From representation to intervention: system change and threshold effects and cross-scale dynamics in social-ecological systems

FROM REPRESENTATION TO INTERVENTION: SYSTEM CHANGE AND THRESHOLD EFFECTS AND CROSS-SCALE DYNAMICS IN SOCIAL-ECOLOGICAL SYSTEMS

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ABSTRACT

The concept of social-ecological systems (SES) is very well accepted, but there are many unanswered questions about the way SES behave. Many of the main concepts, such as thresholds and tipping points, come from ecological understanding, and do not appear to apply so clearly in the social parts of the systems. Thus, it is difficult to assess vulnerabilities and resilience, and to promote interventions to avert reaching critical thresholds. This paper considers some of these theoretical points. The challenges identification of thresholds in SES stems from such factors as the complexity of the systems, the unobservability of resilience, and the dual difficulty of identifying critical states of ecosystems and social systems. The identification of thresholds is one of the frontier problems in the current research of resilience for social-ecological systems. The traditional representational approaches of threshold-identification (such as use of resilience surrogates) focus on transplanting the measurement methods of ecosystem resilience to social-ecological systems. This results in a fundamental dilemma in ability to cope with the challenges of human action.

One of the possible approaches to solve this dilemma lies in the approach of soft systems methodology. I will argue that soft systems analysis and intervention approaches based on social constructivism offer a better way to understand thresholds and tipping points (severe risk points for system change), in order to build system and community resilience. Soft systems interventions(SSI) can include intervention on specific conditions, adaptive collaboration learning, and inducing self-organization. SSI can promote methodological change from interpretation-prediction isomorphism to action-prediction isomorphism under threshold conditions, and help us further identify focal issue and key uncertainties to intervene the initial conditions, then intervene in the implementation process based on boundary judgement, and further promote to generate similar understanding based on nudge and boost. I explore a case study of collaborative soft systems analysis and intervention in China, to illustrate how such methods can be used to identify thresholds as well as guiding intervention while involving the actors responsible for the many parts of the system. At the same time, I discuss philosophical issues in collective action, and knowledge production, systems practice and social construction.

Keywords: social-ecological systems; resilience; representation and intervention; soft systems methodology; threshold effect

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INTRODUCTION

Regarding the thresholds identification of social-ecological resilience, the mainstream paradigm of the current international frontier research is to use the threshold measurement method of the ecosystem (including four methods such as thresholds or tipping points method). The conceptual assumption for this method is to equate social-ecological resilience with ecological resilience, which focuses on looking for observable entities or representations, and then testing with quantitative methods. However, this kind of representation approach focuses on the "natural" factors in the social-ecological system, but ignores the constructive characteristics of "social" factors, and also ignores the important role of intervention approach that emphasize the complexity and challenge of human action. Moreover, this representation approach is also facing a series of challenges such as the holistic representation of social-ecological resilience. The continuous evolution of the concept of resilience reflects the above-mentioned approach changes, while the emergence and development of the concept of social-ecological resilience promotes the application of intervention approach.

THE EMERGENCE AND DEVELOPMENT OF THE CONCEPT OF SOCIAL-ECOLOGICAL RESILIENCE

Etymologically speaking, resilience is derived from the Latin word ‘resilire’, which basically means “jump back”. The Oxford dictionary interprets resilience as “the capacity to recover quickly from difficulties”. The scientific meaning of resilience can be traced back to the 19th century, a naval engineer Robert Mallet used the concept of "modulus of resilience" in the design of warships to evaluate the ability of materials to withstand harsh conditions. Perhaps this is the original concept of engineering resilience. Engineering resilience emphasizes the speed of returning to an equilibrium state after being shocked, and also shows that a system has only a single stable state.

The concept of ecological resilience is derived from the definition of resilience made by the ecologist Holling in 1973, who believes that resilience is a capacity of ecosystem, that is, the capacity that these ecosystems absorb state variables, driving variables and parameter changes and still maintain themselves. The difference between ecological resilience and engineering resilience is that ecological resilience assumes that a system has a variety of alternative equilibrium states, focusing on the amount of disturbance that a system can absorb before it transforms into another system state, and emphasizing that the capacity of a system maintains essential structure and function after a shock (Holling 2001).

