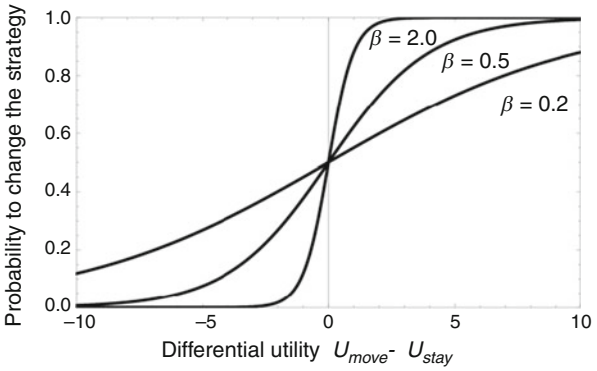


Fig. 7.2 Stochastic best-response dynamics. Herders compare the payoff difference of two options (stay/move). Herders (people) prefer options with higher payoff, but not always, and immediately change their current choice because of the positive margin. Their switch can be smooth and sometimes very slow depending on the sensitivity to the difference (compare three different beta values)

reasons, such as lack/distrust of new information (For more detailed model formulation, see Lee et al. 2015a).

3.3 *Findings*

We find that when the social dynamics is coupled with the grass biomass dynamics, the system generates typical nonlinear behaviors, such as bistability displaying a strong dependence on the initial condition or perpetual large-amplitude fluctuation. Fluctuation means plant biomass and herders in the southern area are not stabilized and continuously changing.

The fact that the system can oscillate has two interesting implications. First, traditionally such fluctuation is regarded as a result derived from environmental change, such as precipitation. However, our model shows that without the well-known environmental factors, the coupling of ecological dynamics and herders' choice dynamics can make such fluctuation (Fig. 7.3).

Second, the fluctuating system may cause more hardship to herders who cannot plan their lives under stable economic conditions, especially with large amplitude. By studying the model, we find how quickly people respond to the expected utility which is one key factor in controlling the fluctuation. As they make a quick decision (more herders decide to stay or move depending on their expectation about the utility from their choice rather than just keeping their current choice), the fluctuation may be dampened (see Fig. 7.4). If we find limiting factors to create such delay, the fluctuation could be prevented. Our model implies that limiting factors might be the lack of accurate information on plant conditions of the focal area and alternative area, unaffordable traveling cost to the northern area, and potential conflicts between herders in the northern area and herders from the southern area.

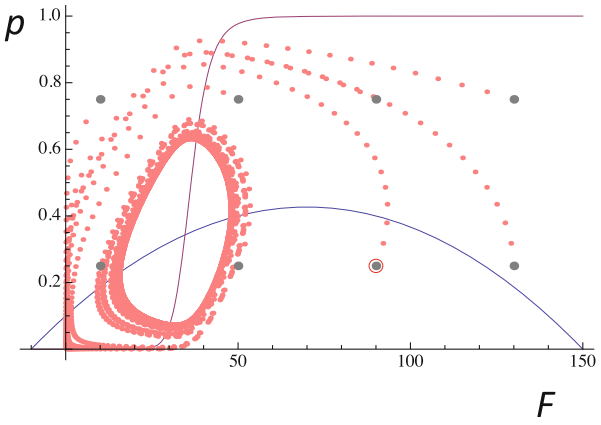


Fig. 7.3 Coupled social and ecological dynamics fluctuation. The x-axis is the level of plant biomass. The y-axis is the fraction of herders who stay in the southern area. p–F phase plane. The equilibrium is unstable, and all trajectories converge to a limit cycle showing a perpetual oscillation . The figure is adapted from Lee et al. (2015a)

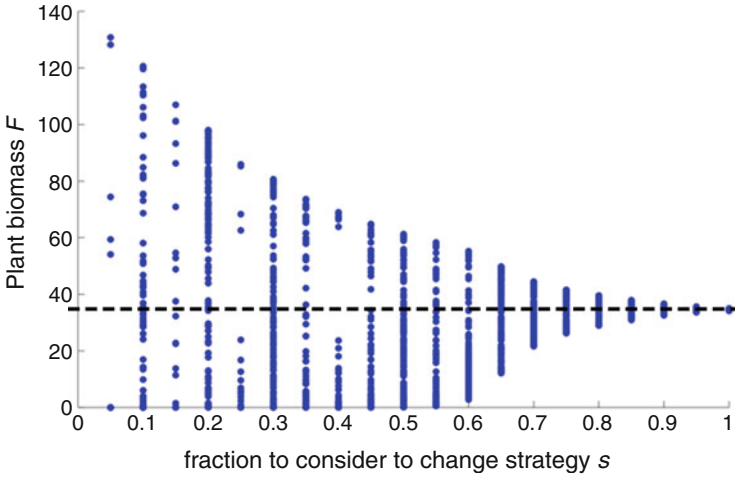


Fig. 7.4 Plant biomass fluctuation depending on the fraction of herders who consider changing their strategy depending on the utility difference between two options. A larger fraction means a larger fraction of herders adjust their strategy to move by comparing utilities

4 Testing Influences of New Stakeholders in Resource Use

Membership is an important factor to sustain stewardship of people over the resource in their use. With the existence of membership, the long-term use of the resource is guaranteed, and also mechanisms to enhance cooperation such as reputation, reciprocity, and social pressure might work well among the members. Despite the advantages, the system may face challenges to disturb it such as introducing a new stakeholder. Often the possible disturbance causes conflicts among people who have different opinions over the challenges. In such cases, a theoretical approach can play a role as a decision support tool by clarifying questions to be asked, stakes of each stakeholder, change of benefit distribution, impact to the ecosystem (level of focal resource), etc. The following example shows how we use a theoretical model as the decision support tool for the challenge.

4.1 Tourists and Traditional Divers in a Common Fishing Ground

The coastal area of Jeju island in South Korea has been utilized only by traditional divers. As the number of traditional divers decreased and they get aged, the local government has been thinking of introducing tourists into the coastal area called common fishing ground for an additional income source for the villagers in the island. Such policy may change resource dynamics and benefit distribution through

introducing new stakeholders, tourists, into the current system consisting of mainly traditional divers and marine resources. Especially when it is considered that traditional divers are known to be concerned about the environment, new stakeholders, for example, tourists, may affect the environment more than the traditional divers.

4.2 Model

We describe the common fishing ground system by marine resource population dynamics, tourists introduced into the fishing ground, and total benefit for the fishing association consisting of benefits from tourists and traditional divers' marine resource catch. As the goal of tourism introduction to the fishing ground is to increase the income for fishing villages, it is required to get benefits from tourists' visits to the fishing ground. In the model, we assume that the entrance fee is collected from tourists who might respond to the level of the fee as well as the abundance of marine products they can access. Because tourists can also catch the resource, now the traditional divers compete with tourists in the fishing ground for the resource such as octopus, seashells, etc. The key is to choose to optimize the entrance fee level. If the fee is too high, tourists might not visit the fishing ground. If it is too low, tourists might catch more resources to the extent that the traditional divers' catch is decreased significantly. The fishing association consisting of traditional divers, fishermen in fishing villages, and retired traditional divers is assumed to have the right to choose the fee level for the model. It reflects the fact that it has the legal right to manage the fishing ground although traditional divers utilize it (for more detailed formulation, see Lee and Iwasa 2011).

4.3 Findings

Decisions made regarding tourism derived from the model are shown to affect the claimed resource depletion of the Jeju island fishing ground. The fishing association can maximize its economic benefit by using the model, which might be quite plausible. However, the resource level may be apart from the sustainable level. The fishing association may seek a short-term benefit to maximize their own profit at the expense of resource sustainability more than traditional divers whose concerns are more about the long-term use of the resource (Ostrom 1990).

The adequacy of the optimal choice, therefore, should be discussed in light of values other than the economic benefits to the fishing village. The result denotes the potential conflict caused by tourists' resource use in competition with the traditional divers (Fig. 7.5). This result suggests that the stakeholders among the fishing association should come to some agreement before introducing tourists. The fact that tourism can negatively affect resources more than traditional diving requires thinking of an alternative tourism in accord with it such as a diver training program.

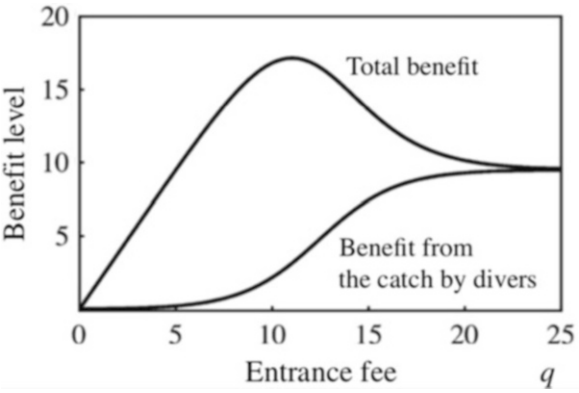


Fig. 7.5 Potential conflict between traditional divers and other members of the fishing association. The optimal entrance fee maximizing the total benefit for the fishing association is lower than the fee level which maximizes the benefit from divers' catch. The figure is adapted from Lee and Iwasa (2011)

It can be an opportunity to recruit new divers as well as to provide interesting experience to tourists.

5 Conclusion

Through the theoretical study of ecosystem management including rule making, coupled social-ecological dynamics, and policy making, we can combine our knowledge on ecological and social sciences in a manner useful for management. We discovered several unexpected behaviors of the social-ecological dynamics, such as a big oscillation in herder-grass systems, abrupt switches between deforestation and forestation, or the potential conflicts among stakeholders. With the help of the model, key factors to control the destruction of the ecosystem service can be identified, and then policy implication is provided.

For its wider use, in the near future, the importance of accumulating and extending knowledge to incorporate social sciences to demonstrate people's behavior into the robust management of common goods may be greatly emphasized. Then social-ecological models strengthened by the knowledge can deal with large-scaled, complicated management challenges with multiple stakeholders over our common resources.

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

European Forest Institute (2005) Impact of the reduction of illegal logging in European Russia on the EU and European Russia forest sector trade. European Forest Institute, Joensuu

Food and Agriculture Organization (FAO) (2005) Best practices for improving law compliance in the forest sector. FAO, Rome

Kakinuma K, Okayasu T, Sasaki T, Jamsaran U, Okuro T, Takeuchi K (2013) Rangeland management in highly variable environments: resource variations across the landscape mediate the impact of grazing on vegetation in Mongolia. Grassl Sci 59:44–51

Lee J-H, Iwasa Y (2011) Tourists and traditional divers in a common fishing ground. Ecol Econ 70:2350–2360

Lee J-H, Kakinuma K, Okuro T, Iwasa Y (2015a) Coupled social and ecological dynamics of herders in Mongolian rangelands. Ecol Econ 114:208–217

Lee J-H, Sigmund K, Dieckmann U, Iwasa Y (2015b) Games of corruption: how to suppress illegal logging. J Theor Biol 367:1–13

Ostrom E (1990) Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge, pp 172–181

Seneca Creek Associates and Wood Resources International (2004) Illegal logging and global wood markets: the competitive impacts on the U.S. wood products industry. American Forest and Paper Association, Washington, DC

Sigmund K (2010) The calculus of selfishness. Princeton University Press, Princeton

Smith DMS, McKeon GM, Watson IW, Henry BK, Stone GS, Hall WB, Howden SM (2007) Learning from episodes of degradation and recovery in variable Australian rangelands. Proc Natl Acad Sci U S A 104:20690–20695

World Bank Group (2006) Strengthening forest law enforcement and governance: strengthening a systemic constraints to sustainable development (report#36638-GLB). Sustainable Development Network, World Bank, Washington, DC

Chapter 8
Environmental Concerns of the Pulp and Paper Industry: Focusing on Household and Sanitary Paper Products

Kun Qian

Abstract The category of household and sanitary products is the most important category in the paper industry, because it is related to people's daily lives all around the world. This category is seeing a rapid increase in consumption, while consumption in other categories, such as printing or writing paper, is presently declining. China is the largest manufacturer, as well as the largest consumer of household and sanitary paper. Nowadays, environmental consciousness and concerns are rising in China and have started to influence customers' behavior in selecting and using paper products. In the present study, surveys were conducted of the paper industry, the retail market for paper, and end consumers of paper. The relationship between new challenges of the paper industry and consumers' environmental concerns has been investigated and reported.

Keywords Customer behavior · Paper consumption · Environmental consciousness · Plantation · Environmental issue

1 Introduction

The pulp and paper industry is one of the industries that have resulted in serious environmental impacts all over the world and is facing increasing challenges in terms of environmental regulations (Young and Akhtar 1998). According to the classification of forest products, paper products (paper and paperboard) are mainly composed of four types (Food and Agriculture Organization of the United Nations 1982): newsprint, other printing and writing paper, household and sanitary paper, and wrapping and packaging paper. The newspaper is defined as an uncoated paper used for newspaper printings. Other printing and writing paper include paper used for other types of printings (e.g., books, magazines, photographs, or other

K. Qian (✉)
The Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan
e-mail: qk@kyudai.jp

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_8

commercial printings) and office use (e.g., copy paper, writing paper). Household and sanitary paper includes paper used in daily life, such as tissues, napkins, paper towels, and toilet paper. Wrapping and packaging paper includes those types of paper mainly used for packaging, such as liner board, craft paper, folding boxboard, and paperboard. The production, as well as the marketing of these four types of paper, is highly dependent on the economic and technological conditions in the global marketplace. Production of paper for newsprint sharply decreased after the 2008 financial crisis. The market for other print and writing paper is now threatened by the growth of digital information and the movement towards paperless offices. Alternatively, household and sanitary paper represents an irreplaceable use of paper, and consumption is still rapidly increasing, especially in some developing countries (Yano Research Institute 2016). The remarkable growth of e-commerce has also provided opportunities for the marketing of wrapping and packaging paper (Ministry of Economy, Trade and Industry of Japan 2016). In this study, household and sanitary paper (hereinafter referred to as "household paper") was selected as the target, because it is most dependent on the personal consumer, compared with other types of paper mainly used for industrial or business purposes, and it is still growing.

China is a big market for the pulp and paper industry, not only for paper production but also for its consumption. In 2009, China overtook the United States as the top producer, as well as the top consumer, of paper products in the world (China Paper Association 2018). In the total market for household paper, China achieved an average growth of 5.5% from 2011 to 2014 and reached 12 billion USD in 2014 (Ministry of Economy, Trade and Industry of Japan 2016). However, the consumption of household paper per capita/year was only 4.7 kg, somewhat lower than the consumption (by 1/3 to 1/5) in developed countries (Ministry of Economy, Trade and Industry of Japan 2016). With future economic growth in China, it is expected that consumption of household paper will also increase. A prospective analysis (RISI Analytics 2014) showed that from 2000 to 2012, China was responsible for one third of the total global growth of tissue consumption (10.5 million tons, 874,000 tons/year) and from 2012 to 2022, China will be responsible for 41% of the expected growth of global tissue consumption (15 million tons). Tissue paper can be considered as a typical example of the whole household paper industry. The development of sanitary conditions and consciousness in China increases demand and consequently supply of household paper. Free toilet paper is increasingly available in public toilets utilizing advanced IoT technologies, which presents a big business opportunity for distributing free toilet paper (Fig. 8.1). On the other hand, environmental consciousness, especially awareness of specific environmental issues, is rising in the Chinese society, because of the noticeable deterioration of air quality in recent years, including the heavy smog in major Chinese cities such as Beijing and Shanghai (Zhao et al. 2016).

Considering the possible environmental impact caused by paper production, increased environmental consciousness may influence or change the behavior of customers in selecting and consuming household paper. In China, tissue and toilet paper products made from bamboo or straw fibers, instead of wood pulp, appeared in the market in 2010 (Ren et al. 2019). The unique selling proposition (USP) of those

Fig. 8.1 Electronic toilet paper distributor in a public washroom in rest area of G2 Beijing-Shanghai Expressway. Use SNS applications and QR code to get free toilet paper

non-wood-based products is their reduced environmental impact from two aspects. First, most wood pulp was produced from the vast plantations in Southeast Asia, where almost all of the old-growth forests have been felled and converted to commercial plantations. This destruction has resulted in serious damage to local ecological systems, eliminating the natural biodiversity. Organisms that lived in the old-growth forests cannot survive in the environment of single species tree plantations. This is the most critical reason why people and environmental organizations oppose to commercial plantations. Bamboo- or straw-based paper products are not derived from wood pulp; thus, they are more environmentally friendly because they do not require the conversion of old-growth forests to plantations. Second, in northern China, wheat is a staple crop. Burning wheat straw in late autumn is considered to be an important contributor to air pollution, especially to the production of smog in winter (Qu et al. 2012). Producers of straw-based household paper appealed to the market by claiming that recycling straw to produce paper can reduce burning it and accordingly, decrease the possible air pollution resulting from straw burning. Both selling propositions are quite reasonable and have brought success and expansion to the market for these paper products made from alternative materials.

Changes to the concentration ratio (CR) of household paper production corroborates the growth of the non-wood-based household paper market. Non-wood-based production is preferred by medium-sized manufacturers, because bamboo or straw materials can be procured domestically. The risk and cost of procurement are much lower than those associated with importing wood-based materials from Southeast Asia. Compared with the other three types of paper products, the CR of household

paper production declined rapidly after 2010. Annual reports from the China Paper Association (2018) showed that the CR4 before 2010 was consistently above 47% and sharply dropped to 27.7% in 2015. Analysis of a report released by Guolian Securities (2019) showed that the top four manufacturers of household paper in China are Gold HongYe Paper (market share 9.7%), Hengan International (8.5%), Vinda International (8.2%), and C&S Paper (4.2%). The CR4 of these companies was 28.2% in 2017. The data suggest that a great number of new manufacturers joined the household paper market in the first 5 years of the 2010 decade.

