Dynamics of Societal Transitions
Driving forces and feedback loops

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof.ir.K.C.A.M. Luyben,
voorzitter van het College voor Promoties,

in het openbaar te verdedigen op maandag 14 november 2011 om 10:00 uur
door

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The research resulting in this thesis was supported by the Dutch Knowledge Network on System Innovations (KSI Research Network, www.ksinetwerk.nl).

Layout, and graphics by the author
Printed by Wohrman Print Services [www.wps.nl]

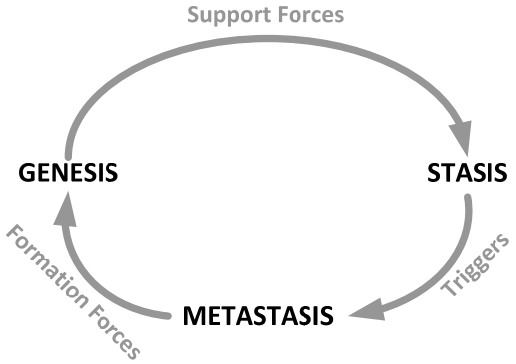
ISBN 9789085705765

Summary

To achieve long-term sustainability a fundamental shift or transformation of a societal system is required. Research on how such fundamental transformative change processes –societal transitions- develop is important for understanding their nature and the possibilities to influence them. The research objective of the present thesis is to add to our insights on the dynamics of societal transitions by an overall understanding of how societal systems behave over the course of a transition.

As a first step, we conceptualize societal transitions as continuous cyclical processes that shift a societal system between stages of dynamic equilibrium. Driving Forces contribute to the shifting from one dynamic equilibrium to another. We propose a framework of Driving Forces of Transformative Change that include: (a) Formation forces, which represent the innovative potential of the societal system and include: Presence of a niche, Presence of a societal demand; Presence of new practices; (b) Support forces, which depict the actions of empowerment or blockage of change and the actions of settlement and institutionalization within a societal system. Support forces are: Standardization of practices, Provision of resources, and Exercise of power; and (c) Triggers, which shock or perturb the system and include those forces that are highly uncertain and whose appearance is uncontrollable. Triggers include Crises, Systemic Failures and Exogenous Events.

The Forces route the system from one stage to another creating evolutionary changes. We conceptualize how a societal system changes over time with the Evolutionary Cycle of the Societal System, which includes three stages that represent the three identified dynamic equilibria: (a) Genesis, (b) Stasis and (c) Metastasis. These dynamic equilibria are characterized by slow dynamics whereas shifting processes to each of these equilibria are characterized by fast dynamics. However, the Forces that contribute to the shifting between stages can also activate feedback loops that keep the system in a particular stage.



The Evolutionary Cycle of the Societal System and the Forces Driving Transitional Change.

The theoretical exploration of societal transitions and the way they develop, added to our conceptualization that the cyclic development can also take place without the Metastasis stage, when bypass processes are in place shifting the system from a Stasis stage to a Genesis stage.

The societal system is conceptualized to consist of different elements that do not change synchronously. Based on this, we propose different types of transitions. By looking at the different types of transitions, we explain how the evolution of a societal system can occur over time. Unfolding of a societal transition as a long-term process with different episodes of change, implies that different aspects of change need to be considered at different times. We propose three types of transitions: institutional transitions, social-ecological transitions and socio-technological transitions.

- We define an **institutional transition** as a type of societal transition in which the forces at play have an impact on the institutions and civil society or, using a mechanical analogue of a force, the forces at play are exerted at institutions and civil society. In a similar way:

- We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment.

- We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology.

In our analysis, we ask the same questions about all the different types of transitions: what are the driving forces? What are patterns that emerge in the evolution of the specific type of transition? We employ an extensive theoretical exploration for grounding the Forces framework and the Evolutionary Cycle in different literature bodies that explain institutional, social-ecological and socio-technological transitions respectively. The theoretical and empirical grounding confirmed that different types of transitions can be distinguished. Understanding that a societal system can undergo different types of transitions, implies that different forces are critical and that different aspects of change have to be taken into account and different instruments need to be devised at different times for facilitating or initiating a societal transition.

We devised the conceptual frameworks of Forces and the Evolutionary Cycle to reconstruct and analyze four case studies, following an instrumental case study approach. Our empirical exploration of the four cases (three of which are non-Dutch cases) confirms the usefulness of the conceptual frameworks and the cyclic character of the unfolding of a transition.

The first case concerns the *institutional transition* of the *water management sector in the Netherlands* (from the 1990s until 2008). This case refers to one regime, the water management regime. Mapping the forces present in the water management transition in the Netherlands on the Evolution Cycle of societal systems, we observe that the water management sector went through two cycles of evolution from 1993 to 2008. It is shown that the institutionalization processes in the water management sector in the Netherlands are lengthy in time. In addition to this, we notice that the 1993 and 1995 floods in combination with the societal demand for flood-safe cities in 1993 initiated the changes in the water management sector in the Netherlands. The Dutch water management case reveals that institutional changes were realized prior to the presence of a societal or socio-political crisis. Provision of resources in the form of research programs to produce input for the policy process on water management as well as frequent adjustments of the main policy on water management with water acts and other legislative actions are prevalent in the water management system. The analysis of the institutional transition showed that in this case, institutional change develops in reaction to *anticipated* environmental changes. This institutional transition thus is policy driven and science driven. Policy-makers and scientific experts constitute a tightly knit group which makes this anticipation possible.

The second case concerns the emergence of an *institutional transition* in the *environmental protection regime in Greece* (for the period of 1986 until early 2000s) in the face of the diversion of the Acheloos river project. The Acheloos River case is an institutional transition between five co-evolving and competing regimes: the environmental protection regime, the energy regime, the water management regime, the Acheloos river restoration issue-regime, and the Acheloos diversion issue-regime. The environmental protection transition in Greece was (and remains) a battlefield for both supporters and opponents of the Acheloos Diversion Project. The opponents of the Acheloos Diversion Project use the environmental protection regulation as a manifesto against the diversion project. The supporters of the Acheloos Diversion Project employed the environmental regulation and especially the Environmental Impact Assessment standards as pre-requirements to a large infrastructure project and strategically supported the perception that the Acheloos river is an infrastructure system and not a social-ecological system. We observe that the forces present set in

motion different feedback loops. These feedback loops reinforce regimes that are in continuous competition; meaning that drivers and counter-drivers (or barriers) are set in place subsequently.

The third case concerns the on-going *institutional transition* of the *electricity sector in Greece* in face of the pressure of the European Union's Directives to increase the use of renewable energy supply. We observe that the energy regime went through four cycles of evolution from 1880s to 2007. We notice that institutional change in Greece takes place in a crisis-induced way, which is the recurrent pattern. Institutional loops were also maintained due to the top-down approach adopted by the Greek Ministries (Ministry of Development, Ministry of Financial Affairs) when dealing with the energy market. Hence, any practice or institutional change that affects the energy market can only be practiced after a law or ministerial decision is set in force. We conclude that the laws preceded any development and condition its trajectory making institutional change central to the energy transition.

The fourth case study concerns the coastal water management regime of the Great Brak River in South Africa and its *social-ecological transition*. The Great Brak Estuary social-ecological transition yielded a new form of institutional arrangements that settled and maintained stewardship of the system's function to the local community. In this case we observe that there were triggers in the initiation of the transition but after that the system evolved without triggers and with the alternation of formation forces and support forces. The good management practices were regularly adjusted and revised following the ecosystem dynamics without triggers (e.g crises). In this way the coastal management system has well adapted its operation to the ecosystem dynamics and the local community with the water managers steward the ecosystem being directly responsible for its health and sustainability.

Our research with the case studies showed that the conceptual frameworks developed fit to explain and detangle transition dynamics. The lessons we derived from applying the conceptual model to the case studies include:

(a) in every case study, forces from every cluster were present over the course of the transition. For a societal transition, different types of forces need to be in place and they act synergistically even when experienced asynchronously.

(b) dynamics of transitions mapped by Forces and Feedback loops reveal the characteristic behavior of the system during its evolution and transition. The behavior of a system depicts the reoccurring tendencies a system shows over time despite the changing triggers or changing problems. For example, the water management regime in the Netherlands showed that it tends to undergo time-lengthy institutionalization processes and then stalemate at the stasis stage. In our diagnostics, this is a behavior of the system and it will re-appear under different triggers or Forces acting upon it.

(c) understanding the dynamics of system transitions as processes including forces and feedback loops opens up the 'black box' of context and its impact on the dynamics of transitions. This contextuality implies that careful analysis of the system dynamics and the context dynamics/influence are required to understand its behavior and history.

(d) the impact of forces can differ when setting a feedback loop in action or putting an end to it. For every system there is a different force that signifies its entry to a loop and its exit from a loop. We consider as critical forces the forces associated with the entry and exit of a system from a feedback loop. From the case studies we observe that there is no homogeneity in the critical forces of the same loops. For example, different forces may signify the entry and exit of self-enforcement loops even in the same system. At the same time, we came across tipping forces: forces that had a significant impact on setting in motion processes in one regime and/or multiple regimes while dampening processes in another regime simultaneously. Tipping forces are forces that tip the system towards a new state of dynamics and that influence different regimes at the same time in similar or different ways.

(e) analyzing and understanding transition dynamics requires a redefinition of the regime as a constellation. The existing conceptualizations of the regime provide a useful ground to base the delineation beyond sub-systems that is needed in explaining societal phenomena, but they require additional characteristics. More specifically, the regime definition by Holtz et al (2008) is broad and comprehensive including all the elements of a societal system, making explicit that technology, institutions and environmental aspects need to be included in the regime analysis. De Haan (2010) differentiated between niches and regimes with the characteristic of dominance of the regime over other entities in the system. The question is: dominance of what? When analyzing the case studies, we add to this by differentiating between policy regimes and issue-related regimes. Policy regimes refer to domain-specific dominant constellations (i.e. energy policy regime or water management policy regime). Issue-related regimes refer to dominant constellations that cluster around a specific issue. Issue-related regimes become established and become empowered by forces or elements from policy regimes and can be inter-domain and inter-level positioned.

(f) Our expectations were that every case would relate to a different type of transition. Our findings did however not match our expectations. For example, the water management system in the Netherlands –focusing on the Rhine river and its branches- experienced an institutional transition despite the strong concerns on rising water level in the river. Institutional dynamics prevail.

The same holds for the environmental protection system in Greece. The Acheloos river diversion project appears as an infrastructure fix to a persistent problem of water shortage for irrigation experienced in Thessaly plain. The two social-ecological systems – the Acheloos river basin and the agricultural system of Thessaly plain- are only linked via the diversion project: they are not directly related (they do not even share the same water table). However the diversion project proposes to employ the Acheloos river basin system as a service to the agricultural system. What our analysis shows is that the competitive relation between the quests for sustainability of two different social-ecological systems was experienced as an institutional transition in the environmental protection system and not as a social-ecological transition. The existing data on the Greek case reveal that environmentally related triggers such as recent droughts have not been reported; while changes in resources flow, environmental protection and impact assessment institutions have been established. Institutional dynamics prevail and the system experiences an institutional transition.

The energy (supply) transition case in Greece also revealed that the system undergoes an institutional transition. Despite the fact that technological push was present, technological changes and progress in the energy supply technologies were not driving the transition. The change of the energy system has been oriented and driven by the institutional and market changes and not by technology. Institutional dynamics prevailed once more.

(g) Institutions are important for realizing societal transitions. We cannot however claim that institutions are the key catalysts in such long-term transformative processes since a sole focus on institutional dynamics as the means to push transitions entails high risks. For understanding the role of institutions in societal transitions a cross-level, cross-sectoral and cross-country analysis and comparison is needed.

Transition theory is needed so as to provide the lenses and knowledge to understand and then search for means to influence or initiate transitions. Research on transition dynamics was so far not explicitly connected to nor informed Transition Management practices. Our research resulted in a number of contributions that address both the understanding of the nature of transitions and inform Transition Management.

We employ the insights we gained by researching transition dynamics to derive governance propositions for promoting ***sustainability transitions***. More specifically, governance based on the understanding of transition dynamics implies that governance interventions are devised in such a way that they consider the dynamics of the system. Our ***governance propositions*** inform the Transition

Management tenet "dynamics of the system create feasible and unfeasible means for governance" and include:

(1) Governance for societal transitions has to strive to produce both formation forces and support forces and to reveal triggers for initiating or setting a transition in motion

(2) Governance for societal transitions has to employ means that mimic the dynamics of transitions in order to internally change the system in a fundamental way

Attempts to change a system that aim at disturbing its dynamics and underlying processes may prove ineffective; especially in systems that tend to self-organize and self-regulate.
Hence, we suggest complementing governance efforts that aim at disturbing the system according to two governance propositions that focus on using the existing dynamics and self-organization of the system so as to incrementally change it in the short-term, with the objective of radically altering it in the long-term.

(3) In a system that undergoes a specific type of transition, means that are homologous[1] to the system dynamics have be to be employed in order to facilitate the on-going transition

Governance Propositions 2 and 3 suggest that governance means need not to disrupt the dynamics of the system. We must note that such means are complementary to governance efforts that aim at shifting the system to a new stage (a new dynamic equilibrium) and/or to a new type of transition (e.g. when a system experiences a social-ecological transition, revealing the potential or benefits of technology may benefit the system and further facilitate the overall transition). We only argue that a governance focus upon means to shift the system may prove ineffective in the face of system dynamics (stages and feedback loops) that are dominant and self-organizing.

(4) Governance for societal transitions has to consider (and if possible anticipate) the existence of and the impact of antagonistic or hampering processes and constellations on the societal system.

In a societal transition, dynamics that evoke change may be counterbalanced by dynamics that resist it. Counter-forces or processes that burden the transition to sustainability may be in place, and consequently countervail or hamper any effort towards sustainability. Governance efforts thus need to consider both enforcing and empowering the new practice or the new regime that has the potential to improve the system's sustainability, while at the same time depowering or deinstitutionalizing the antagonistic (to sustainability) regime.

Our research revealed that there are a number of phenomena/issues that have to be investigated further in the future. These include:
- the role of institutions in diffusing or mediating transitions, as well as the institutionalization and deinstitutionalization processes that are important for the establishment of new niches or new regimes and for the destabilization of existing regime(s) respectively
- the role of actors as carriers of change (policy entrepreneurs versus frontrunners versus transition managers)
- the role of politics in enabling or constraining change.

The research challenges that relate to the Forces Framework concern the quest for understanding the way forces interact in constituting transition dynamics (cumulative versus synergistic interaction) and the impact on the speed of a transition that forces may have (accelerants versus decelerants of societal transitions). Last but not least, how a societal system moves from one type of transition to another towards its (complete) transformation remains a subject for future investigation.

[1] Definition of homologous: Homologous: having the same relative position, value, or structure.

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CHAPTER 1
Introducing transitions, transition dynamics & transition management

Change in societies and in policies is an issue for debate, among scientists and policy makers. It is commonly said that there is nothing more permanent than change (citing Heraklietos) and research has been focused on understanding the change as a subject of research when studying change itself and/or as an object of research when asking what contributes to change. A common argument rests on the impact of crises on societal change. Crises are perceived as the events that have a critical impact on the common routines and perceptions and consequently, on society as a whole.

