# Sustainability Transformation: Towards a Theoretical Framework

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| | |
|---|---|
| SES | Social-Ecological System |
| SE-TR | Social-Ecological Transitional Resilience Framework |
| MSES | Morphogenetic Social-Ecological System Framework |
| SE-CRT | Social-ecological conservative resilience thinking |
| SE-PRT | Social-ecological positive resilience thinking |
| SE | Social-Ontology |
| EP | Explanatory Programme |
| PST | Practical Social Theory |
| SESO | Social-Ecological System Ontology |
| PST | Practical Sustainability Transformation |

# ABSTRACT

Change as a constant topic has been extensively studied in philosophy and in science. Science always shows far more enthusiasm for change whether as a subject of scientific research and /or as an object of scientific research. Sustainability transformation, as a powerful approach and an emerging scientific research field has received great attention from scientific research and discourse. There are two promising and important theoretical and conceptual frameworks in studying sustainability transformation: resilience thinking and transition approach. Many researches have attempted to integrate these two different but connected research fields, but there is still no synthesized theoretical framework for studying sustainability transformation. Although researchers have proposed many good research questions on sustainability transformation, e.g., patterns and mechanisms of sustainability transformation, transformative agency, systematic shift, tipping points, leverage points, to name a few, the basic questions are still under-explored: what makes sustainability transformation as a research field special and unique differing from other research field; what is sustainability transformation; how does sustainability transformation happen. In general, this dissertation is about change, more specifically speaking, it is about radical and irreversible change, and the direction of transformative change in social-ecological system is sustainability. Also this dissertation aims at conceptual, methodological and theoretical contributions on sustainability transformation research field. The objective of my dissertation is to build and develop a middle-range theory (theoretical framework) about understanding what social-ecological transformative change is and how social-ecological transformative change happens. A theory strives to be keeping consistency of ontology and epistemology. This research includes conceptual and theoretical elements. The

conceptual elements aim at clarifying the conceptual foundation between resilience thinking and transition approach. The theoretical elements address the philosophical ontological foundation and the scientific ontological foundation rooted in resilience thinking and transition approach. As a result, one conceptual framework, Social-Ecological Transitional Resilience Framework (SE-TR), and one theoretical framework, Morphogenetic Social-Ecological System Framework (MSES) are developed. SE-TR, centered on resilience is for studying what transformative process is in social-ecological system: resilience as adaptation, as transformation and as transition The theoretical framework, Morphogenetic Social-Ecological System Framework (MSES), is inspired by both of social morphogenesis and the morphogenetic approach for exploring what social-ecological system is, what social-ecological transformation is and what social-ecological transformation happens.

# CHAPTER ONE. FOUNDATIONS

## 1.1 Sustainability Transformation

*"We are standing at a moment in history when a great transformation is needed to respond to the immense threat to our planet. This transformation must begin immediately and is strongly supported by all present at the Potsdam Nobel Laureates Symposium."* ("Global Sustainability: A Nobel Cause", Potsdam, Germany, 8-10 October 2007)

Heraklietos, a Greek philosopher, who is known for his doctrine of change being central to the universe, have discussed about change in his works. The following are some quotes from his works: "Change he called a pathway up and down, and this determines the birth of the world; All entities move and nothing remains still; You could not step twice into the same river." Change as a constant topic has been extensively studied in philosophy and in science. As Heraklietos said, the only perpetual thing in the world is change. Science always shows far more enthusiasm for change as a subject of scientific research and /or as an object of scientific research. In the proceedings of the first Nobel laureate event, Gell-Mann (2010) identified a set of interlinked transitions that must occur if the world is to shift from present trends to greater sustainability: (1) a demographic transition, (2) a technological transition, (3) an economic transition, (4) a social transition, (5) an institutional transition, (6) an informational transition, and (7) an ideological transition. In 2015, On April 25th, Nobel Laureates call on cities to tackle sustainability challenge, that is, "The Great Urban Transformation". As the memorandum states, "We challenge all city governments, innovators, and the private sector to work together to unlock necessary resources and enable evidence-based local action to limit further man-made climate change." More and more scientists, scholars,

policy makers, individuals and organizations have recognized that "business as usual" is not an effective approach for today's persistent problems (Rotmans, 2005; Loorbach, et al., 2009), and that radical systematic shifts are imperative in order to achieve "real sustainability" (Gell-Mann, 2010). The up and coming concept, sustainability transformation, as a powerful approach and an emerging scientific research field and even strong belief has attracted great attention from scientific research and discourse. The reason why many researchers are stormed by this concept is that not only does this concept provide a new significant channel towards sustainability, reconnecting nature, and radical systematic change in social-ecological system (SES), but also ignite people's hope towards sustainable development.

***What is Sustainability Transformation?***

The very connotation of transformation is about the kind of rapid, even disruptive change, instead of incremental change (Table 1-1). As stated by Kates, et al (2012), there are three classes of adaptions that can be seen as transformational change: those that are adopted at a much larger scale or intensity, those that are truly new to a particular region or resource system, and those that transform places and shift locations'. In the background of global environmental change, Park et al (2012) regard transformation as "a discrete process that fundamentally (but not necessarily irreversibly) results in change in the biophysical, social, or economic components of a system from one form, function or location (state) to another, thereby enhancing the capacity for desired values to be achieved given perceived or real changes in the present or future environment."

Table 1-1. Some definitions about transformation (Adapted from Mustelin and Handmer, 2013)

| **Some Definitions of Transformation** |
|---|
| **Transformational adaptation** |
| (1) Transformational Adaptation: Adopted at a much larger scale or intensity; Truly new to a particular region or resource system; Transform places and shift locations. (Kates et al 2013) |
| (2) Transformative Adaptation: distinct deliberate changes in practices, learning through monitoring and re-evaluation (O'Neill and Handmer 2012) |
| (3) Adaptation as Transformation: fundamental shifts in power and representation of interests and values (Pelling 2011) |
| (4) Adaptive Transformation: A fundamental alteration of "actors' perspectives on sustainability, societal objectives and how they can be achieved" (Preston et al 2013) |
| **Deliberate transformation** |
| Multi-definitional concept depending on one's values and worldview; associated with changes in meaning-making processes, calls for new critical approaches and challenges paradigms (O'Brien 2012) |
| **Sustainability transformation** |
| Shifts that fundamentally alter human and environmental interactions and feedbacks (Walker et al. 2011) |
| **Social-ecological transformation** |
| (1) The capacity to create untried beginnings from which to evolve a fundamentally new way of living when existing ecological, economic, and social conditions make the current system untenable. (Gunderson and Holling, 2002; Walker, et al.2004; Folke, et al, 2010) |
| (2) "A fundamental alteration of the nature of a system once the current ecological, social, or economic conditions become untenable or are undesirable"(Nelson et al. 2007) |
| (3) "A discrete process that fundamentally (but not necessarily irreversibly) results in change in the biophysical, social, or economic components of a system from one form, function or location (state) to another, thereby enhancing the capacity for desired values to be achieved given perceived or real changes in the present or future environment"(Park et al 2012) |

According to Olsson, et al (2014), there are two promising and important theoretical and conceptual frameworks in studying sustainability transformation, transition management and resilience theory. In resilience theory, resilience scholar focus on social-ecological system dynamics and interactions, and "reconnecting to the biosphere"(Folke et al. 2011), while in transition management, researcher mainly pay attention to radical changes in societal system or radical systemic changes initiated by change agents (or niches). Olsson, et al (2014) also point that integrating transition management and resilience theory which are far from easy would contribute and create a better understanding of sustainability transformation. Many researches have attempted to integrate or compare these two different but connected research fields (Table 1-2). The reason why these two research fields can be integrated is that 1) both of them theoretically are rooted in non-linear system science; 2) transformation or transformative change as a critical concept once ecological system or social-ecological system or societal system becomes unviable in its current system; 3) both of them regard sustainability as direction towards system should develop.

Table 1-2. Some efforts to integrate or compare resilience theory and transition management

| Resilience theory and Transition management |
| --- |
| **Intergradation** |
| (1) An integrated transition framework, including social-ecological dynamics, network features, and institutional factors (Pahl-Wostl et al. 2005, 2007) |
| (2) How strategic planning should be made operational to enable transition to sustainable urban water management? (Ferguson et al. 2013b) |
| (3) Pilot projects (Vreugdenhil et al. 2010) |
| (4) The role of policy entrepreneurs (Huitema and Meijerink 2010) |
| (5) The role of social innovation for sustainability transformations in the Anthropocene (Westley, et al 2011) |
| (6) Food production (Park et al. 2012) |
| (7) New landscape planning and management (Griffith et al. 2010) |
| (8) Swarm planning (Roggema 2008) |
| (9) Global energy systems (Cherp et al. 2011) |
| (10) Urbanization (Elmqvist et al. 2013) |
| **Comparison** |
| Comparing between resilience theory and transition research (Frantzeskaki et al. 2010; Ferguson et al. 2013*a;* Van der Brugge and van Raak 2007; Foxon et al. 2009) |

Based on Olsson, et al (2014), there are three interconnected research field on which integrated research can focus: patterns of transformations; innovation and social, technological and ecological interactions at multiple levels in relation to sustainability; and agency and its role in sustainability transformation. Recently, researchers from different countries and different disciplines who are studying sustainability transformation are gathered in Stockholm for the conference, Transformation 2015. The aim of Transformation 2015 is "to build a better understanding of large-scale systemic changes and fundamental redirections in people-planet relationships that can have an impact at scales that match the challenges of the Anthropocene, in both developed and developing country contexts. (Transformation 2015)". There are four important themes in this conference (Transformation 2015):

**a. Patterns of transformation**

The research questions are: What are the necessary changes in interactions between key variables for sustainable development, including on the one hand personal, cultural, political and institutional factors and on the other hand ecological ones; how do transformation processes unfold in different types of systems?

**b. Scaling up for transformative impact**

The research question is: How and under which conditions new ideas, experiments and initiatives can have large-scale, systemic impacts;

**c. The role of change agents in sustainability transformations**

The research question is: what is the role of individual agency and networks in driving transformative processes;

**d. New and emerging approaches for studying sustainability transformations**

The research question is: how do new and emerging approaches for studying sustainability transformation differ from current modes of research and can they more effectively advance understanding about transformation and facilitate change

In other words, these four topics of this conference perfectly respond the three promising integrated research fields proposed by Olsson, et al (2014). Even these efforts, there is still no theoretical framework by integrating resilience theory and transition management for studying sustainability transformation. Although researchers have proposed many good research questions, e.g., patterns and mechanisms; transformative agency; systematic shift, tipping points, leverage points, to name a few, the basic questions are still untouched: what makes sustainability transformation as a research field special and unique differing from other research field; what is sustainability transformation; how does sustainability transformation happen. As a matter of fact, the power of sustainability transformation is in its **social-ecological transformation to sustainability**, instead of societal transformation to sustainability or ecological transformation to sustainability. Social-ecological system is an important concept in resilience theory, first coined by Fikret Berkes and Carl Folke in 1998. In short, social-ecological system is defined as interconnected and co-evolving systems of people and nature across spatial and temporal scales. In other words, there are neither natural or pristine systems without people nor social systems without nature. But in most of studies in resilience theory and transition research, social-ecological system is just as a concept not as research subject that can be analyzed with independent casual power, except few (Table1-3). Therefore, if transformation happens in social-ecological, social-ecological system should be analyzed as a research subject. New questions arise:

What is social-ecological system, if it is not just a term or metaphor? In other words, the first urgent question should be answered to make sure the uniqueness of sustainability transformation research field: what is social-ecological system? On the other hand, the effort for integrating transition management and resilience theory is still lack of a sound theoretical basis including philosophical ontology and scientific ontology.

Table1-3. Some literatures on social-ecological system as research subject (Adapted from Binder, et al 2013)

| **Social-ecological system as research subject** |
|---|
| **Simplified social-ecological system**<br>A simplified but non-trivial social–ecological systems (SES) consisting of two social actors and two ecological resources. (Örjan Bodin, Maria Tengö, 2012) |
| **Modeling regional social-ecological system with a holistic approach**<br>A holistic approach to work through the complexity posed by cross-scale interactions, spatial heterogeneity, and multiple uncertainties facing regional social-ecological systems. (Hanspach, J et al, 2014) |
| **A generic system model for operationalizing social-ecological system**<br>A framework for operationalizing the concept of a social-ecological system (SES), through a generic system model that can be applied to different situations and used as a management tool. (Andrew Halliday, 2011) |
| **Three types of social-ecological networks**<br>Three types of social-ecological networks: (1) ecosystems that are connected by people through flows of information or materials, (2) ecosystem networks that are disconnected and fragmented by the actions of people, and (3) artificial ecological networks created by people, such as irrigation systems. (Janssen, et al, 2006) |
| **DPSIR framework**<br>The Driver, Pressure, State, Impact, Response (DPSIR) framework (Eurostat 1999) |

**ES framework**

The Ecosystem Services (ES) framework (Boumans et al. 2002; Limburg et al. 2002; de Groot et al. 2002)

**MT framework**

The Management and Transition Framework (Pahl-Wostl 2009; Pahl-Wostl and Kranz 2010; Pahl- Wostl et al. 2010)

**MEFA/MFA framework**

The Material and Energy Flow Analysis (MEFA/MFA) framework (Ayres, 1978; Haberl et al. 2004; Brunner and Rechberger 2005)

**HES framework**

The Human-Environment System (HES) framework (Scholz and Binder 2003, 2004; Scholz et al. 2011*a,b*)

**ESA framework**

The Earth Systems Analysis (ESA) (Schellnhuber 1998, 1999; Schellnhuber et al. 2005)

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## 1.2 About this dissertation

In general, this dissertation is about change, more specifically speaking, it is about radical and irreversible change, and the direction of transformative change in social-ecological system is sustainability that is one of the great challenges of this century. Also this dissertation aims at methodological and theoretical progress on sustainability transformation research field. As Rotmans et al (2001) stated, the issues of unsustainability are persistent because they are so deeply rooted in societal systems: economic investments, institutional structures, cultures, habits and infrastructure. The research objective of my dissertation is to build and develop a middle-range theory (theoretical framework) about understanding what social-ecological transformative change is and how social-ecological transformative change happens. The middle-rang

theory (Merton, 1957) is “intermediate to general and grand theory of social systems which are too remote from particular classes of social behavior, organization, and change to account for what is observed and to those detailed orderly descriptions of particulars that are not generalized at all ”. **A theory strives to be keeping consistency of ontology and epistemology.** As Archer (1995) argued, what reality is held to be will affect how it is researched. Any given ontology has direct implications for theory building. As for ontology, there are twofold: philosophical ontology and scientific ontology. In other words, a theory needs an inherent consistency of philosophical ontology, scientific ontology and epistemology. In the whole process of theoretical building, the tripartite interlink between ontology, methodology and practical theory is the most important basic principle. In this dissertation, I will follow with the ontology proposed by Reed and Harvey (1992) as complex realism rooted in a synthesis of critical realism (Bhaskar, 1978) as a philosophical ontology, and complexity as a scientific ontology. A theory pursues synthesis and interdisciplinary because current scientific knowledge is so separated and fragmented. As a matter of fact, every important scientific breakthrough bears on synthesis, just like Maxwell’s laws of electromagnetism. It is possible that synthesis would also be a critical key to unification or unified field theory in physics. In any research field, the nature of what exists determines how it is researched and studied. This is reason why I pursue the perfect coherence between ontology, methodology and practice with a strong realist point of view. In this chapter, I will introduce complex system science and critical realism; respectively, and then discuss the compatibility and consistency between them through synthesis.

The overall purpose of this dissertation is to contribute to understanding two basic research questions: what is sustainability transformation and how does transformation

happen. This research includes conceptual and theoretical elements. The conceptual elements aim at clarifying the conceptual foundation between resilience thinking and transition approach. The theoretical elements address the philosophical ontological foundation and the scientific ontological foundation rooted in resilience thinking and transition approach. In this research, one of the most important assumptions is that social-ecological system has its own ontology. Put it simply, it does exist in reality. Social-ecological system is complex adaptive system with its unique properties, dynamic and structures distinguishing from societal system and ecological system. The second assumption is that the connotations behind social-ecological transformation are twofold: transformative process in social-ecological system and system change. Most of studies solely concentrate on transformative process or system change. As a matter of fact, it is not “either-or”, but “both-of”. Transformative process and system change are interdependent and interrelated. Since both of transformative process and system of change happen within systematic level, the adoption of system thinking approach, as the basis for developing theoretical framework is well reasoned. In my research, a high level, referring to as macro- systematic level is adopted to analyze transformative process and system change. A macro-level, that is the level of social-ecological system reaffirms the reality of social-ecological system and also positions my research among the existing research on resilience thinking theory and transition approach. The former mainly focuses on ecological system, while the latter on societal system (Fig.1-1).