The rise of non-wood-based household paper definitely threatens the traditional manufacturers using wood pulp. In 2017, the total consumption of pulp in China was 101 million tons. Sixty-three percent of the pulp was recycled (21% imported, 42% domestic), 31% was wood pulp (21% imported, 10% domestic), and 6% was non-wood pulp (all domestic, United Credit Ratings 2018). Six percent is not a significant percentage, but most of the non-wood pulp was used to produce household paper, and household paper production was just 8.6% of all paper production in 2017. This means, as a material for household paper production, non-wood pulp is playing an important role in China. Not only the end manufacturers but also the whole supply chain of imported wood pulp (21 million tons in 2017, 68% of the wood pulp consumption) will be influenced. Since 2009, the international trade price of wood pulp has continued to rise, putting pressure on paper manufacturers to improve cost control and supply chain management (Sinolink Securities 2018). Non-wood pulps provide an opportune alternative to these companies. China imports wood pulp mainly from Canada (23%), Brazil (19%), Indonesia (12%), Chile (10%), and the United States (9%). The biggest household paper company, Gold HongYe Paper, is a member of the Asia Pulp & Paper Group (APP), based in Indonesia. Even though Indonesia is not the largest supplier of wood pulp for China, imported wood pulp from Indonesia is more likely to be used for household paper production. This means the rise of non-wood-based household paper production in China will negatively impact the plantation industry in Indonesia.

As mentioned above, commercial plantations in Southeast Asia have been criticized by nongovernmental organizations (NGOs), such as the World Wildlife Fund (WWF), because of the plantations' lack of environmental protections and prevalence of social conflicts (Szulecka et al. 2016). Forest fires and the attendant haze have caused more environmental issues (Tacconi 2016). As a result, rising environmental concerns of consumers in China are changing their selection of household paper products. The purpose of this study is to clarify the changing situation, as well as to identify the trends affecting the household paper market in China.

2 Methods

In this study, I conducted surveys of three different aspects of the household and sanitary paper industry: manufacturers, markets, and consumers. APP was selected to represent manufacturers, because it is the largest household paper vendor in China

and has the strongest relationship with the Southeast Asian plantations. As to the surveys of markets and consumers, data were obtained from several economically developed regions in China, where the consumption of household paper is greater than in other regions. In total, 16 surveys (3 to Indonesia and 13 to China) were conducted from 2015 to 2019.

There are a variety of products in the category of household and sanitary paper, such as box tissues, pocket tissues, toilet paper, table napkins, kitchen paper, wet tissues, sanitary napkins, disposable diapers, etc. However, bamboo or straw pulp is used mostly to produce box tissues, pocket tissues, and toilet paper. Thus, I selected these three types of paper products to be the target of the surveys. Surveys 1 and 3 were conducted by using the method of an unstructured interview.

2.1 Survey 1: Visit and Interview APP Paper Mills

As the first step of the research, the manufacture of household paper in China was explored at each point of its supply chain. I visited an APP plantation, an R&D center, and one of its largest pulp and paper mills (Perawang Mill in Sumatra, Indonesia), from 2015 to early 2016, as pilot surveys.

The main surveys were conducted in 2016 and 2017, by visiting six APP member companies, as well as their mills. This included the headquarters of Gold HongYe Paper (GHY), the largest household paper manufacturer in China, located in Jiangsu, Shandong, and Guangdong Provinces of China. As part of the surveys, I interviewed 15 staff members in administrative positions at different mills and departments. Details of the interview sites and informants are listed in Table 8.1.

2.2 Survey 2: Market Survey of Household Paper Products

To grasp the market situation of household paper products, especially the non-wood-based ones, market surveys were conducted from late 2016 to 2017. Twenty-five end retail markets in seven cities (Changzhou in Jiangsu Province, Shenzhen and Qingyuan in Guangdong Province, Langfang in Hebei Province, Qingdao in Shandong Province, Shanghai, Beijing) were included. Most urban citizens in China tend to buy household paper products in the major supermarkets in their cities; thus, this survey focused on the major supermarkets in the seven cities. To investigate the relationship between market share of non-wood-based, or the so-called eco-friendly paper products, and the amount of air pollution in an area, the survey sites were selected from both northern and southern parts of China. Southern China's staple crop is rice, so burning straw is not a contributor to air pollution there. The amount of wood-based box tissues, pocket tissues, and toilet paper products, as well as that of non-wood-based products, was sampled in each end market. Details of the end markets surveyed are shown in Table 8.2, with the sampled data.

Table 8.1 Detailed information on interview sites and informants for survey 1

Time	Place (city, province)	Company and mill	Informant (department)
November–December 2016	Suzhou, Jiangsu	Gold HongYe (GHY) Paper headquarter mill	IF1, publicity
			IF2, finished good expert (region representative)
			IF3, finished good expert (Asia-Pacific department)
			IF4, production line
November–December 2016	Suzhou, Jiangsu	Gold Huasheng (GHS) Paper headquarter mill	IF5, research and development
			IF6, environment and sustainability
			IF7, marketing and sales
November–December 2016	Zhenjiang, Jiangsu	Gold East Paper headquarter mill	IF8, publicity
			IF9, global procurement
			IF10, environment management
February 2017	Qingyuan, Guangdong	Branch mills of GHY and GHS	IF11, supply chain management
			IF12, global procurement
			IF13, production line
March 2017	Qingdao, Shandong	Branch mills of GHY and GHS	IF14, publicity
			IF15, supply chain management

2.3 Survey 3: Interview with End Consumers

Finally, in 2018 and 2019, I interviewed university students as end consumers from six universities in Jiangsu, Shandong, Beijing, and Shanghai. Most university students in China live in dormitories on the campus. They are ideal customers who mainly consume box tissues, pocket tissues, and toilet paper but rarely use other types of household paper products. Also, university students are more concerned about the environment and sustainability and have higher than average social consciousness. They are also more sensitive to new technologies and products in the market.

Thirty-one students (17 females and 14 males; mean age = 21.3 years; SD = 1.3 years) were interviewed for the survey. All of them lived in the dormitories provided by their universities. They are born in 16 provinces around China. Expedited ethical approval for this survey was obtained from the Ethics Committee for Psychological Studies at the Institute of Decision Science for a Sustainable Society, Kyushu University (No. 2018/1-4). The interview method used in this study were conducted in accordance with the relevant guidelines of the ethics committee.

Table 8.2 Results of the market survey. Toilet paper and tissue paper (not including wet tissues) are sampled in this survey

Time	Area	Province	City	District/ town	Market (initial)	Household paper products	Non-wood-based household products	(%)
November 2016	South	Jiangsu	Changzhou	Tianning	T	17	3	(17.6)
November 2016	South	Jiangsu	Changzhou	Tianning	R	18	3	(16.7)
November 2016	South	Jiangsu	Changzhou	Xinbei	S	12	2	(16.7)
November 2016	South	Guangdong	Shenzhen	Longhua	R	25	2	(8)
November 2016	South	Guangdong	Shenzhen	Futian	S	17	2	(11.8)
November 2016	South	Shanghai	Shanghai	Zhabei	R	17	4	(23.5)
November 2016	South	Shanghai	Shanghai	Putuo	W	15	4	(26.7)
February 2017	South	Guangdong	Qingyuan	Qingcheng	R	22	1	(4.5)
February 2017	South	Guangdong	Shenzhen	Nanshan	C	27	3	(11.1)
March 2017	North	Shandong	Qingdao	Shinan	C	19	6	(31.6)
March 2017	North	Shandong	Qingdao	Shibei	W	17	5	(29.4)
March 2017	North	Shandong	Qingdao	Jiaozhou	R	15	3	(20)
March 2017	North	Shandong	Qingdao	Jiaozhou	L	16	4	(25)
October 2017	North	Beijing	Beijing	Chaoyang	W	19	4	(21.1)
October 2017	North	Beijing	Beijing	Chaoyang	R	21	5	(23.8)
October 2017	North	Beijing	Beijing	Haidian	C	20	5	(25)
October 2017	North	Beijing	Beijing	Haidian	W	19	4	(21.1)
October 2017	North	Beijing	Beijing	Fengtai	C	17	5	(29.4)
October 2017	North	Beijing	Beijing	Tongzhou	C	14	4	(28.6)

(continued)

Table 8.2 (continued)

Time	Area	Province	City	District/ town	Market (initial)	Household paper products	Non-wood-based household products	(%)
October 2017	North	Hebei	Langfang	Yanjiao	W	16	3	(18.8)
October 2017	North	Hebei	Langfang	Yanjiao	A	20	4	(20)
October 2017	North	Beijing	Beijing	Xicheng	W	20	4	(20)
October 2017	North	Beijing	Beijing	Xicheng	C	21	5	(23.8)
October 2017	North	Beijing	Beijing	Dongcheng	C	21	5	(23.8)
October 2017	North	Beijing	Beijing	Dongcheng	L	18	4	(22.2)

3 Results

3.1 Challenges for Major Paper Manufacturers in China

From the interviews of APP staff members in various positions and departments, some of the pressures and challenges for APP, as well as all the major paper manufacturers that are its members, were revealed.

The first pressure is from the business itself. Different from other major paper producing or consuming countries like the United States, Indonesia, Canada, or Brazil, the paper industry of China is much more reliant on the import of materials. China is the largest importer of wood pulp in the world. In 2015, China imported 16.5 million tons of pulp, more than the total of the second to the fifth largest importing countries (the United States, Germany, Italy, and South Korea). High reliance on material imports brings more cost, as well as risk, to the Chinese paper industry. Comparing two major subsidiary companies of APP, Perawang Mill in Indonesia is surrounded by thousands of hectares of plantation, which means that the cost of material distribution has never been a problem. However, GHY Mill in China must pay for the high cost of ocean transportation to get the same materials and has to face the rapid change of prices in the international pulp trade. This issue leads to a difficult situation in China, i.e., that the cost of raw materials is extremely high (approximately 65–80% of the total cost in paper manufacturing). Mass production has been considered the best way to mitigate high costs; however, the CR of the major manufacturers is becoming lower and lower in the current decade. Increasingly, mid-sized paper mills, including those who use bamboo or straw fibers instead of wood pulp to control cost, are appearing and becoming part of the household paper market. This directly influences and restrains the production of major manufacturers. In 2017, GHY operated at only 67.4% of capacity. Excess capacity gradually becomes a serious issue for major household paper manufacturers.

The second pressure is from the environmental policies in China, which are getting increasingly stringent during the current decade. In 2017 alone, five regulatory schemes on environmental conservation and emission control were revised or newly released to regulate the paper industry. To comply with the new policies, manufacturers have to change some of their suppliers, update their equipment, adjust their production processes, or even selectively shut down some old production lines, and all of these actions result in additional costs. From the beginning of 2010, the Chinese government has taken serious and drastic measures to improve the environmental situation in China. As one of the industries most highly impacting the environment and sustainability, paper companies are always the first target. Even though this additional cost is a big concern for GHY, all informants declared that concern for the environment and sustainability is

their responsibility. They support the company's huge investment to improve and make their production facilities more eco-friendly and the related actions to comply with regulatory requirements. That is why GHY and the other APP member mills can run stably in the strictest areas of environmental monitoring in China, and why WWF China has not criticized APP China as seriously as companies in Indonesia.

Informants also mentioned the regional differences in the threats to APP's businesses, due to economic status and customer behaviors. Innovative, eco-friendly products, such as bamboo- or straw-based paper, are much more appealing in a region where air pollution is more serious. This was explored in more detail in the second survey.

3.2 *Difference in Market Penetration of Eco-friendly Household Paper Products in North and South China*

The results of the market survey are shown in Table 8.2. The number of household paper products, as well as that of non-wood-based products, was determined in each supermarket included in the survey. The percentage of non-wood-based products was calculated. In South China, the average percentage across nine markets was 15.18%. However, in North China, the average percentage across 16 markets was 23.98%. A two-tailed t-test showed that the percentage of non-wood-based products was significantly higher in North China markets than in South markets ($t(23) = -4.00$, $p < .001$, Cohen's $d = -1.67$). These results support the opinion of mill workers during survey 1, that non-wood-based products are more popular in North China.

Non-wood-based products are normally more expensive, but less compatible than wood-based ones (Fig. 8.2). Buying non-wood-based products means paying more money to get products that will be used every day, but may not be comfortable to use. It seems difficult to understand this behavior, because consumers normally prefer better and cheaper products. One possible reason that customers in North China welcome and are willing to pay more for the so-called eco-friendly products is that they suffer more from air pollution than southern people. In winter, people in many northern cities of China must endure heavy smog resulting from air pollution. The selling proposition of non-wood-based products is consistent with the actual experience of consumers.

Non-wood-based products in the southern market are mainly made from bamboo, because as raw material, straw cannot be steadily supplied to South China. However, even though bamboo paper is irrelevant to reducing air pollution, it is considered to be an eco-friendly product and has won big support in the market. It implies that traditional pulp and paper manufacturing based on plantation trees is considered to

Fig. 8.2 Non-wood-based tissues (left) and wood-based tissues (right) on sale in a supermarket in Qingyuan, Guangdong Province (Feb. 2017). Non-wood products were much more expensive

be a less eco-friendly industry and that any innovation to reduce the environmental impact of this industry is welcomed by the end consumers.

3.3 University Students Value Environment More When Selecting Household Paper Products

All student interviewees indicated that they buy toilet paper and tissue paper in their daily lives. When asked to select factors influencing their purchasing decisions for household paper, 32.2% of them said they consider price as the highest priority, possibly because as students, their disposable income is limited. Quality was named as a priority by 25.8%, while 19.4% selected comfort, and 16.1% selected environmental concerns as the highest influence on their purchase. Obviously, university students do not consider environmental concern as their highest priority when they buy household paper, but environmental concern is the only factor that was included in the top three by all students.

In Beijing and Shandong, 13 students out of 16 reported that they have tried tissues or toilet paper made from straw, due to a consideration for reducing air

pollution. Eight of them kept using those products, even though all of them admit that straw paper is expensive and not as comfortable as normal paper. Straw products could hardly be found in Jiangsu and Shanghai, but bamboo products had more share there than in the northern regions. Ten in fifteen students told that they had consumed bamboo products, and six were still using them. Selecting bamboo products was also based on their consciousness of the environment. All students had a definite opinion that paper production brings serious impacts to the environment, through energy consumption, water consumption, gas and water emissions, and deforestation.

All students complained about smog pollution, but most of them admitted that air pollution has been improved year by year, especially in Beijing. They know that smog is the result of a variety of factors and that straw burning is just one of them, and not the most critical. Yet, they still prefer to purchase eco-friendly paper products that are affordable. This behavior implies their deep consciousness and concerns for the environment and sustainability.

4 Discussion

The present research focused on the marketing and production of household paper products in China; revealed the situation, trends, and challenges in the household paper industry in China; and investigated how the consciousness and concerns of end consumers influence their behavior for selecting and using paper products.

My awareness of issues addressed in this research actually began with my first visit to APP's plantation in Sumatra. After inspecting the boundless plantation, I was told about the environmental issues, social issues, difficult business situations, and the criticisms from NGOs and the academic world. However, as the global CO_2 emission issue is being addressed in China, it is clear that the responsibility lies not only with the countries that produce CO_2 but also with the countries that consume the products from those CO_2-emitting processes. As to the issue of plantations in Indonesia, a large quantity of the wood pulp is exported to China and other countries. In China, the market for household paper produced by using pulp imported from Indonesia is threatened by the change of consumers' environmental concerns. This change is due in large part to the prevalence of air pollution and the desire to improve air quality. As shown in Fig. 8.3, the issues occurring on Indonesian plantations are indirectly, but absolutely related to the economic restructuring taking place in China. To solve the plantation issues in Indonesia, co-design and co-production among multiple stakeholders in Indonesia, as well as in China, are essential.

Surveys and inspections of administrative offices, plantations, and mills created a clear image of the supply chain in the paper industry. Viewing the process in four steps, plantation (produce wood) → pulp mills (turn wood to pulp) → paper mills (turn pulp to paper) → market (sale), I note that earlier stages are reliant on actions in developing countries, while developed countries concentrate on the later stages. Using APP as an example, its products are very popular in the Japanese market, but

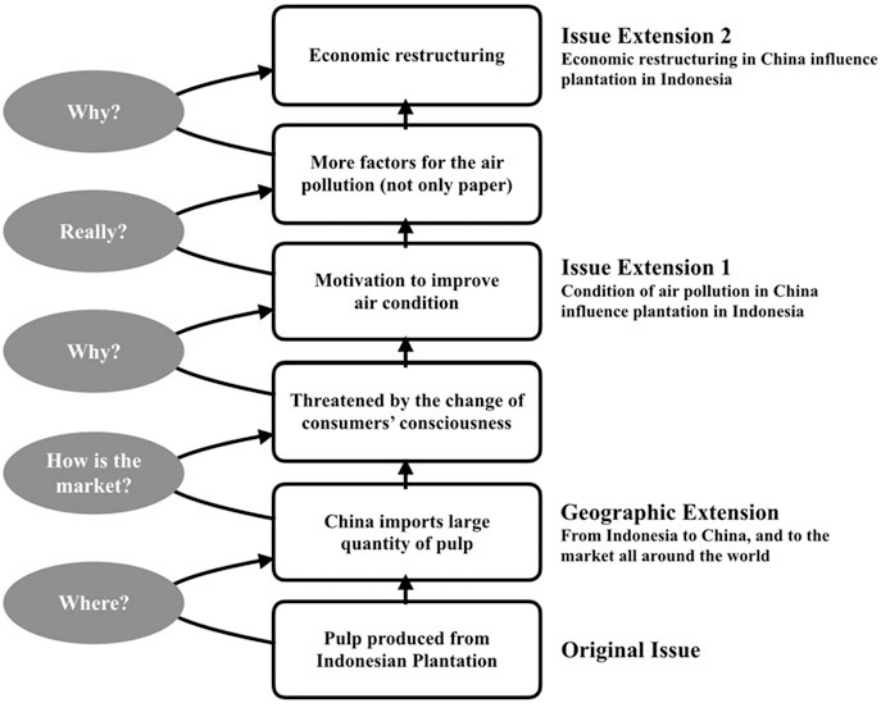


Fig. 8.3 Issue chain of the environmental sustainability of the household paper industry. Issues occurred in Indonesian plantations indirectly but finally related to the economic restructuring in China

there are no production facilities in Japan. This is a good example of the international division of labor and resources, which makes mass industrial production effective and efficient. However, it also explains how a global company like APP must face different stakeholders, difficulties, and issues in different regions and markets. In this case, co-design and co-production with all stakeholders become much more challenging.