We experienced a cascade of crises the last three years (2008-2010): the oil crisis that was manifested by an increase of oil prices worldwide, the economic crisis that had and still has a worldwide impact on stock markets, labor markets and societies, and the environmental crisis manifested by the climate change impacts and the frequent natural disasters (e.g. typhoon Megi, and more). Apart from alarming national governments and international organizations to take action, crises may also alter people's perceptions and opinions about the way we live, act and the choices being made. The unavoidable question is: Does a crisis suffice for a change? Is a crisis all we need for a change to start or to materialize?

Change in societies and in the way governments respond and regulate is a continuous process. In simple words, societies and policies change continuously. The causes of change and the conditions for change however cannot be simplified in a limited number of two or three and are debatable. In citizens' eyes, change occurs due to changes of values that new generations bring forward, and due to changing conditions in society, like the introduction of technology e.g. telephony, electricity, internet. For politicians, changes occur due to changes in interests of both citizen and businesses that influence the political agenda. Scientists have always been interested in change, and tried to explain what lies beneath, with different angles and different methods according to their expertise and discipline.

Change is permanent; it is analyzed in different ways. Thinking of the Egyptians, and the Mesopotamian civilizations, changes in water cycles and environmental conditions were linked with good or bad governance and/or social practices. Looking at historical analyses, prevailing conditions for social change include the end of a war, the introduction of a new government or institutional system (e.g. feudalism, democracy) and recently, the introduction and progress of technology (Parsons, 1977). In political analyses, the focus is on the role of ideology and political scientists point at ideas, paradigms and leaders as the stimulators of change. At the same time, economists talk about market forces and the imperative of demand-supply nexus that drives growth and thus, unavoidably underlines change and progress. In all these analyses, change has been seen as an on-going and unavoidable phenomenon that occurred due to changing conditions such as preferences, values, markets, ideas and paradigms. We therefore ask: Is social change a phenomenon that emerges hence it is unavoidable and uncertain how it happens?

The perceiving of social change as an emergent phenomenon overlooks the impact that targets or visions have in driving change. Societies have striven for betterment of their state led by different visions: the democratic society, the welfare society, the knowledge society, the innovation society or the sustainable society. Since 1987 (with the Brundtland report) sustainable development has been introduced as the alternative societal pathway for our societies to achieve a balance between environment, economy, and society and justice of the rights between generations (current and future). Sustainable development has been argued to be the antidote to a continuing environmental crisis, and a discourse that politicians have recently embraced as a new idea or a new way to escape the recent

cascade of crises. We now wonder whether knowing the desirable direction of change suffices to plan our way out of the crisis or simply, to plan for change. At this point, the question arises: Can change be planned? Have we understood how change evolves so as to make educated choices for planning change?

A policy or public administration scholar may offer a lengthy explanation here about the strengths and effectiveness of policy planning and institutions as well as about their limitations in face of the complexity of social change and society in general. As societies become more interlinked due to globalization and to the presence of networks (e.g. commodities' networks to political networks to social networks), planning and governing become challenged with new types of limitations, unforeseen phenomena (e.g. cooperatives, social movements) and new types of problems. These challenges require new thinking and new ways of governing and governance that understand both the urgency in dealing with them and the complexities involved (problem complexity, societal complexity, and process complexity). Is there a way to deal with the avalanche of complexities (e.g. system complexity, problem complexity, process complexity) that both societal challenges and societal change bring forward?

Our debating of the different views and conceptualizations of change can continue and be as lengthy as the history of society, given that societal change was always an interesting and challenging issue for philosophers and researchers. Understanding societal change becomes of high interest for understanding how our societies are going to learn from past experiences and to which extent can shape their future.

Our research objective is to understand what underlies societal change of a specific type: a radical irreversible change that takes long-term to materialize (longer than a generation), that is conceptualized as a societal transition. Our theoretical lens is systems' theory; more specifically, complex adaptive system theory. We therefore aim to explore what underlies societal transitions by exploring societal conditions that can enable or burden societal transitions leaving space to our explanations for a system-wide understanding. We start with understanding that: first, there could be other conditions than crises that stimulate societal transitions, and second, not all the mechanisms and/or conditions that contribute to societal transitions and its characteristics could be emergent. In our research effort, we employ both theory and case studies to understand and analyze the phenomenon of societal transitions focusing on one basic question: *What drives societal transitions?*

The objective of this chapter is to introduce the transitions approach and transition management by presenting and reviewing the key ideas and the language of transitions in the form of concepts and conceptual frameworks. Our aim is to clarify the differences between the different concepts of transitions, as well as the worldview of the transitions approach and transition management.

A societal transition is a long-term process of fundamental change of the societal system that aims at altering its operation so as to tackle a new type of wicked problems, persistent problems, and (in this way) to strive for sustainability. To further understand the phenomenon of societal transitions, we analyze societal transitions as processes of transformation that have an object, a subject and a direction. We introduce the object of transitions, which is the new type of problems (persistent problems), in Section 1.1. The subject of transitions, which is the societal system and its characteristics, is presented in Section 1.2. Sustainability, as the desirable direction of societal transitions is presented in Section 1.3. We will draw on the interdisciplinary grounds that the transitions approach and transition management have been based upon in Section 1.4. More specifically, the history as well as the definitions of the concepts and conceptualizations of both the Transitions Approach and Transition Management are reviewed in Section 1.4 and include: the multi-level perspective, the multi-phase concept and the multi-paths of transitions. Section 1.5 presents the two streams of research that relate to transitions approach: Transition Management and transition dynamics. A brief analysis of the governance philosophy of Transition Management and the current contributions of the research of transition dynamics are also presented in Section 1.5. The objective and potential contribution of the present research thesis on transition dynamics conclude Section 1.5.

Typographical note: We will capitalize the Transitions Approach and Transition Management so as to differentiate between: i) the research field of sustainability transitions and the related management approach as developed by the Sustainability Transitions Research Network (www.transitionsnetwork.org), and ii) the phenomenon of transitions.

1.1 Persistent problems as the object of societal transitions

On societal complexity

Societal complexity has been used as a container concept to describe different types of complexity. In our view, societal complexity encompasses the complexity of the societal system and its manifestations which include complex problems and complex processes (both systemic processes and processes of change). The systemic complexity or complexity of the societal system can be analyzed by the analytical lens of complex adaptive systems theory. Complex problems and complex processes are of interest due to their implications when analyzing societal transitions and when thinking of governance means to enable societal transitions. Wicked problems, and persistent problems in particular, are understood as complex problems. Processes of transformation such as transition processes are also understood as complex processes.

More specifically, modern societal systems are complex, given that they involve multiple actors with diverse interests and resources and a great number of interdependencies between them. This complexity of societal systems does not only rest on the presence of multiple actors but also results from the function of institutions and from the interaction between institutions and actors.

Complexity or uncertainty?

We need to clarify the difference between complexity and uncertainty when referring to systems and their processes early on. Complexity refers to the characteristic of the subsystems of a system and it is a property of the system. When we know the subsystems and functions of a system but its interdependencies and processes are too nested and too intertwined to disentangle, the system is characterized as complex. Uncertainty refers to the inability to foresee how processes or phenomena will develop over the long-term and/or the unknowability of these processes. The distinction between complexity and uncertainty relies on the dimension of time: uncertainty relates to the time dimension whereas complexity as a property is indifferent or, better, unrelated to time. Uncertainty and complexity are frequently used inconsistently to describe societal phenomena. We therefore

conceptualize societal complexity as a property of the societal system and of its manifestations (which include complex societal problems and complex processes) and uncertainty as the property of societal processes only. A societal transition is therefore both a complex and an uncertain process whereas a societal system –in consistency with our conceptualization- is only complex. Additionally, a complex system can give rise to complex and/or uncertain processes but uncertain processes are not necessarily yielded by complex systems only. Last but not least, complexity and uncertainty are not always coupled. A complex process is not necessarily uncertain and visa versa.

Persistent problems

Societal complexity is often expressed by a type of wicked problems, persistent problems. *Persistent problems* are problems that tend to re-appear when intervention just targets their impacts; hence are diagnosed as persisting intervention. The definition of persistent problems is introduced by Rotmans, (2005); Dirven, Rotmans and Verkaik, (2002) and Loorbach (2007, p.14). Persistent problems are complex, are rooted in the structure of the system, and are difficult to manage since they involve multiple actors which operate in a multitude of sectors and governance levels and have divergent interests (Dirven, Rotmans and Verkaik, 2002). Persistent problems tend to reappear when marginal actions that focus on resolving their symptoms only are undertaken. From a transitions perspective, persistent problems are seen as symptoms of the un-sustainability of a societal system (Loorbach, 2007; Loorbach, et. al., 2009).

The recognition of the existence of new types of problems due to societal complexity is also found in writings of multi-actor policy analysis and sociology. From policy analysis research, Brewer and deLeon (1983) illustrate that complexity of social systems produces new types of problems that add to existing complexity.

> "Because of their complexity, social systems are capable of producing problems neither expected nor results intended. Participants may perceive these surprises as occurring outside of their spheres of interest or responsibility; with increased complexity, beneficial and harmful externalities (…) seem to happen more often." (Brewer and deLeon, 1983, p.93)

Looking at transitions from a governance perspective, Mayntz (2006) noted that a transition to sustainability is a challenge. For a transition to be achieved, it is essential to understand the characteristics of the problem in which a deliberatively steered transition can be employed as a means. The core characteristics of new types of complex social problems include the interdependence between actors, the need of actions at multiple levels, the presence of feedbacks with negative impacts on the system and the ill-structured characteristics of problem(s). This complexity asks for new modes of governance. However the modes of governance depend upon the institutions. Hence, changing governance mode requires changes in the institutions to enable the specific governance mode and its related interventions (Mayntz, 2006).

Box 1.1: An introductory example of a persistent problem.

Micro-climate change in urban areas is a persistent problem. Temperature rise in urban areas influences the quality of life in urban centers and creates increasing demands for electricity for indoor cooling, for air pollution mitigation measures and for urban environment betterment measures. The origin of this problem is the landscape design (urban plan) of the cities that includes the design philosophy (mainly space utilization) and the construction material and practices commonly used in urban areas. For dealing with micro-climate changes in urban areas, changes in the way urban areas are designed (designs adaptive to natural landscape) and constructed (materials used) would be suggested that might result in mitigation of temperature change (e.g. mitigation of the heat island effect) and consequently of micro-climate changes. Changes need to be made to the source of the problem and not (only) marginally at improving existing operations (e.g. improving the energy efficiency of cooling systems). In this example, interventions to the source of the problem may prove sufficient and effective to deal with the persistent problem. For persistent problems, an analysis of the problem and understanding of the complexity it adheres are critical for understanding its origins and evolution.

1.2 Complex adaptive societal systems as the subject of societal transitions

Societies have evolved into complex constructs with interrelated and interdependent subsystems and their respective functions. The complexity of modern societal systems is not a new property discovered when a complex systems' perspective is adopted, but a characteristic inherent to them. However the development of new approaches such as complexity theory and complex adaptive systems approach revealed, with their new analytical lenses and concepts, that societal systems are too complex to be managed with conventional top-down methods.

Complex adaptive systems are a special type of complex systems that can adapt to changes and learn from their experiences. Complex adaptive systems have four distinct properties according to Holland (1995): (a) aggregation, (b) non-linearity, (c) diversity, and (d) flows. Aggregation refers to the multi-level and multi-scalar character of systems that shows how the different levels are interconnected. Non-linearity refers to the behavior of complex adaptive systems and specifically refers to the fact that "nonlinear interactions almost always make the behavior of the aggregate more complicated than would be predicted by summing or averaging" (Holland, 1995, p.23). Non-linearity refers to the fact that a relatively small stimulus can bring in return large changes and impacts to the system. At the same time, non-linearity manifests the complexity of processes and structures. Diversity refers to the differentiated responses and forms of complex adaptive systems. Diversity of complex adaptive systems "is the product of progressive adaptations. Each new adaptation opens the possibility for further interactions and new niches" (Holland, 1995, p.29). Flows of energy and resources are present in complex adaptive systems and are characterized by two distinctive properties: the multiplier effect and the recycle effect. The multiplier effect refers to the impact of complexity networks within the complex adaptive systems and "it typically jeopardizes long-range predictions based on simple trend" (Holland, 1995, p.25). The recycling effect refers to cycles or feedback loops that take place in networks within the complex adaptive system. According to Holland (1995, p.26) "recycling can increase output (…), but the overall effect in a network with many cycles can be striking."

Complex adaptive systems co-evolve, self-organize and produce emergent patterns. (see also the review of complex adaptive systems by Rotmans and Loorbach, 2009). Co-evolution refers to the process in which either (a) two systems or subsystems evolve over time while being interdependent resulting in mutual irreversible changes of both systems, or (b) the system and its environment mutually reinforce each others' change processes which results in an irreversible change of the system due to environmental stimuli. Self-organization refers to the imminent capability of a complex adaptive system to organize itself without external involvement. Self-organization is inherent and distinctive to complex adaptive systems (Prigogine and Stengers, 1984). Emergence describes the presence of processes at a high level of aggregation that are not related linearly to lower level decisions or structures. In agreement with this view, Hedstrom (2005, p.74) explains *social emergence*: "From an epistemological point of view, social emergence refers to social properties that cannot, in practice, be predicted by knowing everything there is to know about the pre-emergent properties of the parts."

Complex adaptive systems are also anticipatory, meaning that they have a memory that refers to past lessons and experiences (Holland, 1995). Experience of the past is taken into account by complex adaptive systems not due to their adaptive capacity but due to their system memory that assigns them with anticipatory responses; meaning responses that are based on past experiences of the system as part of the system's memory.

Societal systems have similar characteristics with and appear to behave as complex adaptive systems given that societal domains consist of numerous interlinked subsystems, there is a high degree of uncertainty about their interactions and feedback(s), they have an open and nested character in organization and they tend to self-organize. Therefore, similar patterns can be observed, as for example emerging structures, co-evolving (policy) domains and self-organizing processes. Arguably, this complexity has increased over the last decades as a result of increased interaction, integration and interdependence. We argue that one of the weaknesses of complex system thinking is that it either leads to reasoning about uncontrollability and 'unknowability' of social issues (Teisman and Klijn,

2008; Klijn, 2008a) or it leads to overly complex analyses that do not provide any basis for choice and/or action.

The use of complex systems thinking as a solely descriptive framework resulted in poor insights on tipping points of such complex systems (especially due to the sole focus on social-ecological systems and the limited transferability of the insights to social systems; Scheffer, et al 2001). The complexity of societal systems is revealed when dose-response (or stimulus-response) patterns prove insufficient to explain their behavior. At the same time, the complex adaptive systems approach and innovation studies (with a focus on technology diffusion and development) provided new insights and conceptualizations for the inherent complexity of societal systems and the problems experienced by them (Raven, 2007; Rosenberg, 2009). The reason is twofold: a different kind of dynamics is present in complex adaptive systems; and, these systems experience a different type of problems which persist intervention given that the problems, as behaviors of the system, are rooted in the structures of the system itself. Complex adaptive societal systems thus ask for a governance mode that understands and considers their complexity.

1.3 Sustainability as the desirable direction of societal transitions

Processes of societal change and societal transitions are not similar phenomena. First, societal transitions refer to fundamental processes of change or transformative change. Second, the Transitions Approach focuses specifically on sustainability transitions, meaning societal transitions that have a direction, hence a normative aspect that is a sustainable system state. In Transition Management writings, transitions to sustainability or sustainability transitions are used interchangeably.