Resilience research is one of the frontier important issues in the field of international sustainable development in the past two decades. It has become the mainstream core paradigm in many aspects of the field of sustainable development, and its derived concepts and key points is shown in the figure below (Figure 1). Among them, the concept of Social-ecological Resilience that emerged in the late 1990s is a new paradigm based on systems thinking for environmental challenges. In addition, social resilience emphasizes the discussion of the community’s ability to deal with external disturbances from the social dimension; development resilience focuses on analysing the vulnerability and robustness of individuals and organizations under external shocks; community resilience emphasizes the process by which social organizations respond to external shocks based on their adaptability, especially self-organising and agency(Berkes and Ross 2013, 2016); psychological resilience focuses on the individual's ability to adapt to stress and adversity.

Resilience	Definition	Emphasis	Key references
Engineering resilience	System's speed of return to equilibrium following a shock	Return time to recover, efficiency, equilibrium	Pimm (1984)
Ecological resilience	Ability of a system to withstand shock and maintain critical relationships and functions	Buffer capacity, withstand shock, persistence, robustness	Holling (1996)
Social-ecological resilience	(i) Amount of disturbance a system can absorb and remain within a domain of attraction; (ii) capacity for learning and adaptation (iii) degree to which the system is capable of self-organizing	Adaptive capacity, learning, innovation	Carpenter *et al.* (2001)
Social resilience	Ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change	Social dimensions, heuristic device	Adger (2000)
Development resilience	Capacity of a person, household or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks over time	Vulnerability, robustness	Pasteur (2011) and Barrett & Constas (2014)
Socioeconomic resilience	Socioeconomic resilience refers to the policy-induced ability of an economy to recover from or adjust to the negative impacts of adverse exogenous shocks and to benefit from positive shocks	Economic response capacity	Mancini *et al.* (2012)
Community resilience	A process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance	Adaptive capacity, disturbance, social	Norris *et al.* (2008)
Psychological resilience	An individual's ability to adapt to stress and adversity. Resilience is a process and can be learned by anyone using positive emotions	Coping, adaptation, process	Tugade, Fredrickson & Feldman Barrett (2004)

Figure 1 Definition of resilience in different fields (Allyson E. Quinlan et al. 2016)

The concept of social-ecological resilience is derived from Holling's definition of ecological resilience. Holling's research work has made the concept of resilience popular in the field of ecology and other disciplines since the 1970s, and some social science scholars have also begun to apply the concept of resilience in certain social contexts. On this basis, the concept of social-ecological resilience emerged in the late 1990s. Berkes and Folke embedded a new paradigm based on systems thinking into the traditional concept of ecological resilience, that is, overcoming the separation of social sciences and natural sciences, creating a new knowledge base for environmental challenges (Berkes and Folke 1998). Meanwhile, they also pointed out that social-ecological resilience can be regarded as an emergent property which includes two dimensions. One dimension is the adaptability of system elements which refers to the ability to learn by combining experience and knowledge, adaptively responding to external driving forces, internal processes and continuous operations of change (Berkes et al. 2003). The other dimension is the transformation ability of system elements. The ability to transform system elements refers to the ability to create a fundamentally new system when the existing system is unsustainable. (Walker et al. 2004: 5). In addition, the concept of social-ecological resilience also includes: (1) the amount of disturbance that a system can absorb; (2) the capacity of a system to learn and adapt; (3) the degree to which the system can self-organize (Carpenter et al. 2001)

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Moreover, the concept of social-ecological resilience emphasizes the nesting characteristics of social-ecological systems and the challenges of cross-level connectivity (Gunderson and Holling, 2002). Through the conceptualization of nesting levels and multi-level interactions, this approach is applicable for analysing the impact of driving forces. Beginning in the 1990s, social-ecological systems began to receive more attention as an object of analysis. However, there is still a lack of theoretical research on the "social" dimension of the social-ecological systems.

The key to understanding the concept of resilience is to regard it as a capacity, especially an active capacity, which is also the fundamental difference from the concept of vulnerability. Vulnerability is a passive state derived from the subject's sensitivity and endurance to external shocks, emphasizing the subject's lack of ability to prevent adverse events. Resilience places more emphasis on the capacity to proactively formulate and implement strategies to cope with vulnerability, including three types of abilities, namely absorptive capacity, adaptive capacity, and transformation capacity (Béné et al. 2015). Resilience is seen as a capacity: (a) absorptive capacity leading to persistence;(b) adaptive capacity leading to incremental adjustments/changes and adaptation; and (c) transformative capacity leading to transformational responses.