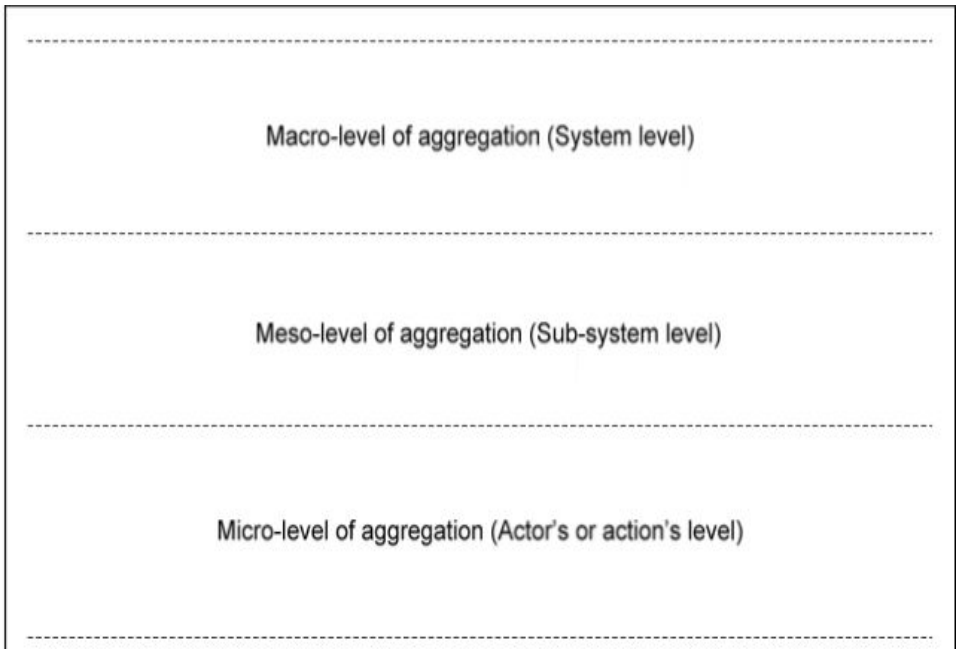


Fig.1-1. Different levels of system thinking approach. This dissertation focuses on the dynamics and phenomenon of social-ecological transformation in systemic level (social-ecological system) that is achieved by lower level (meso-level and micro-levle); The meso-level usually refers to sub-system level, such as energy system, food system, etc.; the micro-level refers to actions initiated by actor(s) (Adapted from Frantzeskaki, 2011)

### 1.3 Complex System

*"A striking difference between linear and nonlinear laws is whether the property of superposition holds or breaks down. In a linear system the ultimate effect of the combined action of two different causes is merely the superposition of the effects of each cause taken individually. But in a nonlinear system adding two elementary actions to one another can induce dramatic new effects reflecting the onset of cooperativity*

*between the constituent elements. This can give rise to unexpected structures and events whose properties can be quite different from those of underlying elementary laws, in the form of abrupt transformations, a multiplicity of states, pattern formation, or an irregularly markedly unpredictable evolution of space and time refereed to as deterministic chaos. Nonlinear science, therefore, is the science of evolution and complexity (Nicolis, 1995)".*

Aristotle had made more than 2000 years earlier in a philosophical treatise, later renamed the Metaphysics, about the significance of "wholes" in the natural world. Aristotle wrote: "The whole is something over and above its parts, and not just the sum of them all..." It is commonly said that the effects produced by wholes are different from what the parts can produce alone. This dissertation is about developing sustainability social-ecological transformation theory. Transformations occur in social-ecological system. There is no doubt that social-ecological system is a complex system and, moreover, transformations themselves are complex phenomena. Thus, it is appropriate to explore "complexity". Given that the field, "complexity science " is so wide and there are many literatures in this field, it is not easy to provide a state of the art overview on it. Therefore, this section aims at offering perspectives on what the consequences of complexity are for theory on complex social-ecological systematic phenomena. It is more than appropriate to take a conceptual travel. I will pay carful attention to these terms: complexity, emergence.

***Complexity***

In the book, Simply Complexity, written by Neil Jonson (2007), Complexity is simplified as a phrase: Two's company, three is crowd. Complexity is defined as the phenomena that emerge from a collection of interacting objects. Accordingly, crowd is

a good metaphor of this emergent phenomenon that emerges from a cluster of interacting people. Also, some necessary ingredients the complex system should have are summed up as following: 1) the system contains a collection of many interacting objects or "agents". For example, the agents may be members of a group and have a good friendship with each other; 2) these object's behavior is affected by memory or "feedback". For example, some decisions in the past may affect the decision made in future, or in other words, the decision made in the past can fed back to the decision in the present; 3) the objects can adapt their strategies according to their history; 4) the system is typically "open"; 4) the system appears to be "alive"; 5) the system exhibits emergent phenomena which are generally surprising, and may be extreme; 6) the emergent phenomena typically arise in the absence of any sort of "invisible hand" or central controller; 7) the system shows a complicated mix of ordered and disordered behavior. In other words, ecological system, societal system and social-ecological system all as complex system should have the above ingredients too. Complexity is a property of systems that is different from "complicated system". The complicated system can be decomposed into its pieces and assembled from those pieces again (e.g. car, clock, etc.); a complex system is one in which, as Aristotle wrote: "The whole is something over and above its parts, and not just the sum of them all..." Complex systems are also characterized as far from equilibric system. It is worth noting that societal system, ecological system, and social-ecological are all defined as complex systems featured as far from equilibric so that complex system theory is basic starting point for creating a synthesis theory on social-ecological transformation. As a matter of fact, systems can be classified as equilibric, close to equilibric or far from equilibric. Many researchers in social science and ecological science have been familiar with equilibric and close to equilibric both rooted in Newtonian science, but studies about

far-equilibric system is still full of challenges even the development of quantum physics and dissipative theory. An equilibric system remains as it is. In other words, an equilibric system depicts a “flat nature world”. A close to equilibric system tends back to its original stable condition when disturbed. Far from equilibric system abandons its original stable condition and changes radically.

Gunderson and Holling, in the book, *Panarchy: Understanding Transformations in Human and Natural Systems*, identify five caricatures of nature, each of which decides explanations of how system works and the implications of those assumptions on empirical research and practical policies and actions (Fig.1-2; Table 1-4). Those worldviews are as following: Nature Flat; Nature Balanced; Nature Anarchic; Nature Resilient; Nature Evolving. Nature flat describes a system where there are few boundaries on the capacity of human being to change the system, and no feedbacks or consequences from human actions. It means that this system is always staying stability without forces. The equilibric system resonates with the world of nature flat. Nature balanced describes a system existing at or near equilibrium or a system having the ability to return to equilibrium through negative feedback. This view of nature resonates with a close to equilibric mentioned above. The worldview of Nature anarchic reveals a system that is globally unstable. This view is not wrong, but completely stands at the side of non-stability and non-equilibrium. Nature resilient of point of view uncovers a system in which there are multi-stable states and persistent stability landscape. This view is the extension of the view of a close to equilibric system but is not completely the view of far from equilibric system because it emphasizes the constant of stability landscape. The emerging fifth view, nature evolving, is consistent with the view of far from equilibric system well. Nature evolving is a worldview that emphasizes adaptive and evolutionary system and process, and exposes a need for understanding

transforming changes (an positively and actively shifting stability landscape). As DeLanda argues (2005): a space with multiple attractors breaks the link between necessity and determinism, giving a system a choice, between different destinies and making the particular end state a system occupies a combination of determinism and choice. Thus, nature-evolving worldview rooted in far from equilibric system view exposes the degree and possibility of freedom for systematic change and for agency to launch change process. Complexity science is not only as ontology, but also provides a possibility beyond the gap between quantity and quality, between natural science and social science, and a possibility for a integrating approach to understating the reality. My core propositions are that humans have agentic powers and these powers are reason and starting points for social-ecological transformation; for social-ecological system, agency has constitutive and transformative potential, and is part of the source of the nature of the system and as a key driver for social-ecological transformation. Although, complexity is defined as the study of the phenomena that emerge from a collection of interacting objects by Johnson's book, Simply complexity (Johnson, 2010). But this is just a part of story about complexity. That means that there is more to emergence than the products of the interactions.

Table 1-4. Characteristics of myths of nature (Gunderson and Holling, 2002)

| | **Stability** | **Processes** | **Policies** | **Consequence** |
|---|---|---|---|---|
| **Nature Flat** | None | Stochastic | Random | Trial and error |
| **Nature Balanced** | Globally stable | Negative feedback | Optimize or return to equilibrium | Pathology of surprise |
| **Nature Anarchic** | Globally unstable | Positive feedback | Precautionary principle | Status quo |
| **Nature Resilient** | Multiple stable states | Exogenous input and internal feedback | Maintain variability | Recovery at local scales or adaptation; structural surprise |
| **Nature Evolving** | Shifting stability landscape | Multiple scales and discontinuous structures | Flexible and actively adaptive, probing | Active learning and new institutions |

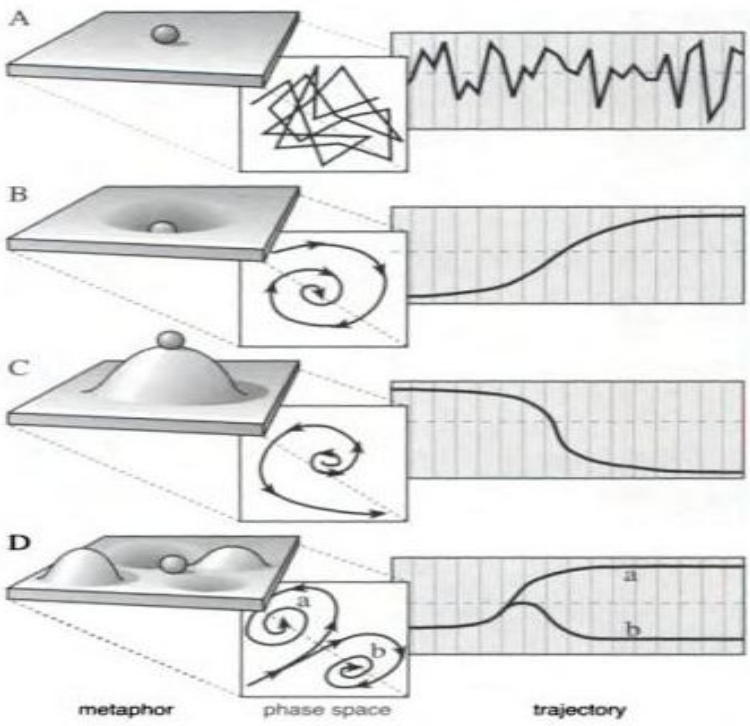


Fig.1-2. Descriptions of four myths of nature: A Nature Flat; B Nature Balanced; C Nature Anarchic; D Nature Resilient. Four myths of nature are shown: nature flat, nature balanced, nature anarchic, and nature resilient. There are three representations in every myth, respectively. From left to right: stability landsape, phase diagram and time-course trajectory. Nature flat holds that nature is infinitely resilient to human control only if humans are able to adopt “right” actions; nature balanced argues that if nature is disturbed, it can return to equilibrium; nature resilient is about a view of multistable state with stationary stability landscape. (Adapted from Gunderson and Holling, 2002)

***Emergence***

Emergence is an important concept in complexity science. The Oxford Dictionary defines, the word, emergency, as "to become apparent", to emanate, to appear as a result; come to light; of something unexpected to turn up, present itself. At the beginning of the whole universe, everything is just a small dot. How does this small dot become such a complex world, as we know it today? What it matters is emergence. In the book, From Complexity to life (Henrik, 2003), it describes that complexity exits on all the scales. Also, as Morowitz(2004) sais, emergence is everything. In his famous article, More is Different, Anderson (1972) states emergence as a qualitative change in the behavior of the system caused by a change of scale. For example, one neuron is not conscious. A collective interplay of neurons can produce consciousness. Simply put, emergence means that the wholes resulting from combinations of lower-level units have properties that their parts lack (Bunge, 2003). Newman (1996) suggest that emergent properties are properties of structured wholes which have a causal influence over the constituents of the whole suggesting that one of emergent properties that a system can has is the power to exert causal influence on the components of the system in a way that is consistent with, but different from, the causal influences that these components exert upon each other. In his thesis, Blitz (1992) states that a certain configuration of parts, or component configuration, is always associated with each emergent property. In the simplest case, this thesis states that an emergent property *q* of a system *a* is associated with some relation *r* between components $y_1$ and $y_2$ in *C (a)*. Thus, the emergent property *q* is a property of *a* and is not a property of any component *y* in *C (a)*, emergent properties are qualitative novel. Based on Archer (1995), properties and powers of some strata are anterior those of others precisely because the latter emerge from the former over time, for emergence takes time since it derives from interaction

and its consequences which necessarily occur in time; Once emergence has taken place the powers and properties defining and distinguishing strata have relative autonomy from one another; Such autonomous properties exert independent causal influences in their own right and it is the identification of these causal powers at work which validates their existence, for they may indeed be non-observables.

### 1.4 Critical Realism

How object is understood in scientific work depends on what ontological and epistemological assumptions are. The basic common ground and point of departure between natural science and social science is, and should be, as critical realism points out, there must exist a deeper level of reality, where these mechanisms make the events happen and then we can make our empirical studies.

This section will offer a short introduction to critical realism and mostly an outline of its consequences for doing research in developing social-ecological transformation theory. The history of scientific development and research is evidenced by the fact that the theoretical and methodological development is closely relative to the development of the metatheoretical development. In other words, a consistent viewpoint on this tripartite relationship, metatheory, theory and methodology should be fundamental premise for scientific progress, though many researchers often ignore this issue when doing scientific work. Metatheory is about the nature of reality and how knowledge can be required, that is, about the ontological and epistemological issues. But, an unhappy gap still exists between ontology, theory and practice. It means that theoretical development is separated from the ontological part, and then the practical part is again separated from the theoretical part and the ontological part. Therefore, before building a theory, it is critical to surpass the unfortunate and serious gap so as to keep the

consistence of the tripartite relationship in scientific work. It is crucial to make an explicit connection between the ontological, the epistemological and the practical in a systematical and consequent way before any scientific work and theory building work. Critical realism is my starting fundamental ontology for building and developing theory.

### 1.4.1 On reality

Ontological questions are about what nature of reality is, and what the essence of things is, while epistemological questions are about how knowledge can be required and how we can know that we know. That Ontology as the beginning of every scientific work is always implicitly ignored or easy to be forgotten by researchers. In fact, what ontology is directly determines how to pursue scientific work systematically and consistently. The initial disagreement between ontology and scientific work, especially theory building would lead to inconsistent and non-systematical accumulations of scientific knowledge, especial theory. On the ontological side, the foundation of critical realism's philosophy of science is that there exists deep dimension in reality, which can be observed directly. Bhaskar (1978) points out that there exists, he calls, epistemic fallacy, in scientific research. That is, scientific work reduces what is to what we can know about.

There are twofold about reality from perspective of critical realism. One is about the three domains of reality. According to Bhaskar (1978), there are three domains of reality constituting an ontological map: the empirical, the actual and the real (Fig.1-3). In empirical domain, there exist events and phenomena that can be experienced and observed directly or indirectly; Events and phenomena happen in the actual domain that can be experienced and observed or not; in real domain, mechanisms are there that have responsibility to produce events and phenomena. It is also noticed that, there are infinite

mechanisms ($M_1$, $M_2$…$M_n$) in real domains, (whether they are discovered or not discovered by human beings, and whether they are trigged or not trigged), events ($EV_1$,$EV_2$…$EV_n$)in actual domain (whether they happen or not, and whether they can be observed or not ) and experiences ($EX_1$, $EX_2$…$EX_n$)in empirical domain (whether they are experienced directly or indirectly). As Fig 1-3 shows, $event_1$ could be exclusively produced by mechanism $_1$ or by many mechanisms concurrently and some mechanism would reinforce or even frustrate the happening of $event_1$.