Transitions to sustainability are defined as the fundamental processes of change that take a long time to materialize (over a generation) and result in irreversible changes towards a more sustainable system state. We will refer to transitions to sustainability with an emphasis on the direction that is sustainability. Not all historically observed transitions can be characterized as sustainability transitions. We need to understand here that the direction of sustainability represents a modern desire rather than a common practice. The Transitions Approach argues that for persistent problems to be tackled, transitions to more sustainable system states are required. Sustainability thus functions as a normative goal of the Transitions Approach. This implies that the lessons and strategies that derive from the Transition Approach aim at ways to direct or enable such processes under the sustainability goals.

Sustainability refers to an aggregate value of the system that encompasses properties defined in sustainable development writings. Sustainable development is the process towards a sustainable society. Since the late 1980's, many countries have committed themselves to sustainable development but are struggling with how to achieve it. Following the Brundtland report *Our Common Future* (WCED, 1987), sustainable development came to be defined as redirection of social development in ways which combine prosperity, environmental protection, and social cohesion. In this report, sustainable development was defined as a development that meets the needs of the current generation, without compromising the needs of future generations (WCED, 1987). This definition is normative, since future generations should have the same possibilities, subjective, since it requires an assessment of what these future needs are, and also ambiguous, since these future needs are determined by cultural, ecological and economic developments that can be weighted in more than one way (Martens and Rotmans, 2002; UN, 1997).

At the international level, there is a consensus on the need for sustainable development and key areas in which significant progress needs to be made in the next decade: poverty, hunger, health, education, life expectancy, environmental sustainability and global partnerships (UN, 2005). The approach to sustainable development adopted by the United Nations is to realize overall consensus while allowing for a variation of strategies and solutions to be chosen by individual countries, regions and actors at different levels (UN, 2005). This means that in practice different countries have taken up different strategies to cope with the challenge of achieving sustainable development. A lot of countries opted for sustainability councils and the development of sustainability indicators (Mulder, 2006, pp.148-

165). In this context, sustainable development has been represented as the intersection of economic, social and environmental agendas and the need to integrate (predominantly) environmental concerns into regular policies.

We can derive some basic characteristics that are attributed to the concept of sustainable development in almost all definitions used in scientific writings. The first is that sustainability is intergenerational. This means that a long-time horizon, at least one or two generations (25-50 years), has to be considered when analyzing the transition and for examining the changes that have been realized. The second characteristic is the importance of scale. Sustainability occurs at different levels; local or regional sustainability does not necessarily mean national or global sustainability and vice versa. The third common characteristic is that sustainability relates to multiple domains. Sustainability encompasses a certain context-specific balance between ecological, economic and socio-cultural values (Kates et. al., 2001; Pezzoli, 1997). Sustainable development is therefore a normative orientation that provides a frame of reference to discuss and bring forward differences in perception, ambition and understanding between actors in light of desired changes in society.

Arguably, sustainable development as a broad notion of integrative and balanced, yet flexible, societal development should be used as guiding principle for future-oriented actions. This means that the challenge of sustainable development can be formulated in terms of the quality and the characteristics of a continuous governance process that enables representation of various perspectives, values and interests and creates space for experimentation, innovation and learning (Loorbach, Frantzeskaki and Thissen, 2011). Understanding the way the dynamics of societal transitions unfold over time and how they can be anticipated, adapted to and influenced towards sustainability is the central aim of the Transitions Approach.

Thus an important difference between the Transitions Approach and any other approach with a focus to change is the direction or normative orientation of the Transitions Approach towards sustainability.

1.4 Transitions and the Transitions Approach

Transitions and Transition Management are concepts that entered public policy and public administration with the Fourth Environmental Policy Plan in 2001 in the Netherlands (VROM, 2001; see also Kemp and Rotmans, 2009, p.312). A research program on transitions named KSI Program was established in 2003 (Rotmans, Grin and Schot, 2003). At the beginning of the research program, experienced policy researchers believed that transitions was not more than a hype concept and Transition Management received both criticism and attention early on (Shove and Walker, 2007). In the last ten years of transition research, there has been research on the concepts of transitions, the explanatory capability of transition frameworks (such as the multi-level framework, the multi-phase framework etc) and in-depth research on both transition dynamics and on (tools of) Transition Management (e.g. transition scenarios, transition experiments).

Informed by societal complexity and the limitations of existing governance approaches, a new approach to deal with persistent problems is introduced (Rotmans, 2005; Martens and Rotmans, 2005): the Transitions Approach. The Transitions Approach starts from the understanding that persistent problems are rooted in the structure of the system. Consequently, marginal changes in organization or operation of systems are seen as ineffective in dealing with persistent problems. Hence a fundamental change of the system is proposed. In simple words, the Transitions Approach proposes a fundamental change in the societal system – a transition- instead of a treatment of the symptoms (of those problems). A transition has been defined by Rotmans et. al., (2001, p.2) as “a gradual, continuous process of structural change within a society or culture”. A societal transition is introduced as a fundamental change to a societal system such as the energy system or the healthcare system. A societal transition includes multiple actors, takes time to materialize, and targets system pathologies that require drastic action so as to be resolved. In Box 1.2 a number of definitions of transitions are included that shows how a transition has been conceptualized from the beginning of the transition research program. A common characteristic to all definitions presented in Box 1.2 is that a

transition is conceptualized as a *process* of fundamental radical change that is the outcome of multiple interconnected processes.

Historical transitions such as energy supply or mobility transitions were *semi*-autonomous societal processes; the majority of historical transitions were not steered in a collective way but emerged as a societal outcome. A transition is thus, a societal process of fundamental change. In our current era, the need to actively influence transitions so that they lead to more sustainable directions, and explorations into the possibility of orienting such societal processes, yielded a new process-oriented approach for management: Transition Management. Along with the research on how to steer transitions (Loorbach, 2007), a new research field for analyzing and understanding such processes of societal change has been created.

Box 1.2: Definitions of transitions.

(a) "A long-term process of change during which a society or a subsystem of society fundamentally changes" (Rotmans, et.al., 2000) and (Rotmans, et.al., 2001)
(b) "A shift from an initial dynamic equilibrium to a new dynamic equilibrium" (Kemp and Rotmans, 2001)
(c) "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)
(d) "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, p.1136- Box 1)
(e) "A transition is a shift from one socio-technical system to another i.e. a system innovation." (Geels, 2005a)
(f) "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)
(g) "A transition denotes a long-term change in an encompassing system that serves a basic societal function" (Elzen and Wieczorek, 2005, p.651)
(h) "A transition emerges out of co-evolutionary processes in which institutional, technological, behavorial, ecological, economic and other processes intertwine and reinforce each other." (Loorbach et. al., 2009)
(i) "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, p.324)

1.4.1 Transition concepts

The concepts and conceptualizations of transitions comprise the language of the Transitions Approach. Among the transition concepts, the transition curve (Rotmans, et. al., 2001) and the multi-level framework or perspective (Geels, 2005a) are the most used and applied to explain how societal transitions develop over time.

History of the Transitions Approach

Social change has been the subject of research by (different approaches of) the social sciences and we can argue that to a certain extent, transitions have been studied by social sciences. This is not to say that all social changes constitute a transition, but several scholars have studied large scale societal change in some form such as political revolutions, industrialization, cultural revolutions, and the secularization. What is distinctive in transitions research is that we deal with a specific form of social change which is transformative change, meaning irreversible radical change that takes a long-term to materialize.

To understand where this language came from it is necessary to understand how the field came into being historically and which scientific fields inspired or were integrated in the Transitions Approach. One strand of transition research stems from the study of socio-technological transitions where the change of a technological regime is studied within the social context surrounding it (Geels, 2004;

2005a; Geels and Schot, 2007). This line of research has its origins in innovation studies with a historical focus as its analytic technique.

The other strand is the research on Integrated Sustainability Assessment. Integrated Sustainability Assessment deals with the intersection between science and policy in multi-actor contexts so as to explore opportunities for dealing with or reframing complex societal problems (Weaver and Rotmans, 2006). Integrated Sustainability Assessment is a participatory process, and as such it includes different stakeholders which often makes problem definition and reframing a problem in itself (Rotmans and Van Asselt 2001; 2002; Pahl-Wostl, 2000). Participation of stakeholders is important given that the reframing and learning in view of sustainability attainment are related to values and translations made by the stakeholders of the system or issue of interest (Pahl-Wostl, 2000, p.267). In Rotmans and De Vries (1997, p.240), Integrated Sustainability Assessment is defined as "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". These two strands collided when they were confronted with sustainability as a topic and transitions towards sustainability as a possible approach.

The multi-level perspective

Processes of change take place at multiple levels. Transitions can be viewed as outcomes of the continuous change of actor's practices and the interactions of practices and developments that take place at different levels. Changes in every level of interaction produce a convergent change that is perceived as a system transition. In the Transitions Approach, and especially in the socio-technological transitions writings (Geels, 2005a; 2010; Geels and Schot, 2007), three levels are identified in which changes take place: The micro level where niches are located, the meso level where regimes are placed, and the macro level that hosts trends, and developments such as globalization (Figure 1.1). More specifically, niches are active at the micro-level and are incubators of innovation, meaning that they are protected spaces within which innovation can be bred. In socio-technological transitions writings and in strategic niche management writings, the focus is on technological innovation that is located in niches (Geels, 2005a; Hoogma et al, 2002). From the perspective of Transition Management however, niches can include institutional, cognitive, and/or behavioral innovations (Loorbach, 2010; van den Bosch, 2010). The regime is located in the meso-level and the macro-level accommodates the developments and impacts that are "external" to niche- and/or regime-actors' influence. These levels are neither hierarchically layered nor aggregated. This implies that a regime does not consist of niches and a landscape does not consist of regimes. The micro, meso and macro-levels are part of a descriptive framework of the constellations that interact during a socio-technological transition.

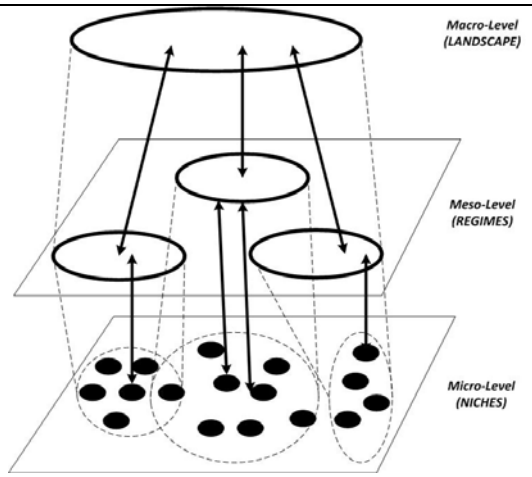


Figure 1.1: The Multi-Level Perspective. (Geels 2005a)

More specifically, Geels, (2004) researched socio-technological transitions and developed the multi-level framework (lately named multi-level perspective - MLP) to describe the development of socio-technological transitions. According to Geels (2004, p.33) the levels "are not ontological descriptions of reality but analytical and heuristic concepts to understand the complex dynamics of socio-technical change." Geels (2004, p.26) views innovation as the outcome of the marriage between market and technology: if a number of market-related conditions are present, innovation is feasible. He does not search in depth for those conditions and how these conditions influence the course of a transition.

Macro level: According to Geels (2005a, p.684) "the macro-level is formed by the socio-technical landscape, which refers to aspects of the wider exogenous environment, which affect socio-technical development (e.g. globalizations, environmental problems, cultural changes). The metaphor 'landscape' is used because of the literal connotation of relative hardness, and to include the material aspects of society, e.g. the material and spatial arrangements of cities, highways, and electricity infrastructures. Landscapes are beyond the direct influence of actors and cannot be changed at will".

In Geels (2004, p.34) "the socio-technical landscape contains a set of heterogeneous, slow-changing factors such as cultural and normative values, broad political coalitions long term economic developments, accumulating environmental problems growth, and emigration. But also contains shocks and surprises, such as wars, rapidly changing oil prices. The main point is that the landscape is an external context for actors in niches and regimes." Landscape factors are difficult to influence, and consequently difficult to change. This however does not imply that every factor that is difficult to influence is placed on the landscape. The multi-level perspective places trends and developments that are mainly external, to the regime and to the niche, at the landscape level.

In their recent analysis of the multi-level perspective, Smith et al (2010, p.441) conceptualize that the socio-technological 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."

Meso level: According to Geels (2005a, p.683) "the meso-level is formed by socio-technical regimes."

We note that the notion of ***regime*** in Transitions Approach and Transition Management has a defining role. The regime is seen as the system unit in which transitions need to take place. The definition of the regime and its characteristics relies on the scope of the analysis and the policy issue at hand. Therefore there is no methodology or theoretical guidance on delineating the regime in transition studies.

In the socio-technological transitions' literature, regime is equivalent to a technological regime, since technology is perceived to play a critical role in on-going transitions. As addressed by Rip and Kemp (1998, p.340), "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." As argued by Geels (2005a, p.683) "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." In our view, technological regimes capture the aspects of both technology and technological changes that dominate socio-technological transitions, but it overlooks social and institutional characteristics and their impacts.

Elzen and Wieckzorek (2005, p.654) specify that "transitions are defined to occur in encompassing regimes (systems) in relation to basic human needs. Each of these regimes is characterized by a range of technologies, infrastructures, patterns of behavior, cultural values, policies etc." Holtz et al (2008) analyze the characteristics of regime in an attempt to specify how to frame, define, analyze, and dissect the regime. Holtz et al (2008, p.626 & 629) provide a definition of the regime that in our view, summarizes how regime is viewed in Transition Management and energy transition studies: "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." With this definition, Holtz et al (2008) (re)conceptualize the regime in a holistic way. His conceptualization complies with the majority of the transition studies that consider the regime as a system-level configuration and consequently it places the regime at the core of the transition process (de Haan, 2010). Last but not least, Geels (2011, p.31) summarizes the

analytical difference between a regime and a system as follows: "System (…) refers to tangible and measurable elements (such as artefacts, market shares, infrastructure, regulations, consumption patterns, public opinion), whereas 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, promises, social expectations and norms)."

Micro level: According to Geels (2005a, p.684) "the micro-level is formed by technological niches, the locus for radical innovations ('variation'). (…) Niches are important because they provide locations for learning processes and space to build the social networks which support innovations." "Niches also provide space to build the social networks which support innovations, like supply chains and user-production relationships." (Geels, 2004, p.35). "Niches are protected experimental settings where norms and practices are developed which depart from those of an incumbent technological regime. According to niche-based understandings, regime changes begin when practices and norms developed in the niche become adopted more widely." (Berkhout, Smith, and Stirling, 2003, p.48; see also discussion over niches Smith, Stirling, and Berkhout, 2004)

Inter-level interaction: Based on Geels (2004, p.913-914), the changes within the regime –changes that take place in the meso level having a meso-to-meso direction- are viewed as tensions. In response to this, Geels (2004, p.914) argued that "tensions and mis-matches occur in the activities of social groups and in socio-technical regimes. This creates 'windows of opportunity' for the break-through of radical novelties." The causes of these tensions are rooted in internal inertia of the regime, inefficiencies of current technology, "negative externalities and effects on other systems", perceptions change ("change in user preferences") and market conditions ("strategic and competitive games between firms").