The function of NGOs and nonprofit organizations (NPOs) should be emphasized here. NGOs and NPOs play an important role in monitoring the environmental impacts of paper manufacturers and in certifying the environmental performance of paper companies that comply with published standards such as those put forth by the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification (PEFC), or the Sustainable Forestry Initiative (SFI). The positions of these organizations should be as impartial as possible, to be effective standard setters. However, the current trend is for certifications from organizations such as WWF or FSC to be used as marketing tools by paper companies, especially in Japan. During EcoPro 2017, the largest annual international exhibition on environment and energy in Japan, I witnessed that the largest retail company in Japan had

placed FSC certifications on their private label household paper products. This could mislead consumers, who may think that all of the company's products are FSC-certified. However, one month before EcoPro 2017, I also witnessed that their best-selling private lable tissue products were produced in APP China, which have not been certified by FSC. The relationship between NGOs and vendors should be evaluated to assure NGOs play their roles in a neutral and fair manner.

Lastly, increasing environmental concerns related to the production of household paper products are also implicated in the innovation or revolution of the overall paper industry. Compared to printing and office paper usage, the usage of household paper products will continue to increase for some decades. However, the usage of paper, in general, is on the decline. Traditional paper production, with its huge environmental costs, will be changed in the future. Especially for the paper enterprises in Asia, innovation and sustainability will be the most important topics to be addressed.

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of the Japan Science and Technology Agency (JST), as part of the Future Earth programs.

References

China Paper Association (2018) Annual report of China paper industry 2018

Food and Agriculture Organization of the United Nations (1982) Classification and definitions of forest products. FAO Forest Pap 32:40–41

Guolian Securities (2019) Analysis report of C&S Paper Co Ltd

Ministry of Economy, Trade and Industry of Japan (2016) Report on Overseas Survey on the Industry of Sanitary Paper. pp 2–3

Qu C, Li B, Wu H, Giesy JP (2012) Controlling air pollution from straw burning in China calls for efficient recycling. Environ Sci Technol 46(15): 7934–7936

Ren J, Yu P, Xu X (2019) Straw utilization in China—status and recommendations. Sustainability 11:1762. https://doi.org/10.3390/su11061762

RISI Analytics (2014) A look at global tissue markets

Sinolink Securities (2018) Analysis report of household paper industry

Szulecka J, Obidzinski K, Dermawan A (2016) Corporate–society engagement in plantation forestry in Indonesia: evolving approaches and their implications. Forest Policy Econ 62:19–29

Tacconi L (2016) Preventing fires and haze in Southeast Asia. Nat Clim Change 6(7):640

United Credit Ratings Co. Ltd. (2018) Research report of China paper industry 2018

Yano Research Institute Ltd. (2016) Overseas research report on sanitary paper industry

Young R, Akhtar M (1998) Environmentally friendly technologies for the pulp and paper industry. Wiley, New York

Zhao S, Yu Y, Yin D, He J, Liu N, Qu J, Xiao J (2016) Annual and diurnal variations of gaseous and particulate pollutants in 31 provincial capital cities based on in situ air quality monitoring data from China National Environmental Monitoring Center. Environ Int 86:92–106

Chapter 9
Contribution of Community-Based Ecotourism to Forest Conservation and Local Livelihoods

Tetsuji Ota, Pichdara Lonn, and Nobuya Mizoue

Abstract Tropical forests significantly contribute to local livelihoods as well as global carbon storage and biodiversity conservation. Therefore, a strategy that harmonizes a better quality of life for local people with tropical forest conservation is required. In Community-based ecotourism (CBET), the local community participates in related economic activities. In this chapter, we summarize our current studies that quantified the contribution of CBET to the income and livelihoods of local people and forest conservation. We selected the Chambok CBET site in Cambodia for our case study. First, we quantified the effectiveness of CBET in forest conservation by analyzing forest cover change with published maps created from satellite images. Second, we evaluated the contribution of CBET to household income and livelihood changes through a household survey using a questionnaire. Analysis of the forest cover change maps revealed that deforestation had significantly decreased inside the CBET area as compared to outside it, although the reduction was not enough to stop net deforestation. The survey revealed that the total monthly income of CBET member households and non-CBET households was not significantly different. It also showed that the community members felt the livelihood change after the implementation of CBET. However, this change may have been caused by general socioeconomic changes in Cambodia. We conclude that CBET effectively contributed to forest conservation but in a limited capacity to household income.

Keywords Community-based ecotourism · Cambodia · Quasi-experimental approach

T. Ota (✉) · N. Mizoue
Faculty of Agriculture, Kyushu University, Fukuoka, Japan
e-mail: ota.tetsuji.887@m.kyushu-u.ac.jp; mizoue@agr.kyushu-u.ac.jp

P. Lonn
Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Fukuoka, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_9

1 Introduction

Tropical forests play a major role in global carbon storage (Bonan 2008; Sullivan et al. 2017) and are also global centers of biodiversity (Scheffers et al. 2012). However, deforestation and forest degradation in tropical areas have become a global concern over the past few decades (Achard et al. 2002; Hansen et al. 2013). While forest cover has increased in some tropical countries in the last decade (FAO 2015; IPBES 2018), severe deforestation and forest degradation is still happening in the tropical forests of many countries. Southeast Asia witnessed a reduction of 12.9% in forest cover between 1990 and 2015, largely caused by an increasing export market for palm oil, pulp, rubber, and timber products (IPBES 2018). Deforestation and forest degradation have put tremendous pressure on biodiversity (Newbold et al. 2014) and forced tropical forests to become a net carbon source (Baccini et al. 2017). Therefore, there is an urgent need to develop mitigation strategies.

In addition to their contribution to the global storage of carbon and biodiversity, tropical forests have also been recognized as an important resource of local livelihoods (Sunderlin et al. 2005). For example, in Cambodia, which is our study site, more than 90% of rural households depend on fuelwood as a primary source for cooking and other activities (Top et al. 2004; San et al. 2012). Thus, any conservation strategy that excludes local people from forests may inevitably affect local livelihoods. Therefore, we need a strategy that harmonizes forest conservation with the quality of life for local people in tropical areas.

Community-based ecotourism (CBET), a kind of community-based forest management, is one of the strategies that could improve both quality of life for local people and conservation efforts in tropical forests. In particular, CBET is where the local community participates in related economic activities (Kiss 2004). Because CBET can generate economic benefits, it is seen as a tool for affording a better quality of life for the participating community. In addition to the economic benefits, CBET may contribute to the conservation of natural resources in a CBET area—natural resources that tourists find attractive are conserved for ecotourism. Thus, CBET may motivate the local community to conserve the area's forests. Reflecting expectations for its benefits, CBET has become popular worldwide. While a number of studies evaluate its impact (see Das and Chatterjee 2015), most of these are qualitative (Das and Chatterjee 2015); there have been fewer efforts to accumulate quantitative data to evaluate the effectiveness of CBET, which include our recent attempts (Lonn et al. 2018b, 2019). While the need for evidence-based decision-making is paramount, it is possible only by collecting quantitative data on local people's livelihoods and forest conservation.

We, therefore, evaluate the effectiveness of CBET by presenting quantitative data on forest cover change in a CBET area and the total income of CBET members. In this chapter, we demonstrate the effectiveness of CBET by summarizing findings from our recent studies (Lonn et al. 2018b, 2019). We first briefly characterize our study site and, then, evaluate how the forest has been conserved through CBET.

Finally, we discuss how CBET contributes to household income and livelihood changes.

2 Chambok CBET

The Chambok CBET site, a flagship model of CBET in Cambodia, was selected as the study area because it is regarded as a good practice of CBET in Cambodia (e.g., Prachvuthy 2006). It is located in the Chambok Commune, Phnom Sruoch District, Kampong Speu Province, southwestern Cambodia (Fig. 9.1). This Commune officially consists of four villages. Its total number of households and population in 2008 were 761 and 3670, respectively (NIS 2008). Half of the Commune has been designated as a national park, called the Kirirom National Park (KNP). According to a 2010 forest cover map of the Forestry Administration in Cambodia, 44% of the total Commune land comprises deciduous forests, followed by 25%, 16%, and 7% of non-forest areas, evergreen forests, and semi-evergreen forests, respectively.

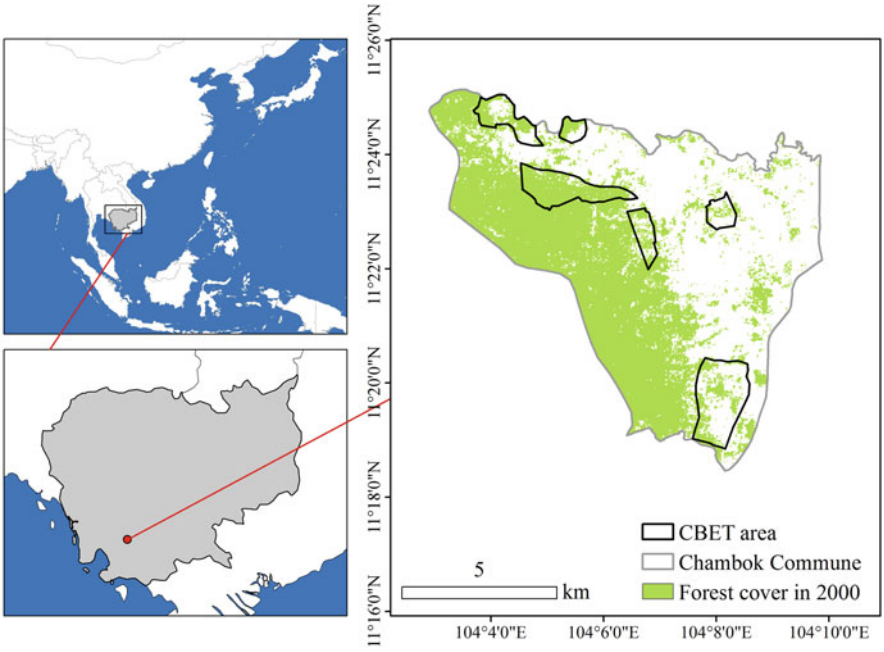


Fig. 9.1 Maps of the Chambok Commune and Community-based ecotourism (CBET) conservation area. We used the World Borders Dataset provided by Thematic Mapping (http://thematicmapping.org/) to show the country's border. The boundaries of Chambok CBET conservation zones were provided by the Mlup Baitong Organization. Forest cover change maps created by Hansen et al. (2013) were used to calculate forest cover in 2000

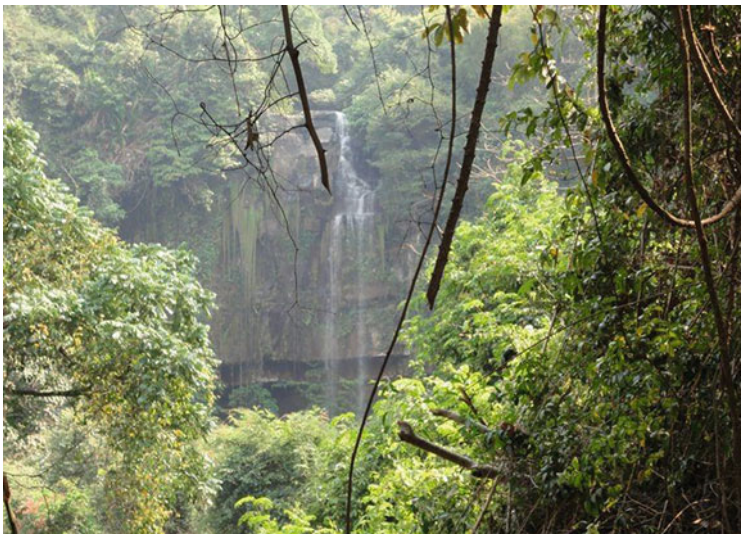


Fig. 9.2 The CBET commune area

Traditionally, the community was heavily dependent on forest resources and caused deforestation and forest degradation due to overexploitation (Prachvuthy 2006). Therefore, Mlup Baitong, a local environmental non-governmental organization, embarked on a project in 2002, aiming to improve the quality of life for the local people and forest conservation. The Chambok CBET program was opened for visitors the following year. Until 2010, Mlup Baitong supported the program; since 2011, the local people have been managing it themselves.

The main attractions of the CBET area are the surrounding forests, a 40-meter waterfall, and local streams (Fig. 9.2). In addition to spending time in the forests and by the water bodies, tourists can enjoy cycling, meals at restaurants, and cultural events such as traditional children's dancing, cooking traditional food, and homestays. According to the Chambok CBET committee, approximately 10,000 tourists visited the site in 2010. The revenue from the program was utilized not only for paying wages but also for infrastructure development, forest conservation in the CBET area, and assistance for poor households among other things. There is no strict rule for undertaking CBET activities, and any Cambodian citizen living in the Commune can work for CBET-related businesses.

It should be noted that not all Commune areas are assigned to the forest conservation zone of the Chambok CBET (Fig. 9.1). This zone comprises three community-protected areas (CPAs) and three community forestry areas (CFAs). The total area of the conservation zone is 10.42 km^2, which is approximately 13% of the total Commune area. The differences between CPAs and CFAs are the locations and the managing authorities. CPAs are located inside the KNP under the management of the Ministry of Environment of Cambodia, while CFAs are located outside the KNP under the management of the Forestry Administration.

However, we have not considered these differences in this chapter because they cooperatively implement the CBET program.

3 Contribution to Forest Conservation

Among the many ways to evaluate the effectiveness of CBET on forest conservation, satellite data can provide wall-to-wall information on forest cover change. Here, we summarize the result obtained from satellite data analysis (Lonn et al. 2019), with which the effectiveness of CBET was evaluated by comparing the forest cover change inside and outside the CBET area. Further details of this comparison have been reported by Lonn et al. (2019)

We used forest cover change maps created from the Landsat satellite (Hansen et al. 2013); a detailed description of the maps is available on his website (https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.1.html). To explain briefly, the data, provided as approximately 30-m spatial resolution raster files, includes the tree canopy cover in 2000 and forest loss or gain between 2000 and 2012 per pixel. From this data set, we calculated deforestation and forest recovery between 2000 and 2012 in the Chambok Commune. We defined forest, deforestation, and forest recovery as follows: we defined the forest cover in 2000 using the tree canopy cover of that year; the threshold of tree canopy cover was set to 30%. Then, we considered that "deforestation" occurred on the pixels that were "forests" in 2000 but were classified as "no forest" by 2012, and "forest recovery" occurred on the pixels that were "no forest" in 2000 but were classified as "forest gain" by 2012.

Using the published forest cover change maps, we conducted a two-fold analysis—a direct comparison and taking a quasi-experimental approach. For the comparison, we calculated the deforested and forest recovery portions both inside and outside the CBET area and compared the values. We did this to determine net forest cover change inside and outside the CBET area.

In addition to this, we used a quasi-experimental approach to evaluate the effectiveness of CBET. This was done because the location of CBET had not been chosen randomly, and it was deduced that the simple comparison could yield biased results. For example, forests that are close to villages or main roads may be chosen as CBET areas due to the higher accessibility for local people and tourists. On the other hand, previous studies have demonstrated that the distance to villages or main roads affects the likelihood of forest loss (Lonn et al. 2018a), because accessibility to a forest increases with its proximity to a village or main road. In other words, the distance to a village or main road may covary with both forest loss and the distribution of CBET. For comparison between inside and outside the CBET area, we need to control this confounding for minimizing the bias due to the correlation between covariates. A quasi-experimental approach can minimize the bias by balancing the distribution of covariates (Stuart 2010). For our analysis, we used a matching method as the quasi-experimental approach. This method compared forest cover change inside the CBET area with the change outside the CBET areas that are

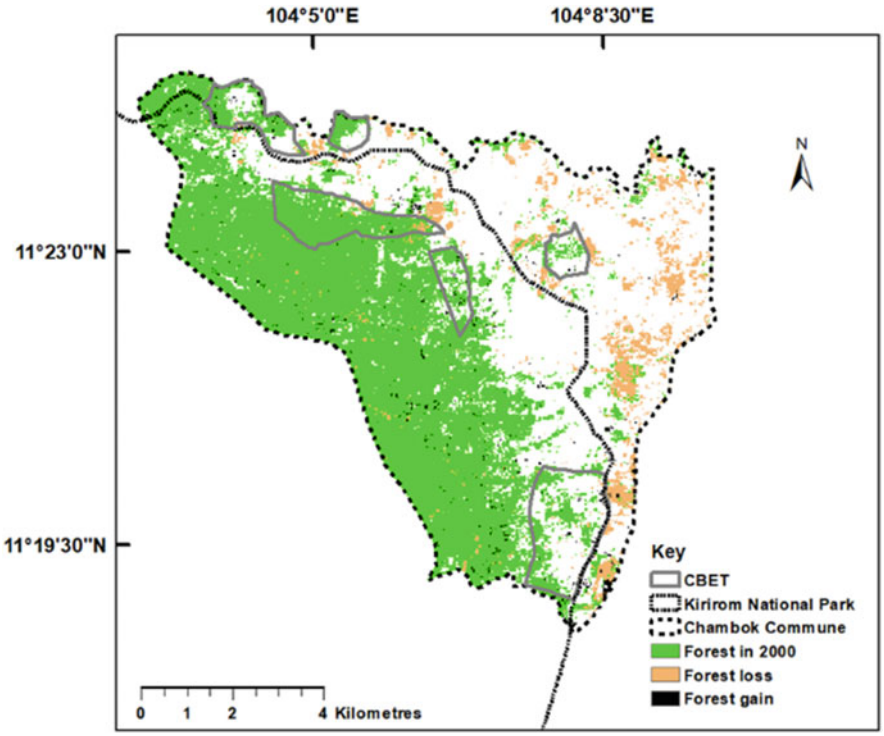


Fig. 9.3 Forest cover change in the study area between 2000 and 2012 from Lonn et al. (2018a). Forest cover in 2000, forest loss, and forest gain were analyzed from the forest cover change maps (Hansen et al. 2013)

very similar to those inside the CBET area for distance to a village or a main road. We employed the matching method using eight covariates, including distance to the nearest road and nearest river. The analysis was conducted with R ver. 3.3.3 (R Core Team 2019) using the "Matching" package (Sekhon 2015).