The other is that, reality is differentiated, structured; reality is also stratified with emergent powers and mechanisms. As Collier (1994) says: “Things have the powers they do because of their structures. ... Structures cause powers to be exercised, given some input, some efficient cause, e.g. the match lights when you strike it.” That is to say, the nature of an object is that its structure not only determines their powers it has, but also the existence of mechanisms, and that the relation between object and its power is an internal and necessary relation, while the relation between generative mechanism is a external and contingent one, which means that a generative mechanism only operates when it is trigged. To sum up, the object have powers whether applied or not, generative mechanism exists whether triggered or not and the effects of the generative mechanism are external and contingent, which means that a certain object tends to behave in a certain way. This fundamental understanding both applies to natural science and social science. On the other hand, there does not exist one level of mechanism in the reality. It means that different mechanisms are located in different layers or strata of reality. Physical mechanism at the bottom is in one stratum, in turn which is the basis of chemical mechanism in the second level, which again is separated from the third level, biological mechanism. The psychological and social mechanisms are in the top strata. As Collier (1994) explains, “It appears that the material universe existed before there

was organic life, and that living organisms can only exist as composed and surrounded by matter. In this sense, matter may be said to be more 'basic' than life; life in turn may be said to be more basic than rationality (in the sense that we are rational animals), and hence than human society and its history." When going up through these layers, each higher-level layer is formed based on the combination of properties at the underlying strata, but what is more important is that each new higher level exists and is emergent in its own right with its specific structures, powers and mechanisms, which are different from the other layer, and cannot be simply reduced to the other layer, which are different from the underlying one and can not be simply reduced into any other more basic one. In other words, this new and unique layer has emergent powers and its occurrence is called emergence. Once Morris (1994) comments as the following: " Behind the facade of modern city life there is the same old naked ape. Only the names have been changed: for 'hunting' read 'working', for 'hunting grounds' read 'place of business', for 'home base' read 'house', for 'pair-bond' read 'marriage', for 'mate' read 'wife', and so on. ... It is the biological nature of the beast that has moulded the social structure of civilization, rather than the other way around." This kind of reductionism neglects that the new non-reducible layer has its own emergent power, even though there is no doubt that, with critical realism as the starting point, the mechanisms within different layers operate simultaneously to produce event and phenomena by reinforcing, weakening and neutralizing the effects. Following Sayer's (1992) expression, "A fortunate consequence of the stratification of the world is that we don't have to work back through all the successive constitutive strata in order to under- stand objects in any specific stratum". In other words, the mechanism of basic layer in some sense has the ability to explain some laws of higher layer just within its basic layer, but not the other way. Due to the consequence of the stratification and emergence of reality, scientific

works have the possibility to only focus on the mechanism, of which the layer consists, but at the same time it is aware of the other mechanism within other layers that have set the conditions for higher layers. For example, social science is in its own layer and has its own casual powers and mechanisms, which can be reduced into biological layer, chemical layer and physical layer. That the strata and emergence exists could shed promising light on inter-scientific research. It means that different theoretical perspectives are necessary to exhaustively explain one concrete phenomenon and event. Social-ecological exists its own layer; it is real, and also its structure is real too. It has its own casual powers and mechanisms and emergent powers. Taken together from critical realism perspective; reality has deep dimension and cannot be observed directly; reality has three domains: the real, the actual and the empirical, respectively; reality is structured, differentiated, and layered with emergent powers. The theory building on social-ecological transformation follows the reality mentioned above. The core ontology of critical realist is that: the significant difference between natural science and social science is that the objects of social science are both socially defined and socially produced, while the objects of natural science are socially defined, but still naturally produced.

It is no doubt that many scientific developments (e.g, the earth is spherical, not flat; the earth revolves the sun, not the opposite.) are closely relative to progress of scientific conceptualization. In other words, these scientific conceptualizations don't change the world what it is and what it exist, but just change cognitions and social practices, sometimes radically and profoundly. The reality, as critical realism states, cannot be observed directly. It means that scientific work is about exploring the deep dimension of reality-the level of generative mechanism, not the immediate and superficial experience of events. Theoretical framework aims at shedding light explanations of what

mechanisms lay behind concrete observations, not are used to classify or predict concrete observations.

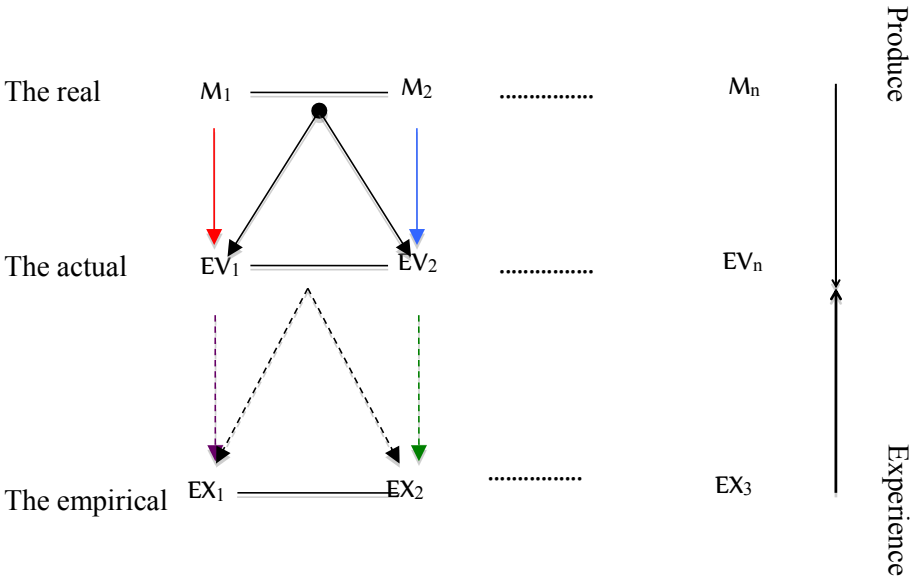


Fig. 1-3. Three domains of reality. There are three domains of reality: the real, the actual and the empirical. The empirical level focuses on experiences; Events happen in the actual level; Mechanisms are in the real level. As shown in this simple figure,, there are two Mechanisms two Events and two Experiences in each level. Event1 can be produced by Mechanism 1 or by interaction between Mechanism 1 and Mechanism 2 ; in the same way, Exprience1 can be produced from Event 1 or by the interaction between Event 1 and Event2 (Adapted from Sayer, 1992)

### 1.4.2 On theory

"Our concepts of concrete objects are likely to be superficial or chaotic. In order to understand their diverse determinations we must first abstract them systematically. When each of the abstracted aspects has been examined it is possible to combine the abstractions so as to form concepts that grasp the concreteness of their objects." (Sayer, 1992)

What the reality is casually determines and forms the foundation of how to build and develop theory, though this significant implication may not always be apparent to the researcher him/her self. Given that this dissertation is about "towards theory", it gives rise to a question: what is theory? It is useful to turn to definitions from Oxford English Dictionary: A supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained (Oxford English Dictionary, 2015). In other words, a theory is a coherent abstract systematic and hypotheses and concepts and has an ability to describe, explain and predict (Here, it is noted that prediction is different from forecast; forecast is a statement about the future state based on historical and present information, like weather forecast; predication is a statement about mechanisms and tendencies.). But from a critical realism perspective, what is theory exactly?

***Two dimensions of science***

"Rival scientific theories necessarily have different transitive objects, or they would not be different; but they are not about different worlds – otherwise how could they be rivals? They would not be scientific theories at all if they were not aimed at deepening our knowledge of the intransitive object of science. (Collier, 1994)"

It is argued that within critical mechanism perspective reality exists independently of concepts and knowledge of it, that knowledge is always fallible, but all knowledge is not equally fallible, and that facts are theory-dependent, not theory-determined. Accordingly, critical realism indicated that there exist two dimensions in science: *intransitive dimension and transitive dimension*. The mechanism in the real level of reality is the intransitive dimension, while theories of which science consists of are the transitive dimension of science, which is as a bridge connecting science and reality. In transitive dimension, old theory always can be replaced by new theory, and in turn, by newer theory. It proves that theory is always in working-process and no ending. In the intransitive dimension, as Bhaskar (1978) says, "If men ceased to exist sound would continue to travel and heavy bodies fall to the earth in exactly the same way, though ex hypothesis there would be no-one to know it." In other words, mechanism is there whether discovered or not. To sum up, theory is the transitive object of science, and is *about* mechanism of reality-intransitive object of science, but not reality itself. From the above it can be seen that critical realism maintains that as there exists deep dimension of reality and events and phenomena cannot be observed directly and immediately, the fundamental task of science is not just about accumulating and registering experiences and events at empirical level, but going beyond superficial and accidental layer, and seeking, exploring and then understanding mechanisms at real level that produce these events and phenomena.

***Natural necessity***

According to Collier (1994), "Things have the powers they do because of their structures. ... Structures cause powers to be exercised, given some input, some 'efficient cause', e.g. the match lights when you strike it." In a science based on critical realism, it is needed to go beyond the superficial and factual empirical assertion of a certain event

and phenomenon, but to identify the internal and necessary relation between structure, power, mechanism and tendency. The object of structure determines its powers and the existence of its mechanism, and the structure, power and mechanism co-determines the nature of the object. There exists an internal and necessary relation between object and its power, but an external and contingent between mechanism and its effect, which makes condition and tendency more promising. Tendency means an object tends to act in some certain way, as the effects and outcomes would be produced by many different mechanisms simultaneously. Condition means the actual effect and outcome of mechanism are dependent on different conditions and circumstances. As Fig.1-4 shows (Sayer 1992), structure and mechanism that are in abstract level determine the nature of object. Events are in concrete level. Structure determines mechanism. When mechanism is triggered or activated, events are produced. Therefore, events in the empirical domain are not object of scientific work; scientific work, especially theoretical work, is not about empirical description of a certain event or some events, but is about what structure is, how structure decides mechanism, how and in what condition mechanism produces events.

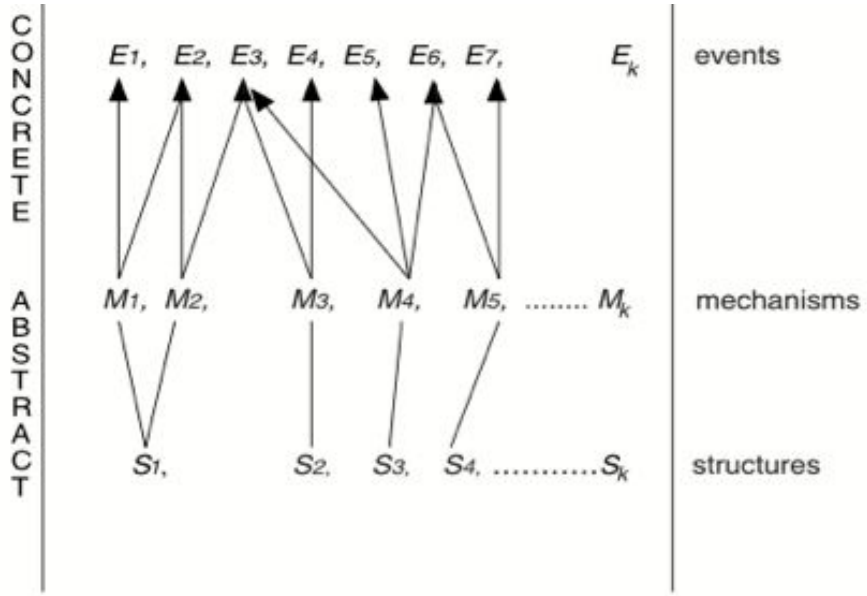


Fig.1-4. Structures, mechanisms and event. As shown in this figure, structure and mechanism that are in abstract level determine the nature of object. Events are in concrete level. Structure determines mechanism. When mechanism is triggered or activated, events are produced. Structures, mechanisms and event (Sayer, 1992)

***What theory is?***

How we understand our object depends on our ontological and epistemological assumptions. Critical realism indicates that the relation between the reality and the theory we build and develop is the focus of the scientific research process. From a critical realism perspective, theory is stated as the following (Berth, D et al., 2005)

(1) Theory as a language is indispensable to science.

(2) Theory is as a framework for interpreting the reality.

(3) Theory as a conceptualization of casual mechanisms is indispensable to explanation.

(4) Theory is abstractions; it describes phenomena with reference to certain aspects, which have been separated from aspects of other concrete events or phenomena.

(5) Theory can be metatheory, normative theory, and also specific descriptive theory.

According to critical realism point, reality has a deeper dimension, which cannot be observed directly. In other words, there is a gap between what really we know, what exactly happens and what it is at all. Science and reality are connected by theory. Scientific theory as one type of language speaks for reality by concepts and conceptualization with meanings, but not reality itself. Thus, concepts and conceptualization are both important scientific process, and also necessary tool for scientific work, though there are differences between natural science and social science as the objects of natural science are indeed socially defined but still naturally produced, the objects of social science are both socially defined and socially produced (Sayer 1992). To a large degree, conceptualization in scientific work is through abstraction. Abstraction comes to play a crucial role in scientific work for interpreting and explaining the reality, because, based on critical realism perspective that scientific work is based on understating natural necessity, due to the reality which comprises a tremendous diverse and heterogeneous events and phenomena, abstraction can separate the contingent properties from the natural necessary properties. Thus, scientific, theoretical concepts are abstract concepts, and theoretical abstraction is a necessary tool for scientific research. Sayer(1992) gives a better understanding about the concrete and the theoretical abstraction as following: "our concepts of concrete objects are likely to be superficial or chaotic. In order to understand their diverse determinations we must first abstract them systematically. When each of the abstracted aspects has been

examined it is possible to combine the abstractions so as to form concepts, which grasp the concreteness of their objects." What is more important is that theory, which should not primarily aim at categorizing, describing, surveying and predicting innumerable concrete events and phenomena, should provide explanations of what generative mechanism exist at the real level, what makes it happen, what produces, generates, creates or determines it, or, more weakly, what enables or leads to it (Sayer, 1992). Thus, the important point is that theory is not only about finding empirical regularities and statistical correlations, but also about how an object works, what mechanism there is in an object, or in what conditions mechanism of an object can be activated. On the other hand, theory is typically a generation. Bhaskar (1978) expresses as following: "Scientifically significant generality does not lie on the face of the world, but in the hidden essence of things". From critical realism point of view, there are two types of generalization: empiricist generalization and realist generalization (Fig.1-5). Empiricist generalization is mainly about empirical extrapolation in the empirical level, which means that general conclusions can be draw from knowledge about a finite number of concrete events and phenomena; realist generalization, to a large extent, refers to transfactual conditions or fundamental structures in the real level. Therefore, "Theory is no longer associated with generality in the sense of repeated series of events but with determining the nature of things or structures, discovering which characteristics are necessary consequences of their being those kinds of objects (Sayer, 1989)". The question about a theory should be like that: If there is an event or phenomenon A, What properties must exist for A to exist and to be what A is or what makes A possible, or what is the ultimate precondition for A? In social science, general or grand theory is usually mistaken for an all-encompassing theory, within which all type of social relations, developments and behaviors can be explained and different empirical

conditions in different areas can be explained (Merton, 1957). But from critical realism perspective, the term, general or grand theory have the third meaning, that is, general theory is about transfactual social structure and mechanism and about analyzing, interpreting and explaining the different ontological levels of reality with their own specific properties. Further, according to Layder (1993), the significance of general or grand theory rests on the ability to generate innovative and deeper knowledge, and fruitfully interpreted reality, not on the empirical verification or falsification. Roslender (2002) point out that there are three types of theory: metathoery, normative theory, and descriptive theory. Metatheory is about ontology and epistemology, that is, basic assumptions and prerequisite of science; normative theory is about a theory with normative dimension of how something should be; descriptive theory is a theory to illuminate and identify more fundamental structures, powers, generative mechanisms, conditions and then tendencies. Regarding descriptive theory, Sayer (1992) distinguishes between theory as ordering framework and theory as conceptualization. Concerning theory as ordering framework, it refers to an ordering relationship between events or phenomena; theory as conceptualization, which is based on critical realism framework, refers to conceptualization fundamental qualitative structures and mechanisms. Keat and Urry (1978) give a better description between the empirical perspective and the critical realism as following: “For the positivist, science is an attempt to gain predictive and explanatory knowledge of the external world. To do this, one must construct theories, which consist of highly general statements, expressing the regular relation- ships that are found to exist in that world. Thus, for the realist, a scientific theory is a description of structures and mechanisms which causally generate the observable phenomena, a description which enables us to explain them.” In addition to that, scientific work is fundamentally about developing and building theoretical

framework, about offering a theoretical starting line for empirical analyses, and about connecting theory with empirical study. Treated thus, theory is also a framework for interpreting reality from a critical realism point of view. Castellani and Hafferty (2009) point that: "Traditional theories, particularly scientific ones, try to explain things. They provide concepts and causal connections (particularly when mathematicised) into some social phenomenon…scientific frameworks, in contrast, are less interested in explanation. They provide researchers effective ways to organize the world; logical structures to arrange their topics of study; scaffolds to assemble the models they construct. When using a scientific framework 'theoretical explanation' is something the researcher creates, not the other way around."

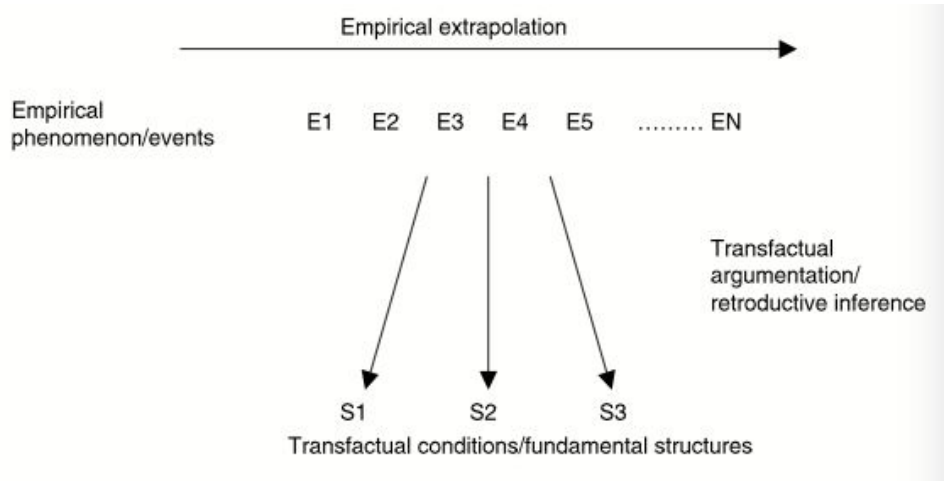


Fig.1-5. Two types of generalization. As pointed by (Berth, D et al., 2005), there are two types of generations: empirical extrapolation and transfactual argumentation. Empirical extrapolation is generated from empirical phenomenon or events (in the actual level); transfactual argumentation is produced from transfactual conditions or fundamental structures (in the real level.)