The application of the concept of resilience is mainly reflected in its value as an analytical framework. Its potential lies in its refocusing of measurement work on certain indicators and data systems, which better capture the dynamics and multi-dimensional complexity of resilience (Béné 2016). In addition, the application value of the concept of resilience lies in guiding people to pay attention to that resilience is seen as a capacity which can results in positive outcome or negative outcome (Béné 2020). The final welfare outcomes are not merely determined by the impact of shocks/extreme events itself, but are instead the result of the combination of these shocks with the response that individuals/households put in place when affected by these shocks.

THE CHALLENGE FOR THE REPRESENTATION APPROACH OF SOCIAL-ECOLOGICAL RESILIENCE

The ontological presupposition of social-ecological resilience is capacity ontology. The social-ecological resilience refers to the active capacities of the social-ecological system, including absorptive capacity, adaptability and transformation capacity. The common sense understanding of "capacity", according to the definition of "Oxford English Dictionary", means "possessing the means or skills to do something". The scientific understanding of capacity can be traced back to Aristotle's concept of "essences", that is, the reason and principle of the existence and change of things are in the things themselves. The important difference between the two understandings is that scientific understanding emphasizes that the characteristic of capacity is "open-endedness" (Cartwright 1999), which can be established in different ways in different situations. Under special circumstances, the intensity of capacity can be quantified and its precise consequences can be predicted.

In the ontological sense, which of the laws of nature or capacity is more fundamental? The capacity is more fundamental than the laws of nature which are recognized by the system components operate repeatedly under certain circumstances (Cartwright 1999). This repetitive operation can occur naturally or under laboratory control conditions. In other words, the laws of nature in the strongest sense are statements about the types of people's repeated manufacturing behaviours under controllable conditions, and the premise is the "nomological machine" emphasized by Cartwright, that is, a system has sufficient and stable capacity to repeatedly operate in a controllable environment to produce types of regular behaviours, which are expressed in the form of natural laws. In other words, "capacity" is regarded as something more fundamental than the laws of nature, and the legality is only a representation of this system capability under the presupposition of "the rest of the situation is the same." Generally speaking, the knowledge about capacity is more inclusive and more useful than regular knowledge, because the former one focuses on utility of knowledge while the latter one only can predict recurring phenomena in a given situation.

The key question is whether this proactive capacity of the social-ecological system be directly identified and tested by us. In other words, can we directly identify the absorption, adaptation, and transformation capabilities of the social-ecological system through our sensory experience? We can recognize the capacity of a system by directly observing the activities (behaviour) of a system and the change of the object. One of the prerequisites for this direct recognition is that "we" and "the system" are independent of each other. As objective and neutral observers, we can recognize that the system has clear boundaries, and we can intervene in objects to produce changes, which can also be observed. However, if we try to directly identify the capacities of the social-ecological system based on the above criteria, we will find that the direct identification is impossible. The reason is that "we" and the identified system cannot be independent of each other, and this making it difficult to observe and determine the activities of absorption, adaptation, and transformation of the system (behaviour) and changes in the object (behaviour).

Since we cannot directly identify the capacity of the social-ecological system, can we indirectly identify it through its representations? The next question is whether we can find representations of the above three capacities. The so-called representation means an object is an alternative maintenance of the represented object. The logical presuppositions of representation methodology as follows: (1) Regarding A, there is a real prototype corresponding to it, therefore, A is real; (2) The description of A can accurately reproduce and reflect the appearance and essence of the prototype, and this description has certainty and uniqueness; (3) The accurate description of A is the description of true and stable conformity to the actual prototype. (Hacking 1999)

Based on the analysis of the above-mentioned representation methodology, the representations of the three capacities of the social ecological system can be observed and detected. At present, the representation approach is based on quantitative methods, and its inherent presupposition lies in the proactive capacities of the social-ecological systems (especially transformation capacity) is real. In other words, the first-level presupposition is that the proactive capacity of the social-ecological systems can be represented, and the second-level presupposition is that the representation of this proactive capacity can be repeatedly observed and identified. Figure 2 shows the current four representation methods of social-ecological resilience in the academic community.