Deforestation and forest recovery in the Chambok Commune are shown in Fig. 9.3; deforested areas are mainly distributed in the eastern part of the Commune (Fig. 9.3). In addition, it seems forest loss occurred more frequently outside the CBET area, while there were a few cases of the same inside. When we compare deforested areas inside and outside the CBET area, both show net decreases in forest cover (Lonn et al. 2019). This result means that the effects of CBET were not enough to stop net deforestation.

While the simple comparison reveals that CBET cannot stop net deforestation, the matching method result shows that deforestation reduced by 2% ($p < 0.01$) inside the CBET area compared to outside it (Lonn et al. 2019). Similarly, it also shows that forest recovery was promoted by 0.5% inside the CBET area as compared to outside it, although the difference was not statistically significant at the 0.1 level (Lonn et al. 2019).

4 Contribution of CBET to Household Income

Here, we summarize the result from the household survey to quantify the contribution of CBET to household income, from Lonn et al. (2018b). A survey questionnaire to interview both CBET member households and non-CBET households, selected systematically, was conducted. In particular, we visited every second household along the main roads and sub-roads in four villages. This was done keeping in mind that the household locations may affect the income of the local people or their livelihoods (Ameha et al. 2014; Rasolofoson et al. 2017). In all, 174 households—77 CBET and 96 non-CBET—were selected from the survey. These accounted for 23% of the total households in the Commune. Details about the questionnaire are described in Lonn et al. (2018b). To explain briefly, our questionnaire included questions on current income and its source, socioeconomic status, and perceptions of livelihood before and after the introduction of the CBET project.

Figure 9.4 represents the total monthly income and ecotourism income of CBET and non-CBET households. Here, ecotourism income includes any ecotourism-related work (e.g., accommodation charge for homestays and wages for working at the CBET site). The median and mean of the ecotourism income of CBET households were 1.2 and 10.1 USD, respectively.

Distributions of the total income, which included income from other sources in addition to ecotourism, were very similar between CBET and non-CBET households (Fig. 9.4). The median and mean of the total income were US $74.1 and 103.7 for CBET households, and US $64.3 and 81.5 for non-CBET ones, respectively (Lonn et al. 2018b). The interview on the perception of livelihood change showed that 60.5% and 42.7% of CBET and non-CBET households, respectively, felt an increase in the quality of their livelihood (Lonn et al. 2018b). On the other hand, 18.4% and 40.0% of CBET and non-CBET households, respectively, felt a decrease in the quality of their livelihood (Lonn et al. 2018b). Both CBET and non-CBET households had similar perceptions of why their livelihood had changed, which is improvement in employment (Lonn et al. 2018b). Only 2% and 0% of CBET and non-CBET households, respectively, felt ecotourism had improved their livelihood (Lonn et al. 2018b).

5 Discussion and Conclusion

In this chapter, we quantified the contribution of CBET to changes in forest cover and the difference in total income between CBET and non-CBET households by summarizing our recent studies (Lonn et al. 2018b, 2019). The analysis using forest cover change maps showed that the Chambok CBET contributed to reducing deforestation, but its contribution was not enough to stop net deforestation. This finding is consistent with previous studies demonstrating that community-based forest management in general was effective in conserving forests. First, according

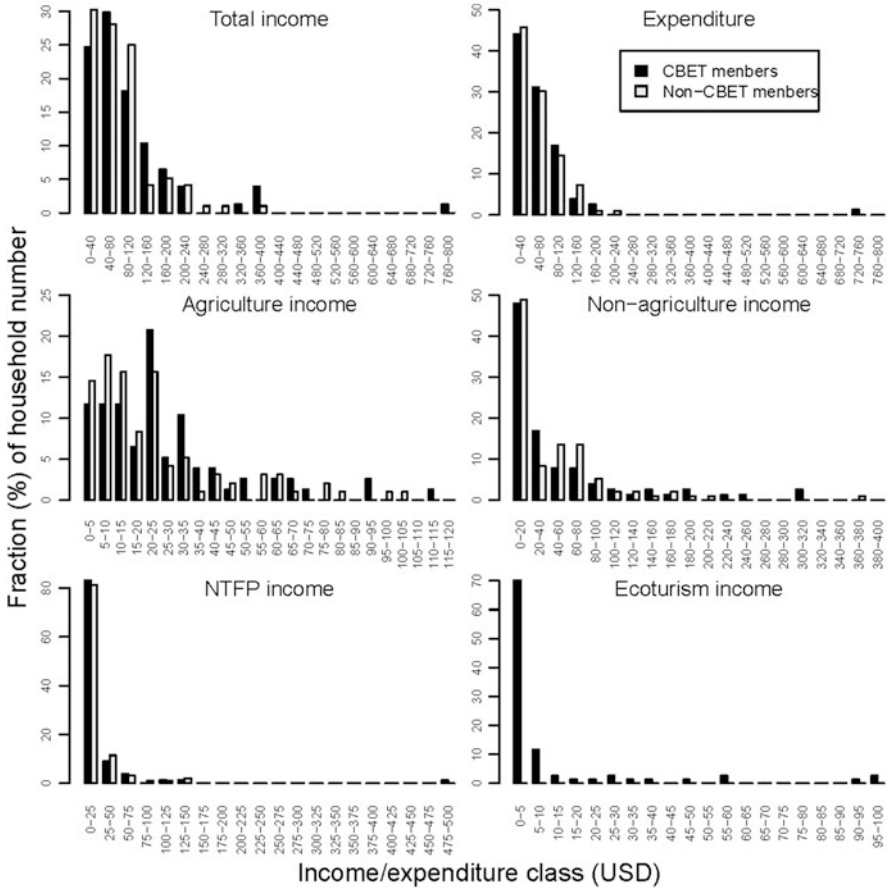


Fig. 9.4 Monthly income and expenditure distributions of CBET and non-CBET households from Lonn et al. (2018b)

to a meta-analysis of case studies in 40 protected areas and 33 community-managed forests, mostly in tropical America, some in Asia, and one in Africa (Porter-Bolland et al. 2012), the community-managed forests presented lower and less variable annual deforestation rates than protected forests. Second, according to a more recent meta-analysis of 159 studies in Central America and Mexico (Min-Venditti et al. 2017), community-based management was associated with a positive impact on forest cover in 81% cases, whereas protected areas were associated with a positive impact in 66% cases.

While we showed the evidently positive contribution of CBET to forest conservation, CBET seldom contributed to any increase in the income of the local people—ecotourism generated the only US $1.2/month in median comparison. Further, the interview on livelihood change showed the limited contribution of CBET to the livelihood of local people. This may be because Cambodia has witnessed remarkable

economic growth since 1998 (Guimbert 2011), and that may provide more employment opportunities. It is notable that the maximum ecotourism income was US $97.5, while the median was US $1.2. This result means there is gross inequality in ecotourism income among Commune members. It is well known that inequality in ecotourism income has a negative impact on ecotourism activities (He et al. 2008; Coria and Calfucura 2012). In the case of Chambok CBET, this inequality depends on the ecotourism-related works that the local people were engaged in and the fact that large incomes were generated only from homestays (Lonn et al. 2019). The revision of ecotourism income distribution may be key to improving the average income of local people.

For archiving the success of CBET, further studies are required to clarify local people's motivation to conserve forests under CBET. Conceptually, ecotourism motivates local people to conserve forests because ecotourism needs attractive natural resources. However, in our case, the conservation effect may not be derived from ecotourism—because ecotourism made a limited contribution in increasing local people's income and few felt it had improved their livelihood, it is unlikely to motivate forest conservation. On the other hand, community-based activities for forest management positively contribute to forest conservation, whether or not it includes ecotourism (Min-Venditti et al. 2017; Pandey et al. 2017). Some studies show that tenure security, clear ownership, and/or effective enforcement are important factors affecting the success or failure of community-based forest management (Pagdee et al. 2006; Baynes et al. 2015). Further studies on the effects of these factors are needed to better understand the success or failure of forest conservation under CBET.

Finally, we would like to make some suggestions to enable the future success of the Chambok CBET. First, further efforts toward forest restoration are needed because CBET was effective but could not stop deforestation. Forest cover in the Chambok CBET has continued to decrease. Therefore, any strategy that effectively accelerates forest recovery should be developed. Second, equalization of the ecotourism income is an urgent issue to improve the income of the majority of local people. Currently, only homestay hosts are making a big profit. Thus, there is a need to create new ecotourism-related jobs for those with low incomes, although it is easier said than done.

In conclusion, CBET is effective in forest conservation, but its contribution to increasing the income of local people is limited. To realize the expectation that CBET can harmonize better quality of life for local people with forest conservation, we need to develop new strategies focusing on forest restoration and income equalization.

Acknowledgments We wish to thank the local authorities, Chambok CBET members, and Chambok Commune members for supporting the study. We are also grateful to the staffs of FA, the Ministry of Agriculture, Forestry and Fisheries of Cambodia based in the provinces and in Phnom Penh, and the Mlup Baitong. A portion of the original content is from Ecological Economics, 151, 62–69, Evaluating the Contribution of Community-based Ecotourism (CBET) to Household Income and Livelihood Changes: A Case Study of the Chambok CBET Program in Cambodia, (2018), with permission for "text extraction" and "reuse of figure" from Elsevier. The other is from

Environmental Conservation, 46, 111–117, Using Forest Cover Maps and Local People's Perceptions to Evaluate the Effectiveness of Community-based Ecotourism for Forest Conservation in Chambok (Cambodia), (2019), with permission for "text extraction" and "reuse of figure" from Cambridge University Press. This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

Achard F, Eva HD, Stibig H-J, Mayaux P, Gallego J, Richards T, Malingreau J-P (2002) Determination of deforestation rates of the world's humid tropical forests. Science 297:999–1002

Ameha A, Nielsen OJ, Larsen HO (2014) Impacts of access and benefit sharing on livelihoods and forest: case of participatory forest management in Ethiopia. Ecol Econ 97:162–171. https://doi.org/10.1016/j.ecolecon.2013.11.011

Baccini A, Walker W, Carvalho L et al (2017) Tropical forests are a net carbon source based on aboveground measurements of gain and loss. Science 358:230–234

Baynes J, Herbohn J, Smith C et al (2015) Key factors which influence the success of community forestry in developing countries. Glob Environ Chang 35:226–238. https://doi.org/10.1016/J.GLOENVCHA.2015.09.011

Bonan GB (2008) Forests and climate change: forcings, feedbacks, and the climate benefits of forests. Science 320:1444–1449

Coria J, Calfucura E (2012) Ecotourism and the development of indigenous communities: the good, the bad, and the ugly. Ecol Econ 73:47–55

Das M, Chatterjee B (2015) Ecotourism: a panacea or a predicament? Tour Manag Perspect 14:3–16. https://doi.org/10.1016/J.TMP.2015.01.002

FAO (2015) Global forest resources assessment 2015: how are the world's forests changing? Rome

Guimbert S (2011) Cambodia 1998–2008: an episode of rapid growth. In: Facets of competitiveness: narratives from ASEAN. World Scientific, Singapore, pp 151–183

Hansen MC, Potapov PV, Moore R et al (2013) High-resolution global maps of 21st-century forest cover change. Science 342:850–853. https://doi.org/10.1126/science.1244693

He G, Chen X, Liu W et al (2008) Distribution of economic benefits from ecotourism: a case study of Wolong nature reserve for Giant Pandas in China. Environ Manag 42:1017–1025. https://doi.org/10.1007/s00267-008-9214-3

IPBES (2018) The IPBES regional assessment report on biodiversity and ecosystem services for Asia and the Pacific. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, 612 p

Kiss A (2004) Is community-based ecotourism a good use of biodiversity conservation funds? Trends Ecol Evol 19:232–237. https://doi.org/10.1016/J.TREE.2004.03.010

Lonn P, Mizoue N, Ota T et al (2018a) Biophysical factors affecting forest cover changes in community forestry: a country scale analysis in Cambodia. Forests 9:273. https://doi.org/10.3390/f9050273

Lonn P, Mizoue N, Ota T et al (2018b) Evaluating the contribution of community-based ecotourism (CBET) to household income and livelihood changes: a case study of the Chambok CBET program in Cambodia. Ecol Econ 151:62–69. https://doi.org/10.1016/j.ecolecon.2018.04.036

Lonn P, Mizoue N, Ota T et al (2019) Using forest cover maps and local people's perceptions to evaluate the effectiveness of community-based ecotourism for forest conservation in Chambok (Cambodia). Environ Conserv 46:111–117. https://doi.org/10.1017/S0376892918000462

Min-Venditti AA, Moore GW, Fleischman F (2017) What policies improve forest cover? A systematic review of research from Mesoamerica. Glob Environ Chang 47:21–27. https://doi.org/10.1016/J.GLOENVCHA.2017.08.010

Newbold T, Hudson LN, Phillips HRP et al (2014) A global model of the response of tropical and sub-tropical forest biodiversity to anthropogenic pressures. Proc R Soc B Biol Sci 281:1371. https://doi.org/10.1098/rspb.2014.1371

NIS (2008) Statistical year book 2008. NIS, Phnom Penh

Pagdee A, Kim Y-S, Daugherty PJ (2006) What makes community forest management successful: a meta-study from community forests throughout the world. Soc Nat Resour 19:33–52. https://doi.org/10.1080/08941920500323260

Pandey SS, Maraseni TN, Reardon-Smith K, Cockfield G (2017) Analysing foregone costs of communities and carbon benefits in small scale community based forestry practice in Nepal. Land Use Policy 69:160–166. https://doi.org/10.1016/J.LANDUSEPOL.2017.09.007

Porter-Bolland L, Ellis EA, Guariguata MR et al (2012) Community managed forests and forest protected areas: an assessment of their conservation effectiveness across the tropics. For Ecol Manag 268:6–17. https://doi.org/10.1016/J.FORECO.2011.05.034

Prachvuthy M (2006) Tourism, poverty, and income distribution: Chambok community-based ecotourism development, Kirirom National Park, Kompong Speu Province, Cambodia. J GMS Dev Stud 3:25–40

R Core Team (2019) R: A language and environment for statistical computing. https://www.r-project.org/. Accessed 29 Aug 2019

Rasolofoson RA, Ferraro PJ, Ruta G et al (2017) Impacts of community forest management on human economic well-being across madagascar. Conserv Lett 10:346–353. https://doi.org/10.1111/conl.12272

San V, Spoann V, Ly D, Chheng NV (2012) Fuelwood consumption patterns in Chumriey Mountain, Kampong Chhnang Province, Cambodia. Energy 44:335–346. https://doi.org/10.1016/J.ENERGY.2012.06.025

Scheffers BR, Joppa LN, Pimm SL, Laurance WF (2012) What we know and don't know about Earth's missing biodiversity. Trends Ecol Evol 27:501–510. https://doi.org/10.1016/j.tree.2012.05.008

Sekhon JS (2015) Package 'Matching' [www document]. http://dirichlet.mat.puc.cl/web/packages/Matching/Matching.pdf

Stuart EA (2010) Matching methods for causal inference: a review and a look forward. Stat Sci 25:1–21. https://doi.org/10.1214/09-STS313

Sullivan MJP, Talbot J, Lewis SL et al (2017) Diversity and carbon storage across the tropical forest biome. Sci Rep 7:39102

Sunderlin WD, Belcher B, Santoso L et al (2005) Livelihoods, forests, and conservation in developing countries: an overview. World Dev 33:1383–1402. https://doi.org/10.1016/j.worlddev.2004.10.004

Top N, Mizoue N, Kai S, Nakao T (2004) Variation in woodfuel consumption patterns in response to forest availability in Kampong Thom Province, Cambodia. Biomass Bioenergy 27:57–68. https://doi.org/10.1016/J.BIOMBIOE.2003.10.008

Part IV
Co-designs in a Disaster Recovery Process: Case Studies in the Area Affected by the Kumamoto Earthquake

Chapter 10
Oral Care that Supports Healthy Lives as a Case Study of the Kumamoto Earthquake

Michikazu Hiramatsu and Hideto Ohta

Abstract Immediately after the Great Hanshin-Awaji Earthquake in 1995 and the Great East Japan Earthquake in 2011, pneumonia outbreak among the elderly increased the rate of fatalities. What caused this? To use lessons learned during the large-scale disaster, specialists concerned with the field of dentistry began to take action using new perspectives. Consequently, they noticed the importance of giving care to the entire oral cavity as well as the teeth. Based on reports from a dentist and a dental hygienist who tackled the oral care of the Kumamoto Earthquake victims in 2016, their methods of effective health care following a disaster is presented in this paper. We also propose a preventative medical activity that can be conducted sustainably for anyone, not just medical personnel.

Keywords Disaster-related deaths · Oral care · Pneumonia outbreak · Preventive health care

1 The Rapid Increase of Pneumonia After the Disaster

In the last quarter-century, Japan experienced four large-scale earthquakes: the Great Hanshin-Awaji Earthquake of 1995 (M7.3), the Niigata-Chuetsu Earthquake of 2004 (M6.8), the Great East Japan Earthquake of 2011 (M9.0), and the Kumamoto Earthquake of 2016 (M6.5, M7.3). In every case, many fell victim to house and building collapses, landslides, and tsunamis, but many earthquake-related deaths occurred in the evacuation shelter afterward.

Pneumonia was the top cause of death (Takakura et al. 1997; Suzuki et al. 2011; Daito et al. 2013; Shibata et al. 2016). Although the proportion of death from

M. Hiramatsu (✉)
The Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan

H. Ohta
Fukuoka Dental Association, Dazaifu, Japan
e-mail: droota@grace.ocn.ne.jp

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_10

pneumonia is usually about 10%, in the disaster-related death toll after the Great Hanshin-Awaji Earthquake, it was reported as 24% (Adachi 2015).