In other words, the theory I will create is really a theoretical framework that is not only as an ontological framework of the nature of what reality is, but also as an epistemological one of the nature of how reality can be approached. The theory is both ontological and epistemological. It is ontological because it asserts that social-ecological system and social-ecological transformation are both real in that they exist and simultaneously have a reality that is constituted by agent actions. This dissertation aims at analyzing the phenomenon of social-ecological transformation from multiple theoretical grounds.

### 1.5 Synthesis

"Nonlinearities clearly abound in social phenomena, where a yawn, a desire for an automobile with fins, or a life-style can spread contagiously throughout a population; where a judicious investment can trigger an explosive growth; and where a steady increase in traffic density provokes, at some critical value, a sudden decrease in the speed of vehicles. We see that, in general terms, the systems that interest us are large, non- linear systems operating far from thermodynamic equilibrium. It is precisely in such systems that coherent self-organization phenomena can occur, characterized by some macroscopic organization or pattern, on a scale much larger than that of the individual elements in interaction. It is a structure whose characteristics is a property of the collectivity and cannot be inferred from a study of the individual elements in isolation. We may say that reductionism, long a strongly criticized attitude in the social sciences, is found to be inadequate even in the physical sciences. The whole is more than the sum of its parts for such systems (Prigogine and Allen, 1982; 7)"

Critical realism as philosophical ontology depicts the world as being a complex, emergently structured and multi-layered universe of discrete entities and mechanisms.

Complex science also describes the world (nature and society) as being interactively and structurally complex at all systematic levels and non-reductive and indeterminate, but amenable to rational explanation, which fits well critical realism. Both of them all emphasize the nature of system: a far-from equilibrium and non-linearity. A far-from equilibrium and non-linear system is not conservative, homeostatic and reactive, but relentlessly innovative, ontologically and historically open and discontinuous with capacities for spontaneous change and long-range tendencies toward evolutionary behavior. According to (Prigogine and Allen, 1982), it is argued that each endorses an approach that treats both nature and society as if they were open, historically delineated systems; both assume that the particular province of reality they study is hierarchically structured and nested, yet interactively and stochastically complex. As for their respective methodologies, both are committed to non-reductive perspectives. Both assume that the real world has a built-in indeterminacy, yet each strives to achieve a rational scientific explanation, which will fit the peculiar nature of its respective object. Finally, each sees nature as a self-organizing enterprise without succumbing to anthropomorphism or reification.

# CHAPTER TWO. THEORETICAL BASIS

## 2.1 Transition approach

### 2.1.1 Societal transition and persistent problems

There has been significant progress in science and technology in human society. This progress has allowed people, particularly those in developed countries, to live a convenient and comfortable life. Food is always available at convenience stores and supermarkets, and a wide variety of new products, including automobiles and electrical appliances, have been developed. In this era of material abundance, people place great emphasis on profit, given that this is an income-oriented society. On the other hand, people are faced with a variety of problems, including deforestation, shortages of food and water, and waste disposal. Companies produce and distribute eco-products, which are aimed, at least officially, to address these problems. Nowadays, not a single day passes without the phrases “eco-friendly products” and “eco-products” being mentioned on TV. Will the development of “eco-products” by those companies and their use by consumers solve environmental problems? I do not think so. In my opinion, the environmental burden of “environmentally friendly” products is similar to or even greater than that of other products. For example, as long as a person drives an automobile, it makes little difference whether the amount of its $CO_2$ emissions is large or small (K.Furukawa and M.Yamashita, 2014). Significant amounts of energy and resources are required to develop even low-emission automobiles, and, if these automobiles sell well, even larger amounts of energy and resources will be required. Trading in a used automobile for a new one generates waste. A production and consumption cycle like this does not solve environmental problems after all. What is

necessary to solve environmental problems in a real sense, then? What is the core of environmental issues in the first place?

The purpose of this section is to introduce transition approach (Frantzeskaki, 2011; Rotmans, 2005; Martens and Rotmans, 2005) by reviewing the key concept and conceptual framework. Although the concept of transition has been researched for many years in different disciplines, e.g. in ecology, in economics, in biology, and in system science, the phenomenon of societal transition implicated in sustainable development with complex and multi-dimensional systematic transformative process and change is still uncharted territory for scientific research. As Rotmans et al (2011) argue, it should be wide-awake to the problems that a more radical and fundamental societal transition is needed for achieving sustainability, as these persistent unsustainable problems are so deeply originated from societal fabric: culture, habits, institutional structures, infrastructure and economic investments (Fig.2-1), to name a few. The concept of transition (Table2-1) and transition management (Fig.2-2) for dealing with environmental problems is one of the most important pillars of the Fourth Environmental Policy Plan in 2001 in Netherlands. With the advent of this concept, there is an expanding international scientific research studying the dynamics (focusing on theoretical and conceptual level, called, transition approach), and transition management (focusing on practical and prescriptive level). The transition approach informed by system theory and complex science aiming at dealing with ***persistent problems*** rooted in the structure system is a new approach to understand dynamics of societal transition. Since this dissertation is mainly based on transition approach, the following will revolve around transition approach.

Transition research stems from two-research strand. One is socio-technological transition research strand in which it focuses on the change of technological regime (Geels, 2004; 2005a; Geels and Schot, 2007); the other one is the study on Integrated Sustainability Assessment in which it focuses on "an iterative, continuing process where integrated insights from the scientific and stakeholder community are communicated to the decision-making community, and experiences and learning effects from decision-makers form on input for scientific and social assessment (Rotmans and De Vries 1997)." Societal transition is fundamental change of the societal system with a long-term process aiming at dealing with persistent problems. Transition can be defined as: 1) a specific kind of change as deep structural, radical, fundamental or transformative change instead of incremental change; 2) a specific kind of change as change dominant culture, structure and practice of a societal system; 3) a specific kind of change as irreversible change; 4) a long term continuous process of societal complex change (Rotmans et al., 2011; Rotmans, 2005; Loorbach and Rotmans, 2006). Rotmans et al (2001) attribute the following three characteristics to a transition: A transition is a long-term process, spanning one or two generations; A transition is a long-term process, spanning one or two generations; A transition involves technological, economical, ecological, socio-cultural and institutional developments that influence and reinforce each other; A transition is the result of mutually reinforcing developments at different scale levels. From the time dimension of view, it points out the time scale of change with above 5 years or even longer. It is recognized that societal transition does not intend to treat superficial symptoms of unsustainability, but to overthrow the fundamental source of it with more patience and more ambition; from the nature of change, it emphasizes irreversibly deep, radical and transformative change. It is worth noting that deep, radical and transformative change cannot be formed in a flash, but is

developed with incremental deep, radical and transformative changes in multi-systematic level; from the nature of systematical level of societal transition, societal transition research is informed by system thinking, especially complex adaptive systems characterized as aggregation, non-linearity, diversity and flows (Holland, 1995). Societal system is as complex adaptive system that co-evolves, self-organizes and produces emergent patterns (Rotmans and Loorbach, 2009). Therefore, the phenomenon of societal transition based on system thinking has two-research subjects: societal transformative process and transitional societal system. In the research system of transition approach, persistent problems are usually regarded as research object, societal system as research subject, and sustainability as desirable direction (Franteskaki, 2001). Persistent problems proposed by (Rotmans, 2005; Loorban, 2007) have four characteristics: complexity (there are multiple causes and consequences); uncertainty (there are no easy solutions and there are no enough knowledge); uncontrollability (covering different institutions, sectors and actors); fuzzy boundaries (strong complex system and systematic dynamics) (T.J. Schuitmaker, 2012). Therefore, from the point of transition approach, persistent problems are symptoms of unsustainability and these reappearing symptoms cannot be eradicated by only marginal actions.

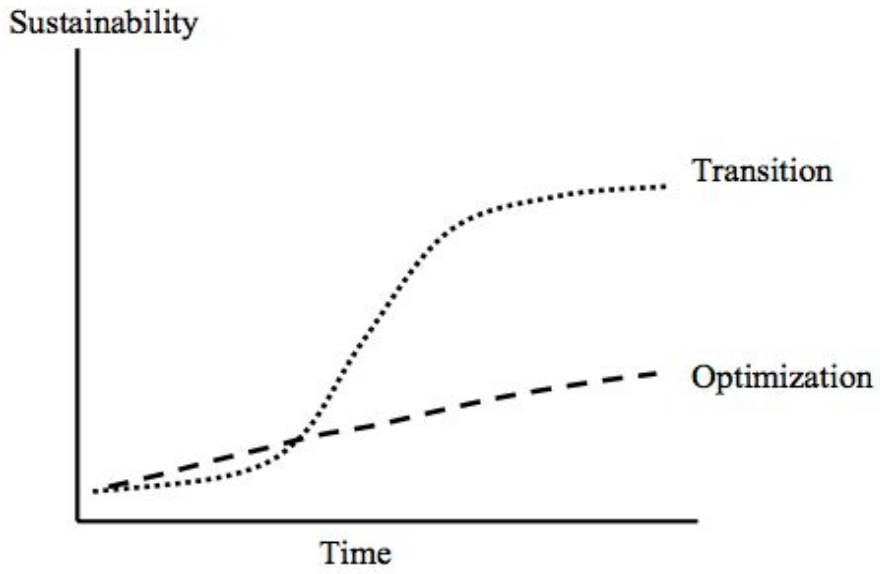


Fig. 2-1. Illustration of optimization versus transition. In transition studies, an important assumption is that incremental change will lead to a sub-optimal situation and a more radical societal transition will lead a better optimization. (Rotmans et al, 2000)

Table 2-1. Some definitions of transitions (Adapted from Frantzeskai,2011)

| **Definitions of transition concept** |
|---|
| (1) "A long-term process of change during which a society or a subsystem of society fundamentally changes." (Rotmans, et.al., 2000; Rotmans, et.al., 2001) |
| (2) "A shift from an initial dynamic equilibrium to a new dynamic equilibrium."(Kemp and Rotmans, 2001) |
| (3) "Transitions are understood as processes of structural change in major societal subsystem. They involve a shift in the dominant 'rules of the game', a transformation of established technologies and societal practices, movement from one dynamic equilibrium to another – typically stretching over several generations (25-50 years)."(Meadowcroft, 2009) |
| (4) "A transition can be described as a set of connected changes which reinforce each other but take place in several different areas such as technology, the economy, institutions, behavior, culture, ecology and belief systems. A transition can be seen as a spiral that reinforces itself; there is multiple causality and co-evolution caused by independent developments."(Rotmans, et al., 2001) |
| (5) "A transition denotes a long-term change in an encompassing system that serves a basic societal function."(Elzen and Wieczorek, 2005) |
| (6) "A transition is a shift from one socio-technical system to another i.e. a system innovation." (Geels, 2005a) |
| (7) "A transition emerges out of co-evolutionary processes in which institutional, technological, behavioral, ecological, economic and other processes intertwine and reinforce each other." (Loorbach et. al., 2009) |
| (8) "A transition can be defined as a gradual, continuous process of societal change where the structural character of society (or a complex sub-system of society) transforms. (...) A transition can be described as a set of connected changes, which may reinforce each other but take place in several different areas, such as technology, the economy, institutions, behavior, culture, ecology and belief systems." (Martens and Rotmans, 2005) |
| (9) "A transition is a structural societal change that is the result of economic, cultural, technological, institutional as well as environmental developments, which both influence and strengthen each other." (Rotmans, 2005) |

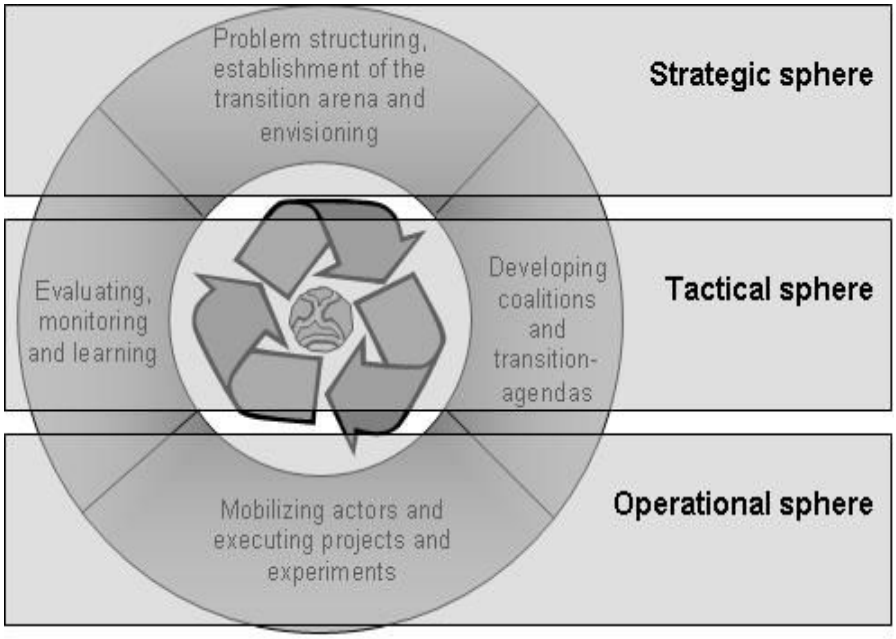


Fig.2-2. A cyclical coordinated multi-actor process at strategic, tactical and operational levels and four co-evolving activity clusters: (1) the establishment and development of a transition arena, (2) the creation of long-term integrated visions, transition pathways and agendas, (3) mobilizing actors and knowledge development through experimenting and (4) monitoring and evaluating the transition process (Loorbach and Rotmans, 2006).

### 2.1.2 The Transition Approach framework

Two critical and basis questions of societal transition research are: how do transitions unfold and how can we manage them? The first question constitutes the theoretical and conceptual part of societal transition research; the latter one, called transition management (Fig.2-2), constitutes the practical and normative part of societal transition

research. It is worth noting that transition approach is still theory-in-development. Still now, there are four conceptual framework constituting transition approaches: multi-level concept; multi-phase concept; multi-path concept and multi-pattern concept.

***The multi-level concept***

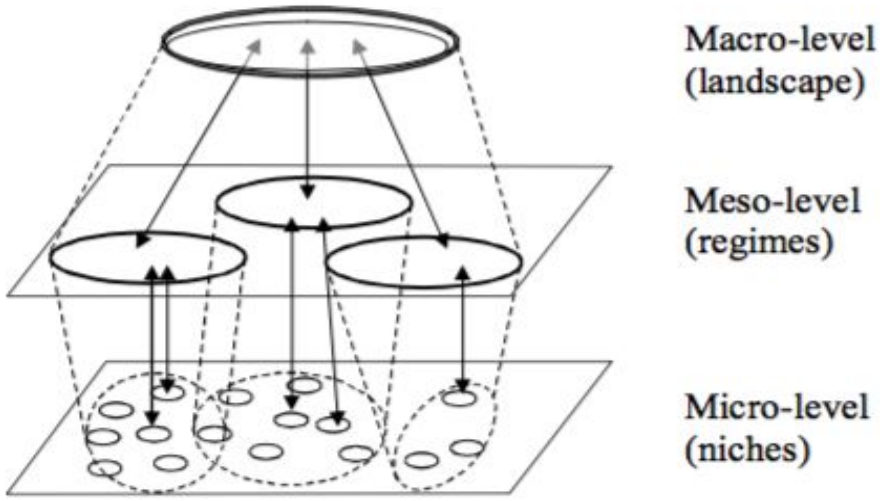


Fig. 2-3 The multi-level concept. There are three levels in multi-level concept or framework. Landscape is located at macro-level, which refers to broader structures and environment; a regime in the meso-level refers to rules, stable social networks, etc.; in the micro-level, it is niches that refer to individual persons, or organizations. (Adapted from Geels, 2002)

The multi-level concept (Fig.2-3) is proposed by (Geels, 2002) to make a difference between changes operating at three different levels, from relatively slow changes at the marco-level to fast changes as the micro-level. The first concept in the transition framework is the multi-level concept, which makes a distinction between developments that operate at different scales, from quasi- autonomous and relatively slow changes at the macro-level to relatively fast changes at micro-level. Societal systematic transition

is seen as a convergent transformative change produced by interactive dynamics changes located at different level. According to Geels (2004), the three different levels "are not ontological descriptions of reality but analytical and heuristic concepts to understand the complex dynamics of socio-technical change." At the micro-level, niches are placed as incubations and protective spaces for breeding innovations. There are two important characteristics of niches: 1) Locations for leaning process and developing social networks (Geels, 2005a); 2) locations for experimental practices. Thus, niches (Table 2-2) as abstract conceptualization can include transformative actors, institutions, policies, and technological innovation, behavioral innovations (Loorbach, 2010). Regime (Table 2-3) as dominant set of interconnected elements is located in meso-level and persistent problems are often located at this level. There are two different conceptualizations about regime. The first conceptualization about regime is used as describing socio-technical system (Schot, 1998a, Geels, 2002, Berkhout et al., 2004, Nelson and Winter, 1977, Dosi, 1982, Rip and Kemp, 1998), defining regime as dominant technological paradigm; the second one is used to describe societal system, defining regime as deep structure of societal system. Landscape is placed at the macro-level. Landscape as a metaphor refers to the hardness and width of exogenous context for agents in niches and regime, in which slow changes including cultural and normative values, accumulating environmental problems are developed. The factors in landscape are difficult to influence and transform. According to Smith et al (2010), landscape "includes processes that span societal functions and unfold autonomously of particular socio-technical regimes. Landscape processes include environmental and demographic change, new social movements, shifts in general political ideology, broad economic restructuring, emerging scientific paradigms, and cultural developments."