The multi-level perspective of transitions as developed by Geels (2004; 2005a) is a valuable conceptualization of the nature of transitions. The multi-level perspective has been employed as a descriptive framework by different scholars to explain socio-technological transitions and to aid both the analysis and the suggestion of alternatives for innovation support (e.g. Kivits et al, 2010; Nykvist and Whitmarsh, 2008; Markard and Truffer, 2008). Geels (2010, p.495) in his recent discussion about the multi-level perspective, notes that it is an analytical tool and that it "provides an overall view of the multi-dimensional complexity of changes in socio-technical systems".

The multi-phase concept of transitions

Revisiting the concept of transition, it is a long-lasting process of change. When attempting to explain the development of long-lasting transitional changes, the delineation of phases of change is essential. In every phase different processes and dynamics take place, and at the end of every phase the state of the societal system is significantly different.

A transition can be viewed to progress in episodes of change (inspired by Giddens, 1984, p.244 & 374) where significant changes in the system signal the passage of the system from one phase to another. More specifically, transition phases are time periods in which developments take place that result in irreversibly changing the system. Hence, the passages from one phase to the other signal different types of changes and processes. Along the phases, existing structural subsystems of the societal system (values, institutions, regulations, markets etc.) fade away while new ones emerge (Geels, 2004; Loorbach et al, 2008). This is in line with the central conceptualization of the Transitions Approach, according to which societal systems go through long periods of relative stability and optimization that are followed by relatively short periods of radical change. Specifically, the multi-phase framework of transitions is rooted in the hypothesis that "the dynamics of transitions in time can be described as altering phases of relatively fast and slow dynamics, which together form a strongly non-linear pattern where there is a shift from one dynamic state of equilibrium to the other" (Rotmans, 2005, p.23).

Martens and Rotmans (2005) and Van der Brugge and Rotmans (2007) have described a quad-phase framework of transitions and they are presented below (Figure 1.2).

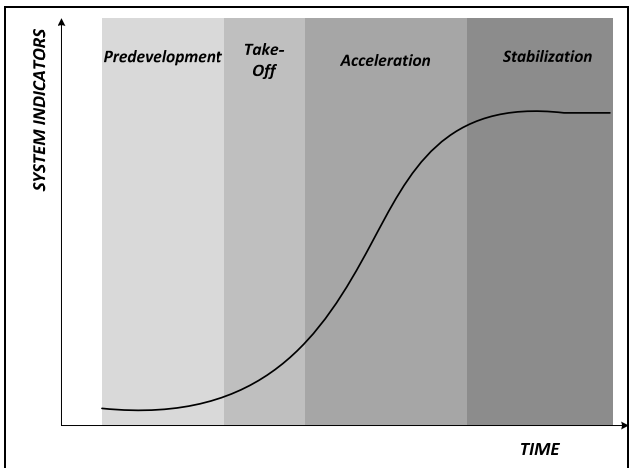


Figure 1.2: Transition Phases.
(Rotmans, Kemp and Van Asselt, 2001)

The phases of transitions are defined by Van der Brugge and Rotmans (2007, p.254-256):
Predevelopment phase: "co-evolutionary regime dynamics increase regime interdependencies"; "innovations are still isolated and fragmented, improperly embedded and insufficiently developed enough to compete with the existing regime".
Take-off phase: "Triggering change and build up of a new regime", "innovations start acting as perturbation of the status quo" ,"regime dynamics collapse when the systems key functions fall out", "build-up of innovation networks based on alternative ideas, concepts, theories, and technology"

Acceleration phase: "the 'old' regime transforms and consequently the 'selection environment' changes and is primarily based upon selection rules from the up-scaled innovation network"

Stabilization phase: "the new regime settles down. Transformation processes turn into optimization processes. Regime dynamics now are equilibrium dynamics in order to enhance efficiency. If this equilibrium is not reached, the new regime can still breakdown."

The multi-paths of transitions

A first step to explain transitions is a classification of transitions using the sigmoid curve as an initial mapping of the transition evolution. A *transition path* is one curve that maps the transitional evolution of a system (Figure 1.3). Since every system is viewed as a substantially unique entity, its transition path differs from the transition paths of other systems. As stated by Rotmans, Kemp and Van Asselt (2001, p.18) "it is possible to have different paths to the same equilibrium level as well as it is possible for the same transition pattern to be realized in different ways." Although transition paths lead the systems to their new state, characteristics of the end state of the systems can be used as foundations for a classification scheme.

History has witnessed numerous transitions in economy, agriculture, mobility, and energy, but also in areas such as education, health care, and social structure (Geels, 2004; Rotmans et al, 2001). In these domains, relatively long temporal stretches of stability alternated with relatively short periods of rapid social change.

According to Rotmans (2005, p.23-24) "the manifestation of alternating phases is the so-called S-curve: an aggregation of underlying curves. However other manifestations in time are also possible as given in Figure 1.3. The S-curve represents an ideal transition, in which the system adjusts itself successfully to the changing internal and external circumstances, while achieving a higher order of organization and complexity. However, non-ideal or even reverse transitions are possible." These transitions do not always follow the S-curve but can also be mapped with other transition paths as shown in Figure 1.3. Given the complexity and the uncertainty incorporated in a societal transition, the transition paths do not represent all changes that take place over time. In our view, a transition path can represent the evolution of a practice in time.

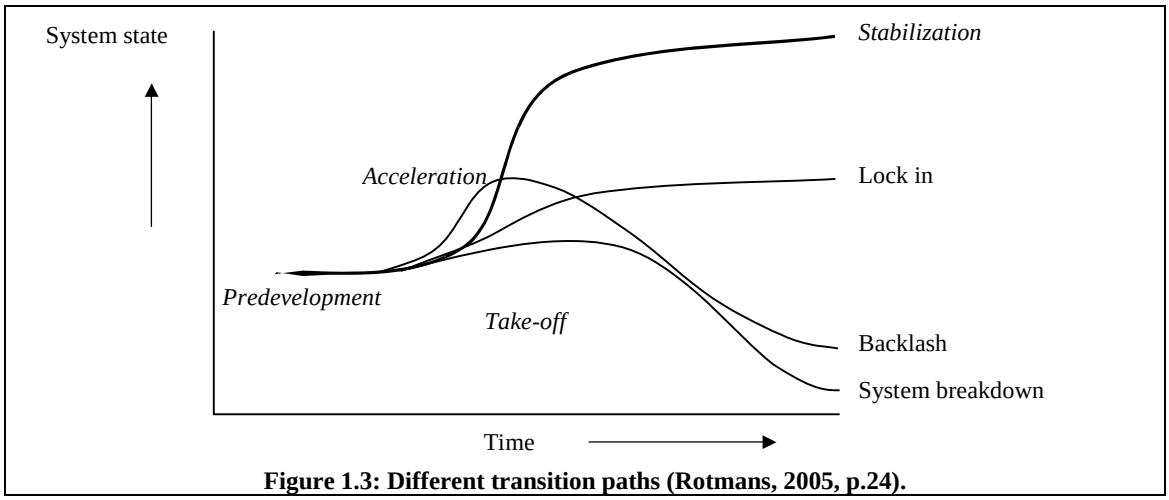


Figure 1.3: Different transition paths (Rotmans, 2005, p.24).

In Rotmans and Loorbach (2010a, p.130) is noted that the indicators on the vertical axis are unknown and "rather meaningless and needs to be formulated more accurately."

In our opinion, the Y-axis indicator –placed in the transition path plots- should reflect the case specific characteristics related to the system state. For example, the different transition paths could map the development of an activity or of a new practice in time, whereas the Y-axis may indicate the percentage of actors (or the population size of actors) using the new practice or innovation.

1.4.2 Principles of transitions

The above concepts constitute the language of transitions and the basic conceptual frameworks of the Transitions Approach (especially the multi-level and the multi-phase perspectives). The Transitions Approach also includes (a number of) conceptual principles that communicate in a simple form the main conceptualizations complementary to those described above. The conceptual principles present how the Transitions Approach builds on its underpinning disciplines (e.g. social theory, complex adaptive systems approach and more). In this way, the conceptual principles show what the Transition Approach contributes to existing theories by showing how it extends existing concepts and knowledge.

The conceptual principles have raised criticism among practitioners and researchers of public administration and policy science because in their formulation the conceptual principles include terms that contradict each other; thus formed as oxymora. The formulation of conceptual principles as oxymora provides a novel expression of the concepts to be introduced since the contradiction is only apparent.

In this thesis, we will introduce, as oxymora, the two conceptual principles that depict the nature of a transition: (a) coordinated emergence, and (b) evolutionary revolution. The objective of this section is to elaborate on these concepts and to discuss the aspects (within them) that require more research. The analysis will be realized in two steps: First, an elaboration of each oxymoron in the form of opposing statements while grounding them in governance theories, and second, a presentation of the meaning of each conceptual principle within the Transitions Approach.

Coordinated Emergence

A transition is conceived as a process of fundamental change that has both an emergent and coordinated aspect. The Transitions Approach and Transition Management build on concepts of complex adaptive systems, such as coordination and emergence (Rotmans and Loorbach, 2009, p.186&189-190). The contradiction comes from the combination of two seemingly exclusive characteristics: coordination refers to the stimulus-response pattern of complex adaptive systems and emergence refers to the autonomous response that appears to emerge.

Complex adaptive systems' theory offers the ground for explaining the contradicting elements of this conceptual principle. In complex adaptive systems, stimulus-response is the pattern of behavior of an agent that relates to a "collection of rules" (Holland, 1995, p.7) and the relation between the stimulus and the effect are not linear, meaning that a small input may yield major changes or a big influence may yield insignificant changes in response (Holland, 1995, p.5). In addition to this, a complex adaptive system is a system that continuously adapts to changing contexts and learns from its environment (McMillan, 2008, p.60). We can conclude that a form of causality between action and reaction exists referring also to the stimulus-response pattern apparent in complex adaptive systems. Coordination in this regard refers to the 'collection of rules' that can be in place and in a limited fashion explains stimuli-responses patterns.

Emergence as a property of complex adaptive systems relates to the system's structure as it is formed by previous decisions. The structure of the complex adaptive system allows processes to emerge (Dyke, 1988, pp.26-27). Emergence refers to phenomena that may rise on a higher level of aggregation from the level where existing structures are placed. At the same time, there is no immediate relation between the emergent phenomena and the structure of the system. Additionally, emergence is the outcome of the continuous interaction between the multiple agents and the multiple levels of complex adaptive systems (McMillan, 2008, p.63). Emergence is therefore a property of complex adaptive systems that manifests the complexity of their structure and systemic (immanent) processes and implicitly reveals that causal explanations of behavior of complex adaptive systems are incomplete.

Emergence however has also been studied by scholars in sociology such as Durkheim and more recent ones like Sawyer (2001; 2002; 2005). A definition in Sawyer (2002, p.228) of emergent systems says that those systems have a "global behavior that cannot be predicted from a full and complete description of the component units of the system". In line with this, emergence as a property of complex adaptive systems implies that direct causality between structure and processes does not exist.

A transition is conceptualized as a societal process of fundamental change that has both an emergent and a coordinated character. Coordinated emergence describes the principle of radical change in incremental steps that combines both the emergence and the coordination. In this way, the Transitions Approach integrates both coordination and emergence in conceptualizing the nature of the transition as a phenomenon: it can be coordinated while having an emergent character.

Evolutionary Revolution

A transition is further conceptualized as a process of fundamental change that includes revolutions in different times and domains that jointly contribute to the evolution of the system on the long term. A revolution is an action or movement that is radical and sudden and changes fundamentally the existing system or regime. Prevailing examples of revolutions include the Copernican revolution in science where a paradigm change took place (from the Ptolemain view of the universe that positioned the Earth at the center of the universe towards positioning the sun in the center of the universe, the heliocentric system), or a political revolution where a political regime is overthrown by another.

A revolution within the Transitions Approach is seen as constructive for the transformation of the societal system. The opposition comes from the contradiction between two ontologically exclusive characteristics of change: evolution refers to continuous adaptation, mutation and selection while revolution refers to drastic immediate and irreversible changes. The development time of the two change processes differs as does the way change is realized.

Political theories and evolution theory offer the grounds for understanding the opposing elements of this conceptual principle. Evolution in nature found his main expresser in the face of Darwin. There are three key elements of evolution that cast our focus: (a) the process of evolution (b) the nature of evolution and (c) the complexity of evolution. First, Darwin's variational evolution postulates that "evolution is the turnover of the individuals of every population from generation to generation".

Evolution is thus the outcome of continuous processes of adaptations, selections and mutations (Mayr, 2001, p.92). Second, evolution is a random but guided process. As Mayr (2001, p.234) presents, the characteristic of evolution is that "is a directional change". What we can also add to the characteristics of the nature of evolution is that evolution as a process that might take decades to be realized but it happens; hence there is no uncertainty on the realization of it but only on its outcome. Third, evolution is a complex process, given that interactions and changes of one organism impacts and influences its related organisms. Given that organisms however are not standing alone in nature, the evolution of one organism has an effect on the evolution of its related and surrounded organisms. During the interaction of "two kinds of organisms (…) lets say a predator and its prey (…), each will exert a selection pressure on the other" and "the result is that they co-evolve" (Mayr, 2001, p.231). Summarizing, evolution is a directional change that is the outcome of continuous processes of adaptation, selection and mutation, and the evolution of an organism has an impact on the evolution of its related organisms, a phenomenon of co-evolution.

Revolutions on the contrary, are drastic radical changes that have a high impact on the societal system and are highly uncertain. Sanderson (2005, p.3) perceives revolutions as "modern phenomena (…) and product of modern world (…) because of the enormous changes wrought by the rise of modern capitalism and the growth of the modern state". Sanderson (2005, p.1-2) adopts the definition of Cohan (1975) for the nature of revolutions as a change that alters the basic values of a society, its social structure and institutions, brings changes in the structure of leadership, alters and shifts power in non-legal or illegal way and is characterized by the presence or dominance of violence in the actions that make a regime to collapse. Sanderson (2005; 2007) reviews and discusses a number of approaches from political science and social science that deal with the nature and the causes of revolutions. In his explaination of revolutions, it is summarized that revolutions occur as a conjunction of events that are "the necessary structural forces behind the revolutions" and that revolutions "are (…) the result of unintended consequences" (Sanderson, 2005, p.106; following Skocpol, 1979).

From cultural studies and cultural anthropology, we find explanations that come in line with the arguments of social evolutionists. More specifically, White (1959, p.281; cited by Wolf, 1976, p.70) says "when the changes are quantitative we call the process evolution, when they are qualitative we call revolution. Evolution is change within the framework and the limits of the system. Revolution is a radical transformation of a system; the substitution of one principle or basis of organization for another." The cultural anthropologists focus on the magnitude of change and their nature when referring to revolution and evolution, giving a consistent interpretation. In the same vein as White (1959), Hockett and Ascher (1964, p.135), argue that "a revolution is a relatively sudden set of changes that yield a state of affairs from which a return to the situation just before the revolution is virtually impossible." From the review of social, cultural and political theories thus, we understand revolutions as drastic changes that alter societal systems in their structure, institutions and ideologies, and which are highly uncertain (Table 1.1).

Table 1.1: Evolution versus Revolution in a nutshell.