Based on the report, the medical stakeholders began to acknowledge that "pneumonia of the elderly increases after a large earthquake occurs" or "oral care to the elderly is necessary to prevent pneumonia." Indeed, in the Niigata-Chuetsu Earthquake in 2004, the oral care team was organized for the elderly by dental personnel, who previously concentrated their attention on the identification of the dead and emergency dental care as their main disaster support. The Niigata-Chuetsu Earthquake was the first event where oral care was used in victim relief (Tanaka 2009; Nakakuki et al. 2012).

2 Pneumonia Outbreak After the Great East Japan Earthquake

The Great East Japan Earthquake of March 11, 2011, caused a major tsunami that struck the coast of the Tohoku region and was a catastrophe that caused death and missing people beyond the extent of the Great Hanshin-Awaji Earthquake. In this chaotic situation of an unprecedented catastrophe, the repeated nightmare of a sudden increase in fatalities due to pneumonia was reported by detailed data tracking by physicians who assisted in the disaster area.

Kesennuma, Miyagi prefecture is a city with a population of 70,000 located on the east coast of Tohoku that was affected by the Great East Japan Earthquake. After the disaster, pneumonia patients were carried incessantly into Kesennuma City Hospital, and the hospital filled with patients immediately in a few days.

Daito et al. (2013) conducted a detailed analysis of the rapid increase in pneumonia based on the medical records and X-ray photographs of pneumonia patients aged 18 and more before and after the earthquake at three city hospitals. The research revealed that 225 people (The frequency per week was 5.7 times before the disaster) were hospitalized with pneumonia within three and a half months afterward. One hundred and eighty-four (88%) were elderly aged over 65 years. Forty-nine people (24%; frequency was 8.9 times before the disaster) had lost their lives. Daito et al. (2013) eventually ascertained that typical pneumonia seen in the elderly increased more than in normal times, though it was also believed that pneumonia would spread if oil dust floating in the disaster area were inhaled.

It should be stressed that the pneumonia mortality rate (2.1%) at the elderly nursing home was far higher than the pneumonia mortality rate (0.1% or less) at the evacuation center. In the elderly nursing home in the city—where 125 patients were kept in overwhelming numbers, and six people were being accommodated per quadruple-sized rooms—five people developed pneumonia in the first 20 days, and all of whom died.

Detailed data on the rapid increase of pneumonia after the disaster by Daito et al. (2013) effectively shows how important it is to protect elderly people who need

long-term care from pneumonia in an adverse environment where their lifeline is disrupted during a severely cold season. In Daito et al.'s survey, however, it was not concluded what the main factor among multiple conditions such as age and stress involved with pneumonia was.

3 The Importance of Oral Care

How can I protect the elderly from pneumonia? The answer was unexpectedly given by another special elderly nursing home—Keichoen in Kesennuma city. After the earthquake, among 100 elderly people, no one developed pneumonia or was hospitalized who had evacuated to this nursing home (https://www.nhk.or.jp/ashita/english/stories/tmrw3-pneu.html).

This miracle at the facility, given the generally high risk of developing pneumonia, became possible through oral hygiene management by dental doctors who came from local and other prefectures. Considering the water shortages, the inside of oral cavities were cleaned using a forefinger wrapped in wet, nonwoven fabric instead of a toothbrush, and the salivary glands were massaged to promote saliva secretion. Yoneyama et al. (1999) also reported that 2 years of incidences of pneumonia at a special nursing home (where residents were visited by a dentist or a dental hygienist conducting specialized oral cleaning) was reduced by about 40% compared with those without such cleaning. Such oral hygiene management might suppress bacterial growth in the oral cavity.

Doctor Daito, who learned the effectiveness of this oral hygiene management, mentioned later that "I could never imagine at that time that the dentist had predicted the pneumonia outbreak and was involved in aggressive oral care to prevent it." As his view explains, it was challenging to predict pneumonia at the time of disaster within normal specialized frameworks and prevent its rapid surge.

As mentioned, the experience and wisdom of disaster-stricken medical care providers from the Great Hanshin-Awaji Earthquake to the Great East Japan Earthquake increased awareness for the importance of collaborative medicine between medical and dental fields beyond their specialties. Gradually, preparing support systems for oral care for victims during a disaster accelerated (Nakakuki et al. 2012, 2013). Ohta, an author of this present review, is also a dental care worker who learned and began providing oral care support for victims after their medical volunteer activities at a disaster site.

4 Oral Care Activities by Dentists and Dental Hygienists for Reducing Pneumonia Outbreak After the Kumamoto Earthquake

Like Daito, Ohta et al. (2019) learned the scientific basis for the importance of professional oral cleaning after he experienced on-site dental support in Minamisanriku, Miyagi Prefecture, 2 months after the Great East Japan Earthquake. Through that experience, Ohta realized that, if more dental personnel could conduct oral care activities targeting patients with a high risk of pneumonia within two weeks after an earthquake, more people would be saved.

The opportunity to test the idea came on April 16, 2016, when a substantial earthquake hit Kumamoto, approximately 100 km away from Ohta's residence. After the earthquake, Ohta and other dental workers were requested to join local Kumamoto dentist associations in the field, and dental health support activities were conducted.

In the severely damaged Minamiaso village (approximately 11,600 population), the Disaster Medical Assistance Team (DMAT), Japan Medical Association Team (JMAT), public health nurses, and pharmacists formed a team under the direction of the Aso Disaster Recovery Organization (ADRO) immediately after the main shock to conduct emergency medical activities. The local Kumamoto Prefecture dentist members also participated in this. Ohta's dental team dispatched from outside Kumamoto Prefecture entered the village on April 23, seven days after the earthquake. The dental team mainly developed cross-organizational support activities through multidisciplinary professional collaboration with the Japan Rehabilitation Assistance Team (JRAT) and the Japan Dietetic Association-Disaster Assistance Team (JDA-DAT).

Ohta's dental support team used the national standardized assessment form (http://jsdphd.umin.jp/shiryo.html) for the first time in the disaster area. Consequently, it is possible to clarify the necessity of dental treatment and oral care at the individual and group level, and to quickly collect information on persons who require special consideration in shelters and nursing homes that were blind spots in the Great East Japan Earthquake. The dental team developed a support plan for the entire region based on the collected information and shared it with non-dental occupations such as doctors, nurses, nutritionists, physical therapists, social workers, and logistic officers at the emergency management headquarters meeting. The Disaster Feeding Support Team (DFST), which is composed of trans-disciplinary professional members, provided meals to prevent dysphagia in elderly people requiring special consideration (Maeda et al. 2017; Kato et al. 2019).

In Minamiaso village, Ohta's emergency team received 46 dental and 252 oral care treatments (Ohta et al. 2019). Sixty-nine swallowing evaluations and 12 swallowing rehabilitations were performed within the one-month dispatch period from April 23 to May 22, 2016. During this period, there was one pneumonia patient who required hospitalization, and no disaster-related deaths due to pneumonia were identified until a half year after the disaster.

As already mentioned, the pneumonia incidence in the Great Hanshin-Awaji Earthquake was as high as 24% of the deaths related to the earthquake (Adachi 2015). Although the incidence of pneumonia due to the Kumamoto earthquake is not yet clear, A Nishinippon Shimbun newspaper published on May 22, 2016, reported that the number of pneumonia patients during the 16 days after the Kumamoto Earthquake increased compared to the same period of the previous year in the two disaster base medical hospitals in Kumamoto city (population, 740,000) (https://www.nishinippon.co.jp/nnp/medical/article/247976/). Based on these facts, it can thus be said that the medical and health activity through collaboration between dentistry, dental hygiene, and various professionals in Minamiaso village was a successful example of reducing disaster-related deaths.

Recently, the importance of medical-dental collaboration through oral care is widely recognized in the field of medical welfare. In medical treatment at the time of a disaster, however, since full-time doctors are often pursued to manage patients urgently transported under the relatively poor working conditions, there may be cases where normal oral care cannot be sufficiently performed. There are various types of facilities for receiving victims, such as base hospitals, clinics, welfare facilities, and temporary shelters, and the handling scale and content differ by the facility.

To functionally work preventative oral care for elderly pneumonia sufferers, even during disasters, it is necessary to predict the condition and number of patients that can be accepted during a disaster. Eventually, each facility will be requested to establish a business continuity plan (BCP) including how to accept medical supporters from outside the organization, to check it daily, and improve it after the disaster.

5 Mouth Breathing, Its Causes, and Adverse Effects: What People Can Do for Sustainable Health

Life after disasters tends to be worse than is normal, and it is important for health maintenance that medical supporters and evacuees prevent a decline in autoimmunity. One example is the "A-I-U-Be" exercise proposed by Imai, a physician (https://mirai-iryou.com/aiube/aiube-english/).

People who take modern diets of soft foods that do not require much chewing power tend to weaken the muscle strength around the mouth and that of the tongue, and will eventually be in a state of "mouth breathing," where the mouth is always open. A person in the mouth breathing state takes air directly into the mouth more easily. Thus, saliva secretion is suppressed, and their oral cavities become drier. This reduces autoimmunity and increases the chances of suffering from diseases caused by bacteria and viruses.

The A-I-U-Be exercise prevents mouth breathing and raises autoimmunity by returning the tongue to a normal position and naturally closing the mouth. This

exercise has often been adopted in schools due to the simplicity of doing it anytime, anywhere without cost. Although not statistically estimated, clear suppression of winter flu in school children was reported from some elementary school that adopted the exercise.

Evacuees in disaster areas can significantly reduce the risk of respiratory diseases such as flu and pneumonia by performing self-cleaning in the oral cavity and such simple exercises. Consequently, it will be possible to prevent disaster-related deaths. At Minamiaso village, Ohta's dental team urged evacuees to use the A-I-U-Be exercise while handing out cards (https://mirai-iryou.com/aiube/contact-aiube/#i-3) explaining the method and effect of this exercise. Therefore, educating residents likely to become disaster victims on the knowledge and skills to maintain their health, even in a poor environment, is also indispensable for saving lives in the disaster areas. Moreover, the accumulation of scientific evidence on the effect of these health activities in disaster areas is a challenge for the future.

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

Adachi R (2015) Importance of oral health in large-scale disasters – to halt an increase in disaster-related deaths. J Kanagawa Odontol Soc 50:18–21

Daito H, Suzuki M, Shiihara J, Kilgore PE, Ohtomo H, Morimoto K, Ishida M, Kamigaki T, Oshitani H, Hashizume M, Endo W, Hagiwara K, Ariyoshi K, Okinaga S (2013) Impact of the Tohoku earthquake and tsunami on pneumonia hospitalisations and mortality among adults in northern Miyagi, Japan: a multicentre observational study. Thorax 68:544–550

Kato T, Morita H, Tsuzuki T, Yamaguchi M, Ohta H, Tanoue D, Nakakuki K (2019) Emerging role of dental professionals with medical staff collaboration in disaster relief following the 2016 Kumamoto earthquakes: implications for the expansion of the scope of dental practice. Int Dent J 69:79–83

Maeda K, Shamoto H, Furuya S (2017) Feeding support team for frail, disabled, or elderly people during the early phase of a disaster. Tohoku J Exp Med 242:259–261

Nakakuki K, Tohara H, Kojo A (2012) Research for arrangement of dysphagia in a dental health care management system during large-scale disasters. Jpn J Dysphagia Rehab 16:57–63

Nakakuki K, Arikawa K, Taguchi C, Ogura M, Nasu I, Teraoka K (2013) Preparation for disaster dental aid and health system in prefectures. Health Sci Health Care 13:67–75

Ohta H, Nakakuki K, Tanoue D, Katayama K, Niibu I, Kumai T, Mimori Y, Tamura N, Ganaha S, Koshikawa Y, Ushijima T, Urata K (2019) Multidisciplinary "eating" support by maintaining oral function for vulnerable people in Minamiaso area after the 2016 Kumamoto Earthquake. J Jpn Disaster Food Soc 6:69–76

Shibata Y, Ojima T, Tomata Y, Okada E, Nakamura M, Kawado M, Hashimoto S (2016) Characteristics of pneumonia deaths after an earthquake and tsunami: an ecological study of 5.7 million participants in 131 municipalities, Japan. BMJ Open 6:e009190

Suzuki M, Uwano C, Ohrui T, Ebihara T, Yamasaki M, Asamura T, Tomita N, Kosaka Y, Furukawa K, Arai H (2011) Shelter-acquired pneumonia after a catastrophic earthquake in Japan. J Am Geriatr Soc 59:1968–1970

Takakura R, Himeno S, Kanayama Y, Sonoda T, Kiriyama K, Furubayashi T, Yabu M, Yoshida S, Nagasawa Y, Inoue S, Iwao N (1997) Follow-up after the Hanshin-Awaji Earthquake: diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. Intern Med 36:87–91

Tanaka A (2009) Dental health support activities for struck senior citizen in the large-scale disaster. J Jpn Dent Assoc 62:392–404

Yoneyama T, Yoshida M, Matsui T, Sasaki H, Oral Care Working Group (1999) Oral care and pneumonia. Lancet 354:515

Chapter 11
Experiences of University Student Volunteer Activities to Revitalize the Area Affected by the Kumamoto Earthquake

Yukyong Jeong, Michikazu Hiramatsu, and Kun Qian

Abstract The purpose of this paper is to clarify the situation and issues of volunteer activities through the example of the students' voluntary activities after the Kumamoto earthquake. In the case study, we described the volunteer activities of Tokai University students starting from the time immediately after the Kumamoto Earthquake, and the revitalization activities they conducted in the disaster area. We focused on how the motivations and actions of university students are changing over time. The students of the Faculty of Agriculture of Tokai University established a student volunteer group called Aso Fukkoheno Michi which means "Path for Revitalization of Aso". The group is currently working on the revitalization of Minami-aso Village, with a particular focus on developing the sustainability of the Kurokawa area. With this intention, members of Aso Fukkoheno Michi started to tell the story of Minami-aso Village to visitors. Through this storytelling activity, the students are able to convey their own experiences of the disaster to visitors. From the survey conducted among student volunteers, we learned about the effective ways in which the students undertook such activities. However, we identified problems faced by the volunteers regarding the continuation of their efforts in the future, and regarding maintaining their involvement with the local community.

Keywords Kumamoto earthquake · Local community · Storytelling activity · Revitalization · University students

1 Introduction

Until today (August 2019) since the Kumamoto earthquake occurred in April 2016 (Kato et al. 2016), various people, including residents, administrators, students, and volunteers, have been participating in revitalization efforts in the areas affected by

Y. Jeong (✉) · M. Hiramatsu · K. Qian
The Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan
e-mail: jeong.yukyong.033@m.kyushu-u.ac.jp

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_11

the disaster. Compared to the situation immediately after the earthquake, however, there have since been various changes in the way that revitalization efforts have been undertaken by these various actors. To make revitalization efforts more sustainable, we need to understand how the motivations and actions of these people are changing over time. This chapter focuses on the changes in the revitalization efforts made by students of Tokai University, as an example of the students' voluntary activities after the earthquake.

This chapter begins by describing the significance of the students' revitalization activities and their purpose. Immediately after the Kumamoto earthquake struck, university students independently began to operate shelters in some disaster areas. For example, Kumamoto Gakuen University established its own shelter after the foreshock of the earthquake (Takagi 2017). Some professors and students in the Faculty of Social Welfare participated in voluntary activities, taking care of elderly and handicapped people in the local community. As another example, the Prefectural University of Kumamoto temporarily opened its campus to local disaster victims. At that time, through their own initiative, university students formed groups to operate several missions at shelters—even though they were also themselves victims. The students appealed to members of university clubs and faculty members to participate in voluntary activities. They also used social media to recruit participants.

From this response, it is evident that the relationships and networks that had been established prior to the earthquake were practically utilized to operate the shelters. In this way, at an early stage after the earthquake, the students were able to act independently and respond quickly. Some universities in Kumamoto City temporarily opened their campuses as a shelter for victims (Takagi 2017). After these shelters closed, many of the students continued to work as volunteers in the disaster area. Thus, these students made significant efforts towards helping to rebuild areas affected by the earthquake. This chapter focuses on the actions of university students in helping to sustain the local community and examines what might be learned from those efforts. It also introduces the involvement of the Decision Science Center at Kyushu University, which can act as a case example of the role that a university might play in disaster recovery.

2 Students' Volunteer Activities After the Earthquake

2.1 Students' Actions in the Early Stage After the Earthquake

We conducted field surveys from March 1–2, 2017 in Kumamoto City and Minami-aso Village, to record the students' actions in the early stage after the earthquake. As noted above, these students undertook their actions independently and responded quickly; they were also able to organize voluntary groups.

The Prefectural University of Kumamoto opened its campus and facilities to the public on April 14, 2016, when the foreshock occurred. The students' volunteer activities started on the same day. The main earthquake occurred on April 16 (Kato

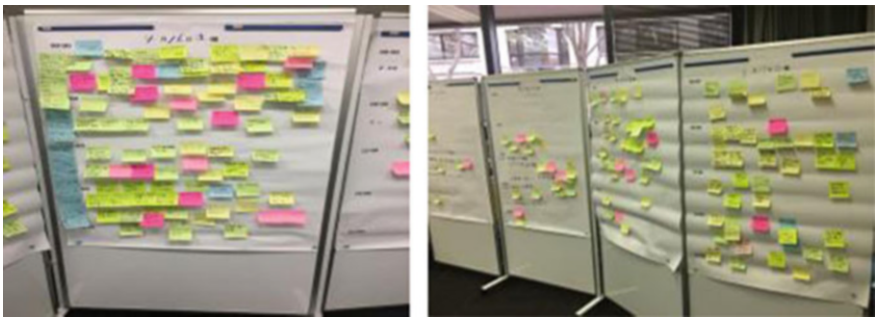


Fig. 11.1 Whiteboards showing the thoughts, feelings, and memories posted by volunteer students at Prefectural University of Kumamoto at the time of the disaster (photos taken by the author)

et al. 2016). Subsequently, the student groups, which had until this point been acting separately, became integrated into the Student Volunteer LINE Group; in total, about 200 students joined (Iwasaki 2017). The integrated student group organized a meeting of group leaders. Various groups shared the workload of managing the shelters, and they operated systematically.[1] The Prefectural University of Kumamoto closed its shelter on April 18, 2016, because the shelter had only been intended to be a temporary evacuation area. When the shelter was closed, the students and staff members of the volunteer center made efforts to remembering and recording the efforts that student volunteers had made. The students who had worked as volunteers were requested to post their thoughts and feelings at the time of the disaster on whiteboards (Fig. 11.1).