Method	Key words	Representation	Reference
Thresold or Tipping Point Method	Threshold feedback	Key variables	Folke (2010)
Resilience Surrogate Method	Evaluation options	Surrogate	Bennett (2005)
State Space Method	Model	Multiple Stable States	Walker (2004)
Spatial Signatures of Resilience	Patch	Spatial distribution	Carpenter (2013)

Figure 2 The representation methods of social-ecological resilience

The first representation method is the Threshold or Tipping Point Method. The premise of this type of method is to assume that in a multi-stable ecosystem, the system can cross the border into another stable state. The so-called threshold refers to a certain level of slow variables that control the critical feedback, so that the system self-organizes to run towards different trajectories or different attractors (Folke 2010). The concept of threshold expresses the range boundary of the system, which is also the range of resilience. The representation of the threshold is the key variable (usually a slow variable). The Tipping point is the critical point at which the stable system is destroyed and will enter instability. It is a related existence corresponding to the threshold. Both the threshold and the tipping point represent the critical state of the system, which is fully reflected in the Panarchy model (Holling et al. 2003), and that is the connection points between systems in different scales or states. The second method of representation is the Resilience Surrogate Method (Bennett et al, 2005), which are not indicators in the general ecological sense, but thresholds, tipping points and related variables extracted during the evaluation for the ecosystem.

The third representation method is the State Space Method, which is the main research method of modern system theory and cybernetics, establishes the relationship between the internal variables of the system, the external input variables and output variables through the spatial changes of state variables. It is not only the collection of information and the dynamic continuity in space, but also

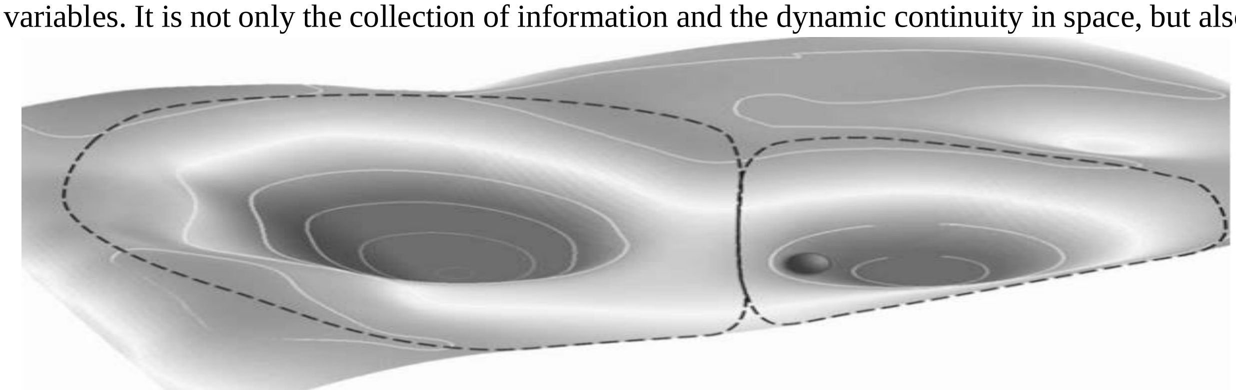

Figure 3 The Basins of Attraction in a Stability Landscape (Walker et al. 2004)

the description of the external characteristics and internal performance status of the system. The state space method in ecology is mostly used for the evaluation of ecological carrying capacity. It is usually composed of the three-dimensional state space axis of the environment axis, resource axis and human activity axis, representing the state vector of each element of the system, and it is quantitatively described by the carrying state points in the state space. In the basins model (Figure 3), the basin represents a group of state spaces, and the system in the same basin has the same structure, function and feedback mode. The state space of the system can be defined by key variables, which are permutations and combinations that contain all the possible states of the system. The black ball in the basin represents the state of the social-ecological systems, and the ball keeps moving towards balance in the basin. The dotted line represents the boundaries of different basins, that is the threshold.

The fourth representation method is the Spatial Signatures of Resilience (Carpenter, 2013), which mainly takes spatial information as the research object, and its concept is based on the spatial distribution and change process of organisms. This method also adopts the concept of patch from the landscape ecology.

The representation approaches of the social-ecological systems still face the challenge from holistic representation. First of all, a certain object whether can represent the three capacities of the social-ecological system. For example, the key variable of lake eutrophication is the continuous input of phosphorus, which leads to changes in the lake ecosystem. Once the threshold is crossed, the entire system will change and enter into another stable state, or change from a clear state to a turbid state. Phosphorus is a representation of the threshold of lake ecosystems. It represents the transformation capacity of the system, but it cannot simultaneously represent the absorption capacity and adaptability of the system.