Table 2-2. Some definitions about niches

| References | Definition |
|---|---|
| Rip and Kemp, 1998 | Technologies are introduced against the backdrop of existing regimes and landscapes, following diffusion trajectories in which the technology and social context co-evolve under influence of large scale trends |
| Schot (1998a) | Local alliances, or networks, between the party that produces the new technology and the party that uses it (the sponsor), which shields the development from the existing regime. |

Table 2-3. Some definitions of regime

| Definitions of regime |
|---|
| **Technological regime** |
| (1). A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems, all of them embedded in institutions and infrastructures.( Rip and Kemp ,1998) |
| (2). Socio-technical regimes not only refer to the social group of engineers and firms, but also to other social groups. Socio-technical systems are actively created and maintained by several social groups. ( Geels, 2005a) |
| **Regime as rules** |
| (1) Regimes serve a purpose, they are coherent, they are dynamically stable, they are not guided by a single actor or small group of actors and they are autonomous. (...) A regime comprises a coherent configuration of technological, institutional, economic, social, cognitive and physical elements and actors with individual goals, values and beliefs.( Holtz et al.,2008) |
| (2) Regimes refer to intangible and underlying deep structures (such as engineering beliefs, heuristics, rules of thumb, routines, standardized ways of doing things, policy paradigms, visions." (Geels, 2011) |

***The multi-phase concept***

The second concept in transition approach is multi-phase concept (Fig.2-4). The multi-phase framework describes four phases in a societal transition and each phase has different qualitative dynamics. During the pre-development phase, the change in system dynamic is still not visible. Existing regimes are still as dominant ones; innovations have emerged from niches, but they are still isolated and fragmented, improperly embedded and insufficiently developed enough to compete with the existing regime. During the take-off phase, innovations in niches start perturbing of the status quo of current regimes. Some new regimes emerge, while some old regimes collapse. System starts to transform itself. During the acceleration phase, the system transforms structurally, new socio-cultural, economic, ecological and institutional capital starts to accumulate. During the stabilization phase, the new regime is formed and stabilizes into equilibrium dynamics. A new system is formed and also stabilizes into a new equilibrium.

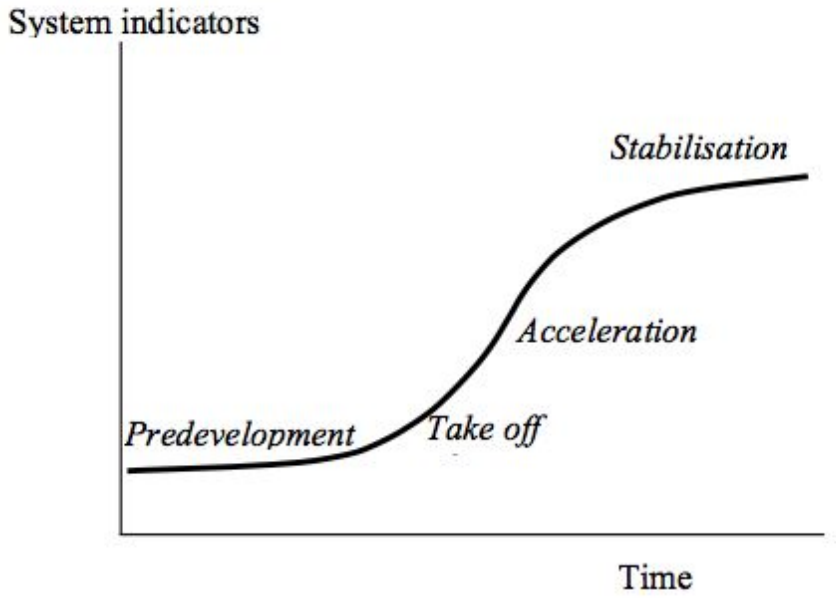


Fig. 2-4 The multi-phase concept. This is an aggregation of underlying curves. The dynamics of societal transition in time are described as a sequence of alternative phases of relatively fast dynamics (take off phase and acceleration phase) and slow dynamics (predevelopment phase and stabilization phase). There are four distinguished phases: predevelopment, take off; acceleration and stabilization. In the predevelopment phase, changes happening in the status of quo of the system are invisible. In the take-off phase, the changes are about to happen after structural changes are accumulated in the phase of predevelopment; in the phase of acceleration, structural changes are visible, and a new dynamics of equilibrium is achieved in the phase of stabilization. (Rotmans et al., 2000)

***The multi-paths concept***

The third concept is called multi-paths concept. The multi-paths concept is inspired by the multi-phase concept, using a sigmoid curve to map the evolution of systematic transition. There are four possible paths of systematic transition: stabilization; lock in; backlash and system breakdown. In this concept, it emphasizes the manifestation of an aggregation of underlying curves produced by alternating phases.

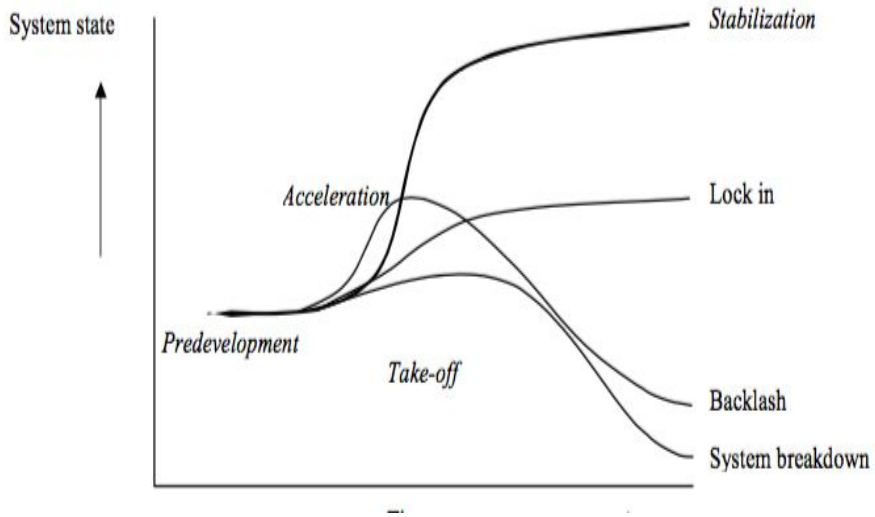


Fig. 2-5. The multi-paths concept .The multi-paths concept is further developed from the multi-phase concept. After the acceleration phase, there are four possible trajectories: stabilization, lock in and backlash and system breakdown. These new three possible paths for societal transition means societal transitions do not always end in success. (Rotmans, 2005)

### *The multi-pattern concept*

The multi-pattern concept is the fourth concept of transition approach developed by (De Haan, 2007). This concept is derived from the synthesis of multi-level concept and complex adaptive system theory. According to (De Haan, 2007), the multi-pattern has three different patterns of changes: empowerment; re-constellation and adaptation. Empowerment patter depicts the scaling up of niches, that is, how a small-scale niche develops into a new regime or eventually replaces the incumbent regime. The second pattern, re-constellation, focuses on the influences upon incumbent regime from a large-scale regime. Adaptation is the third pattern. This pattern describes how the incumbent regime responds to niches in two different ways: niche-absorption and niche-regime. Niche-absorption refers to that the incumbent regime friendly adopting the niches, and thus leads to the change of the incumbent regime. Niche-regime is referred as that the incumbent regime co-evolves with a niche-regime and both adopt certain aspects of the other (co-evolution).

## 2.2 Resilience Theory

Three disasters at nuclear power plants: on Three Mile Island, in Chernobyl (1986), and Fukushima (2011), have shocked the world and actually had significant impacts on the global environment (ANS, 2013; IAEA, 2013; TEPCO, 2011). When the most recent occurred in Fukushima, staff of Tokyo Electric Power Company and specialists in nuclear power engineering frequently used the word “unexpected”. Similar unexpected catastrophes occurred two times involving space shuttles during a short period of time - rockets for shuttle flights between the earth and space developed by the U.S. with particular emphasis on their safety, although the risk of an accident was estimated to be

very low (Rogers Commission report, 1986; Internet Archive, 1986; The White House, 2003).

***Resilience Concept***

The original-ecological resilience concept first proposed by Holling (1973) in his seminal paper Resilience and stability of ecological systems, emphasizes the existence of alternative stable regimes in ecological systems (including alternative irreversible stable regimes and alternative reversible stable regimes), in this sense, resilience is defined as measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (Holling, 1973) or magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior (Holling and Gunderson, 2002), which distinguishes itself from global stability viewpoint in ecological system with focus on only one stable equilibrium, which is also called engineering resilience (Holling and Gunderson, 2002), in this vein, resilience is referred to the time a system takes to recover from a disturbance (Pimm's, 1984) or as rate and speed of return to pre-existing and original conditions after disturbance (Holling and Gunderson, 2002). The original ecological meaning of resilience is defined as "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973). This definition is composed of six interconnected and replaceable "building blocks": persistence, populations, ecosystems, disturbance, ability and collapse. Not only do these building blocks include state, dynamics, process, forces and systems, but also combine together to define research object, subject and direction. It can be found that the conceptual development following original-ecosystem resilience concept is built by in-depth re-exploring the above six building blocks such as

substituting one or more elements and then recombining them. One typical case is that resilience concept is introduced into social system (Adger, 2000), ecological-economic system (Brock, et al, 2002;Perrings, 2006), or social-ecological system (Adger, et al, 2005; Folke, et al, 2002; Folke, 2006), respectively, in which cases system is reset. Another typical examples are manifested as substituting research object while still in ecological system or deepening ecosystem dynamics (Holling and Gunderson, 2002; Walker, et al 2006; Walker, et al, 2002; Folke, et al 2004; Holling, 2001; Cumming and Collier, 2005;Perrings, 2006).(Table 2-4)

Table 2-4. Some definitions of resilience concept (Adapted from Fridolin Simon Brandt and Kurt Jax, 2007)

| **Definitions of Resilience** |
|---|
| **Ecological resilience** |
| Holling (1973) |
| Measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables. |
| Folke, et al (2002) |
| The underlying capacity of an ecosystem to maintain desired ecosystem services in the face of a fluctuating environment and human use |
| **Social-ecological resilience** |
| Gunderson and Holling (2002) |
| The magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior |
| Folke, et al (2006) |
| The capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity |

Walker, et al (2002)

Capacities i) to absorb disturbances, ii) for self-organization, and iii) for learning and adaptation

Folke, et al (2004)

Quantitative property that changes throughout ecosystem dynamics and occurs on each level of an ecosystem's hierarchy

Adger, (2005)

The capacity of a social-ecological systems to absorb recurrent disturbances (...) so as to retain essential structures, processes and feedbacks

Folke, 2006

A perspective or approach to analyze social-ecological systems

**Disturbance resilience**

Carpenter, et al (2001)

The ability of the system to maintain its identity in the face of internal change and external shocks and disturbances

Perrings, 2006

The ability of the system to withstand either market or environmental shocks without loosing the capacity to allocate resources efficiently

**Community resilience**

Adger, (2000)

The ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change

**Transitional resilience**

Brock, et al (2002)

Transition probability between states as a function of the consumption and production activities of decision makers

***Three Basic models in resilience theory***

According to Holling (2001) and Folke (2006), resilience theory is a leading theoretical framework to understand the dynamics of complex adaptive system, especially social-ecological system, though most of the early resilience studies are mainly about ecological system and its capacity to absorb shock. Social-ecological system is an important concept in resilience theory, first coined by Fikret Berkes and Carl Folke in 1998. In short, social-ecological system is defined as interconnected and co-evolving systems of people and nature across spatial and temporal scales. In other words, there are neither natural or pristine systems without people nor social systems without nature. Still now, there are mainly three research strands in resilience research: ecological resilience, social resilience and social-ecological resilience. As the name implies, ecological resilience focus on ecological system, social resilience on social system and social-ecological resilience on social-ecological system. Since my dissertation is about social-ecological system, the following part will revolve around resilience theory on social-ecological resilience. In resilience theory, there are three important theoretical frameworks: basin model (Fig.2-6), adaptive cycle (Fig.2-7), and panarchy(Fig.2-8). These three theoretical frameworks can be applied ecological resilience research, social resilience research and social-ecological resilience research. The first one is called basin model, proposed by (Walker et al, 2004). Basin model as a metaphor describes social-ecological system with more than one basin of attractions (Fig.2-6). Fig.2-6 depicts a social-ecological system with two domains of attraction. Each basin illustrates an alternative attractor domain. The black dot represents the current state of the system in state space (The state space is defined by state variables constituting the system). The dotted line represents the boundaries of the basins or technically stability landscape. Adaptive cycle is the second theoretical framework. In adaptive cycle, there are four

general phases and two dimensions in the evolution of social-ecological system (Fig.2-7). Exploitation is the first phase, in which there is a rapid colonization of recent disturbed places. Materials and energies are stored and accumulated at the second phase, conservation. The two phases constitute the front loop. As the accumulations increase, the system becomes too rigid and interdependencies with decreasing resilience. At the end of the conservation phase, even small disturbances can trigger the release of the accumulated energies and materials before. The system comes into the third phase, release. During the fourth phase, the reorganization phase, the unreleased accumulations prepare energies and materials start the next cycle. The release phase and the reorganization phase are called, back loop. The third theoretical framework is coined as panarchy that is a further elaboration of the adaptive cycle framework. In the book, *Panarchy: Understanding transformation in human systems* (Gunderson and Holling 2002), panarchy is used as to explain transformation in social-ecological system.

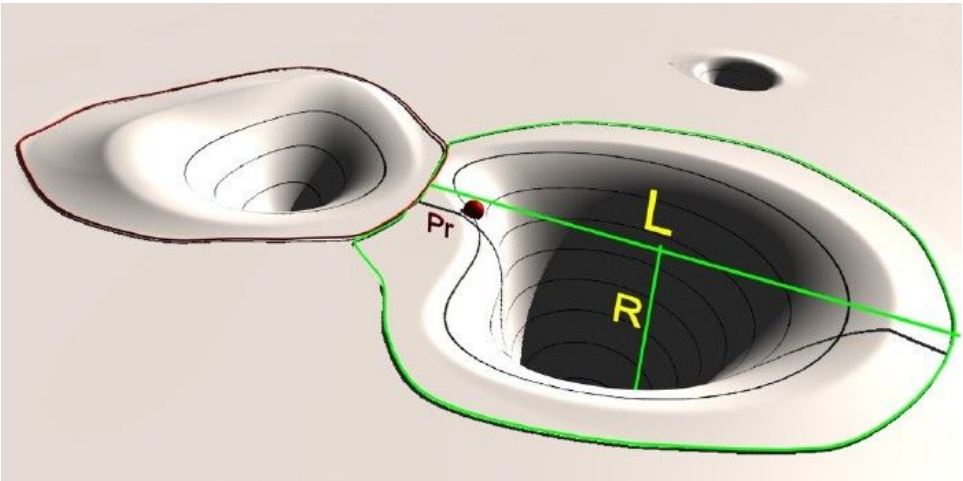


Fig.2-6. Three-dimensional stability landscape with two basins of attraction showing. L = latitude(the maximum amount the system can be changed before losing its ability to recover; basically the width of the basin of attraction. Wide

basins mean a greater number of system states can be experienced without crossing a threshold), R = resistance (the ease or difficulty of changing the system; related to the topology of the basin—deep basins of attraction indicate that greater forces or perturbations are required to change the current state of the system away from the attractor), Pr = precariousness (the current trajectory of the system, and how close it currently is to a limit or "threshold" which, if breached, makes recovery difficult or impossible). (Walker et al, 2004).