One staff member at the Volunteer Center of Kumamoto Gakuen University described the students' actions and the situation in operating the university shelter as follows:

> Volunteering has an educational meaning. However, the actions undertaken by the university students after the Kumamoto Earthquake seemed to have a sense of mission more than of volunteering. Students had close relationships with members of university clubs and members of faculty, and those relationships naturally led to taking part in volunteer activities. Students could respond quickly to disaster victims who were in urgent need of help by mobilizing people and spreading information using social media. I think it was important that the victims could make use of such advantages.[2]

As noted above, it would be beneficial to examine the efforts made by the various people who played different roles at the time of the disaster. For example, the Social Welfare Council generally maintains a strong network among the residents of the

[1]Students at the Prefectural University of Kumamoto immediately took action by organizing volunteer groups to run shelters. Club leaders became the leaders of the voluntary groups; there was no compulsion to join. This information was based on the survey conducted on March 1, 2017 at the Prefectural University of Kumamoto. Prefectural University of Kumamoto (2017) "大学COC事業/創造的復興支援プロジェクト報告書."

[2]Based on the survey of March 2, 2017, Volunteer Center, Kumamoto Gakuen University.

local community. Thus, the Social Welfare Council can identify the needs of local residents accurately if time is allowed. However, its decision-making process is often slow, particularly during a time of crisis. Accordingly, the Social Welfare Council is better suited to helping with the reconstruction and revitalization process, rather than reacting during a crisis. For example, following the earthquake, the Social Welfare Council was responsible for supporting people who were living in temporary accommodation. On the other hand, the student volunteers were able to respond quickly to the more urgent needs of the disaster victims.

Even after the universities stopped operating the shelters, most students continued to engage in volunteer activities. At present, students are still involved in various volunteer activities. While some students continue to visit disaster areas through the volunteer center of their university (or an organization related to volunteer activities), others have instead begun to organize such activities by themselves. Due to this development, this chapter focuses on the activities of these university students. Supporting these student activities helps to promote the sustainability of the local area.

2.2 Tokai University Students in Minami-Aso Village

This chapter introduces a case study focused on a student group that has continued to undertake volunteer activities to revitalize Minami-aso Village. The Aso Campus of Tokai University is located in the Kurokawa area of Minami-aso Village. Students of the Faculty of Agriculture had formerly lodged in Kurokawa. After the earthquake struck on April 16, the Aso Campus suffered considerable damage: some lecture halls were destroyed completely, and cracks appeared in the campus grounds (Matsuura 2017). The Faculty of Agriculture recommenced lectures in the Kumamoto Campus of Tokai University on July 1, having concluded that reopening the Aso Campus would be difficult owing to security problems. At the time of writing, the Aso Campus is still closed, and around 800 students who had been living in Kurokawa have been forced to relocate to Kumamoto city. The students of the Faculty of Agriculture attend lectures in the city: they can use only certain facilities at Aso Campus, for the purpose of on-site training for agricultural practice. Special permission was granted for them to continue using these facilities.

Before the earthquake, around 800 students and around 200 local residents had lived together as a community in Kurokawa. Most of these local residents were making a living by providing student lodgings. The Aso Campus of Tokai University was established in 1973, and Kurokawa subsequently became a kind of student village; the students and residents there developed a very close relationship. Thus, in Kurokawa, students and local residents had already developed strong networks before the earthquake struck. The Kumamoto Earthquake forced these two groups of people to live far apart and lead different lives. Most of the residents had to move to temporary accommodation or other places, whereas the students moved to Kumamoto City. The intimate relationship that had developed between the students

Fig. 11.2 A photograph of Kurokawa's landscape after the Kumamoto Earthquake: large cracks in the ground are evident

and residents remained, however. Under the new situation, the students of the Faculty of Agriculture of Tokai University established a student volunteer group called Aso Fukkoheno Michi: the group's name means "Path for Revitalization of Aso." The group is currently working on the revitalization of Minami-aso Village, with particular focus on developing the sustainability of the Kurokawa area. Kurokawa was badly affected by the earthquake, as demonstrated by the collapse of Aso Bridge, which had connected the main road and Minami-aso Village. The bridge was an irreplaceable piece of infrastructure that supported the daily lives of Kurokawa's residents, and was also an attractive site for local tourists. The collapse of the bridge therefore seriously damaged Kurokawa.

Aso Fukkoheno Michi is involved in various volunteer activities in Kurokawa. After the earthquake, some students engaged in volunteer activities, such as the management of shelters and the transportation of supplies to elderly residents. Those students had lived in Kurokawa, and were therefore affected by the earthquake themselves. Students who shared the same lodgings contacted each other to confirm their safety after the disaster struck, for example (Fig. 11.2).

One student who was active as a group leader at the beginning of the volunteer activities explained the significance of the activities:

> We wanted to make an effort to maintain our relationship with the local residents in Kurokawa. So we organized groups devoted to sustainability and revitalization of this community. It was unfortunate that most students left the community after graduation. But some students who experienced the disaster of the Kumamoto Earthquake are still living there, although their numbers are decreasing. On the other hand, some new students joined the community. We senior students may be able to communicate something valuable to Minami-aso Village based on our experience and promote good relationships with local residents and new students. We are conveying our experiences of the Kumamoto Earthquake to the new students. We are working on activities to share our memories with the next generation.[3]

[3]From an interview with the former leader of Aso Fukkoeno Michi, who was a student of Tokai University, on March 1, 2017.

With this intention, members of Aso Fukkoheno Michi started to tell the story of Minami-aso Village to visitors. Through this storytelling activity, the students are able to convey their own experiences of the disaster to visitors. The students are enthusiastic about preserving their memories of the disaster, and in doing so they are assisting new students in creating close relationships with the local community.

3 Aso Fukkoheno Michi: Experiences and Problems in Activities

Throughout the years that have elapsed since the Kumamoto Earthquake, Aso Fukkoheno Michi (Path for Revitalizatio of Aso) has continued its efforts to improve its activities. This section describes the experiences learned from these efforts and identifies the challenges that the group is now facing. We conducted a research survey to clarify the problems of managing voluntary activities in the disaster area. We regularly visited the area and observed the group's storytelling activities to visitors of Minami-aso Village. We also interviewed students individually to record their awareness of the disaster.

As noted above, storytelling is one of Aso Fukkoheno Michi's main activities. Another main activity of the group is holding exchange meetings with local residents and students in Minami-aso Village. In 2016, most of the group's members were living in Kurokawa and therefore became victims of the earthquake. In 2017, however, 15 new students joined the group, with a further five new students joining in 2018. Most of these new students did not experience the disaster, and none of them had lived in Kurokawa, and therefore they had not developed a relationship with the residents. These new students were keen to work towards local revitalization, however: they wished to know more about Aso, and play any role in the development of Minami-aso Village. These wishes were their motivation for taking part in Aso Fukkoheno Michi's activities.

According to interviews with the students, it seems that there are differences in their awareness of the disaster, and furthermore their motivations for wanting to revitalize the area differed between the senior and new students. The senior students helped the new students to achieve the group's tasks by managing the group: in this way, they could help to reduce the differences in awareness of the disaster, and could also maintain the group's intimate relationship with the local community. The storytelling activities are mainly undertaken by the senior students who lived in Kurokawa, and who therefore experienced the earthquake. If Aso Fukkoheno Michi receives requests for storytelling from visitors, some group members travel to Minami-aso Village from Kumamoto. At present (August 2019), it is impossible to reach Kurokawa using any public transport, so students have to go there by car. The students consider this transport problem something of a burden: only a limited number of students have their own cars, so most group members have no way of getting to Kurokawa on their own.

Fig. 11.3 Storytelling activity (May 7, 2017) in front of Aso Bridge, which collapsed due to the earthquake

The narrator does of course play a key role in storytelling. With the passage of time, the number of Aso Fukkoheno Michi members who are able to narrate about their own experiences has decreased. New students are also involved in the storytelling, but they feel that they are unable to describe the disaster situation as vividly as the students with firsthand experience. Accordingly, Aso Fukkoheno Michi is making efforts to pass on the storytelling techniques to new students. Maintaining a sustainable relationship between students and local residents is important in revitalizing the disaster area (Figs. 11.3 and 11.4).

The senior students of Aso Fukkoheno Michi agreed that it would be necessary for new students to become well acquainted with both Minami-aso Village and Kurokawa. They believed that if the new students could better understand Minami-aso Village, and therefore feel more familiar with the community, their motivation towards the revitalization efforts would increase. Furthermore, through this process, the difference in awareness of the disaster between senior students and new students could be reduced even a little. However, the new students had their own ideas about revitalization, and about the types of activities that should be undertaken in the disaster area. It is therefore difficult to generalize the attitudes of the new students with respect to revitalization. The senior students thought it would be beneficial to let the new students experience for themselves Minami-aso Village and the surrounding area, and therefore organized a revitalization tour for the new students (Fig. 11.5).

Fig. 11.4 Using pictures in storytelling: the scenery of Minami-aso Village

As noted above, the group's number of storytelling narrators with personal experience of the disaster had declined, and the new students had become aware of this problem. The new students became particularly aware of this situation when they participated in various group events. They organized activities on their own, and these activities had a big social effect. The new students believed it would be better to broaden the activities of Aso Fukkoeno Michi and to elicit support for those activities. They believed it was important to effectively utilize their capabilities as students.

4 Involvement of the Decision Science Center of Kyushu University Project Team and Its Activities

There are ongoing recovery operations and revitalization activities in the areas badly affected by the Kumamoto Earthquake. Various actors, such as local government officials, university students, tourist organizations, and non-profit organizations, are making concerted efforts to revitalize these disaster areas. The Decision Science Center of Kyushu University formed the Kumamoto Project team to help in revitalizing the disaster areas. In this section, we describe the role of this project team, which was composed of university researchers. Initially, the Kumamoto Project team attempted to find a way to provide support to the disaster areas. In the initial process of surveying disaster areas, project team members came to learn about student volunteer activities, which at the time were focused on building trust and forming a cooperative relationship within the student group. The Kumamoto Project team has since started observing the student volunteers' activities by regularly visiting them and interviewing members of Aso Fukkoheno Michi. In this observation, we set our

Fig. 11.5 In the tour for revitalization organized by Aso Fukkoeno Michi, new students experience the natural environment of Minami-aso Village

project goal to identify the challenges faced by the student volunteers' revitalization activities in the disaster area. After observing the students' storytelling activities, the Kumamoto Project team concluded that there was a big difference between the narrators with personal experience of the disaster and those without it. Visitors to the area badly affected by the earthquake could change their ideas about the disaster and the revitalization efforts by listening to the stories related by the narrator. The storytelling activities therefore had the potential to greatly influence people. On the other hand, the new student members of Aso Fukkoheno Michi lacked the personal

experience of the disaster, and so they had to develop their own way of continuing the positive efforts towards the local community.

Accordingly, the Kumamoto Project team attempted to widen the circle of involvement for those making revitalization efforts in the disaster area. The team thought it would be beneficial to include individuals interested in wishing to make a contribution to revitalization, as well as those people already engaged in such actions. The project team recognized that it would be worthwhile for Kyushu University to inform its society about the activities of Tokai University students. The Kumamoto Project team of Kyushu University could play a role in encouraging the activities of Tokai University students. To carry out this idea, the project team organized an event on a campus of Kyushu University in Fukuoka City (March 11, 2018), in which the project team could bring the activities of Tokai University students to the attention of citizens. This meeting also allowed the participants to exchange ideas regarding activities for revitalization, and regarding their ideas for a desirable future of the disaster area. Participants at the event included dentists and dental hygienists who had conducted volunteer activities on the dental health of victims after the disaster and also attracted Kyushu University students. The purpose of the event was as follows:

- Exchange information about individual and group volunteer activities.
- Provide information about volunteer activities by such individuals as university students, dentists, dental hygienists, and volunteer participants; it was for this reason that the event took place in the city of Fukuoka, not in the disaster area.
- ·Create a new role model for universities, linking all volunteers working in the disaster area.

Most of the participants recognized the need for further revitalization from the disaster, and following the meeting could better understand the activities of the various players, including Aso Fukkoheno Michi (Fig. 11.6). At the event, the participants gave presentations about their activities. The Tokai University students of Aso Fukkoheno Michi talked about their various efforts; they shared their experiences in storytelling, and addressed the ways in which their experiences could be handed on to new members of the group. The dentists and dental hygienists introduced their experience of the disaster area. Their volunteer activities consisted of providing dental care to elderly people who were affected by the disaster. The project team of Kyushu University (including the authors) gave a presentation on how to support the volunteer activities of the Tokai University students. After these presentations, all participants were given the opportunities to share their ideas and thoughts. Most participants recognized that the volunteers had acted independently, but that everyone had the same goal: the revitalization of the disaster areas. A student at Kyushu University stated as follows:

> I have never had any experience of a disaster, and I had never thought about disasters and revitalization. But those presentations made me recognize the need for revitalization. I will think more about what I can do personally to help with revitalization even though I don't live in Kumamoto.

Fig. 11.6 Talking about volunteer activities following the disaster

Participants also understood the possibilities for cooperative actions, as part of a unified mission working towards revitalizing the disaster areas. In particular, the members of Aso Fukkoheno Michi learned about the different approaches that they

could apply to their activities. They also learned that it was necessary to organize their group so that the new generation of members could continue their work in the future. These new ideas were propelled by exchanges with leading figures. The event provided a good opportunity for people dealing with the same issues to exchange opinions and information. The Kumamoto Project team organized the event, and also played a meditating role.

5 Conclusions

In this case study, we described the volunteer activities of Tokai University students starting from the time immediately after the Kumamoto Earthquake, and the revitalization activities they conducted in the disaster area. From the survey conducted among student volunteers, the Kumamoto Project team learned about the effective ways in which the students undertook such activities. However, the team identified problems faced by the volunteers regarding the continuation of their efforts in the future, and regarding maintaining their involvement with the local community. The group's new students seemed to be aware that they cannot be as effective as storytellers as the senior students, so they are instead trying to develop new ways to operate "Aso Fukkoheno Michi'" in the future. The Kumamoto Project team of the Decision Science Center of Kyushu University played a role of observing the group and gave them opinions and comments from a third party. In this project, we could not contribute to problem solving, but we could observe and analyze students' activities from an objective standpoint. This must be a cornerstone for the next step.

6 Data Sources

This case study was based on fieldwork and interviews conducted with the following people and groups (from March 1–2, 2017):

- Prefectural University of Kumamoto
- Kumamoto Gakuen University
- Council of Social Welfare in Kumamoto City
- Council of Social Welfare in Kumamoto Prefecture
- Former student of Tokai University (Aso Campus)
- Student members of Aso Fukkoheno Michi

Interviews with members of Aso Fukkoheno Michi included the following:

- Former student leader of the group Tokai University, Kumamoto Campus (April 27, 2017)
- Storytelling by group members in Minami-aso Village (May 7, 2017)
- Storytelling by group in Minami-aso Village (May 26, 2017)

- Three new students at Tokai University, Kumamoto Campus (June 22, 2017)
- Revitalization tour for new students, organized by Aso Fukkoheno Michi, in Minami-aso Village (July 15, 2017)
- Student leader of Aso Fukkoheno Michi (March 7, 2018)
- Two second grade students and one third grade student members (May 9, 2019)
- Two first grade students and two fourth grade student members (July 23, 2019)

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

Iwasaki T (2017) Activities of local students in the Kumamoto earthquake. Local Auton Fukuoka 62:32–37

Kato A, Nakamura K, Yohei H (2016) The 2016 Kumamoto earthquake sequence. Proc Jpn Acad Ser B 92:358–371

Matsuura A (2017) Damage caused by the Kumamoto earthquake and the current state at the university: Considering non-everyday situations. Rep Kyushu Br Crop Sci Soci Jpn 83:69–71

Takagi A (2017) Rehabilitation from the 2016 Kumamoto Earthquake and Volunteer Activities. Abstract of the 2017 meeting, The Association of Japanese Geographers, p S0104

Chapter 12
Attempt to Develop High-Value Rice in the Shimojin District, Mashiki Town, Kumamoto Prefecture: Transition Into Sustainable Local Community Using Disaster Recovery from the 2016 Kumamoto Earthquakes as a Branding Strategy

Wataru Tanaka and Rei Itsukushima

Abstract In this chapter, we report the case of a co-design project undertaken in the Shimojin district that was severely damaged by the 2016 Kumamoto Earthquakes. We, IDS3, and local residents have not only attempted to recover the aforementioned district from the damages it suffered due to the earthquakes but also unite its entire community, which is currently suffering from population decline and aging. To supplement its local agriculture, we initiated the co-design project as a means to promote rice branding by adding value by utilizing the biodiversity in the district and transforming the district's rice paddy fields into eco-friendly paddy systems. We were involved with the project since the consensus building phase owing to our co-design experience with regard to restoration planning at disaster restoration sites and knowledge about the district. We primarily conducted our research in three fields: (1) design of the recovery plan of eco-friendly paddy fields and agricultural ditches, (2) consensus formation for rice branding, (3) exploration of eco-friendly farming method suitable for the region under study.

Keywords Co-design · Co-production · Disaster recovery · Community invigoration · Eco-friendly farming · Brand rice

W. Tanaka (✉)
Faculty of Engineering, Nagasaki University, Nagasaki, Japan

R. Itsukushima
School of Environment and Society, Tokyo Institute of Technology, Yokohama, Japan

T. Yahara (ed.), *Decision Science for Future Earth*,
https://doi.org/10.1007/978-981-15-8632-3_12

1 Introduction

Due to the 2016 Kumamoto earthquakes, paddy fields in Mashiki town suffered serious damages. Before the occurrence of the earthquakes, the Institute of Decision Science for a Sustainable Society (IDS3) has been implementing research for the winter flooded rice paddy fields in the Shimojin district, Mashiki town to improve regional water cycle and biodiversity, developing a cooperative relationship with the local community and companies (Fig. 12.1). Based on the relationship, we, IDS3, have offered to design the recovery plan of eco-friendly paddy ditches as a part of the recovery plan of the rice paddy fields in the Shimojin district from the 2016 Kumamoto Earthquakes.