Secondly, the process of selecting representations based on linear causal criteria often adopts simplified methods, focusing on finding key variables similar to "causes" in natural phenomena, but ignoring the holistic causal factors of the ecosystem. The small-scale models used to represent natural phenomena often fail to accurately reflect real causal features, because things that are ignored by the small-scale model are likely to be decisive in the large-scale causal mechanism (J. Woodward 2003).

Meanwhile, the representation method of the social-ecological systems also faces the challenge from authenticity representation. The third problem is whether the representation can truly reproduce the capacity of the social-ecological systems. If we only equate the social-ecological system with the ecosystem, we may find a representation through observation and experimentation, and if the changes in the representation can explain and predict the phenomenon of the ecosystem, we believe that the representation can reproduce the capacity of the social-ecological systems. However, if we consider the human activities, we will face a kind of "materialization dilemma", that is, whether we can use human activities as materials. However, the difference is human activities have dynamic characteristics such as continuous change, heterogeneity, and openness. Although the materialization (such as symbolization) of human activities can help us to have more clear understanding about representation, but it perhaps makes a gap between us and real human activities.

The forth problem is the "entanglement dilemma" between the subject and the object of cognition. The resilience representation approach emphasizes studying social-ecological systems from the perspective of outsiders, which is also related to the inherent characteristics of the representation method. Representation includes the subject, representation and object. The subject identifies the object through the representation. The basic presupposition is that the subject is separated from the object, and the subject is outside from the object. Based on the perspective of outsiders, we will define the social-ecological systems as the represented object. We understand the social-ecological systems through representations. However, the real situation is that the subject is always entangled with the object, especially at the social level of the social-ecological systems, where individuals and society continue to interact. In this sense, the cognitive subject is constantly constructing the cognitive object.

CASE STUDY: AN ANALYSIS ON THE SOCIAL-ECOLOGICAL RESILIENCE OF HAIZHU WETLAND

Guangzhou Haizhu Wetland is an extremely special and rare delta city lake and river wetland type in China, belonging to a composite wetland ecological type. It includes Haizhu Lake, island, rivers and fruit forests. The water supply mainly depends on the tidal water from the delta, and there is no upstream water at all. The daily "ebb and flow" changes the water level and flow direction of lakes, rivers and 10,000 acres of orchard wetlands. This Wetland play an extremely important role in regulating Guangzhou’s climate, purifying urban air, and regulating the city water bodies, and improving the urban ecological environment, and providing a good ecological environment for the economic and social development of mega cities like Guangzhou. The Haizhu Wetland Ecosystem occupies an area of 1,100 hectares, which is three times the size of the Central Park in New York, USA. It is currently the world’s largest wetland park in the central area of the city, which derived from the semi-natural fruit forests based on the Pearl River Delta wetlands.

Haizhu Wetland is a diversified Lingnan symbiosis wetland social-ecological system driven jointly by human activities and nature. Its predecessor, "Ten Thousand Acres Orchard" is a semi-natural fruit production base in Haizhu District, Guangzhou, with more than 40 kinds of fruits with 79 species. The four most popular fruit tree varieties are litchi, longan, carambola and yellow bark. The area where the gullies and semi-natural fruit forests in the wetland are located has been called "Lingnan Duoji Fruit Forest Wetland", which has the important historical and cultural value. The agro-ecological model is the unique "fruit-based fish pond" model of Lingnan water village. Since hundreds of years ago, the ancestors of Lingnan have dug ditches along the rivers to drain the rivers and piled up mud in this delta area with developed river network. Tropical fruit trees are planted on the pile foundation, fish are raised in rivers (canals, ponds), birds inhabit the river beaches, and small rivers are available for boats, which are convenient for field management and long-distance transportation of production and living materials. Fruit trees, base ponds, fish, shrimps, birds and their excrement continuously circulates material and energy, forming a hundreds-year fruit-based agricultural culture full of farming wisdom. At the same time, this social-ecological system model can also respond well to floods in low-level delta regions, and can make full use of water and soil resources to bring well-being to the people. Moreover, the Haizhu Wetland has also nurtured a rich Lingnan folk culture. The Huangpu Ancient Port and Xiaozhou

Ancient Village built around the wetland benefited from the historical heritage of salt water songs, dragon boats, Cantonese opera, Cantonese embroidery, Lingnan painting and calligraphy, etc. All of these benefited from the social-ecological resilience of the Haizhu Wetland.