Characteristics	Evolution	Revolution
Nature of change	Directional change	Radical and sudden change
	Convergence of processes of adaptation, selection and mutation	Conjuncture of social forces
Degree of complexity	Complex process that impacts related elements and context (co-evolution)	Outcome of complex processes and events
Degree of uncertainty	Certainty as natural phenomenon Uncertainty of outcomes	Highly uncertain as phenomenon Uncertainty of outcomes

In the Transitions Approach, transitions are conceptualized as processes of change that are realized over the long term and are products of the combined effect of structural forces and developments in multiple sectors and levels (Rotmans et al, 2001). In Loorbach et al, (2009) it is pointed out that

"transition emerges out of a co-evolutionary processes in which institutional, behavioral, ecological, economic and other processes intertwine and reinforce each other". Evolutionary revolution thus refers to the process of fundamental change (revolution) as a sum of incremental changes (evolution) that constitutes a transition of the societal system.

The principle of evolutionary revolution is also discussed by Rotmans and Loorbach (2009). They refer to the governance viewpoint that underlies "radical change in incremental steps":

> "Radical structural change is needed to erode the existing deep structure (incumbent regime) of a system and ultimately dismantle it. (…) Incremental change allows the system to adjust to the new circumstances and to build up new structures that align to the new configuration. Radical change in incremental steps implies that the system heads in a new direction toward new attractors but in small steps." (Rotmans and Loorbach, 2009, pp.189-190)

More specifically, when describing and analyzing a transition, a fundamental change in the societal system is recognized on a long-term horizon that is the product of changes that are spread along time (short-term incremental changes). This however does not imply that all short term changes need to be radical but that a combination of radical and incremental changes is needed to yield a transition.

Later in this thesis, these two conceptual principles will be revisited with insights from the research on the dynamics of transitions, so as to better inform Transition Management for enabling transitions in various regimes or systems.

1.5 Transition dynamics and Transition Management

Societal transitions are phenomena that take place in a societal system and are processes of fundamental change. Even though concepts and conceptual frameworks on transitions have been developed, research on the phenomenon of the transition and the different ways it may be influenced and oriented is required. Hence, two streams of research have been distinguished: (a) Research on transitions as societal processes and phenomena of the societal system, that focuses on the *dynamics of societal transitions* and (b) research about the different ways a transition can be initiated, oriented or steered, that focuses on *Transition Management*.

1.5.1 Transition Management

Research on Transition Management preceded in time the research on transition dynamics, given the urgent need for a new way of managing societal complexity and for finding new tools to intervene, initiate and/or orient such processes of change. Transition Management[2] is a new governance approach that provides instruments with the potential to steer societal systems (e.g. energy system or health care system) towards sustainability goals by creating space for innovations, by enabling innovations, and by experimenting (Loorbach, 2010). Transition Management has been characterized as a governance approach for long-term policy planning (Voss, Smith and Grin, 2009).

> "Transition management combines an orientation toward a long-term vision of 'sustainable development' with short-term experimental learning to probe options and find pathways to realize the vision. Its time horizon is 25-50 years. Over the course of the process the vision may be adapted as learning about options proceeds. This in turn, may shift criteria for designing and evaluating experiments. This recursive cycle for meeting substantive goals (e.g. reductions in carbon emissions, increases in resource efficiency, enhancements in biodiversity) is a key characteristic of transition management. (...) Whilst substantial goals drive the process, transition management refrains from fixing specific measures and strategies too early and too rigidly. At the core is the idea to modulate co-evolutionary dynamics that already drive socio-

[2] In this section, we describe what Transition Management scholars consider as the characteristics, and promises of Transition Management.

> technical change, and to bend them in ways that facilitate transformative innovation (...). The general approach is one of nurturing and growing rather than planning and controlling long-term societal change." (Voss, Smith and Grin, 2009, p.277).

Transition Management focuses on frontrunners only and not on broad participation. Frontrunners are selected by the transition managers. The design of the transition arena process is based on the premise of small-group effectiveness and the transition arena aims at a formation of (a societal movement with an initial form of) an advocacy coalition for sustainability with the focus on a specific regime or issue (Loorbach, 2010; Frantzeskaki, Loorbach and Meadowcroft, 2012 forthcoming). A transition arena is a platform for cooperation, co-management of actors and co-creation of ideas.

Transition Management as a governance approach focuses on redefining the problem, specifying the areas of influence where radical changes can be realized for transitions to be initiated or empowered. These areas of influence are indicated by the actors participating in the transition arena. Loorbach et.al., (2009) argue that "Transition Management takes a process approach that aims to change the dominant culture, structures and practices of unsustainable systems by linking innovations at the micro level to macro level changes in mindsets."

Is Transition Management then suitable and effective in dealing with persistent problems? Transition Management is a new approach adopted in the Netherlands to respond to needs for innovation in public policy (Hendriks, 2009; Kemp and Rotmans, 2009). In different countries, different approaches appear to be in place for responding to wicked problems as Bovaird (2003, p.19-20) mentions. In their reflections about Transition Management, Rotmans and Loorbach (2010a, p.213) respond that Transition Management should be seen as neither a Dutch model nor an update of the Polder model. The aim of Transition Management is to provide space and "proliferation of visionary ideas through multi-scale network management and self-steering of small innovation networks which might emerge and co-evolve into larger communities."

The discourse of Transition Management has a managerialistic tone (Hendriks, 2009) and the Transition Management tenets recommend a way of dealing with processes and networks of actors, hence presenting a new public governance approach towards innovation and experimentation (see also Bovaird and Loffler, 2003, p.6-7). Transition Management tenets are not set in stone but can and will evolve due to scientific debate and practical implementation. This approach is fundamentally different from a (more) descriptive and analytical scientific approach that would primarily focus on understanding these processes and describing them (Box 1.3).

Box 1.3: Transition Management Tenets.
(Loorbach 2007; 2010; Rotmans and Loorbach, 2010a, p.142-143**)**

The Transition Management tenets are partly descriptive, in the sense of basic principles, and partly prescriptive, in terms of rules for management:
(a) Management at the system level is important. A system's level perspective helps to get a better insight into spillover of the complex problem.
(b) The dynamics of the system create feasible and non-feasible means for management: this implies that content and process are inseparable. Insight into the dynamics of the system is essential for effective management.
(c) Objectives should be flexible and adjustable at the system level.
(d) Timing of the intervention is crucial. The nearer one is to the critical point in the system, i.e. on the dividing line between two attractors, the more effective the intervention.
(e) Managing a complex, adaptive system means using disequilibria rather than equilibria. The relatively short periods of non-equilibrium therefore offer opportunities to direct the system in a desirable direction.
(f) Creating diversity to stimulate the formation of emergent structures.

In writings of the Transitions Approach, it is noted that existing dynamics are being enabled or "harnessed" (Voss, Smith and Grin, 2009, p.283). In our view, the way that dynamics are being perceived is in the form of social trends (e.g. movements) or in the form of frontrunners that include

actors who think differently, who understand boundary problems, the nature of problems and un-sustainability, and who can also be social entrepreneurs. This however does not guarantee that Transition Management builds upon or utilizes existing ongoing dynamics in a society since the frontrunners and the social trends are always selected based upon their relation to a specific issue e.g. the energy arena or the healthcare arena. At the same time, Transition Management neglects countering dynamics or other mechanisms such as institutionalization or self-organization that occur in social systems.

It is noteworthy that Transition Management has shown its potential and capability for dealing with complex problems and for bringing along innovations (Loorbach and Rotmans, 2010; Heiskanen et al, 2009). Its refinement and development continues and may benefit from insights by the research on transition dynamics.

1.5.2 Transition dynamics

The phenomenon of a transition is expressed in dynamics of change; meaning that the dynamics of transitions explain how transitions come about. Hence, the understanding of the dynamics of transitions translates into an understanding of how transitions unfold. Studies on historical transitions, historical studies of socio-technological transitions and agricultural transitions indirectly contribute to the research on the dynamics of transition since they analyze how socio-technological transitions were realized and illustrate their different patterns. The focus of socio-technological transitions research is on the patterns of transitions (at a generic level) and not on the underlying conditions or factors that produce such patterns[3]. The contributions of such a descriptive approach need to be complemented with research on what underlies the dynamics of transitions.

From socio-technological transitions' writings, Geels (2010), comments on transition dynamics from multiple theoretical perspectives in his elaboration of the ontological foundations of the multi-level perspective. In our view, Geels in his analysis fails to capture the complexity of the dynamics and the field in which dynamics need to be researched. In his review of the different theoretical perspectives about transition dynamics, he focuses on the interactions between agents and regime or other relevant patterns of interaction so as to enrich the multi-level perspective from different theoretical angles. His review overlooks other aspects of dynamics such as the complexity of transitions and consequently of transition dynamics, the factors that may contribute to the dynamics of transitions, and the implications for governance given the complexity of socio-technical transitions.

Van der Brugge (2009) researched the regime dynamics that relate to the Dutch water management system under transition (van der Brugge and Rotmans, 2007; van der Brugge, Rotmans, and Loorbach, 2005; van der Brugge and van Raak, 2007). In his dissertation van der Brugge (2009) focused on processes of change conceptualized in a double loop that includes both the reproduction cycle of structures and actors (duality of structure, Giddens, 1984) and a loop on processes that change structures. Conceptualizing the dynamics as a product of processes of change, van der Brugge (2009) translated the dynamics into processes that occur in sequence and construct patterns of change. Those processes ranged from top-down (regime-to-niche) to bottom-up (niche-to-regime) in respect to the direction of the influence, and from endogenous to exogenous based on the drivers of the dynamics (van der Brugge, 2009, p.214). The contribution of van der Brugge (2009) rests on explaining the dynamics of the regime over the course of a transition by specifying its tipping points and behavior from one to another basin of attraction.

On a higher level of abstraction, de Haan (2010) explains dynamics of transitions in a way that is analogous to physics. Transitions occur when conditions for transitional change are in place that drive and render the interactions between system constellations. De Haan names any organized system or any system with a defined function/operation as a constellation. The focus is on the way constellations interact with each other. The conditions of transitional change include tension with the landscape, stress within constellations and pressure from constellations. The conditions of transitional change

[3] An analysis of the different approaches of socio-technological transitions is given in Chapter 6.

describe the endogenous and exogenous impediments of the societal system taking a generic and aggregate standpoint. De Haan (2010) continues with three patterns of transitional change (reconstellation, empowerment and adaptation) and conceptualizes transitions as sequences of those patterns. The analysis and theorizing of transitions in the form of conditions and patterns that are generic in their form and very abstract has both strengths and limitations. Among its strengths are the coherence such a theoretical framing brings for the up-take of the concepts to a lower level of aggregation, and the explanatory capability of the introduced concepts (conditions and patterns) to analyze different types of transitions. In our view, a limitation of de Haan (2010)'s pillar treatise is the overlooked link to policy implications and policy in general. De Haan leaves the operational exercise to the researcher or even to the policy designer who has to understand the pillars (conditions, patterns and paths) and make educated designs of policies.

1.5.3 What research on transition dynamics can contribute to Transition Management

Research on transition dynamics is needed since the dynamics represent the way complex processes develop. Thus, for understanding societal complexity we need to investigate complex processes of change such as transitions in the form of their dynamics. In the KSI Knowledge Project in 2005, two overarching research questions were identified:

> - What are – scientifically derived and validated – the characteristics and dynamics of transitions in relation to the system in which they occur, and in relation to the possibilities actors have to influence them? (KSI Knowledge Project, 2005, p.12)
> - Is there a generic pattern to be found in the driving forces of the various past and current transitions and system innovations? Is the co-evolution between economic, technological, institutional and social-cultural factors generic by nature or does it unfold in a transition-specific pattern? (KSI Knowledge Project, 2005, p.21)

Transition Management has developed a governance philosophy and a number of transition management tools (e.g. the transition arena and the transition experiments). There are however a number of issues concerning the nature of transitions and the interaction between instruments and societal behavior that require attention. From our review of the Transitions Approach and from the Transition Management tenets, we indicate a working list of issues where research on transition dynamics can contribute to Transition Management. We propose that research on transition dynamics can specifically contribute by investigating the nature of transitions, and its implications for the governance of transitions. More specifically, issues for research related to the *nature of transitions as conceptualized by the principles of evolutionary revolution and coordinated emergence* include the following:

> - For an understanding of the ontology of a transition and its characteristics, research on the mechanisms of change of societal systems is suggested.
> - For an understanding of the evolutionary characteristics of a societal transition, research on the nature of the processes (enabling versus inhibiting, coordinated versus emergent and more) in relation to the system response is suggested.
> - For mapping and distinguishing which elements of a system can be coordinated and which are emergent, research on the subjects of change at a system level is suggested.

Transition researchers have been working on these issues, a number of them remain to be further researched. More specifically, van der Brugge (2009), de Haan (2010), and Yucel (2010) have contributed their research on understanding transition dynamics, with a focus mainly on mechanisms of transitions.

The work of van der Brugge (2009) contributes the explanation of the regime dynamics and especially the regime shifts as passages from one basin of attraction to another. Van der Brugge (2009) explains that preferences and paradigms can shift the regimes in policy and institutions in an emergent fashion without neglecting the role of actor-coordination, especially the role of frontrunners in policy regimes.

The work of de Haan (2010) shows that transitions can be analyzed and described in three pillars: conditions, patterns and paths. The patterns of transitions as elaborated by De Haan (2010) (adaptation, empowerment and reconstellation) comprise the mechanisms that capture in an aggregate form how transitions come about. At the same time, the variations of the adaptation mechanism presented in the later work of de Haan and Rotmans (2011) contributes to the understanding of the evolutionary nature of transitions as processes that can include different forms of system adaptations.

The work of Yucel (2010) contributes to the understanding of the mechanisms by focusing on the relations between agents of change and the technological regime. Yucel's actor-option framework proposes mechanisms that concern option change, actor's knowledge and actor's identity. The coherent formalization and restructuring of the agency and its decision making process provides insights about the acts of agency and agency's role in changing the technological regime. The analysis however does not offer insights either on the role of institutions in the effectiveness of the mechanisms, nor on the interaction between agency and structure for the sociotechnical dynamics in the studied systems.

Role of this thesis to the transition research

The present thesis contributes to the transition research by researching the dynamics of transitions in a form of *forces that drive transitional change*. For an understanding of what contributes to a transition in the form of drivers of change (and what might constrain a transition in the form of barriers of change), research on drivers is suggested. The knowledge of the drivers of change and their role in the course of a societal transition will provide insights about the nature of transitions, and transition dynamics, and will substantiate the characterizations of transitions as processes of coordinated emergence and evolutionary revolutions. Knowledge of what drives and what inhibits transitions will also the existing Transition Management tenets with understanding of how to dissect transition dynamics and how to influence the dynamics with feasible means of governance.

CHAPTER 2 - RESEARCH FRAMEWORK

In Chapter 2 we elaborate on the research objective and the research methodology that backbones the research on transition dynamics.

Main Contributions

The methodology chapter presents how the conceptual models were deduced and tested. The main questions include: Which methods are used in the research? How have the different methods been applied? How do they contribute to the creation of the conceptual models for understanding transition dynamics?

The choices made concerning the level of aggregation, the process of grounding in both theoretical and empirical material, and the selection of theories are discussed in detail. The main questions answered include: What are the implications of choosing a macro-level of aggregation for theorizing about transition dynamics? What are the implications of choosing a systems approach for studying long-term transformative system change (transitions)?