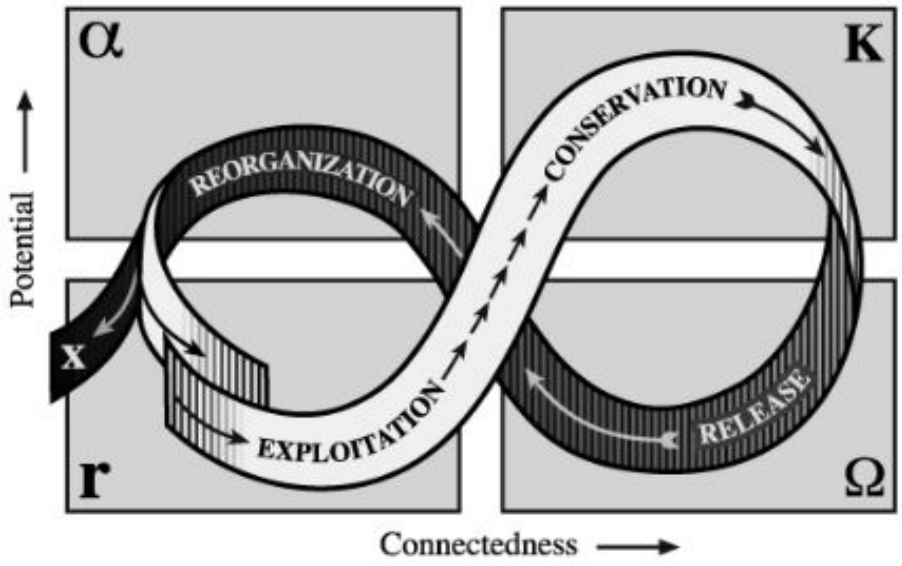


Fig. 2-7. Adaptive cycle. There are four phases and two attributes in adaptive cycle. These four phases are distinguished as exploitation, conservation, release and reorganization. During adaptive cycle, the ecological progression proceeds from exploitation phase, slowly to conservation phase, which is referred as foreloop; very quickly to release phase, quickly to reorganization phase, which is referred as backloop. Potential and connectedness are attributes in adaptive cycle, respectively. (Gunderson and Holling, 2002)

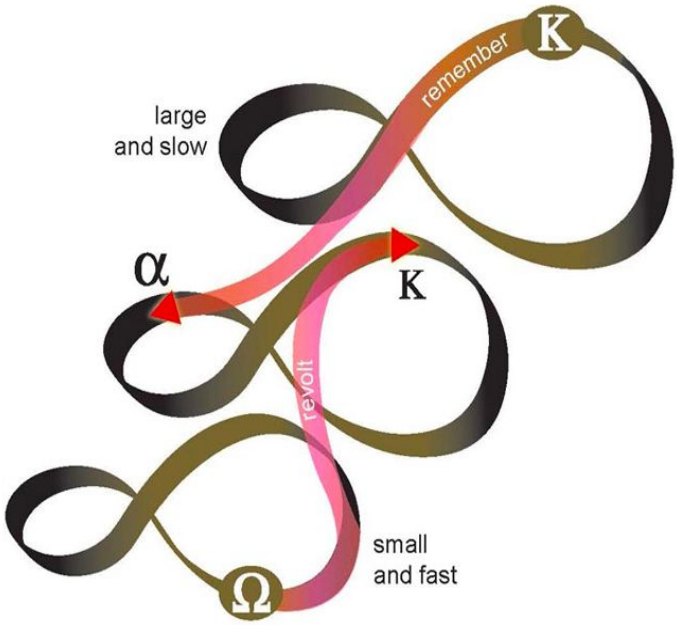


Fig.2-8. The panarchy is further developed from adaptive cycle, which focuses on multi-scale dynamics and interactions. There are two critical interactions in panarchy framework: revolt and reconnection. Revolt means "a critical change in one cycle to cascade up to a vulnerable stage in a large and slower one"; Remember means that renewal process is facilitated by potential capital that is stored in a larger and slower cycle. (Gunderson and Holling, 2002).

## 2.3 Morphogenetic Approach

According to Archer (1995), society as an entity has three conceptually unique characteristics: 1) that the existence of society is not separable from human activities; 2) that society can be transformed; 3) humans in society can be also transformed. The last two characteristics emphasize the transformability of the society and the humans in society. Morphogenetic approach is firstly proposed by Archer (1995). The ingredients

of social changes, that is, structure, culture, and agency and their generic form of interaction are identified in morphogenetic approach. Analytical distinction between structure and agency are proposed in morphogenetic approach. Archer's analytical dualisms not only provide a good lubricant for holism and individualism, but also introduce the concept, emergence into societal system. The 'morpho' element says that society has no pre-set form or preferred state, while the 'genetic' element is a acknowledgement that it takes its shape from, and is formed by, agents, originating from the intended and unintended consequences of their activities. The morphogenetic approach is not just a meta-theoretical framework, but also as an explanatory and theoretical framework for studying societal change and societal systematic change. Archer's approach as a realist approach aims at avoiding any form of conflationary theorizing at the theoretical and the practical level that is different from Giddensian's structuration theory (1984). This theoretical approach aims at linking structure and agency instead of sinking one into the other. The basic argument of the morphogenetic perspective is that time is an important element to resolve the conflicts between structure and agency, and structure and agency can only be examined by studying the interconnections between them over time. Emergence is the most important concept in morphogenetic approach, which means that structure and agency are not only analytically and ontologically separable, but also they are interlinked over different tracts of the time dimension. As argued by Archer, social reality has the stratified nature, in which different strata have different emergent properties and powers. Morphogenetic approach emphasizes the importance of emergent properties at the level of structure and agency, both of which are different from each other and cannot be irreducible to each other. Different strata with their own properties and causal powers have relative autonomy from one other. Additionally, emergent properties are also relational, formed

from combination. For example, high productivity comes from the division of labor. High productivity can react back on the division of labor, e.g., fashioning monotonous work. But division of labor has its own causal powers that can be irreducible to the power of its components, e.g., individual employees. Morphogenetic approach is mainly based on two fundamental propositions: 1) That structure necessarily pre-dates the action(s) leading to its reproduction or transformation; 2) structural elaboration necessarily post-dates the action sequences that gave rise to it. The morphogenetic approach consists of a three stage morphogenetic cycle in which there are structure, culture and agency. The morphogenetic approach has strong power explain how these three relative autonomous and interconnected entities emerge, interact, and redefine each other. As Fig.2-9 and Fig.2-10, there are three-part cycles in morphogenetic approach: conditioning; interaction and elaboration. Time is an important factor in morphogenetic approach. In morphogenetic perspective, time is not as a medium, yet as sequential tracts and phases in its own right. As for conditioning, morphogenetic perspective argues that: 1) systematical properties are seen as the emergent or aggregate consequences of past actions; 2) they have their own casual power as independent strata, and exert causal influence upon subsequent interaction. Thus from morphogenetic perspective, the realist notion of emergence and its own causal power are endowed to systemic properties and their effects as constraining or facilitating influences on interactions strata. In the interaction, social interaction is regard as being conditioned but not as determined, since social agents have their own irreducible emergent powers. Elaboration means the modification of previous structural properties and /or the introductions of new ones. In the new book, *Social Morphogenesis,* morphogenesis is not just a meta-theoretical concept, but also as theoretical framework. There are two different theoretical levels: meta-theory or theory; formal or substantive theory.

Meta-theory usually refers to conceptual framework or theoretical framework, while thus, the concept, morphogenetic society aims at advancing the concept, morphogenesis to a specific social theory to identify particular mechanisms of social radical change. As the book *Social Morphogenesis* mentioned, the concept of morphogenetic society suggests that:

(1) Morphogenesis (versus morphostasis) does not refer to the outcome of one M/M cycle, but to a whole type of society a whole form of social order…
(2) …which characterizes the (relatively) enduring state of structures, cultures and social groups, not just in a few spots or sub-systems, but as the main framework of society. This means that the structural, cultural and agential conditions that make change more likely than reproduction are obtaining on a large scale-i.e., for the whole society and not only in some particular areas or subsystems-and that they will be around for some time, characterizing not just one or two M/M cycles, but a type of society;
(3) Therefore, it involves an ambitious claim as to (social) space and time;
(4) Moreover, it amounts to saying that morphogenesis prevails over morphostasis everywhere and for a more or less long chain of M/M cycles.

In other words, from morphogenetic approach to morphogenesis to social morphogenesis, this theory as an independent and rigorous approach to the bring complexity science and social science together can be interpreted as a grand theory to understand the working of contemporary society on a more specific theoretical level.

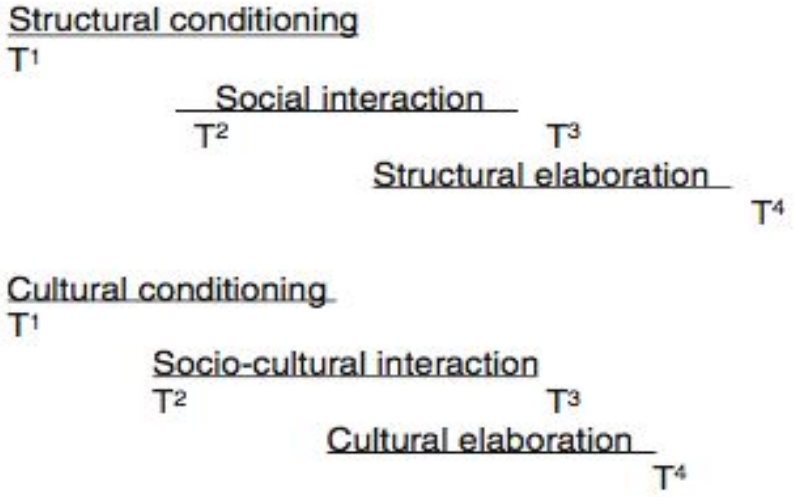


Fig. 2-9. The morphogenesis of structure and culture. Analytical dualism is one of most important methodological principles Archer proposed. Analytical dualism emphasizes, “non-conflationary theorizing”. As shown in this figure, structural domain and cultural domain are casually separated for studying the interplay between these two levels. (Archer, 1995)

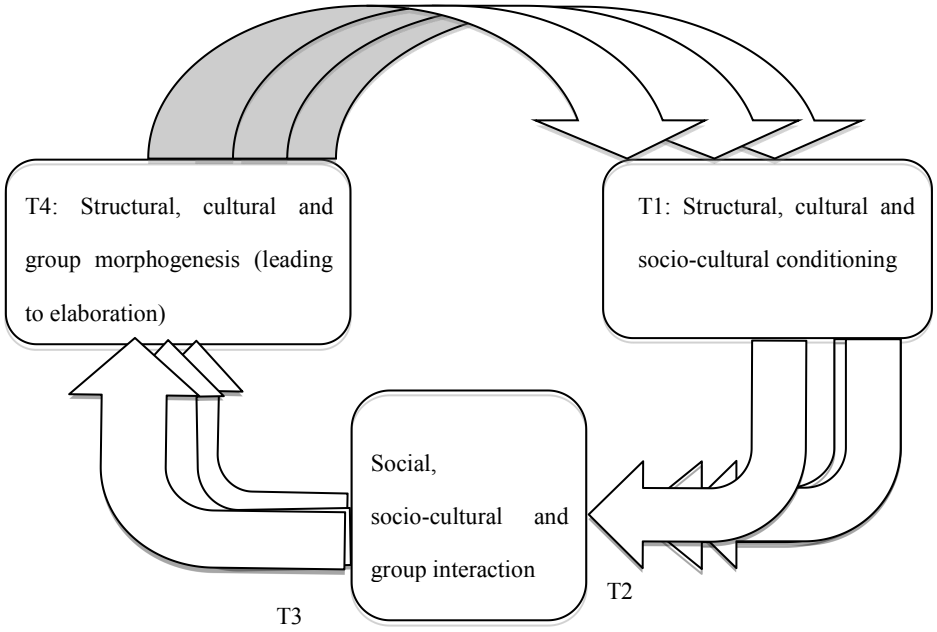


Fig. 2-10. The morphogenesis with agency, structure and culture. The morphogenesis with agency, structure and culture. A three-stage morphogenetic cycle is represented, which includes structure, culture and agency, respectively. Structure, culture and agency are relative independent and yet interlinked with each other. (Adapted from Horrocks,I.,2009)

Table 2-5. Holism vs. Individualism

| Science of society (Holism) | Study of wo/man (Individualism) |
|---|---|
| **Human has no casual role in social system; Society its self has complete casual power in social system. Some viewpoints on Holism are as following:** | **Human has casual role and power in social system instead of society. Some viewpoints on Individualism are as following:** |
| a. To deny the significance of society's human constitution. (Epiphenomenalism);<br>b. The nature of social reality is held to be such that the necessary concepts could never be statements about individual people, whether for purposed of description or explanation;<br>c. Correct explanations could not be reductionist;<br>d. Individuals are held to be indeterminate material, which is unilaterally molded by society, whose holistic properties have complete monopoly over causation.<br>e. Society is no more decomposable into individuals than a geometrical surface is into lines, or a line into points"(Comte, 1951)."Whenever certain elements combine, and there by produce, by the fact of their combination, new phenomena, it is plain that these new phenomena reside not in the original elements but in the totality formed by their union (Durkheim, 1962) ". | a. To nullify the importance of what is, has been, and will be constituted as society in the process of human interaction. (Epiphenomenalism);<br>b. Social reality consisted of nothing but individuals and their activities;<br>c. Explanations consist in reduction;<br>d. People are held to monopolize causal power which therefore operates in a one-way, upwards direction:<br>e. "Men in a state of society are still men. Their actions and passions are obedient to the law of individual human nature. Men are not, when brought together, converted into another kind of substance with different properties, as hydrogen and oxygen are different from water" (Mill, 1884);<br>f. "Only a certain kind of development of actual or possible actions of individual persons"(Weber, 1964) |

# CHAPTER THREE. TOWARDS SUSTAINABLITY TRANSFORMAITON THEORY

Olsson, et al., (2014) indicate that, on the one hand, a clear-cut understanding of the underlying mechanisms and patters, as well as conditions, of transformation, which might greatly promote our opportunities for "persistent problems" and successfully steering prominent transformation to sustainability, is still in infancy; on the other hand, that as resilience theory and transition management are two critical conceptual and theoretical frameworks for studying sustainability transformation so far, thus, combining and integrating with the two different research fields could provide a promising attempt for sustainability transformation theoretical building and empirical study, which will be certainly not easy due to different theoretical background and social-ecological systematic complex processes. However, I aim at coming across these disciplinary boundaries and create a better understand of social-ecological transformation to sustainability.

## 3.1 Reframing Resilience Theory

Ecosystem Resilience as a theoretical concept focusing on ecosystem dynamics and as a new paradigm for natural resources management is firstly introduced by Holling (1973). In his seminal paper *Resilience and Stability of Ecological Systems*, resilience is defined as *measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables* (Holling, 1973) or *magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior* (Holling and Gunderson, 2002). This concept emphasizes the existence of alternative stable regimes in ecological systems (including alternative irreversible stable

regimes and alternative reversible stable regimes). On the other hand, engineering resilience (Holling and Gunderson, 2002), which emphasizes only one stable equilibrium in ecological system, is referred to the time a system takes to recover from a disturbance (Pimm's, 1984) or as rate and speed of return to pre-existing and original conditions after disturbance (Holling and Gunderson, 2002). However, there is an unfortunate phenomenon in conceptual and practical development of resilience concept so as to mislead the essence of the original ecosystem resilience concept: ecosystem resilience is equal to engineering residence ontologically and epistemologically and is mistakenly regarded as returning original state and maintaining status quo. Therefore, it is imperative to reconfirm the ontological aspect of ecosystem resilience concept. It is obvious that there are two essential attributes about ecosystem resilience: persistence and collapse, both of which are as two extreme endpoints on the conceptual spectrum of ecosystem resilience, respectively. In Oxford Dictionaries (2015), persistence is defined as: 1) continuing firmly or obstinately in an opinion or course of action in spite of difficulty or opposition; 2) continuing to exist or occur over a prolonged period; 3) remaining within the environment for a long time after introduction; 4) remaining attached instead of falling off in the normal manner. By definition, it indicates that "to continue when facing difficulties while still within critical threshold in long-time dimension" is the core meaning of persistence. Thus, I assume that the ontology of ecosystem resilience concept is *the capacity and process of positive changes and changing the changes positively between persistence and collapse or between 0 and 1* (Strunz, 2012) *with or without external disturbances*. There is no doubt that change is the core philosophy and research object in resilience research and that the place for change is system in which change have been changed or is being changed. It is easy to see that the ontology of ecosystem resilience is fundamentally positive, open, and

inclusive. Thus, this concept with inter-and trans-disciplinary qualities can smoothly extend to SES research and sustainability research. In next section, I will discuss resilience thinking that matches partially to the ontology of ecosystem resilience. To say, "partially match", there is still a need of distinguishing "ecosystem resilience-based resilience thinking" from "engineering resilience-based resilience thinking".

### 3.1.2 Resilience Thinking: From "Bounce Back" to "Bounce Forth"

The theoretical and conceptual foundation of resilience thinking is developed from a series of papers and books (Walker, et al., 2004; Walker and Salt, 2006; Folke, 2006; Walker, et al., 2009; Folke, et al, 2010), especially the paper, *Resilience Thinking: Integrating Resilience, Adaptability and Transformability*. The significant contributions of this paper are that: 1) ecosystem resilience is extended from ecological system into SES; 2) another new two concepts, adaptation and transformation are added as essential perquisites for social-ecological resilience; 3) confusion between resilience and transformation is tactfully resolved by "multi-scalar and temporal resilience" perspective; 4) three aspects of SES is addressed: resilience as persistence, adaptability, transformability (Folke, et al 2010). However, resilience and adaptation is, implicitly or explicitly, understood as "maintenance", "recovering to the original state" or "business as usual" when applied in wider research field, e.g. climate change research, community research and disaster research, to name a few.