In the 1980s, the economy of the Pearl River Delta developed rapidly and the urbanization process of Guangzhou accelerated. The rapidly developing city began to encircle the 10,000 acres of orchards in the Haizhu wetland area of Guangzhou. The original composite wetland system of "river-fruit fish pond" and a large area of fruit forests was abandoned, forming gradually a semi-natural ecosystem (another new stable state) without supervision and protection. Major urban diseases such as air, water quality, and soil pollution have reduced the output and benefits of fruit trees, and the production and life of farmers have been severely affected. At the same time, due to strict restrictions on the development and construction of 10,000 acres of orchards, the local village community cannot rely on the introduction of industries to seek development, and the gap with the surrounding village community is widening. Driven by interests, some farmers began to invade the fruit forests for various operations and development. Ten thousand acres of orchards have been continuously used for nutrient pig farms, small workshops, and barbecue stalls. The pressure on land law enforcement is increasing, and the conflict between the government and the villagers has become more and more prominent. The orchard area has shrunk from nearly 40,000 acres to more than 10,000 acres, and the wetland ecology has been severely damaged. Although the "river-fruit fish pond" composite wetland system and large areas of fruit forests were finally retained, with the interference of uncertain factors, a series of problems emerged in the Haizhu Wetland, such as the wetland water environment quality, or the wetland ecosystem structure and function. In addition, due to the poor quality of the water environment in some areas, the complete wetland ecological network structure formed by the original drainage ditches and fruit forests has been destroyed, and the biodiversity in the Haizhu Wetland has also been severely damaged.

The synergy governance of multiple agents drive jointly the transformation of this social-ecological system since 2010. As the leader of governance, the government has great advantages, but the government alone cannot implement a sustainable development strategy. In the process of the restoration, construction, protection and supervision of the Haizhu Wetland, the traditional governance model of government hierarchical management faces some challenges. Instead, social enterprises, non-profit organizations, scientific research institutions and the public participate in a collaborative model of wetland governance. By promoting different groups and different knowledge structures to play a role in governance, the government's decision-making goals are dynamically adapted to the restoration and development of the wetland system, and the relevant information of the wetland system is open and transparent, so that the governance of system has sufficient resilience.

First of all, government management agencies play the role of organization, coordination, guidance and supervision. In addition to administrative departments such as forestry, marine fishery, agriculture, and environmental protection, the government also established a Haizhu Wetland Management Office to operate independently and report directly to the Haizhu District Government. The Haizhu Wetland Management Office also urged the village committee in the wetland to set up a village council to conduct public opinion surveys through a combination of offline questionnaires and online WeChat and Weibo consultations, this fully mobilize and listen to public opinions and promote the sustainable development of the community.

Secondly, multiple agents promote the sustainable development of the wetland system by playing their respective advantages. Scientific research institutions and universities (Guangdong Institute of Entomology, Provincial Academy of Environmental Sciences, Sun Yat-sen University, Guangzhou University, South China Normal University, etc.) have established partnerships with wetlands to jointly carry out scientific research projects, and cooperate with South China Institute of Endangered Animals, Pearl River Fisheries Research Institute, and Provincial Environmental Protection Scientific research institutions carry out various wetland ecological factor monitoring projects. These scientific research projects and monitoring projects provide theoretical and technical support for the protection and development of wetlands. For example, South China Normal University has jointly established nature schools with wetlands to promote nature education courses to the public, participate in park management, advocate green travel concepts, etc., and guide the whole social-ecological system to participate in this way to awaken the public's environmental protection and promote the sustainable development of wetlands.

Nowadays, a science museum has been built in the wetland, covering an area of 660 square meters, 3 bird watching towers, and more than 10 science promenades. In 2017, the Haizhu Wetland Management Office initiated the establishment of the "China National Wetland Park Creation Alliance" to obtain funding for the construction of wetland protection from international organizations and foreign non-governmental organizations. At present, many private fund-raising channels have been opened and good results have been achieved. In the future, Haizhu Wetland will continue to strengthen exchanges and collaboration with the World-Wide Fund for Nature (WWF) and the Alxa SEE Ecological Association in the fields of volunteer management, talent training, and professional skills.

