論文の内容の要旨

CONCEPTUALIZING SUSTAINABILITY DYNAMICS: A FRAMEWORK FOR INTERFACE OF COMPLEX DYNAMICS AND SUSTAINABILITY IN HUMAN-NATURAL SYSTEMS

(サステイナビリティダイナミクスの概念の明確化：人間–自然システムにおける複雑系ダイナミクスとサステイナビリティを繋ぐための枠組み)

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Sustainability is an evolving concept in an age of complexity. Human–natural systems where unsustainability issues appear are highly complex and dynamic. Sustainability or unsustainability conditions in these systems are diverse and change across space, time, and organizing relationships. The diversities and changes are not readily visible, which makes observing and evaluating sustainability in them a challenging task. Sustainability also has a significant conceptual diversity. Incorporating both holistic and context-specific conceptual understanding is necessary for interpretations of sustainability. Failing to do so could result in specific but not generally representative interpretations, or overly simplified or generalized interpretations. These challenges also extend to frameworks and methodologies used for evaluating sustainability. Often sustainability-evaluation frameworks and methodologies tend to focus on interpretations of a static state of a system. Further, they also support the analysis of parts and the specific processes that can scrutinize individual aspects of complexities. In contrast,

they can also produce generalized overviews that aim to reduce the complexities. However, the conceptual nature of complex dynamics demands that the frameworks and methodologies should adequately internalize both these ends. It means that in the face of complex dynamics, the observation process plays a key role in sustainability evaluation. Observing sustainability involves a cognitive process of organizing the knowledge related to human–natural systems' evolutionary paths, general sustainability principles, system-specific sustainability or unsustainability conditions, and complex dynamics involved in the observation process. In the field of sustainability, there have been milestone works to address the complex dynamics of human–natural systems along with their implications of sustainability in those systems. However, sensitivity to the process of observation of sustainability and sustainability change seems to still be lacking, which subsequently adds up to erroneous and incomplete interpretations and evaluations of sustainability.

This thesis explores the complex dynamics linked to sustainability in human–natural systems, and proposes a framework that embeds a methodology to reflexively observe and evaluate complex dynamic sustainability contexts by using the concept of 'sustainability boundaries'. The framework is developed by incorporating basic ideas of complex dynamics linked to human–natural systems, and the complex dynamics linked to observing sustainability and sustainability changes in these systems. Two complementary methods are proposed to observe sustainability contexts and sustainability boundaries. First, by utilizing a 'system and background' unit as an observation unit, the layer view-based method places the foundation to recognize sustainability contexts in a relatively fixed time frame. The observation process supported by the method is grounded in key ideas of complexity, which makes it a complex dynamic process in itself. Second, the 'system and background' units are examined through a set of dimensions that represent general and contextual principles of sustainability to recognize explicit sustainability or unsustainability conditions and their changes over the time. The proposed dimensions are, (i) sustainability-linked knowledge (ii) sustainability-linked worldviews (iii) resource limitation/availability (iv) well-being views (v) policies, rules, regulation, and governing practices (vi) new creations, innovations, and artifacts. They are considered to be relatively independent dimensions in terms of their role in forming and changing sustainability boundaries, yet with mutual interaction, collectively reinforce the sustainability or unsustainability path of a system. By combining these two complementary methods into an observation methodology that support a reflexive and iterative understanding process, the framework enable us to see multiple different sustainability contexts and their changing patterns and mechanisms. In overall, the methodology supported by the framework represents an integrated differentiation, analysis, and synthesis process that translates sustainability contexts to sustainability boundaries.

In order to illustrate its applications, the framework is supported with two case studies—one addressing the dynamics of a global-level unsustainability issue, and the other addressing historical sustainability change of a local-level village-forest socio-ecological system. In both cases, applying the framework led to holistic interpretations and evaluations, and in addition, made these interpretations and evaluations change-conscious. The framework also highlighted the drivers of change that had brought the systems from one sustainability state to another. Among these drivers, sustainability-linked worldviews seems to have played a synthesising role in emergence of new sustainability states that could transform itself. The case evaluations with the framework also have strengthened the previous understanding that sustainability resembles a dynamic process and a path than a static state.

In overall, the complex dynamics linked to the process of observing and evaluating sustainability change in human–natural systems are referred to as 'sustainability dynamics' in this thesis. The framework was developed to reflexively explore sustainability dynamics of human–natural systems by utilizing observation metastructures that support holistic interpretations and evaluations of sustainability and sustainability change. Together with those interpretations and evaluations, the thesis explores the patterns and mechanisms of sustainability dynamics.