Rather than doing a state of art literature review, I will identify two basic exemplary conceptual dimensions of resilience thinking, I call, social-ecological conservative resilience thinking and social-ecological positive resilience thinking (Table 3-1). As shown in Table 3-1, social-ecological conservative resilience thinking *(SE-CRT)* is featured as: *buffer capacity for preserving what we have and recovering to where we*

*have; all about absorbing shocks; survival and bounce-back ability and process; avoiding negative regime shift and keeping staying the "original" regime; adaptive resilience*, while *social-ecological positive resilience thinking (SE-PRT)* is as: *the ability to change, adapt, and importantly transform with or without external disturbance; the process to continually reinvent and innovate for doing new things and new possibilities with hope; not necessarily about absorbing shocks; bounce forward, to-forth and bounce beyond ability and process; to change and not to continue doing the same thing and to be stronger and better than before; positive and active regime shift with intentionality of human actions; transformative resilience.* It is apparent that social-ecological positive resilience thinking takes root in ecosystem resilience; social-ecological conservative resilience thinking in engineering resilience. It is social-ecological positive resilience thinking to we should turn as theoretical and conceptual foundation for sustainability transformation. The reason why I use this conceptualization, social-ecological positive resilience thinking, is that I accentuate radical change process in complex adaptive SES, not ecological system or social system. It means that SES as a unique system has independent ontology and thus differs from ecological system and social system. This proposition is also consistent with resilience perspective and sustainability science. Social-ecological positive resilience thinking as a promising conceptualization can direct development of interdisciplinary research when translating resilience thinking into, or integrating resilience thinking with other research fields. As Mcevory and Fünfgeld (2011) argue, there are two prominent inconsistences and alienations: *to mostly concern with "staying the status quo", while to ignore transformation potential and process; to bound itself within "engineering resilience " which underlines "bouncing back to the previous stable state as soon as possible"*.

Sustainability transformation is usually defined as “shifts that fundamentally alter human and environmental interactions and feedbacks (Olsson, et al 2014)” or as “physical and/or qualitative changes in form, structure, or meaning-making (O’Brien and Sygna, 2013)” or as “the capacity to create untried beginnings from which to evolve a fundamentally new way of living when existing ecological, economic, and social conditions make the current system untenable”(Westley., et al 2011). Apparently, these above definitions of sustainability transformation are consistent with social-ecological positive resilience thinking. But it is worth noting that social-ecological conservative resilience thinking and social-ecological positive resilience thinking is not completely opposite to each other. To great degree, social-ecological conservative resilience thinking only expresses naïve appeal and comfort. In other words, we can return and recover, but not to the original one, only to a “new original one”; to this point, social-ecological conservative thinking is connected with social-ecological positive resilience thinking.

Table 3-1. Some Characters of Social-Ecological Conservative Resilience Thinking and Social-Ecological Positive Resilience Thinking

| **Social-Ecological Conservative Resilience Thinking** | **Social-Ecological Positive Resilience Thinking** |
|---|---|
| **Bounce back** | **Bounce forth** |
| As buffer capacity for preserving what we have and recovering to where we have (Folke., et al 2010) | As the ability to change, adapt, and importantly transform with or without external disturbance and as the process to continually reinvent and innovate for doing new things and new possibilities with hope (Scheffer, 2009; Simmie and Martin, 2010; Folke, et al 2010) |
| Survival and Bounce-Back ability and process (Shaw, 2012; Valikangas, 2010) | |
| Resilience 1.0 (Hodgson, 2011) | |
| Avoiding negative regime shift and keeping staying the "original" regime (Disturbances and shocks move SES into alternative undesirable regime within the same system or into another undesirable regime within different system.) | Bounce forward, to-forth and bounce beyond ability and process (Shaw, 2012;Leach, 2008) |
| | Resilience 2.0 (Hodgson, 2011) |
| Adaptive resilience (Wilson, et al, 2013; Robinson, 2010; Anthony, et al 2015; Nilakant, et al, 2014;Cutter, et al, 2008) | To change and not to continue doing the same thing and to be stronger and better than before (Seville, 2009) |
| | Positive and active regime shift with intentionality of human actions (Hodgson, 2011) |
| | Transformative resilience (Hodgson, 2011;Gotham and Campanella, 2010) |
| | Evolutionary resilience (Simmie and Martin, 2010) |

## 3.2 Social-Ecological Transitional Resilience Framework (SE-TR) and Morphogenetic Social-Ecological System Framework (MSES)

These two frameworks aim at two questions about sustainability transformation in SES: what sustainability transformation is and how transformative process happens in SES. I concur with Archer's notion that the ontology must be addressed before methodology and explanation so as to keep the consistence between ontology, epistemology and practice. Thus, I strive to develop the theory of sustainability transformation with recognizing the tripartite connections and consistence between ontology, epistemology and practice. Archer (1995) delineates the structure of social theory as consistent three parts as follows (Fig.3-1). According to this, the theoretical structure of sustainability transformation in SES can be developed (Fig.3-2).

SO →→→→ EP →→→→ PST

Social Ontology Explanatory Programme Practical Social Theory

Fig.3-1. Structure of social theory. According to Archer (1995), social theory is composed of social ontology (SO), explanatory programme (EP), and practical social theory (PST). Among them, EP as "bridge " plays critical role and function for connecting SO and PST. In most cases, SO and PST are disjointed so as to lost consistency between SO and PST.

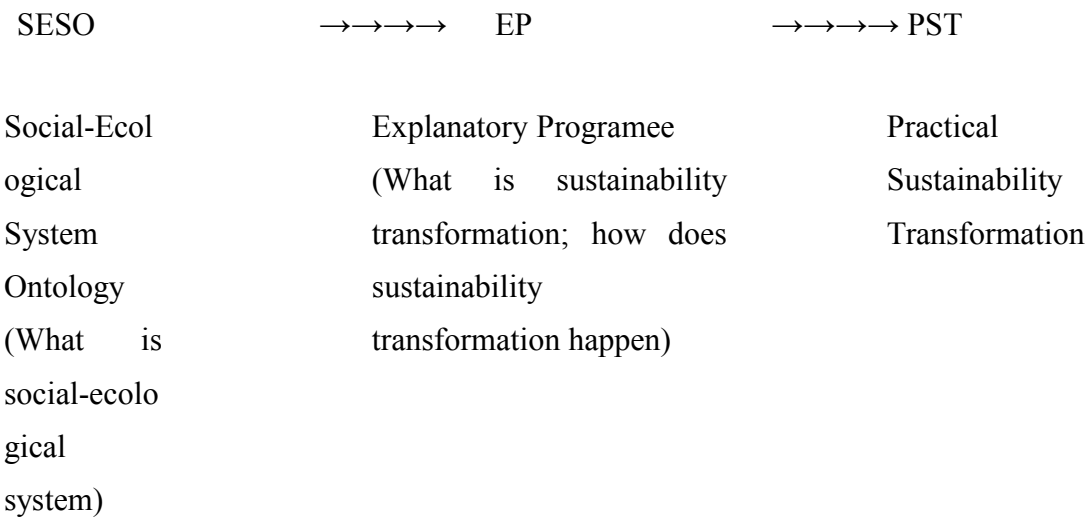


Fig.3-2. Structure of The Theory of Sustainability Transformation in Social-Ecological System (SES). Drawing from the structure of social theory (Fig.16), the theoretical structure of sustainability transformation is composed of social-ecological system ontology (SESO), explanatory programee (EP), and practical sustainability transformation (EP). This dissertation is aimed at developing a theoretical framework, which is positioned at the layer of EP so as to keep the consistency between SESO, EP and PST. (Wang, et al 2015)

During developing the theory of sustainability transformation in SES, I advocate an overarching ontology in which SESO is rooted in, complex realism (Chapter 1) that synthesizes critical realism as philosophical ontology with complexity theory as a scientific ontology (Reed and Harvey, 1992). I argue that SES, together with social system and ecological system are all complex adaptive system and they are all unique systems and different from each other. In other words, I assume that SES has

independent ontology distinguishing from the ontology of social system and ecological system. Thus, SES can be as an object of scientific research. SES focusing on linked complex systems of people and nature is first coined by (Berkes and Folke, 1998) because they did not want to treat the social or ecological dimension as a prefix, but rather give the two same weights during their analysis. The reason why the concept, sustainability transformation, is so appealing lies in that transformative process doesn't happen in the social or the ecological, but in SES. Thus, the clarification for the ontological part of SES makes the theoretical building of sustainability transformation in SES feasible. Given that the theory of sustainability transformation in SES is in work-in-progress, I maintain that there are nothing in SESO, EP and PST that are self-contradictory from the beginning stage of theoretical building, and that good explanation can not be at the level of experience (the empirical level) or at the level of events (the actual level), but needs to explore a real mechanism which, in the complex adaptive system, is responsible for sustainability transformation. That is to say, the following approaches, which are all, rooted in complex realism: resilience thinking, transition approach and Archer's realist theory of morphogenesis, resonate in harmony with each other. Thus, their synthesis will hold an explanatory power to uncover generative mechanism for sustainability transformation in SES.

***Reframing***

Olsson, et al (2014) argue that resilience theory and transition management, among others, are two promising conceptual frameworks for researching sustainability transformation. Before introducing SE-TR theoretical framework, I will make some differences between resilience theory and resilience thinking, and between transition management and transition approach. Regarding resilience theory, we assume that resilience theory is located between descriptive resilience (including two conceptual

dimension: ecological resilience and engineering resilience) and resilience thinking (including two conceptual dimension: social-ecological conservative resilience thinking and social-ecological positive resilience thinking) and that theoretical foundation of sustainability transformation is nearer the end-point of resilience thinking, more specifically, is based on social-ecological positive resilience thinking dimension of resilience thinking. Thus, I call one of conceptual framework, resilience thinking, instead of resilience theory. As regards the other conceptual framework, transition management, I will use transition approach (Rotmans, 2005;Martens and Rotmans, 2005) instead of transition management. Transition approach focusing on persistent problems in societal system draw attention to a gradual, continuous and fundamental process of structural change within a society or culture, instead of treating symptoms of those problems with marginal changes and adjustments (Frantzeskaki, 2011; Rotmans, et al., 2001); transition approach is also characterized as "transformative change, meaning irreversible racial change that takes a long-term to materialize (Frantzeskaki, 2011)", which perfectly coincides with the essence of ecosystem resilience and the ontology of social-ecological positive resilience thinking.

***Synthesis***

As marked by Hatt (2013), there are two uncomfortable mistakes when applying resilience thinking in SES: *when translating resilience thinking into social system, resilience thinking is ironically based itself on structural functionalism theory that is determined by the assumption of social system committing itself to equilibrium and" status quo", which is strikingly in conflict with the ontology of resilience thinking positioning itself as adaptive equilibrium rather than mechanical equilibrium; given that resilience thinking is obsessed with systematical level, there is no room for human agency.* Hence, a new picture emerges when integrating resilience thinking with

transition research: transition approach supplies human agency for resilience thinking and removes the embarrassing ontological contraction indicated by Hatt (2013); this integration makes ecological system or social system extend to SES. Otherwise, resilience thinking is just at the edge of ecological system of SES, while transition approach is completely within social system. I also argue that there are still three problematical issues in resilience thinking theoretical framework (Folke, et al., 2010): 1) resilience thinking, that is, resilience as adaptability, as transformability and as persistence is too much concerned with capacity, and process is implicitly ignored, to some degree; 2) the concept, persistence, is not as the same conceptual level as the other concepts, adaptability and transformability. It means that a new concept is needed and this new concept needs to be in the same conceptual level as transformability and adaptability; 3) it remains in vague about agency itself, interaction between agency and structure as structure and agency is a critical topic in social science. Drawing on this, I propose a conceptual framework for studying what transformative process is in social-ecological system, centered on resilience: resilience as adaptation, as transformation and as transition (Fig.3-3).

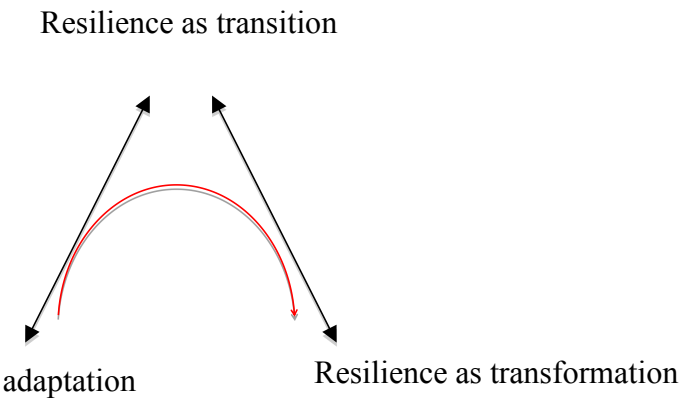


Fig.3-3.Social-Ecological Transitional Resilience Framework (Wang, et al 2015). Centered on resilience, there are three aspects of social-ecological system: resilience as transition, as adaptation and as transformation.

Why does this framework center on resilience? My biggest ambition is to try to study transformative process in SES as a real research object in which humans and nature as an integrated whole are co-evolving within a health planet. For this reason, what resilience thinking counts are SES dynamics and interactions, and "reconnecting to the biosphere" (Folke et al, 2011;Berkes and Folke 1998). Thus, the significance of sustainability transformation in SES is that both of the social and the ecological should be transformed through positive changes started by agency. In other words, transformative process generates further transformative process. Again, social-ecological transitional resilience framework builds on social-ecological positive resilience thinking of conceptual dimension that focuses on "positively bounce forth" instead "negatively bounce back". As a new conceptual level, transition, is not simply and mechanically added, because its true connotation consists in, on the one hand, producing new emergent relation between and among adaptation and transformation; on the other hand, making SES not be within current stability domain or basin of attraction, that is, adaptation (Berkes et al.2003), but shift to an alternative regime in the same SES, or "jump" to an new kind of basin in an new SES (Walker, et al.2004). I call "shift to an alternative regime in the same SES", *adaptive transition*, as one of transformative process; I call "jump" to a new kind of basin in a new SES", *transformative transition*, as the other transformative process. Here, these two transformative processes, *adaptive transition* and *transformative transition*, are emergent systematic process initiated by "change agents". How can these two transformative processes be studied in SES? I will synthesize this framework with Archer's realist theory of morphogenesis into a new theoretical framework, I call, Morphogenetic Social-Ecological System Framework (Fig.3-4), so as to study these two processes in SES.

Why is Archer's realist theory of morphogenesis? Archer's realist theory of morphogenesis consistently matches its ontology with the ontology of resilience thinking and transition approach; Archer's realist theory of morphogenesis (Fig.2-10) maintains an analytical distinction between structure and agency, which means that structure and agency is interrelated causally, but separated ontologically (Porpora, 2013). This analytical distinction liberates “change agent” from structure, which resonates with our proposition that every transformative change originates from “change agent”(Fig.19); in recent book, *Social Morphogenesis* edited by Archer (2013), morphogenetic society as a theory is proposed, and it expands the morphogenetic approach as a meta-theory to a theoretical conception.

The theoretical framework, Morphogenetic Social-Ecological System Framework (MSES), is inspired by both of social morphogenesis and the morphogenetic approach. MSES comprise three conceptual entities that are interconnected causally, but separated ontologically: the agential, the societal and the ecological. Three emergent levels are constituted by conditioning, interaction and elaboration. Here, I synthesize the cultural domain and the structural domain (Acrher, 1995) as the societal domain. The societal domain is the emergent outcome between/among the cultural domain and the structural domain, but the cultural domain and the structural domain still maintain analytical distinction. Moreover, time dimension plays an important role in MSES as the mismatches between the social dynamic and ecosystem dynamics push life-supporting ecosystems over critical thresholds into more degraded, less productive regimes to which resilience scholars also pay great attention (Olsson, et al 2014). Thus the temporal dimension in MSES accentuates consistency of the social and the ecological when transformative processes happen. In MSES, the ecological domain explicitly highlights interaction between and within slow variable and fast variable, these concepts

of which originate from ecosystem resilience theory. As argued by Walker, et al (2012), it is critical to take into account the interaction between and within "slow variables", "fast variables" and external drivers in order to successfully steer SES to a desired direction. According to Gunderson and Holling, 2002, a small set (three to five) of critical variables with different speeds (fastest, slower and slowest) can capture key systemic behaviors. Thus, it is vital to identify these critical fast/slow variables and study the dynamics between these critical fast/slow variables for launching any social-ecological transformation, which is still studied insufficiently. An important departure point of MSES is that every transformative change is initiated by agency and then the interactions between agential interaction and interaction between/among fast/slow variables are transformed first, which of them are all conditioned by agential conditioning, social conditioning, and ecological conditioning at T1 moment. From T2 to T3, the interaction between agential interaction and interaction between/among fast/slow variables has been changed radically with positive feedbacks, and at the same time, both of Agential interaction in the agential domain, and Interaction between and within slow variable and fast variable are transformed. As mentioned before, time dimension plays a critical role in MSES. T2 and T3 means that not only do social-ecological transformation obey time dimension of the agential domain and societal domain, but also the ecological domain. Traditional studies on ecological transformation and societal transformation usually emphasize one-side time dimension: ecological time dimension or societal time dimension (agential time dimension is always overlooked.) In MSES, every social-ecological transformative change must involve ecological elaboration. At this point, it is different from resilience thinking, and transition approach, both of which exclusively focus on one-side elaboration, the social or the ecological. A whole morphogenetic process in MSES means the realization of

agential elaboration, societal elaboration and ecological elaboration simultaneously, three of which are as emergent entities, respectively. It is noted that "simultaneous realization" does not refer to "at the same time". Generally speaking, agential elaboration, societal elaboration and ecological elaboration are achieved at different times. T4 represents the moment when agential elaboration, societal elaboration and ecological elaboration are all realized. As shown in this framework, two prototypic morphogenetic cycles can be deduced from MSES. One is *the agential-the ecological cycle*. In this cycle, every agential interaction is constrained by agential conditioning, societal conditioning and ecological conditioning. The outcome of this cycle is the realization of both of agential elaboration and ecological elaboration by transformative transition process or either of them by adaptive transition process; another cycle is *the agential elaboration- the societal elaboration-the ecological elaboration.* This process finishes a complete cycle. In this cycle, three of them achieve elaboration through transformative transition process or two of them realize elaboration through adaptive transition process. As shown in MSES, the time arrow at the right means social-ecological transformation enters into a new morphogenetic cycle with new agential domain, societal domain and ecological domain.