DISCUSSIONS

How to respond to the challenge of resilience representation based on intervention methodology? Compared to Midgley's systemic intervention, which focus on purposeful action by an agent to create change (Gerald Midgley 2000), the practice-oriented soft system intervention(SSI) methodology pays more attention to the mutual transformation of subject and object, or the integration of nature and society. It can also be said that it emphasizes the cyclical and progressive transformation between representation and intervention, forming a kind systems practice compatible of representation and intervention. Under certain circumstances, based on the heterogeneous construction capabilities of different subjects, the intervention of the subject can even create representations, which in a sense also resolves the dilemma of representation methodology.

	SSM (Soft Systems Methodology)	TSI(Total Systems Intervention)	SI (Systemic Intervention)	SSI (Soft Systems Intervention)
Ontological principle	Systems are not assumed to exist in the real world; social world of attributing meaning	Systems are not assumed to exist in the real world; emphasizes meanings based on the critical dialogue among social agent	Systems are assumed to exist in the real world. The certain social world has meaning for social agent	Systems are not assumed to exist in the real world. The interventions on uncertain social world interaction and behaviours have meaning for social agents
Epistemological principle	Interpretivist, phenomenological and (possible) hermeneutical claims	Interpretivist, critical heuristics	Interpretivist and hermeneutical assumptions	Interpretivist, rationalistic, phenomenological, and social constructivism assumptions.
Methodological stages	Systemic approach based on "logical" linked human activity systems	Systemic approach based on critical systems thinking and methodological pluralism	Systemic approach based on boundaries reflections and methodological pluralism	Systemic approach based on "logical" linked human activity systems and "operational" cause-effect relationships

Figure 4 Intervention Methodological Comparison

Initial condition intervention based on human action scenarios

The key step of soft system intervention(SSI) in changing human action scenarios is to intervene in the initial conditions in an appropriate way. Does the controllable causal intervention in the experimental operation scenario apply to the human action scenario? The basic view of the manipulation theory of causality is that the cause is a potential means of manipulation and control effect. This is roughly the case. Assuming that C causes E, then if we can change C in a proper way and in a proper environment, E will also be modified. If in a proper manner and in a proper environment, the change to C is related to the change of E, then C causes E (Cartwright 1999). In an ideal experimental operation scenario, C causes E, which means nothing more, that is, if a properly designed experimental manipulation of C is done, then the value of E (or the probability of S) will be make change (Cartwright 1999). This leads to a causal explanation based on interventionism, pointing out that the real causality lies in the intervention of one or more variables to change the observed phenomenon. It can be further expressed as: (1) The change of a certain variable X must be entirely due to a certain intervention I; (2) If an intervention I does change another variable Y, then it must only pass through the variable X, but not through other Path; (3) an Intervention I must have nothing to do with reasons other than variable X.

Of course, there is a fundamental difference between the human action scenario and the experimental operation scenario. Human action scenarios have been constantly changing, unable to repeatedly test directional causal dependence, and unable to accurately manipulate causes to produce recurring results. However, we know that the intervention of the initial conditions will definitely cause changes in the output results of the human activity system. Although the initial conditions of intervention cannot achieve the precise repetitive effects of the control causes on the results, the sensitive characteristics of the initial conditions can make the intervention of the agent more likely to achieve the goal and increase the probability of achieving the expected change. In this sense, the initial conditions of intervention in the human action scenario are similar to the manipulation of the reason in the laboratory scenario. The difference is that the former focuses on predicting trends in the sense of probability, while the latter focuses on predicting precise results under experimental manipulation. The interventions of researchers and users of soft system methodology at the initial stage can put more emphasis on identifying focal issues to further guide the identification of possible key uncertainties (Peterson et al. 2003), and enhance their understanding of key uncertainties through community criticism, instead of emphasizing on equal dialogue to form a Rich Picture(RP) and Root Definition(RD).

According to SSI, there are some principles that we can follow: (1) we can use an initial question to identify a focal issue based on Rich Picture in the process of intervention on face-to-face situation; (2) we can make second-order root definition for social-ecological resilience based on first-order CATWOE analysis, such as the role transformation of the government in Haizhu Wetland Case, the identification of key uncertainties; (3) we can hybrid use second-order root definition as an inquiry process and an action-oriented method.

System boundary reflection and process intervention

The primary principle of process intervention is that the agent should make system boundary judgments on the basis of pre-declared methodology. Since we cannot presuppose a system with a clear boundary in the changing human action scenarios, we can only construct the system and the boundary of the system on the basis of community criticism and consensus, and in view of the variability of the constructed system boundary, we need to adhere to the system boundary judgment principle is an important criterion for SSI throughout the process. The agent distinguishes the system process and the system result through the system boundary judgment, which is the prerequisite for the next step to discuss whether the intervention produces the system result change.