In contrast, preserving the local community in the Shimojin district is becoming an increasingly challenging task owing to the declining trend of birthrate and aging population and the ever-increasing flow of young people to urban areas. In view of the future of the Shimojin district, it was considered that the revitalization of the local

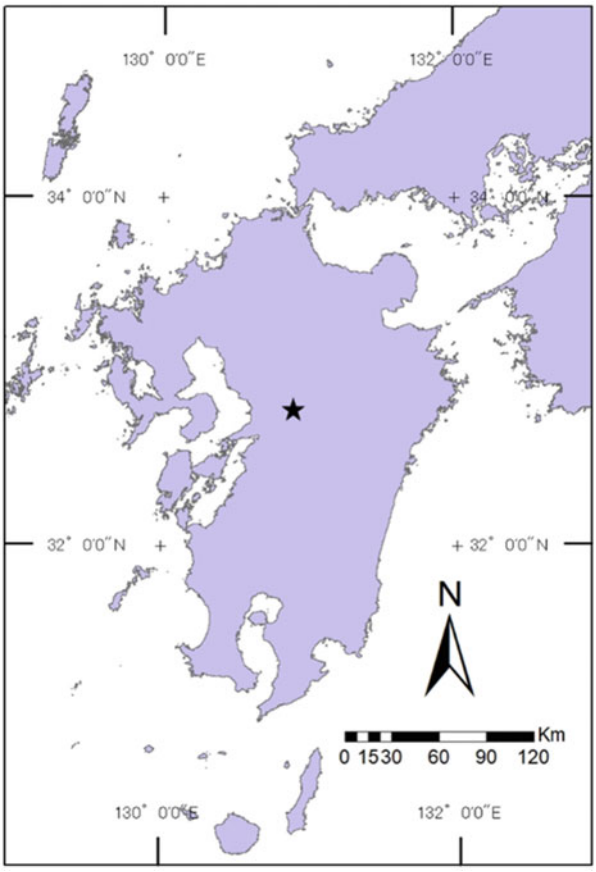


Fig. 12.1 Location of the Shimojin district, Mashiki Town

community and establishment of sustainable local community should be given the highest priority. For this, we proposed the production of high-value rice branded by eco-friendly farming and eco-friendly rice paddy fields to promote rice production in the local community, which is a major occupation in the district and can therefore lead to an increase in employment opportunities. We proposed that the recovery of rice paddy fields is a good way of rebuilding rice paddy fields, thereby contributing to a branding strategy for high-value rice production.

Because the establishment of a branding strategy initiated by IDS3 does not lead to sustainable and autonomous agricultural management by the local entity, co-design, and co-production process was considered to be the most suitable for the success of a new branding strategy and was thought to help localize the branding strategy.

Therefore, we conducted research in three fields: (1) design of the recovery plan of eco-friendly paddy fields and agricultural ditches, (2) consensus formation for rice branding, (3) exploration of eco-friendly farming method suitable for the region.

2 Background

2.1 Effort for the Development of High-Quality Rice Production Before the Earthquakes: "Winter Flooded Rice Paddy Fields" and "Shimojin Organic Agriculture Research Group"

Kumamoto city is famous for its abundant groundwater resources, as roughly a million people in Kumamoto city use groundwater as their primary source of water supply (Imasaka 2014). This city is therefore also known as the "Groundwater city." In addition, a beverage company has a large-scale beer factory shipping its products to western Japan owing to the city's plentiful groundwater resource. Groundwater is an important resource in this area both socially and economically.

In the past few decades, groundwater levels in the surrounding area of Kumamoto city have been decreasing because of the increase of impervious areas such as residential area and the decrease of the pervious area such as paddy field area (Kumamoto Prefecture 2008). A winter flooded rice field is conducted irrigation in the winter season (fallow period), which is the way to increase the amount of infiltration from each paddy field. In the area, winter flooded rice fields are introduced by the subsidies from local governments or the beverage company (Kumamoto Prefecture 2008) The beverage company has also been conducted its own winter irrigation subsidy for the rice paddy fields in the groundwater basin of its beverage plant where includes the Shimojin district (Yamada 2013). Over 3 ha rice paddy fields in the Shimojin district have been conducted winter irrigation under the various subsidies.

Notably, winter flooded rice fields in the Shimojin district is to focus on the quality of groundwater to be recharged. Based on the cooperation of volunteers of local farmers and guidance by the beverage company, making a rice by organic agriculture not using pesticides and chemical fertilizers to get pure groundwater. For the purpose of reducing the environmental burden on groundwater and product high-quality rice by organic agriculture, local farmers and the beverage company are organizing "Shimojin Organic Agriculture Research Group" and conduct study sessions inviting organic agriculture experts. We, Kyushu University IDS3, joined the research group in charge of the environmental evaluator of organic agriculture.

2.2 Damage to Paddy Fields in the Shimojin District Caused by the 2016 Kumamoto Earthquakes

On April 14 and 16, 2016, two enormous earthquakes caused serious damage to the Shimojin district, Mashiki Town. These earthquakes were caused by the Futagawa fault across Mashiki Town, and the fault line moved 2 m as a result of serious damage caused to the villages and farmland in the area (Fig. 12.2).

Out of the 100 paddy fields (accounting for 20 ha in total) in the Shimojin district, 60 paddy fields were cracked. Almost of non-damaged paddy fields also became impossible to farm because the irrigation channel system in the district was broken. The afflicted agricultural land in Kyushu became an enormous scale, and the agricultural land restoration project by the Ministry of Agriculture and Fishery took two to three years to complete a restoration of farmland from the application by its farmer. The beverage company, who has been doing the winter flooded rice fields project in the Shimojin district, decided to restore the paddy fields, regardless of the farmland restoration projects by the Ministry of Agriculture and Forestry for its own sake to restore the groundwater used its plant promptly.

To co-design a restoration plan among the company, local people, and local governments, a consensus is required to be formed for the restoration of paddy fields. We, Kyushu University IDS3, join the consensus building as one of the facilitators, because we possess co-design experience relating to restoration plans at disaster restoration sites and are well acquainted with the district.

3 Consensus Building Process in the Damaged Paddy Restoration in the Shimojin District: Why Did We Aim for High-Value Rice?

To understand the current situation and identify the problems that need to be solved in the Shimojin community, reminiscent talks (called "Mukasigatari" in Japanese) concerning the district were conducted several times (Fig. 12.3). A reminiscent talk

Fig. 12.2 Damaged paddy fields in the Shimojin district

Fig. 12.3 Picture of a reminiscent talk taking place. Local people talked about the old days based on the map describing the ancient conditions of this district

is a meeting wherein the local residents discuss and recall the memories of the old days when the community was full of energy. Comparison between the past and present of the Shimojin community acted as a clarification of the image of an ideal situation of the community in the future. We conducted two reminiscent talks, which are listed as follows:

- The first reminiscent talks (November 14, 2016)
- The second reminiscent talks (January 10, 2017)

It is important that a maximum number of people participate in the aforementioned talks, thereby forming a local entity to collectively tackle the problems of the community, because participation creates a sense of responsibility with regard to community affairs. We mailed invitation letters and newsletters that targeted absentees to all the local residents of the community. Participants were encouraged to recall the memories of other participants by talking about old memories. This in turn worked as a common language, wherein every community member could engage in and enjoyed reminiscing. By sharing information and feelings during these talks, relationships of local people were strengthened, and a common purpose and belief are developed toward a future community. Reminiscent talks are also effective when overcoming existing conflict between local people such as relationship and interest conflicts.

In the reminiscent talks, a local resident said the following regarding the future of Shimojin rice fields; “I want to leave the rice fields in the Shimojin district and hope children of future community will have an experience to eat the Tanishi snail and the Dojo loach in the rice fields and diches without having to worry about agricultural chemicals just like old days.” As a common view created by the two times of reminiscent talks, people of the Shimojin community found virtue in the nature of the district and hope the past relationship between the local nature and people will recover in the future.

Two reminiscent talks deepened our understanding of the future of Shimojin rice fields that the local residents hoped to see. We therefore moved to the stage of the workshop where the future Shimojin rice fields was discussed with the local people (especially those who were involved in the winter flooded rice paddy fields). The name of the meeting was “Iki-iki rice field meeting,” wherein Iki-iki means “full of energy” in Japanese. The name was given in the hope that the community will be vibrant just like it used to be.

- Iki-iki rice field meetings were held five times;
  - February 7, 2017
  - March 7, 2017
  - April 23, 2017
  - May 24, 2017
  - July 24, 2017
  - October 26, 2017

In the meetings,

Because the stories and memories about the local creatures and nature were particularly frequent in the reminiscent talks, we provided the topic of eco-friendly rice fields, and high value-added rice by biodiversity friendly branding, and suggested eco-friendly agricultural channel and farmland in the district.

At a study session conducted during the Iki-iki rice field meetings, branding experts from the beverage company provided guidance on marketing or branding products and some cases of branding strategy for farm goods. Several residents showed interest in cultivating branding high value-added rice in the Shimojin district for community sustainability. In addition to taste and quality, topics as organic or decreased use of chemicals, limpid stream (The Kanayama river which flows across the district), biodiversity, and firefly were discussed as branding components during the meeting. Especially, fireflies were considered as the iconic species of the paddy fields of the Shimojin district by the residents, because a myriad of fireflies danced in the paddy fields in old days. This discussion led to the recollection of sweet memories of firefly watching and catching experiences.

To promote the Shimojin brand rice, we established a new entity called "Mashiki Shimojin Organic Rice Research Study Group," which includes local residents, Kyushu University, and the beverage company. In the study group, every actor plays a different role;

- Local residents practice organic or eco-friendly agriculture and sales in the same branding.
- Kyushu University reports on the effects of eco-friendly agriculture on organisms and taste. Kyushu University also design eco-friendly drainage channel and farmland in the district.
- The beverage company provides indirect support such as proposal of branding image and provision of information on sales channels.

Most importantly, we decided that when branding gets on track and farmers wish to participate in the study group, they will be permitted to do so.

4 Shimojin Branding Rice in Practice

4.1 Design of an Eco-Friendly Agricultural Channel

During the recovery of paddy fields and agricultural channels from the damages caused by earthquakes, we took up measures to improve the environmental conditions of agricultural channels.

From the interviews of local farmers, we identified that the agricultural channels are faced with drought during seasons of non-irrigation (from October to April for the general crop calendar in the district) except for a winter flooded rice paddy field where channels are faced with drought from October to early November when winter flooded rice paddy field starts. This is because customary water right of the district prohibits the intake of river water for irrigation from October to April (or to early

November for winter flooded rice paddy field). The limited amount of river water is allowed for using as antifire water from early November, winter flooded rice paddy field therefore starts in the timing. According to our pre-survey before the environmental improvement, the population of aquatic organisms of the rice fields and the channels in the district was poor and it is considered that the population was heavily impacted by the drought. Another problem of the paddy fields and the channels in the district was the poor connectivity of paddy fields with drainage channels. Steep and long outlets between paddy fields and channels prevent the migration of aquatic organisms such as Dojo loach (*Misgurnus anguillicaudatus*) and Japanese common catfish (*Silurus asotus*). When branding gets on track and eco-friendly agriculture spread in the district in the future, the poor environmental carrying capacity of the channels will become a bottleneck on aquatic biodiversity.

We decided that the objective of the environmental improvement of agricultural channels is to create a permanent aquatic area where common native fish species such as crucian carp (*Carassius auratus langsdorfii*), Dojo loach, and Japanese common catfish can survive through the drought period.

For creating a permanent aquatic area in the channels, small dams were constructed in March 2018. To examine the workability and strength of these structures, they were constructed in three different types using different materials (Figs. 12.4 and 12.5). We initiated the assessment of the impact of these restorations on aquatic organisms. Although the survey had only just begun, some species such as firefly and Dojo loach have been increasing and some goby species colonized at rapid flows created by step structures of the dams.

5 Eco-friendly Farming Method Suitable for the Region

Introduction In this session, we will examine the feasibility of high value-added rice in the Shimojin district, as a means to establish a sustainable Shimojin community. With the aim of the development of high value-added rice having high biodiversity and produced through eco-friendly farming, we practice multiple eco-friendly farming methods and examined the responses of organisms in the paddy field. The ever eco-friendly farming method was assessed by comparing the taste of the harvested rice and its effect on the biodiversity of the paddy field.

Material and Method The location of the paddy field where the examination was conducted is shown in Fig. 12.6. The paddy field is located in the Shimojin District and is adjacent to the Kanayama River, where the spring water from mountains is used as irrigation water and drains into the river. In addition, the outlet releases water from the top edge of a 5-m-high embankment with a gradient of 1/1. Therefore, it is supposed that fishes in the river cannot swim up to the paddy field under study.

In this study, six experimental plots were created in the paddy field, and rice cultivation and biological research were conducted. A schematic diagram of the experimental plot is shown in Fig. 12.7. The experimental plots were created by

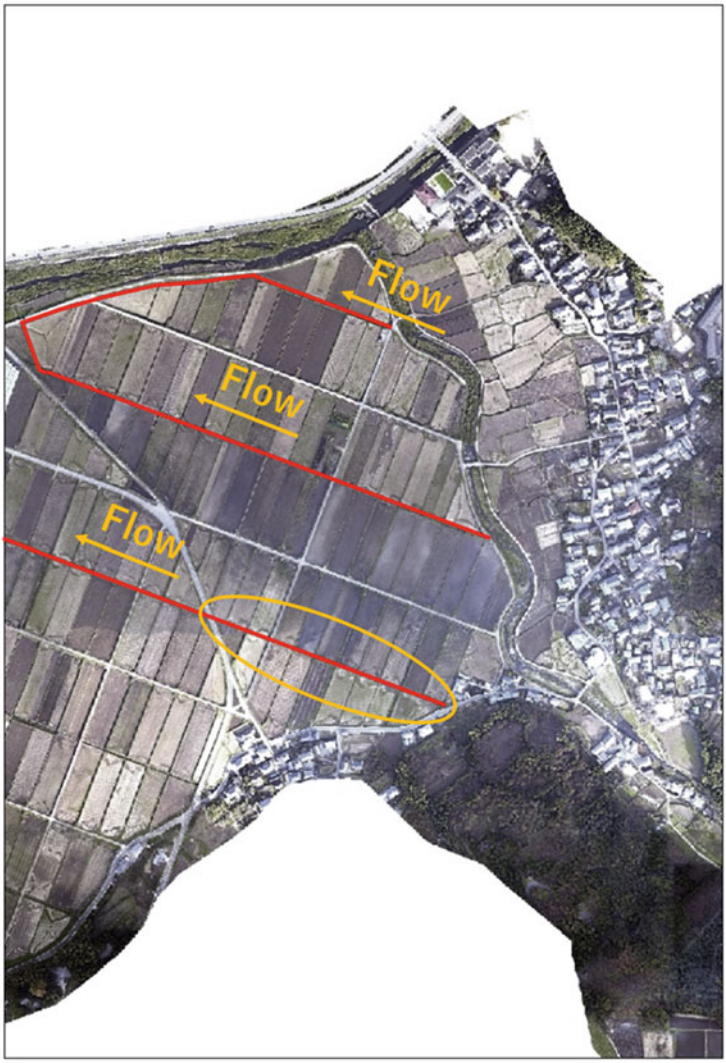


Fig. 12.4 Aerial photo of the Shimojin district. Red lines indicate the main drainage agricultural channels and the orange circle indicates the region where environmental improvement was done

dividing a 5 × 20 m rectangle by a PVC wall having a height of 30 cm. These PVC walls were embedded on the ground at a depth of 10–15 cm to prevent water penetration into neighboring plots. Watergates with a width of 10 cm were installed on both inlet and outlet sides of each plot, and the height of the watergate from the bottom was changed from 3 cm to 20 cm. In addition, we created ridges on the inlet side of each experimental plot so that organisms such as adult frogs can freely come and go (Fig. 12.8).

Fig. 12.5 Resulting structure of dams. Dams create permanent aquatic areas and step-pool structures in the channels. Dams were built using three types of materials. (**a**) Stonework. (**b**) Flashboard. (**c**) Log

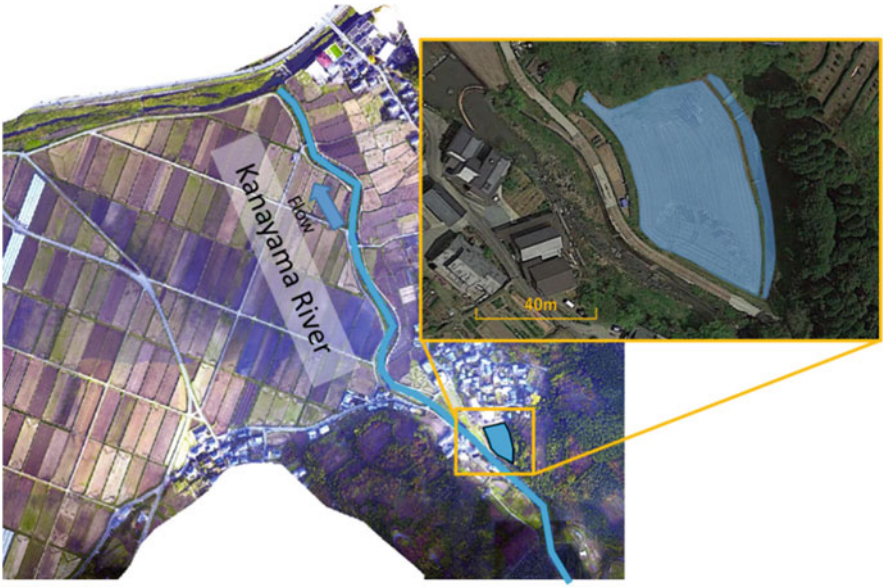


Fig. 12.6 Location of the paddy field where the examination was conducted

As common cultivation conditions of each experimental plot, rice was manually planted at an interval of 21 × 33 cm, and the yield amount was compared after harvest. Rice planting was conducted on June 17, 2017, and Hinohikari (a common variety of rice in Kyushu Island) was used. We did not record the amount of weeding effort and weed mass for each plot, a challenge encountered by farmers practicing eco-friendly farming, because weeds did not grow in the paddy field likely due to weed consumption of golden apple snail (*Pomacea canaliculata*) in the research.