We believe that it is important to present the choices that formed the development of our research so as to make transparent our assumptions, conceptions and worldview and in this way to allow the assessment of consistency, and integration of our conceptual and theoretical contribution.

CHAPTER 2
Research Framework

In this chapter we list our research objective and elaborate the approach we used to fulfill this objective. Chapter 2 includes five sections. Section 2.1 presents the research objective and the related research questions. Section 2.2 presents our starting conceptualizations concerning transitions and transition dynamics. These comprise the basis of the conceptual models to be presented in Chapter 3. Section 2.3 presents the research approach that is *systems thinking*, and then discusses research issues that arise from our use of the systems thinking approach. Section 2.4 presents the research methodology in a systematic way. Section 2.5 presents the thesis organization, and the relation of each chapter to the research objective.

2.1 Research objective and research questions

The overall objective of this thesis is to contribute to the understanding of the dynamics of societal transitions and what can be done to influence these dynamics. This overall objective is framed as follows:

Understand how societal systems behave over the course of a transition

In this chapter we will elaborate how we researched and what approach we used to fulfill the above research objective. The research study contains conceptual, theoretical, and prescriptive elements. For understanding the dynamics of transitions, we aim to unravel the complex dynamics into simple elements that can explain how the dynamics are produced. The conceptual research aims at developing (conceptual) models for dissecting and analyzing the dynamics of transitions. The prescriptive research addresses the feasibility and possibility of intervening in a transition, following governance propositions that aim at enabling dynamics of transitions with focus upon institutions. The theoretical element of this thesis includes the contributions of the research on both transition theory (theory of transition dynamics and transition management) and on existing theories on system change (such as social-ecological systems literature) with insights on dynamics of transitions.

A starting point for the exploration and understanding of the dynamics of societal transitions is to investigate the following research questions (that are addressed by the KSI Knowledge Project (2005)) linked to the research objective:

- What are the characteristics and dynamics of transitions? (KSI Knowledge Project, 2005, p.12)
- Is there a generic pattern to be found in the driving forces of the various past and current transitions and system innovations? (KSI Knowledge Project, 2005, p.21).
- Is the co-evolution between different elements of the societal system (such as economic, technological, institutional and social-cultural elements) generic by nature, or does it unfold in a transition-specific pattern? (KSI Knowledge Project, 2005, p.21).
- What do the characteristics and dynamics of transitions reflect to the possibilities to influence them? (KSI Knowledge Project, 2005, p.12)

We aim at analyzing the phenomenon of a transition from multiple theoretical grounds. We will use these diverse theoretical approaches to explore how (diverse types of) systems respond to change. In this investigation we are not focusing upon redefining the transition as a phenomenon but, rather, upon understanding how transitions develop by investigating how different systems respond to change. An empirical exploration complements the theoretical exploration by investigating how several actual cases of societal systems have behaved over the course of a transition. The empirical exploration includes cases of on-going processes of change with a time span longer than 20 years. The exploration focuses upon what changes, how it changes, and what contributed or related to the

change. The research study also aims to make prescriptive contributions on governance propositions to enable and stimulate transitions.

The outcomes of the research include: (a) A conceptual model developed so as to investigate the dynamics of transitions; (b) theoretical contributions on the conceptualization of the dynamics of transitions and the way they are produced, (c) induction of generic patterns to be found by the exploration of transition dynamics, and (d) governance propositions, based on knowledge of dynamics of transitions, for enabling and initiating transitions.

2.2 Starting conceptualizations of transition dynamics

Keeping in mind the aforementioned research objective and the associated research questions, a number of starting conceptualizations will aid our research direction and choices. The starting conceptualizations present our early view and early understanding of societal transitions and will be further elaborated in the conceptualization phase of the research (that is presented in Chapter 3).

We will research the dynamics of transitions by looking at the behavior of societal systems as a whole; not at the dynamics of different types of systems (e.g. socio-technological system or socio-economic system). We start with investigating what types of change take place and how the dynamics of transitions develop. We postulate that the dynamics are produced by two types of interactions: those that take place *within* the societal system, and those that take place between the context and the societal system. For understanding what constitutes the dynamics, research on the interacting subsystems is therefore necessary.

2.3 Primary Research Approach: Systems thinking and systems approach

Considering these starting conceptualizations and the research objective, we chose a systems approach as the research basis for the development of the conceptual models and for the design of the research approach.

> "The synthetic mode of thought, when applied to systems problems, is called the *systems approach*. This way of thinking is based on the observation that, when each part of a system performs as well as possible, the system as a whole may not perform as well as possible. This follows from the fact that the sum of the functioning of the parts is seldom equal to the functioning of the whole. Accordingly, the synthetic mode seeks to overcome the often observed predisposition to perfect details and ignore system outcomes." (Blanchard and Fabrycky, 2005, p.15-16)

There are three reasons that support the choice of a systems thinking approach:

(a) The systems approach aids the *setting of the boundary for the subject of research* – that is the societal system - and, consequently, the narrowing of the research focus.
(b) The systems approach aids the investigation of *what constitutes the structure* of the system by searching for subsystems as well as relations *between* the defined subsystems, so as to further investigate where change takes place.
(c) The systems approach *allows for "objectivity" when it comes to change of systems*. The systems approach allows the exploration of phenomena that arise due to operation, interaction and change of societal systems particularly, without forcing assumptions about the societal system's function or organization. By adopting a systems approach as the primary research approach, the societal system is examined as an entity with sub-units and interactions, changes and organization defined by a system's view only. Hence, change in the societal system is perceived neither as negative (see criticism by Von Bertalanffy, 1969, p.196) nor as desirable.

Note that we address here the desirability of system change and not the desirability of system change towards a sustainable state that is the focus of transitions research. The research aim is to understand the dynamics of societal change and what are the factors that underlie it. The normative aspect of

sustainability will be brought in when distilling governance propositions for initiating, enabling or steering the dynamics of a system to sustainability.

In the systems approach, a system is viewed as a composite of subsystems that form a unitary whole (Von Bertalanffy, 1969). The function of the different subsystems of the system and their interdependency are important for understanding the structure of the system (Blanchard and Fabrycky, 2005, p.3). The core conceptualization in systems thinking is that by understanding the structure of the system its behaviour can be explained. A relation –or causality- between structure and behaviour exists and comprises the basis for understanding system's behavior and recommending (or designing) means of intervention to produce desirable system behaviour.

There are different approaches for analyzing a system and for setting the boundaries to a system. For example, a system can be broken down into subsystems that represent consistent parts of its whole, or into a hierarchy of systems. Thereby we speak of systems-of-systems conceptualization and compartmentalization of a system. Systems that consist of highly interconnected and interdependent subsystems have structures that are difficult to understand. These are referred to as complex systems (Prigogine and Stengers, 1985).

As presented in the previous chapter, complex adaptive systems are a special type of complex systems that can adapt to changes and learn from experiences. Complex adaptive systems co-evolve, self-organize and give rise to emergent patterns. Emergence in a complex adaptive system refers to mechanisms or behavioral patterns of the system. According to Bunge (2003, p.15) "a property of a complex object is said to be emergent if neither of the constituents or precursors of the object possesses it." For complex adaptive systems, the presence of emergence implies that direct causality between structure and processes does not exist.

The complex adaptive systems approach is the approach most applicable to societal systems given that societal systems have characteristics similar to complex adaptive systems (as previously discussed in Section 1.2). Considering a societal system as a complex adaptive system leads to several considerations:

(a) Why structure? The objective for analyzing the structure relates to our search for where change takes place, and not primarily for linking behavior to structure. Our primary conceptualization concerns the drivers of change, the presence and synergy of which constitute the dynamics of societal transitions. The analysis of structure of societal systems aids the overall analysis by mapping the grounds from whence the drivers originate. Having an understanding of the structure aids us in knowing what can change in the system.
(b) Endogenous and exogenous dynamics: The analysis and understanding of the structure of societal systems and of the interaction between (structural) subsystems will aid our understanding of inherent dynamics towards change. In our research, we are interested in dynamics of change, the causes of which can be endogenous to the system and/or exogenous to it.
(c) Universal versus representative explanations: The behavior to be deduced by the empirical exploration will aid our understanding of possible behaviors of societal systems over the course of a transition, bound to the context and to the systemic conditions. This means that the deduced behaviors *will not be theorized as universal explanations but as representative behaviors of a specific societal system in transition e.g the energy system or a socio-technological system.*
(d) Single versus multiple explanations: The behavior to be deduced by both theoretical and empirical explorations will show the multiplicity of behaviors of a societal system. This means that we are expecting multiple behaviors to be associated to every structure. This coincides with the non-causality between structure and behavior characteristic of complex adaptive systems.

2.3.1 Implications of the systems approach for the research of societal transitions and transition dynamics

An understanding of the structure aids us in knowing what can change in the system. This conceptualization along with the choice of the systems approach as a method for researching the dynamics of societal transitions leads to several implications:

System's and subsystems' function

In the present research study, a society is conceptualized as a societal system that has different subsystems -such as institutions- that are interlinked and interdependent and have different functions. Following structural functionalism, we perceive the societal system and its subsystems to have different but useful functions (Merton, 1957; Parsons, 1949; 1977, p.6). We will focus upon how society is organized as a composite of functional subsystems.

In line with this view of society, Ackoff and Emery (1972) theorize on systems as entities that have a purpose strongly related with their function. For Ackoff and Emery (1972, pp.16-18) the critical element of a system is its function - not its structure. For use in explaining the change in a system, the concept of event is introduced by Ackoff and Emery (1972, p.25) as "a change in one or more structural properties of either an object, a system, an environment or a relationship between them over a time period of specified duration".

In our research we do not focus only upon distinguishing the subsystems of the societal system as functional subsystems. We also focus upon explaining how those functional subsystems change and how, consequently, the societal system changes. Note here that our agreement with structural functionalists is only agreement with their concept of the functions of the societal system, and is not agreement with their view that system change is undesirable.

System change

Adopting a systems approach to researching societal change is not new. Among the social evolutionists, Talcot Parsons used system theory elements in his theory of long-term social change. Parsons (1977) presented causal explanations of change and viewed societal change as driven by the adaptive capacity and consequently, as adaptive upgrading. Parsons was the first to introduce the concept of adaptive capacity to sociologists, to mean that "societies are goal-oriented systems that seek ways of adapting themselves to their environments." (Sanderson, 2007, p.133; Parsons, 1977). In Parsons' (1977) view, the evolution of societies is an evolution of the organization of their subsystems, from a stratified architecture in primitive societies to more complex forms, such as integration, in modern societies. This focus on the process of *change* of the societal system and its subsystems complements the structural functionalistic view of societal systems, which emphasized "how structural subsystems fit together and function as an integrated whole, rather than on how they change" (Cocks, 1937, p.169).

In our research, we conceptualize that a societal system *experiences change* when any subsystem of its structure changes. But for a system change to be characterized as a *transition*, subsystems of the societal system must change radically and irreversibly.

2.3.2 Research choices entailed by the systems approach

The adoption of a systems approach as the basis for the development of the conceptual models, and for the research approach, necessitates a number of related choices:

(a) the level of aggregation for developing the conceptual models, conducting the research and presenting the results, and
(b) the grounding process of the developed conceptual models and findings to existing theories given the level of aggregation chosen.

Level of aggregation

In our research we adopt a high level of aggregation (which we will refer to as "macro-level") to analyze the dynamics of societal transitions. We conceptualize the dynamics taking place in a societal system, which is an entity that includes both actors and their social constructs (i.e. institutions).

Consequently, the dynamics are researched at the system level; which is the macro-level.

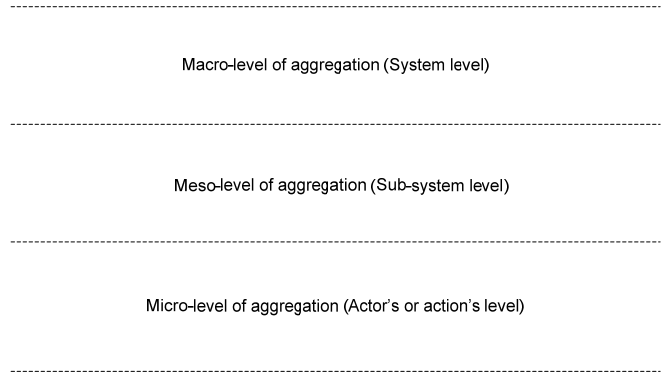


Figure 2.1: Different levels of aggregation as oriented by the systems approach.

A macro-level of aggregation allows for a global view on the phenomenon of transitions that is not achieved in descriptive frameworks that adopt a lower level. A contrasting example of an analytical framework that adheres to a meso-level of aggregation is the framework of functions of innovation systems by Hekkert et al., (2007). Their focus is upon a subsystem of the societal system, that is the innovation or technological system. Their view aids the understanding of innovation dynamics, and of a specified technological system; but it does not embed the technological system in its broad societal context. The choice of the level of aggregation in Hekkert et al (2007, p.429) is argued to be a meso-level so as "to explain a restricted set of social phenomena and to avoid grand theories that can not be validated or delineated easily". We understand and agree with the argument of restrained validation; it is difficult to validate the conceptual link between theories at highly distant levels of aggregation. We respond to this implication of a macro-level of aggregation by designing carefully the process of grounding of our conceptual models. Therefore there has been a clear identification of the level of aggregation of the theories used for grounding our conceptual tools.

A macro-level of aggregation does not restrict our research from iterating and linking with theories and approaches found at a meso-level. What is learned and understood at the macro-level (or system's level) will be linked or translated to the meso-level. Given that most of the general analysis and research on societal transitions and their dynamics are performed at a macro-level, the developed conceptual models and outcomes may be read as descriptive stories of "almost everything". At such a high level of aggregation we run the risk of over-generalizing the dynamics and thus not understanding how those dynamics are produced, and what actions can contribute to change or reinforce them. Our research objective is also to link back and to communicate our research findings to lower-levels of aggregation (meso-level) especially for making our findings policy relevant. Hence the governance propositions that we design will be operational at a meso-level.

A macro-level of aggregation -that is, the level of the societal system- positions our research among the sociological theories of (understanding and explaining) societal change and societal evolution. But there are differences between our research on societal transitions, and sociological theories. Specifically, there are differences between our research and: i) theories of social evolutionism; and ii) theories of social indicators. The two key differences from theories of social evolutionism are: (a) theories of social evolutionism, in the majority, have as common a directionality of change; and, (b) social evolutionists did not address the relation of technology to social change (see also Box 2.1). The two key differences from theories of social indicators are: (a) social indicators theories investigate and elaborate their findings on a lower level of aggregation; and, (b) although the subject of research appears to be societal change for both social indicators theory and transition dynamics research, the research outcome of social indicators theory is a composite of metrics that can monitor social welfare and well-being, rather than change processes (see also Box 2.2 for a brief analysis).

Box 2.1: Differences between social evolution theories and the Transitions Approach.