This is derived from Midgley’s constructing a systematic intervention methodology that brings improvement actions. "Improvement" needs to be considered in the time dimension and the context dimension. Different agents may use different boundary judgments, which is recognized by one subject, while the other subject may have a completely opposite attitude. Even if different agents reach a broad consensus on "improvement," this consensus may not be extended to the next generation. The temporary nature of improvement makes "sustainable improvement" particularly important. Taking a step back, for the next generation of agents, even if sustainable improvement cannot be sustained, it is fundamentally important to obtain a long-term stable improvement. We can say that when a vision result is achieved through intervention, an improvement is achieved. On the contrary, when there is no non-vision result in the uncertain future, a sustainable improvement is achieved.

The secondary principle is that an agent produces expected changes in the sense of probability through purposeful intervention. The expected change in the sense of probability emphasizes the isomorphism of action and prediction, rather than the isomorphism of explanation and prediction. The isomorphism of explanation and prediction means that Hempel's deduction-law explanation model (D-N model) emphasizes that a scientific explanation and a scientific prediction are isomorphic in the argument mode. Therefore, it can be said that a scientific explanation is potentially a scientific prediction. The theoretical presupposition of explaining and predicting the isomorphism comes from the reproducible causality law under the experimental operation scenario. However, the human action scenario constantly changes, and other conditions that cannot be same. Human activities are more adaptive feedbacks to the emergence of unexpected situations. The flow of action continuously produces consequences that are not intended by the actor. These unexpected consequences may in turn form the unintended consequences of the action in a certain way of feedback. How to deal with the relationship between expected changes and unintended consequences is the core content of process intervention. The process intervention help us attempts to analyse the unintended consequences, then carry out adaptive interventions to keep close to our expected changes.

Repeatedly construct similar understanding based on result intervention (intervention create representation)

The result intervention needs to meet the "sufficiently similar" requirements of reproducible research, but it mainly emphasizes that different agents repeatedly construct a "sufficiently similar" understanding on the problem situation. The results interventions for the repeated construction of different agents include: (1) Pay attention to the original data and the final output (outcome, conclusion or understanding) and all the connections; (2) When comparing the original research and the reproducible research, taking a strict statistical approach or a more qualitative approach; (3) Define the degree of similarity to be understood for a successful repeatable research.

How to repeatedly construct similar understandings in changing human action scenarios? In this scenario, although it is impossible to apply the mathematical symbolic method that can produce direct repetitive understanding in natural science, we can use indirect action result intervention methods to generate sufficiently similar understandings, and we can combine the conceptual tools of soft system methodology with indirect intervention methods. For example, combining the Rich Picture and the Root Definition respectively with the Nudge intervention and boosting intervention in the field of behavioural public policy, the indirect intervention individuals produce sufficiently similar understandings. The concept of Nudge (Thaler & Sunstein 2008) refers to not relying on obvious economic stimulus or administrative means, while maintaining individual freedom of choice in a non-mandatory way of intervention, people's behaviour is guided to change in the expected direction by changing the selection structure. By designing the default option icons of the Rich Picture(RP), it is possible to repeatedly promote the construction of similar understandings. The concept of boost (Herwig 2017) focuses on cultivating the ability of individuals to make better decisions rather than the behaviour itself. By intervening in behavioural cognition or the decision-making environment, people can exercise their power and make decisions that are truly in line with themselves. By designing the cognitive ability or decision-making environment of the agents in the root definition, it helps the community to repeatedly produce similar understandings of changing problem situation.

According to SSI, there are some principles that we can follow: (1) Interventions based on individual cognitive plasticity;(2) Long-term educative empowering on identify the critical, slow-changing variables that can either trigger abrupt change or interact with other system variables causing other thresholds to be crossed;(3) Inducing self-organization design by the method of objectification of intersubjectivity, such as products, symbol, institution, and knowledge.

CONCLUSION

The soft systems intervention(SSI) based on the soft system methodology and systemic intervention, provides a more boosting possible approach for the study on social-ecological resilience. The initial condition intervention emphasizes the identification of focal issues to further guide the identification of possible key uncertainties; the process intervention emphasizes the determination of the system boundary and focuses on the prediction trend in the sense of probability; the result intervention emphasizes the use of indirect intervention methods to help generate sufficiently similar understandings.

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