The experiment was conducted based on the following five farming methods and a control plot.

Experimental Plot 1: Conventional Cultivation

In the plot, a farming method based on Hinohikari cultivation generally performed in Kumamoto Prefecture. According to interviews from local farmers

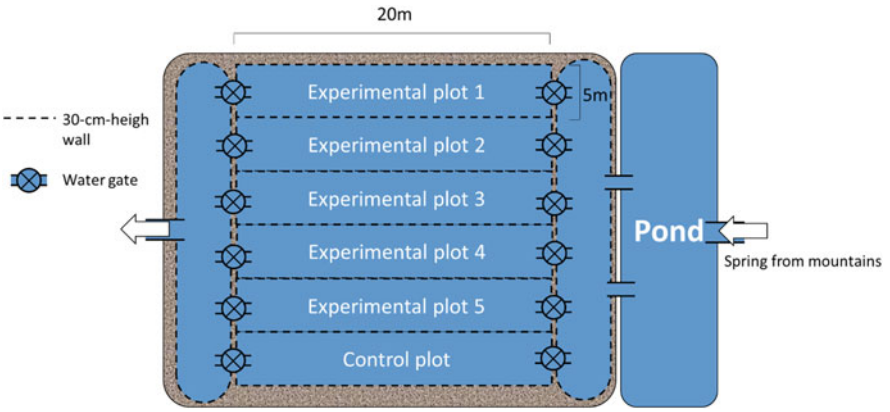


Fig. 12.7 Schematic diagram of the experiment plots

Fig. 12.8 Ridges on the inlet side of each experimental plot

and a crop calendar published by Japan Agricultural Cooperatives Chikuzen (2017), we decided the timing of irrigating, drying, harvesting rice, fertilizing, and pesticide use.

Fertilization:

Rice bran (100 kg/10 a) and chemical fertilizers (nitrogen 1 kg/10 a) were used as a base fertilizer. In addition, another chemical fertilizer (nitrogen 3 kg/10 a) was also used.

Pesticide:

Herbicide and pesticide were used twice at the time of rice planting and midseason drainage.

Experimental Plot 2: Postponed Midseason Drainage

The same numbers and timings of fertilization and agricultural chemical use as plot 1 (conventional cultivation). In plot 2, we delayed the start time of midseason drainage for roughly two weeks. It was started in Toyooka City, Hyogo Prefecture to preserve the foraging sites of oriental white storks by extending the irrigation period between rice planting and midseason drainage which aims to secure sufficient time for larvae of tadpoles and dragonflies to metamorphose (Naito et al. 2011).

Fertilization:

Rice bran (100 kg/10 a) and chemical fertilizer (nitrogen 1 kg/10 a) were used as a base fertilizer. A chemical fertilizer (nitrogen 3 kg/10a) was used as additional fertilizer.

Pesticide:

Herbicide and pesticide were used twice at the time of rice planting and midseason drainage.

Experimental Plot 3: Reduction of Agricultural Chemical Uses

The same water management as conventional cultivation, however the number and amount of agricultural chemical uses were halved compared to that of conventional cultivation of Kumamoto prefecture. A farming method that reduces usage fees compared to (Kumamoto Prefecture 2015).

Fertilization:

Rice bran (100 kg/10 a) was used as a base fertilizer. Rice bran (40 kg/10 a) was also scattered at the time of rice planting as a fertilizer and an herbicide. Chemical fertilizer (nitrogen 3 kg/10a) was used as additional fertilizer.

Pesticide:

A chemical herbicide was used at the time of rice planting and a pesticide was used at the time of midseason drainage.

Experimental Plot 4: Organic Cultivation

In the plot, an organic farming method was conducted. Water management and fertilization were decided according to Imasaka (2014) and interviews with local organic farmers.

Fertilization:

Rice bran was used as a base fertilizer (100 kg/10 a) and an additional fertilizer (40 kg/10a). Rice bran (40 kg/10 a) was also scattered at the time of rice planting as a fertilizer and an herbicide.

Pesticide:

Not used.

Experiment plot 5: Organic cultivation with bamboo chip fertilization

In addition to water management and fertilization similar to organic farming, bamboo chips each of 1.4 mm in thickness were scattered at the time of planting rice. These chips were used for the purpose of weed suppression.

Fertilization:

Rice bran was used as a base fertilizer (100 kg/10 a) and an additional fertilizer (40 kg/10a) was also used. Rice bran (40 kg/10 a) and bamboo chips (280 kg/10 a) were also scattered as a fertilizer and an herbicide, respectively, at the time of rice planting.

Pesticides:

Not used.

Control Plot:

This plot is a control area for bio-assessment where it is filled with water during the rice-growing season, without midseason drainage, fertilizers, pesticides. It was decided that rice will not be planted here.

Aquatic organism surveys were conducted eight times (between 27 June to 28 September) at every experimental plot and the pond that stored the spring water from the mountains. Rice harvested from each plot was tested along with its eating quality using component analysis.

5.1 Result and Discussion

The aquatic organisms collected in the recent study are listed in Table 12.1.

In this survey, two fish species were collected; the fluvial Kawa-yoshinobori (*Rhinogobius flumineus*) and the Dojo loach (*Misgurnus anguillicaudatus*). Dojo loach is known to utilize paddy as its spawning and nursery habitat. The number of juvenile Dojo loach is depicted in Fig. 12.9. These juveniles were collected from all the survey plots including that of the pond. Although adult loaches were collected only from the pond, all other organisms collected from the paddy survey plots were therefore juveniles.

Although the juveniles of the loach were collected until the June 20 survey in the six experimental plot and the control plot, the population of the loach juvenile started increasing from 30 June survey (Fig. 12.9).

Tanaka (1999) conducted a survey of the loach population in paddy fields, temporary creeks, and permanent creeks in Matsuyama city, Ehime Prefecture, and found that the loaches hatched and grew in the paddy fields migrated into neighbor creeks around midseason drainage, which is consistent with the results of this study. It is supposed that the loach juveniles in the paddy plots migrate to the pond or Kanayama River via an outlet.

In contrast, Tanaka (1999) found that a part of the loach juveniles burrow into the soil during the midseason drainage period and endure drying, and the population of loaches in paddy fields population increased slightly after midseason drainage.

In this study, the recovery of the loach population could not be found in the paddy field after midseason drainage. When the water levels were decreasing in experimental plots 1 and 3 for midseason drainage on July 14, the loaches gathered to form

Table 12.1 Aquatic organisms collected in the recent study

Class	Order	Family	Species
Actinopterygii	Perciformes	Gobiidae	*Rhinogobius flumineus*
	Cypriniformes	Cobitidae	*Misgurnus anguillicaudatus*
Amphibia	Anura	Hylidae	*Hyla japonica* (larvae)
		Ranidae	*Fejervarya kawamurai* (larvae)
			Rana rugosa (larvae)
			Rana nigromaculata (larvae)
Insecta	Diptera	Chironomidae	*Chironomidae* spp. (larvae)
	Hemiptera	Gerridae	*Aquarius paludum*
			Aquarius elongatus
			Aquarius spp. (larvae)
			Gerris lacustris
		Veliidae	*Veliidae* spp.
		Nepidae	*Ranatra chinensis*
			Ranatra unicolor
		Notonectidae	*Notonecta triguttata*
			Anisops ogasawarensis
		Corixidae	*Corixidae* spp.
	Coleoptera	Dytiscidae	*Hydroglyphus japonicus*
			Cybister tripunctatus lateralis
			Cybister tripunctatus lateralis (larvae)
			Eretes griseus
			Dytiscidae spp. (larvae)
		Hydrophilidae	*Sternolophus rufipes*
			Sternolophus rufipes (larvae)
			Amphiops mater
			Berosus lewisius
			Enochrus subsignatus
			Enochrus simulans
			Coelostoma stultum
			Hydrophilidae spp. (larvae)
	Odonata	Libelluidae	*Pantala flavescens* (larvae)
			Orthetrum albistylum speciosum (larvae)
			Libelluidae spp. (larvae)
		Baetoidea	*Baetoidea* spp. (larvae)
Malacostraca	Decapoda	Atyidae	*Atyidae* spp. (larvae)
Branchiopoda	Anostraca	Chirocephalidae	*Branchinella kugenumaensis*
Gastropoda	Architaenioglossa	Ampullariidae	*Pomacea canaliculata*
	Sorbeoconcha	Pleuroceridae	*Semisulcospira libertina*
Bivalvia	Veneroida	Spheridae	*Sphaerium japonicum*

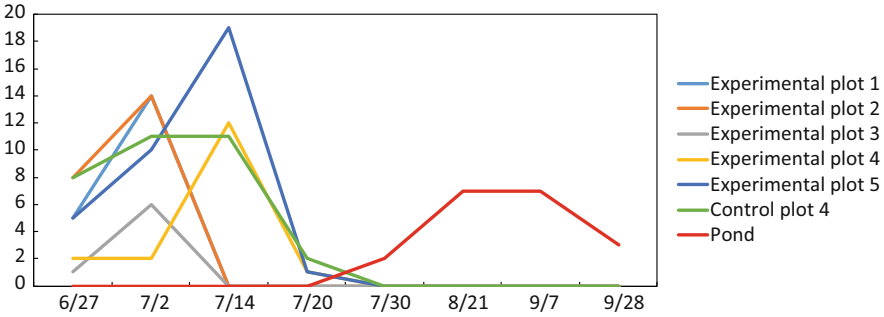


Fig. 12.9 Population of juvenile Dojo loach at each survey plot

Fig. 12.10 Dojo loaches gathered to form loach balls (Dojo Dama)

loach balls (Dojo Dama) before burrowing underground, a behavior known to maintain moisture as long as possible in dry soil (Fig. 12.10). However, in the subsequent survey on July 20, no loaches were found under the soil where they were

forming loach balls. It was presumed that these loaches that remained in the paddy field after midseason drainage could not endure dryness or high temperature.

In the experimental plot 6, despite the water being permanently filled, the loach was no longer captured after 7/20. We assumed that this was due to the fact that there was no sunlight shielding such as rice stalks and water temperature became too high for the loaches to survive. The possibility that water temperature has risen around this period is also supported by the fact that the number of loaches collected in the other experimental sections 2, 4, and 5, similarly decreased in the survey conducted on July 20 and 30.

Kawa-Yoshinobori was collected only in the pond. Because the temperature in the paddy field is too high for the inhabitation of goby, which thrives on flowing water environment such as a large river. In fact, a dead goby was found on a plot of paddy field during the survey conducted on July 14. It is presumed that the goby moved into the paddy field due to the heavy rain just before the survey and therefore could not return to the pond.

The black-spotted pond frog (*Rana nigromaculata*) generally spawns in early June in central Kyushu, and the larva of the frog approximately two months to metamorphose. In the southern part of Japan, the delay of irrigation and the shorten period from irrigation to midseason drainage in modern rice cultivation comparing with traditional cultivations inhibit the metamorphose of the larva and impact the distribution of the frog (Murakami and Osawa 2008). In the present study, the eggs of the frog were found at the time of planting rice, and tadpoles were collected in subsequent surveys until July 20. After July 20, no tadpoles or juvenile frogs were found, and therefore, it was supposed that all the tadpoles metamorphosed and migrated to mountainous areas. The larvae of the tree frog (*Hyla japonica*) started metamorphosing and getting onshore from July 14. The larvae of the Indian rice frog (*Fejervarya kawamurai*) started metamorphosing and getting onshore from July 20. The general start time of midseason drainage in conventional cultivation in the region is in the middle of July, therefore, it is considered effective to delay the drainage time a little more to conserve the three species.

In experimental plot 6 (control zone), where there was an open water surface, relatively greater number of water strider (*Aquarius paludum*) was recorded as compared with the other plots. Whereas, it was found that a relatively small number of plant beetles was collected. These plant beetles were collected right after the rice planting was performed in the experimental plots 4 and 5, which are organic paddy fields. The plant beetles may have been attracted by rice brans or bamboo chips in these organic paddy fields.

Regarding dragonflies, larvae of the globe skimmer (*Pantala flavescens*) and the white-tailed skimmer (*Orthetrum albistylum*). All were only organic paddy fields in the experimental plot 4 and 5 and experimental plot 6 (control zone). Previous study has suggested that dragonfly larvae are vulnerable to pesticides (Nakanishi et al. 2009), and it supports the result of our study.

Table 12.2 Yield of each survey plot

Experimental plot	Fertilizer used at rice planting	Additional fertilizer	Yield (kg/10a)
Experimental plot 1	Chemical	Chemical	425
Experimental plot 2	Chemical	Chemical	418
Experimental plot 3	Organic (rice bran)	Chemical	390
Experimental plot 4	Organic (rice bran)	Organic (rice bran)	382
Experimental plot 5	Organic (rice bran)	Organic (rice bran)	384

The yields of each experimental plot are presented in Table 12.2. A yield of around 420 kg/10a was obtained in the conventional cultivation plot (plot 1), and postponed midseason drainage paddy field (plot 2), while the yield is reduced to 380–390 kg/10a in the reduced agricultural chemicals plot (plot 3), organic cultivation (plot 4) and organic cultivation with bamboo chip fertilization (plot 5). The difference in yield between conventional cultivation and organic cultivation was about 10%, which was in general agreement with previous reports (Asai et al. 2016). It was suggested that in all the agricultural methods using rice bran at the timing of rice planting, the yield decreased compared to conventional cultivation. Rice bran was sprayed for the purpose of suppressing weeds, which may affect not only weeds but also rice. In some cases of biodiversity conservation branding rice in other areas, the market prices are more than twice that of conventional rice (for example, Toki funjatta Mai). A loss of approximately 10% in yield can be covered by high added value.

Table 12.3 presents the results of eating quality analysis conducted by Satake Co., Ltd. Based on the results, it was determined that Hinohikari in Kumamoto city had the highest eating quality. From the viewpoint of ingredients, the rice harvested in this study was overdried and the protein intake was higher in Hinohikari in Kumamoto city. In general, amylose is known to depend on rice varieties and the temperature condition in the ripening period. As a cultivation method aimed at reducing the protein content of rice, deep water management, or midseason drainage at the time of secondary tiller, and non-use of the excessive amount of additional fertilization are crucial (Matsunami et al. 2016). In this study, it is considered that there was no problem associated with water management of each plot because deep water management was conducted in experimental plot 2 and midseason drainage in other experimental plots in late July, which is the time of secondary tiller. As for the additional fertilization, the amount of nitrogen 3 kg/10 was decided based on the interviews conducted with the local farmers and a crop calendar published by JA Chikuzen Asakura. However, we did not base it on the soil fertility diagnosis. The overuse of fertilizers could have led to decreased eating quality.

Table 12.3 Result of eating quality analysis

	Experimental plot 1	Experimental plot 2	Experimental plot 3	Experimental plot 4	Experimental plot 5	Hinohikari from Kumamoto City
Eating quality score	66	59	60	66	61	72
Protein (%)	7.9	8.8	8.6	7.7	8.3	7.3
Wet (%)	11.4	11.4	11.0	10.9	12.0	13.8
Amylose (%)	19.9	20.5	20.4	19.8	20.4	19.3

Acknowledgments This work was supported by a grant JPMJRX16F1 from the Research Institute of Science and Technology for the Society (RISTEX) of Japan Science and Technology Agency (JST) as part of the Future Earth programs.

References

Asai T, Tobina H, Maeda S, Nishikawa K (2016) Growth characteristics, yield and eating quality of paddy rice in different organic cultivation continued fifteen years. Jpn J Crop Sci 85(3):274–281

Chikuzen JA (2017) A crop calendar for rice 2017. http://www.asakura-fk-ja.or.jp/docs/inasaku_2017.pdf. Accessed 11 Nov 2018

Imasaka C (2014) Sustainable groundwater conservation in the Kumamoto area: one of the most proactive project in the world. Water Sci 58(2):20–32

Kumamoto Prefecture et al (2008) Subsequent plan for comprehensive control of groundwater in Kumamoto Area. https://www.pref.kumamoto.jp/common/UploadFileOutput.ashx?c_id=3&id=574&sub_id=1&flid=1&dan_id=1. Accessed 11 Nov 2018

Kumamoto Prefecture (2015) Guideline to specially cultivated agricultural products: the level of agricultural chemical uses of conventional cultivation in Kumamoto prefecture. http://www.pref.kumamoto.jp/common/UploadFileOutput.ashx?c_id=3&id=1208&sub_id=3&flid=53456

Matsunami T, Kodama T, Sano H, Kon K (2016) Agronomic approaches to maximize the palatability of rice. Jpn J Crop Sci 85(3):231–240

Murakami H, Osawa S (2008) Effects of paddy rice cultivation type on the distribution of Rana nigromaculata and Fejervarya limnocharis. Jpn J Conserv Ecol 13:187–198

Naito K, Kikuchi N, Ikeda H (2011) Reintroduction of oriental white storks: ecological restoration and preparation for release into the wild based on the guidelines of IUCN. Jpn J Conserv Ecol 16 (2):181–193

Nakanishi K, Tawa K, Kanbara B, Noma N, Sawada H (2009) Comparisons of macro-aquatic animal communities among paddy fields under different cultivation management systems. Jpn J Environ Entomol Zool 20:103–114

Tanaka M (1999) Influence of different aquatic habitats on distribution and population density of Misgurnus anguillicaudatus in paddy fields. Jpn J Ichthyol 46(2):75–81

Yamada T (2013) Forest husbandry for water cultivation: suntory natural water sanctuary. J Groundw Hydrol 55(2):187–192