Research on transitions and transition dynamics focuses on the way a societal system evolves, observing the interactions or the dynamics over time. This might seem similar to social theories and/or sociological theories that deal with social evolution. Social evolutionism theories include writings of classical evolutionism (Herbert Spencer, Morgan and Tylor), social evolutionism fundamentalists (Parsons, Lenski, Turner, Wallerstein and Durham, and more), and anthropological evolutionism (Sahlins, Service, Carneiro and Harris). Social evolutions theorize and analyze how societies evolve. Their analysis focus mainly on their conception of evolution as either cyclic or directional, and on the end-state of the evolved society. The drivers or conditions and constraints of change are identified as desires of the society for change, and are investigated mainly by anthropological evolutionism writings. A review of the entire spectrum of social evolutionism is out of the scope of the current research, but we will include a specification of the differences between the transition dynamics research and some writings on social evolutionism (see Sanderson, 2007).

There are two key differences between theories of social evolutionism when comparing to research on transition dynamics: (a) theories of social evolutionism in their majority have as common the directionality of change. For a majority of social evolutionists that means that societal change or evolution equated progress (see Tylor, Morgan as cited also in Sanderson, 2007). This is addressed also by critics, as well as by supporters and followers of evolutionists. In his analysis of Parsons, Sanderson (2007, p.143) notes that the mono-focus of social evolution theorists on change for progress is addressed as unilinearism. Even Parsons (1977; cited in Sanderson, 2007, p.140-143) presented social change as a shift to advancement and progress. What we have seen however is that societal change can also lead to non progressive states and also declines e.g. the decline of Roman Empire, the decline or destruction of the Soviet Union, the collapse of Easter Island and more. Research on transition dynamics investigates different end-states of the transition, something that is already shown in the different transition paths (see Figure 1.4). (b) social evolutionists did not address the relation of technology to social change. Lenski, Childe and White (cited in Sanderson, 2007, p.193) also referred to technology but viewed it as solely socially embedded, meaning that technology is employed only to serve society in situations when environment is overexploited to serve its needs and to ease the production practices. The way technology changed in relation with societal preferences and practices, and visa versa, are not analyzed by social evolutionism. Research on socio-technological transitions investigates the dynamics of technology and society interaction, and their relation to transitions (Geels, 2004a, b; 2005; Geels and Schot, 2007).

Box 2.2: Differences between social change theories and the Transitions Approach.

Sociology and social theories offer a ground for understanding how societies are formed and function. Social theory scholars have also strived to understand and explain social change. Among among social change theorists we distinguish the neo-functionalists such as Giddens (founder of structuration theory) and the social metrics theorists such as the researchers of the social indicators approach (indicative: Bauer, 1966; Clewet and Olson, 1974; Rossi and Gilmartin, 1980). Our focus here will be on the social indicators approach. In our research on transition dynamics, we conceptualize dynamics to be produced by the interaction and presence of macro-social conditions. This conceptualization may seem similar to the social indicators' conceptualization, therefore we will furhter elaborate on the differences. The social indicators approach focused mainly on those metrics or indicators that capture the characteristics of the population that can relate to social well-being. Sheldon and Freeman (1970) present the initial promises of the approach as social monitoring and potentially social change. Starting in the 1970s, social indicators approach aimed initially to explain how societies change (Bauer, 1966) but socio-political conditions of that era redirected the approach towards an investigation of metrics that can relate inherent societal characteristics to well-being. Social indicators thus developed into metrics of social welfare (Rossi and Gilmartin, 1980, p.18) and then into social performance of markets through a stream of marketing research in later stages (social marketing performance audit) (Wilcox et al, 1973). The social indicators capture population or demographic characteristics such as fertility rates, infant mortality rates, household incomes and household compositions. What social indicators approach contributes is a composite of metrics for societal conditions that are linked to the state of the societal system and, more specifically, to "indicators of living standards" (OECD, 1970-Social Indicators Research). As such, social indicators provide a measure for societal conditions that can be used to monitor societal change. But the communication revolution and the rise of network society (Castells, 1996; Wittel, 2001) changed not only the form of modern societies but also the way social change is perceived. Modern societies are now analyzed in terms of different types of innovations, starting with technological innovations (Hall, 1994) and moving towards societal innovations (Rotmans et al, 2001). Research on the dynamics of transitions, and its focus on conditions for change, asks for societal determinants that capture the innovation potential within the society that produces change. Hence the subjects of research, for the social indicators approach versus the transition approach, are ontologically different.

Grounding process

The process of grounding the conceptual models and the patterns developed in our research needs to be specified and explained. We refer to the grounding of the conceptual framework to low-level ingredients from a multitude of bodies of literature. The grounding process and the objective of the grounding process are different than the grounded theory approach.

The process of grounding the developed conceptual models to existing theories is driven by the level of aggregation. Given the macro-level used for researching transition dynamics, the theories to be reviewed need to conceptually have either the same level of aggregation or one level lower (Figure 2.2). For example, investigating the change in societal systems (macro-level) by focusing on institutional subsystem makes theories of organizational change within the institutions unsuitable because they conceptually theorize at the micro-level. For grounding and developing conceptual models with a macro-level focus, the theoretical grounds need not be highly disaggregated. Using an ***inductive mode*** for building the conceptual models, we chose to ground with theories that conceptually present a meso-level of aggregation in their conceptualizations. Therefore, the theories chosen to ground the conceptual models need to also focus on change in the subsystems of the system (Figure 2.2).

For both theoretical and empirical grounding we chose both theories and empirical material that aid us to understand how systems change and not necessarily how systems change towards a sustainable state. We believe that by exploring how systems change under any context provides an unbiased base for dissecting the dynamics. The focus of sustainability as a direction of change will be considered when operationalizing the knowledge of the dynamics into governance propositions for sustainability transitions.

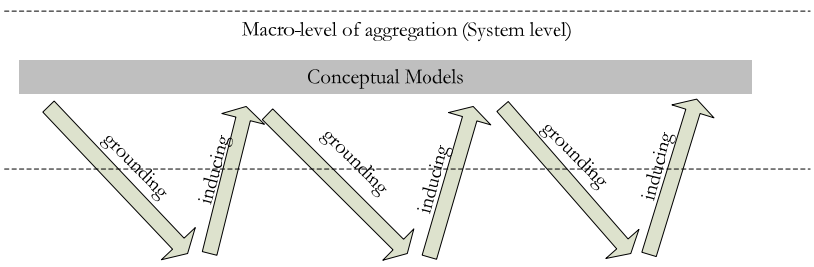


Figure 2.2: Grounding process and up-scaling between different levels of aggregation.

2.3.3 Limitations of adopting a systems approach

Taking a systems approach to research a societal phenomenon such as a transition raises some points of criticism. First, a systems approach may appear too reductionist for social sciences' studies. Representing the society as a system may appear simplistic considering the complexity inherent to societal phenomena. We respond to this criicism by extensively and consistently grounding the conceptual framework in multiple theories.

Second, a systems approach may raise the criticism that it is a mechanistic approach for researching societal phenomena. Our response is that we do not research the societal system and the phenomenon

of societal transitions so as to engineer the societal system. More specifically, perceiving society as constituted of societal systems requires a careful view: Thinking of society as a system is not the same as thinking that it can be engineered (given that only mechanistic systems can be engineered). The systems approach provides the research base for a systematic and theoretically sound analysis of a complex phenomenon such as the societal transition. It is not a framework to 'engineer' the societal.

Third, a systems approach implies direct causality between cause (or trigger) and effect (or output). Our response to the implied causality is that the complex adaptive systems approach is the theoretical basis for the conceptual framework and takes into account not only direct causality but also indirect causality including emergent phenomena (or, simply, "emergence").

Fourth, having the societal system as a reference, the positioning of the actor and the role of the actors in societal transitions are overlooked (see also Etzioni, 1968, p.81). We respond to this limitation by including actors' actions and demands in the form of the drivers that constitute transition dynamics.

2.3.4 Why explanation of research choices is important

For theoretical research, there is no standard research methodology either for development or for testing of the theory. We believe that apart from showing the added value of our conceptual models via their explanatory capability and the new insights they can offer for understanding and researching societal transitions, it is important to present the choices that formed the development of our research. In this way, we make transparent our assumptions, conceptions and worldview to allow the assessment of consistency and integration.

> Even though we do not adopt grounded theory as research method, we got inspired by the analysis of grounded theory by Glaser and Strauss (1967) concerning the choices that needed to be made in setting our research framework.
>
> "One canon for judging the usefulness of a theory is how it was generated – and we suggest that it is likely to be a better theory to the degree that it has been inductively developed from social research. We also believe that other canons for assessing a theory, such as logical consistency, clarity, parsimony, density, scope, integration, as well as its fit and its ability to work, are also significant development on how the theory was generated." (Glaser and Strauss, 1967, p.5)

2.4 Research methodology and research strategy

In our research, we adopt an inductive approach for theory development where "the analyst is forced to develop ideas on a level of generality higher in conceptual abstraction than the qualitative material being analyzed." (Glaser and Strauss, 1967, p.114). The theoretical and empirical material being analyzed concern the function and the change of subsystems. The steps we took in our research are described below:

Research Output

STEP ONE

Formulation of the Conceptual Framework

A literature review of theories of social change and regime change (in the transitions' sense) comprised the basis for the formulation of the conceptual framework. The conceptual framework includes three conceptual models that aid the research on the dynamics of transitions: i) the Evolution Cycle of the Societal System that conceptualizes how the societal system evolves over time; ii) the Forces Framework that includes the forces constituting the transition dynamics; and, iii) the Conceptual Map of the Societal System that conceptualizes what constitutes a societal system.

Conceptual Framework

The **nature of research is inductive**[4]. An inductive mode means that we conduct a "process of reasoning from particular observations to general claims and the assumptions that warrant such claims." (Dunn, 1981, p.231). The conceptual frameworks have been formulated by the researcher and elements within them are induced from multiple theories and approaches.

STEP TWO

Multi-Grounding of the Conceptual Framework

The conceptual framework and more specifically, the Forces Framework and the Evolutionary Cycle of the Societal System have been grounded in (three) different theoretical and empirical materials. The grounding is realized in different fields of theories, namely institutional change theory (type A), social-ecological change theories (type B) and technological or socio-technological change theories (type C). The grounding and derivation of feedback loops and archetypical responses of different systems has been realized in a sequence (see Figure 3.3). We will describe how the derivation has been realized by the grounding in the theory, given that the same methodology and process hold for all three fields (A, B, C).

Theoretical Grounding: The conceptual models have been grounded in different theories. The theoretical grounding aided the formulation of preliminary patterns of transitions and feedback loops, which are described in the theory but reconceptualized and revised in our research. The theories have been chosen based on the criteria already discussed in Section 2.3.2.

The feedback loops and the different archetypical responses (or patterns) are derived by **induction of a special form**: we infer theoretical elements (feedback loops) from particulars found also in theory. The reasoning is realized from collected theoretical parts to theoretical constructs (conceptualizations); hence we refer to this research mode as a special form of induction.

Feedback Loops

[4] Given that there is no other term suitable to describe the research process used to develop the conceptual frameworks, we use inductive while being aware that it is generally associated with the process of taking ingredients from empirical grounds to inform theory. In our research approach, we use induction of a special form to describe the taking of ingredients from theories to inform theory.

Empirical Grounding: Empirical material has been analyzed with the conceptual framework so as to test the analytical potential and fitness of the conceptual models to the phenomenon of transition in the specific field (e.g. institutional change). The empirical investigation also aided the testing and verification of the preliminary patterns of transitions and the feedback loops. The research position of the empirical grounding is induction: reasoning is realized from collected facts back to theory.
The empirical material includes case studies and published cases found in literature. The case studies and the published cases have an **instrumental use** since they are used to provide insight into transition dynamics and to test the conceptual models (for instrumental case studies see Stake, 2000, p.437-438).

Case study research: For the case studies we followed a four-step approach:
(a) Data collection: The data were collected using mixed methods that include: in-person open and semi-structured interviews, phone-interviews, archival research and analysis, and expert consultation. For the archival research, a variety of data was collected including research articles, newspaper articles, reports, websites, and data from legislative databases.
The interviewees and the interview designs for every case study are given in seperate tables in Appendix A. Appendix A also includes information about selecting desk research material and information about the field research.
(b) Data analysis: The data were structured in a chronological order in different tables. We identified the events with induction from the texts and databases. We also identified events from input from the interviews.
(c) Analysis and translation into Forces: We used the forces framework to relate the events to specific forces based on the impact of the different events on the system evolution and consequent transition.
(d) Analysis of the cases with the Evolution Cycle of the Societal System.

Selecting case studies: Given the focus on understanding how societal transitions develop over time, we select cases with a long time span (over 20 years), with knowledge that changes have taken place and that sustainability issues or targets are directly or indirectly relevant. We selected the case studies based on the type of system to which they correspond to: institutional system, social-ecological system and socio-technological system (see Section 3.7.2 & discussion in Chapter 7, Section 7.14). We took to heart the criticism that the Transitions Approach and Transition Thinking in general is a context-biased approach –namely, being a Dutch approach-; hence we decided to research non-Dutch cases as well.

Published cases: The idea of using published cases as complementary empirical material comes from the desire to have different types of empirical material for testing the conceptual models outside the transition research field. The published cases with their re-interpretation using the conceptual framework (especially the Forces Framework) are presented in a separate appendix (Appendix C, Tables C1 for institutional transitions, C2 for social-ecological transitions, and C3 for socio-technological transitions).

The research outputs of the theoretical and empirical grounding include a theoretical validation and an empirical testing of the conceptual models as well as the induction and empirical testing of the different feedback loops. Multiple methods are used for testing the explanatory capacity of the conceptual models and for corroborating each model in a form of methodological triangulation (see Mason, 1996, p.25).

STEP FOUR

Aggregating the different (types of) feedback loops

In this step, we use the Forces Framework and reconceptualize system's behaviors found in the different theories to derive the different feedback loops that we also tested in both theoretical and empirical grounds. We induce a conceptualization of different types of feedback loops, which are added to the evolution cycle of societal systems and comprise a theoretical contribution of the research. The research position is induction.

Understanding the dynamics of transitions

STEP FIVE

Formulating governance propositions

In this step, we formulate governance propositions that consider transition dynamics. The governance propositions refer to and complement the existing Transition Management tenets (see Box 1.3).

Governance Propositions

STEP SIX

Multiple reflections about the research and the research outcomes

The last step of the research on transition dynamics is a reflection on both the dynamics of societal transitions and the *research on* these dynamics. The first part will be an analysis of the limitations that transitions as complex phenomena imply for governance. The second part will be a reflection and analysis on the limitations of the research about the phenomenon of societal transitions.

STEP SEVEN

Drawing a research agenda

The research on the dynamics of societal transitions surfaced various topics for future research that can contribute to both Transition Management and the Transitions Approach. We believe that taking a Transitions Approach to investigate both the resilience of social systems and their potential for their transition to sustainability will benefit the research community with new knowledge and the society with new knowledge about a lock-out of the current un-sustainable track.

Future Reserach Agenda

2.5 Thesis organization

The current thesis includes eight chapters in total. Chapter 1 introduces transitions, transition dynamics and transition management.

In Chapter 2 we elaborate on the research objective and the research methodology that backbones the research on transition dynamics. The methodology chapter presents how the conceptual models were deduced and tested.

In Chapter 3 we present the core conceptualizations and the conceptual framework for understanding transition dynamics. We present: (i) the Forces Framework that consists of three clusters of forces: formation forces, support forces and trigger, (ii) a Conceptual Map of a Social System that shows the different subsystems of the societal system that may be subject to change during a transition, and (iii) the Evolution Cycle of a Societal System that represents the consecutive phases and dynamic equilibria (stages) that a system undergoes over the course of a transition. We relate every conceptual tool to existing theories and to existing conceptualizations of the transitions approach.