MSES provides a good theoretical start for further discovering underlining generative mechanisms of transformative process towards sustainability. Olsson, et al 2014 propose three interconnected research areas that need a combined approach in sustainability transformation research: 1) patterns of transformation; 2) innovation and social, technological, and ecological interactions at multiple levels in relation to sustainability; 3) agency and its role in sustainability transformations. I assume that MSES would be as a promising candidate to realize theoretical integration and collaboration in sustainability transformation research. The two prototypic

morphogenetic cycles, as proposed above, *the agential-the ecological* cycle and *the agential elaboration-the societal elaboration-the ecological elaboration* cycle focus on the emergence of new configurations of interlined SES with different sets of feedbacks (Olsson, et al 2014); it is noted that innovations can originate from the agential domain and/or the societal domain. Nevertheless, in MSES, it emphasizes on considering ecological integrity when applying innovations so as to avoid unsustainable development pathways (Olsson and Galaz, 2012); in MSES, it underlines that every transformative change should come from "change agent/s". The following are three typical cases, which can be explained by MSES. In 1970s, many Latin American countries achieved an unsustainable level due to land degradation (as slow variable) and deceasing agriculture productivity (as fast variable). Some local farmers and researchers as " change agents" are forced to use unconventional method (as innovation), no-tillage, to enhance soil organic matter and fertility (Derpsch and Friedrich, 2009), which transforms the interaction between agent and interaction between fast/slow variables. It should be noted that transformations would be conditioned by the agential conditioning (in this case, conventional plow-based agriculture users), the societal conditioning (in this case, conventional plow-based institutions and cultures), and the ecological conditioning (in this case, land degradation). Also, these three conditioning provide change opportunities and also change barriers. Along with the new innovative experimental breakthroughs, the changes in land management, such as weed management, mulch-farming and green techniques, as well as new machines for direct planting will be required, which causes the transformation of the whole farming system, or social-ecological system. In this process, it finishes a complete *the agential elaboration -the societal elaboration-the ecological elaboration* cycle or we can say, it jumps to a new kind of basin in a new SES through transformative transition. The

second case is about navigating transformation in governance of Chilean marine coastal resources (Gelcicha, S., et al 2010). A critical departure point for the realization of Chilean governance transformation in marine coastal resources (societal elaboration) is an increasing understanding the links between ecological system and the role of fishes in structuring marine ecosystems in Chile. Two small experimental no take coastal reserves are firstly initiated by universities (as change agent). Studies on these reserves show that humans control the abundance of Loco populations (The Loco is the most important shellfish in Chile from historical and economical point of view), and the ecological system will shift to a mussel-dominated intertidal seascape that has no economic value, when Loco is absent. That artisanal fishes are concerned about the depletion and recovery possibility of these natural resources (agential conditioning and ecological conditioning) creates an opportunity for scientists and existing fisher associations to exchange information and to launch a participatory research (agential interaction). The first pilot management and exploitation experimental area is implemented (which means a new agential conditioning is created), within which a learning process about the dynamic between ecosystems and society is led by the intensive communication between scientists and fishers (which means a new agential interaction is created). At the same time, artisanal fishers in Chile is in the process of reorganizing a single national confederation that aims at convening all artisanal fisher associations (agential elaboration), in turn which becomes a critical national player (societal elaboration). In this case, before achieving ecological elaboration and societal elaboration), agential interaction and agential conditioning are constantly transformed, and the agential domain is achieved firstly. In other words, the agential domain is transformed firstly. After that, societal elaboration is achieved and then ecological elaboration. In this process, the achievement of ecological elaboration is hysteretic

compared with agential elaboration and ecological elaboration. The third case is about social-ecological transformation for ecosystem management of a wetland landscape in Southern Sweden (Olsson., P et al 2004). During the whole process of social-ecological transformation of wetland landscape management in Southern Sweden, one local individual, called SEM by his initials, plays an important role. This social-ecological transformation revolves around establishing a new municipal organization, the Ecomuseum Kristianstads Vattenrike (EKV), which functions as a bridge between local actors, government and wetland landscape. During the whole process of social-ecological transformation, agential elaboration is arrived firstly by the new agential interaction between researchers, officers, senior lecturers, the director of the National Museum of Natural History, and a senior municipal politician and farmers. After successful agential elaboration, societal elaboration is achieved by realizing adaptive co-management arrangements. The ecological elaboration is still hysteretic.

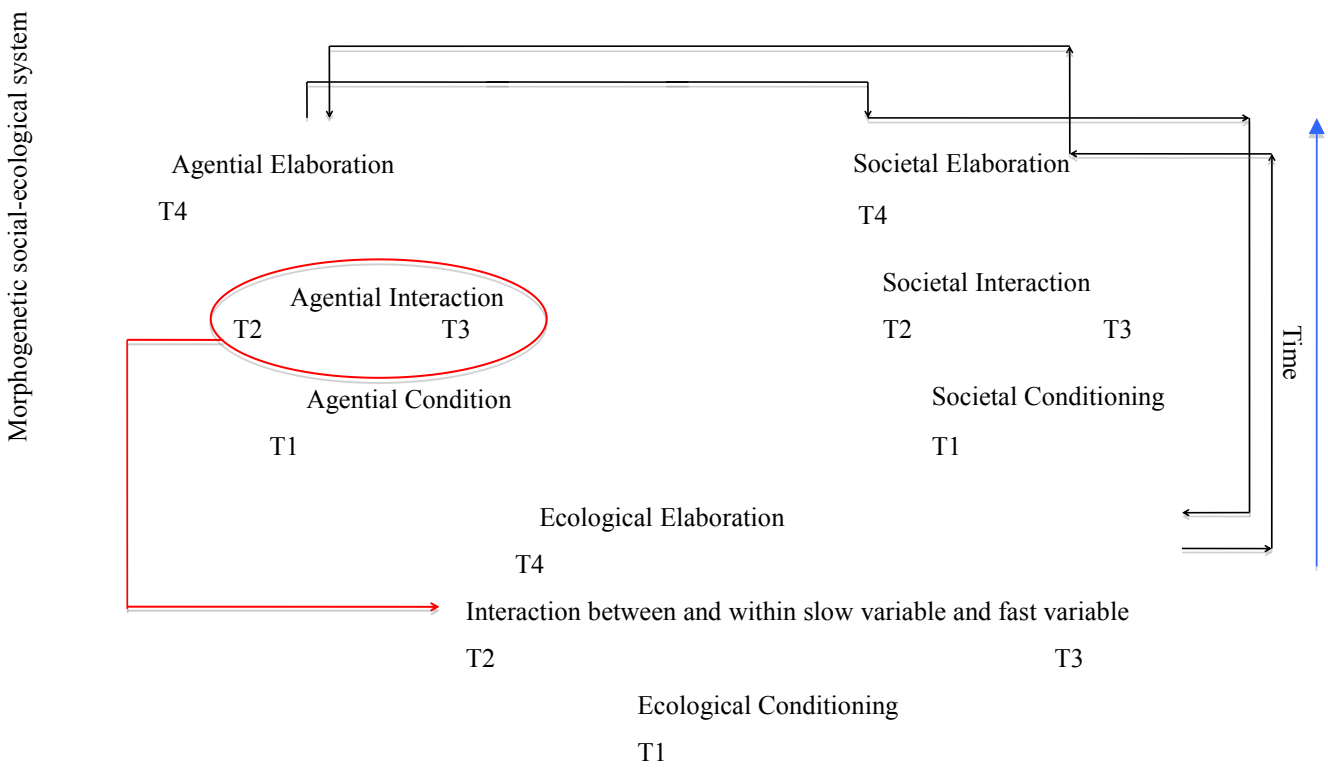


Fig.3-4. Morhogenetic Social-Ecological System Framework (Wang, et al 2015). In MSES, there two critical elements: social-ecological system and time. Social-ecological system is composed of three emergent domains: the agential, the societal and the ecological. Each of these three domains has three emergent levels: condition, interaction and elaboration. Every systematic transformation will start from transforming the interaction between agency in the agential domain and slow variable in the ecological domain. Time dimension emphasizes the matching between the agential domain, the social domain and the ecological domain.

## CHAPTER FOUR. CONCLSION

When the Conclusion part comes, this long dissertation is near the end. As matter of fact, it also means that my new research journey will turn a new chapter based on this theoretical framework. But are these basic research questions (What is social-ecological system? What is sustainability transformation? How does transformation happen in social-ecological system? How can resilience theory and transition management be integrated for studying sustainability transformation well) I mentioned answered by the theoretical framework? The answer is positive. The efforts many researchers have made to integrate resilience theory and transition management suffer from one fundamental flaw: Always does not look deeper than what is on the surface between and among resilience theory and transition management. Before any synthesis or integration, it is necessary to trace to the source of these two research fields, which may appear to be different. In this dissertation, a precise common ground, complex realist, from philosophical ontology and scientific ontology is provided. This sound common ground guarantees the consistency of ontology and epistemology of theoretical framework from beginning of synthesis and integration. On the other hand, the major difference between two is that: resilience theory focuses more on ecological system and social-ecological system. Even regarding for social-ecological system, it has a strong emphasis on social system within ecological system (Fig.4-1). Or social system and ecological system are seen as “black box”, feedbacks between social system and ecological system matter (Fig.4-2). Transformation in resilience theory also focuses more on ecological transformation; in transition approach, it pays close attention to societal system. Transition approach holds that ecological system is within societal system (Fig.4-1). As for transformation in transition approach, transformation mainly happens in regime

initiated by niches, while landscape as environment usually can be transformed. Other than transition approach, the landscape in basin model of resilience theory can be transformed. The other major difference between the two is time dimension. In resilience theory, ecological time dimension is the first priority. Many researchers pay much attention to the mismatches between environmental governance systems and ecological dynamics. In transition approach, societal time dimension is the most important factor. In other words, it is usually measured that how long it will take from an unsustainable energy system to another more sustainable system. The major common ground between the two is that both of them underline transformative change in systematic level. The biggest obstacles to integrating the two are the mismatch between time dimension and the ambiguity of the concept of social-ecological system. Whether ecological system within societal system or societal system within or feedback between societal system and ecological system is just part of the whole story. In MSES, social-ecological system is composed of a simplified three independent, separated but interlinked entities: the agent (A), the societal (S), the ecological (E). Both of societal system and ecological system are not “black boxes” any more. Transformation is also endowed with starting point. Moreover, the three entities are not another three “black boxes”. In MSES, three independent, separated but interdependent emergent levels constitute three entities, respectively. In other words, MESE not only focuses on the interaction between these three entities, but also among different emergent level within and between these three entities. As for time dimension, the interaction between and within slow variable and fast variable becomes an ideal reference point to calibrate the mismatch of time dimension between resilience theory and transition approach. According to MSES, sustainability transformation can be redefined as realization of both of ecological elaboration and agential elaboration or realization of ecological

elaboration, agential elaboration and societal elaboration. In other words, every transformation should realize the ecological elaboration. Or more specifically, sustainability transformation is about emergent elaboration between the ecological elaboration and the agential elaboration, or between the ecological elaboration, the agential elaboration, and the societal elaboration (Fig.4-3 and Fig.4-4). In MSES, every transformation will start from the interaction between agent and fast variable or slow variable or the interaction between fast variable and slow variable, and then could ignite the whole systemic transformation through scaling-up. MSES not only provide a theoretical framework to answer what social-ecological system is, what sustainability transformation is and how social-ecological transformation happen, but also the explanatory methodology on how to pursue sustainability transformation scientific research. Sustainability transformation is still in infancy. There are still no patters and mechanism for understanding sustainability transformation. In my next phase research career, I hope that through reviewing and doing case studies on successful social-ecological transformations, under the MSES, a general patter and mechanism could be got by using agent-based models.

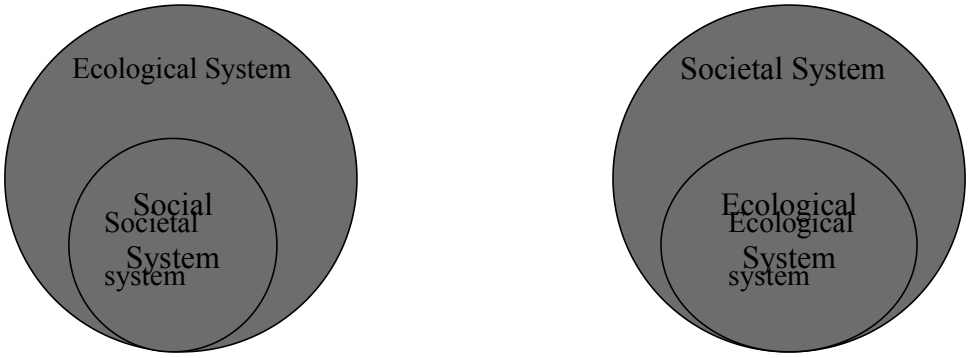


Fig.4-1. Different research view between resilience theory and transition approach

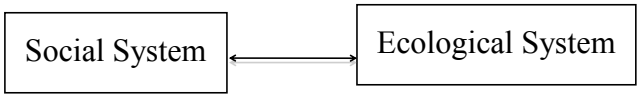


Fig.4-2 Feedbacks between social system and ecological system. Most of studies have focused on flows (energy flow, information flow or material flow) between social system and ecological system. To great degree, social system and ecological system are seen as “black boxes”.

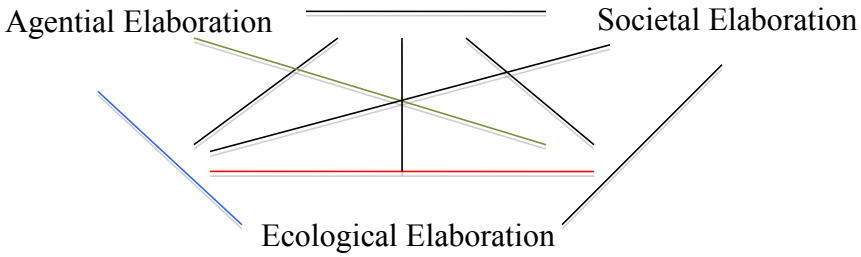


Fig. 4-3. Nodes with 9 relations. In most cases, three nodes have three interactive relationships. “Interactive interaction” is still overlooked by social-ecological research.

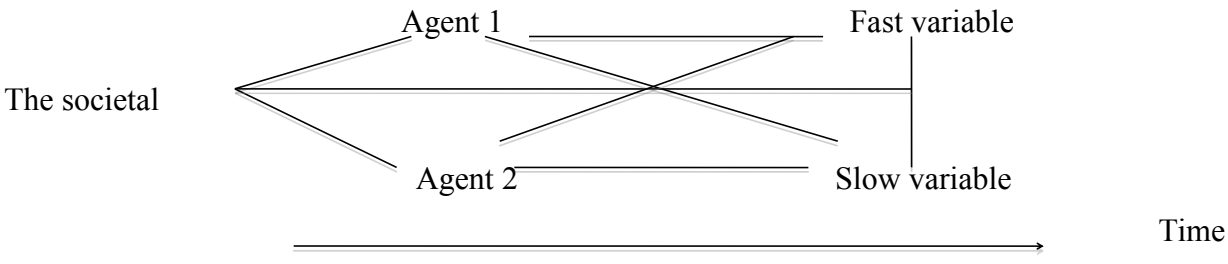


Fig.4-4. Simple MSES model with two agents, two variables, and one the societal

## Summery in Japanese

地球環境問題の解決のために、生態的変革や社会的な変革についての各種のモデルが提案されてきている。そうしたモデルでは、工学や生態学において提案されたレジリエンス理論が応用されている。

本論文では、これまでの社会、生態的レジリエンス理論についての検討を行った。これまで個別に扱われてきた社会と生態系システムを統一的な構造を持つシステムとしてとらえ、持続可能なシステムの変化を生み出すメカニズムについての理論的な構築を提案した。

環境問題は、社会システム―生態系システムの相互関係から説明されてきたが、各々のシステムをブラックボックスとして扱ってきており、内部の構造特性が考慮されていない。この論文で提案する「社会―生態系複合システムの構造理論」では、社会システムを社会構造と文化的背景構造の２つの構造を持つモデルとして構築した。

このモデルでは、個人が構成の基本単位となっていることが特徴である。つぎに、ドライビング要因(agent)の社会―生態系複合システムへのフィードバックを検討した。ここで提案した社会―生態系複合モデルは社会システムに個人を単位とした文化的と社会的構造を入れることで、生態系、人間系のへの個人構成要素の働きを分析的に研究することを可能とする方法論を提案している。こうした方法論の提案は今後の環境問題の対応において、重要な意義をもっている。

## Acknowledgments

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