In Chapter 4 we present the first type of societal transitions, institutional transitions. We define an **institutional transition** as a type of societal transition in which the forces at play have an impact on the institutions and civil society or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions and civil society. We present three additional feedback loops that complement the Evolution Cycle of the Societal System and relate to institutional transitions: the self-enforcement loop, the deinstitutionalization loop, and the anarchy loop. These are reinforcing feedback loops and refer to dynamics of the system that are sustained at different stages by the

continuum of (the same type of) forces. In Chapter 4, we analyze three case studies with the Forces and the Evolution Cycle: the water management transition in the Netherlands, the environmental protection transition in Greece and the energy transition in Greece.

In Chapter 5 we present the second type of societal transitions, social-ecological transitions. We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment. Three feedback loops are found to complement the Evolution Cycle of the Societal System that relate to social-ecological transitions: the institutional over-reliance or over-institutionalization loop, the catastrophe loop and the stewardship loop. The coastal management transition of the Great Brak River in South Africa is analyzed with the Forces framework and the Evolution Cycle.

In Chapter 6 we explore the third type of societal transitions, socio-technological transitions. We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions, civil society and technology. Two feedback loops are found to complement the Evolution Cycle of the Societal System that relate to socio-technological transitions: the institutional restraining loop, and the technological lock-in loop. A bypass process is also added to the Evolution Cycle as induced by social deterministic approaches, namely the demand-pull bypass.

In Chapter 7 we present the **research outputs in response to the research questions** and the implications of the research findings in terms of theoretical contributions and in terms of governance for societal transitions to sustainability. The governance propositions that we derive inform the Transition Management tenet noting "dynamics of the system create feasible and unfeasible means for governance". The limitations of governing societal transitions are also presented focusing on the different types of societal transitions.

In Chapter 8 **critical reflections of the research and related future research challenges** are presented. A reflective view on the research design, research process, and findings is included. The research challenges that have been identified relate to the critical reflections and to the research findings about transition dynamics. The research challenges that relate to the understanding of transitions as long-term processes unfolding in different episodes of change, include the quest for future understanding of the role of institutions in societal transitions, the role of actors as carriers of change (policy entrepreneurs versus frontrunners versus transition managers) and the role of politics (as a canvas of the transition dynamics).

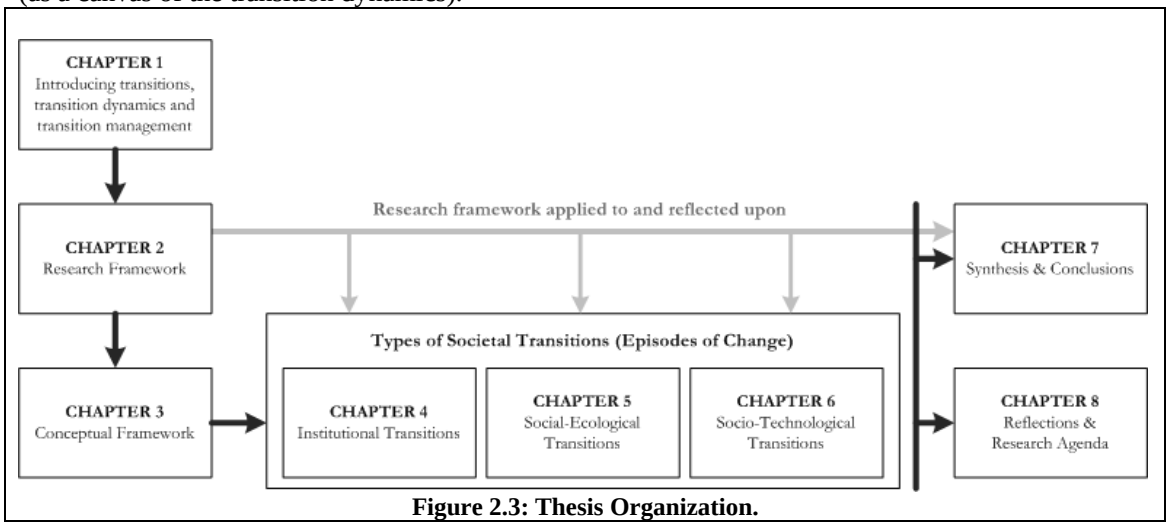


Figure 2.3: Thesis Organization.

In Chapter 3 we present the core conceptualizations and the conceptual framework for understanding transition dynamics.

Main Contributions

We present the Forces Framework that includes macro societal determinants of transitions. The Forces Framework consists of three clusters of forces: formation forces, support forces and triggers. The core conceptualization is that for a transition to occur, forces from all the clusters need to be at play.

We present a Conceptual Map of a Social System that agrees with the duality of structure-practices while complementing it with resources and means in the form of natural resources and technology. The Conceptual Map of a Societal System shows the different subsystems of the societal system that may be subject to change during a transition.

The third part of the conceptual framework is the Evolution Cycle of a Societal System that represents the consecutive phases and dynamic equilibria (stages) that a system undergoes over the course of a transition. The Forces route the system from one stage to another creating evolutionary changes while different subsystems of the system co-evolve towards a radical transformation.

A societal transition is a transformative process that results from the continuous cyclic evolution of the societal system over time. This is a definition of the transition from the perspective of how it unfolds and develops.

CHAPTER 3
Conceptual Framework

In Chapter 2 we presented the existing concepts and conceptual frameworks of the Transitions Approach and Transition Management. In Chapter 3 we explain what our research contributes to existing theories on societal transitions and especially on the research of transition dynamics. We aim to develop a conceptual framework (that includes different conceptual tools) that explains what drives societal transitions and that shows what constitutes (and produces) transition dynamics. In this way, we will better understand transition dynamics and we will inform Transition Management practices. The conceptual framework will be ontologically based upon relevant approaches and theory and will be explained in this chapter. The conceptual framework is the descriptive module with which we operate and it provides the "nouns" of (the vocabulary of) our analysis. The conceptual framework will be further developed and grounded theoretically and empirically in the following chapters (Chapter 4, 5, and 6).

We start with the definition of a societal transition in Section 3.1. The defining elements of a societal transition are related to the conceptual tools that are initially presented in Section 3.2. The conceptual tools are the primary conceptual research outcomes. More specifically, we will present the following conceptual tools and concepts: (a) the Evolution Cycle of the Societal System (Section 3.3); (b) the Forces Driving Transitional Change tool (Section 3.4); (c) the Conceptual Map of the Societal System (Section 3.5), and the (d) Intermediate Changes (Section 3.6). The different types of societal transitions as the episodes of an overall societal transition are also presented in Section 3.7.

3.1 Conceptualizing societal transitions

Societal transitions are phenomena that take place in societal systems throughout their evolution. Societal systems are considered complex adaptive systems that have a non linear relation between the stimulus and the response (Holland, 1995) and present a co-existence of numerous interacting elements "each of which is behaving in its local context according to some rule(s), law(s) or force(s)" (Maguire and McKelvey, 1999, p.26). A small change or influence in one subsystem of the societal system is able to cause drastic changes in different subsystems and consequently in the entire system.

At the same time, the societal system is characterized as adaptive since it has the capacity to adjust its functions to experienced stimuli. Adaptation as a response to change was borrowed by evolutionary theory. Adaptation enjoys different interpretations and conceptualizations. Kay (2004, p.214) considers adaptation as the ability of the system to sustain its function or to have a "behavior that fits the environment". An adaptive system consequently adapts its behavior to its context so as to fit with it. Adaptation as a characteristic of the system is important and essential to understand its development and evolution.

We conceptualize a transition to be a continuous process that takes place in different stages of the system's evolution. The system adapts to its context and adapts its function via its evolution cycle. This continuous cyclic processes of the societal system result in a fundamental change of the societal system over time. **A societal transition is (considered to be) a transformative process that results from the continuous cyclic evolution of the societal system over time.** This is a definition of the transition looking at how it unfolds and develops.

We need to understand what a societal transition entails. The definitions provided by transition scholars (see Box 1.2 in Chapter 1) present common characteristics of a societal transition. We consider those definitions are starting points for reconceptualizing the nature of a societal transition. Its defining characteristics, however, are not clearly explained. We will try to define a societal

transition by using attributes of change so as to show what the distinguishing characteristics of a societal transition are as a change process.

Defining attributes of a change process include the impact scale of change, the magnitude of change, the locus of change, and the development time. The first attribute of change is the *impact scale of change* translated to a spectrum from reversible to irreversible impact on the subsystems of the societal system and their function. The *magnitude of change* captures whether the change has an impact on one subsystem or influences more subsystems. The magnitude of change is also referred to as the extent of change by Rotmans, Kemp, and Van Asselt, (2001, p.18) and by Giddens, (1984, p.246). The *locus of change* (meaning where change takes place) are investigated in different subsystems of the societal system, namely the society, the market, the institutions, the technology, the culture and the environment.

The *development time* is the time period that a change process needs to materialize. The development time is referred to as fermentation time or throughput time by Rotmans, Kemp, and Van Asselt, (2001, p.18) and as momentum by Giddens (1984, p.246). Whether the development time of a change can be included as a defining attribute is debatable. In the transitions field, the time length is considered as an important aspect when discussing transitions (Rotmans, Kemp, and Van Asselt, 2001) and is considered to span over a generation (more than 25 years). In our view, it is essential to define the development time when comparisons need to be made between different systems about the change processes. We find it relevant to consider the development time as a characteristic to mark the time length of a change process and not as a necessary attribute to define its type. We consider a transition to materialize over the long-term period due to two reasons: (a) given that it is a complex process, the impact of any driver may materialize on the long-term due to the complexity of the process, and (b) given that a transition is a social process (to some extent), the changes in perceptions and practices need to be explored over the period longer than a generation so as to capture (potential) intergenerational shifts.

In consistency with the above defining attributes of change processes, we can now define what a societal transition entails:

Defining attribute of change	Range of Values	Societal Transition
Impact scale	Reversible versus irreversible	Irreversible
Magnitude	One subsystem versus more subsystems	Majority of the subsystems
Locus	Subsystems of societal system	Multiplicity of subsystems
Development time	Short-Term, Medium-Term versus Long-Term	Long-term (>25years)

A societal transition can be defined as a high magnitude change that irreversibly changes the function of the subsystems of the system. The transition is also perceived as a long-term change that may exceed one generation in time scale. The above definition of a societal transition incorporates all the common aspects of the definitions provided such as: process of fundamental change (Rotmans, et.al., 2000), long-term horizon of change, shift from one system to another (Kemp and Rotmans, 2001; Geels, 2005a, p.682), "set of connected changes which reinforce each other" (Rotmans, Kemp and Van Asselt, 2001) and the common idea of looking in different fields to sense what causes this change (Geels, 2002).

3.2 Conceptual tools

In the above paragraphs, we state two conceptualizations: (a) A societal transition entails irreversible changes in different and multiple subsystems of the societal system. Every change that takes place and contributes to the overall transition can be realized over one or more cycles of the evolution of the societal system. (b) In view of the first conceptualization, we conceive a societal transition as the

transformation process that results from continuous cyclic (processes of the) evolution of the societal system over time.

In order to explore and understand how societal systems respond over the course of a societal transition, we need to investigate the phenomenon of societal transitions and its dynamics. More specifically, we need to explore how the societal system evolves over time. We identify the stages of the system's evolution as derived by different disciplines of social sciences and institutional research. The first conceptual tool is the **Evolution Cycle of the Societal System** and relates to the research question: *Is there a generic pattern to be found in the way societal transitions develop?*

Following a complex adaptive systems perspective, the state of the system and of its context is considered to be manifested in (the presence and action of) forces. In line with this, Kooiman (2003, p.205) also points to societal forces as the stimuli of dynamics: "dynamics can be seen as the result of all kinds of societal forces and the tensions emanating from them." Consequently, the dynamics of the system are subject to the underlying conditions of the system; hence systemic and/or exogenous forces can influence the evolution of the system that undergoes a transition.

We identify the forces that prevail and are effective in every stage of the Evolution Cycle of the Societal System. The second conceptual tool is the Forces Framework that includes **Forces Driving Transitional Change** and relates to the research question: *What are the characteristics and dynamics of transitions?* Forces can be stimulating or inhibiting, as in the mechanical equivalents of driving and dampening forces. Also as in the mechanical analogue, forces can be thought of as the result of several factors (Frantzeskaki and de Haan, 2009).

Every force has a different impact on the societal system, a different subsystem in which it exerts (its influence) and a different locus within the societal system. At the same time, the variety of forces present over the course of the transition results in a synergistic effect on the evolution of the societal system. This diversity of origin and action and the synergism result (partially) in the complexity of the societal transitions. It is therefore important to explore and conceptualize where the societal forces of transitions are being exerted. In order to differentiate and distinguish systemic and exogenous forces, we follow a systems approach.

In addition to our conceptualization of the evolution of the societal system and the related forces, we conceptualize on the structure of the societal system so as to investigate where change takes place. More specifically, we identify subsystems of the societal system that depict its structure and respond to functions that it serves. The delineation of a societal system into structural subsystems is performed so as to systematize our research on the forces of transitions. The third conceptual tool of our conceptual framework is a ***Conceptual Map of the Societal System*** (an adapted version of which is presented in Frantzeskaki and de Haan, 2009).

3.3 Evolution Cycle of Societal System

In this section we will present the Evolution Cycle of the Societal System, its different stages and the grounding of the different stages in theory. For the grounding we have selected theories that explain societal change or societal evolution or parts of societal evolution. We intentionally excluded existing frameworks and conceptualizations from the transitions field so as to ground our conceptual tools to existing theories, as discussed in our research methodology (Chapter 2). After the grounding of the stages, we will introduce the forces that drive the system from one stage to the other as induced by the different theories.

A societal system undergoes different stages during its evolution. A societal system is formed by new ideas, and new practices upon initial structure, and with support and flows of resources the system settles. A system can further change but marginally via continuous support of its existing stability. It can be triggered by internal or external shocks. Then shocked and destabilized, it can be further unsettled and be driven into a new stage by innovative ideas, practices and paradigms towards a new system or amalgam of the (old) system with adapted new ideas and practices.

During every stage of the development of the societal system (SS) different processes and forces prevail. We define three stages of the evolution cycle: ***Genesis, Stasis and Metastasis*** (Figure 3.1).

Every stage represents a dynamic equilibrium with its own dynamics and characteristics. A stage represents a period in the system evolution where the systemic forces are at equilibrium with the context. This also implies that the forces that drove the system towards a stage continue preserving its equilibrium at the respective stage.

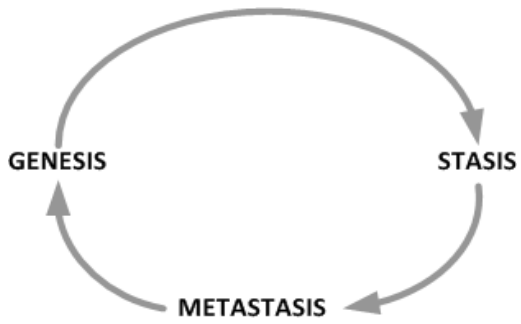


Figure 3.1: The Evolution Cycle of the Societal System.

Our conceptualization agrees with the definition of the dynamic equilibrium as introduced by Rogers (2003, p.453): "dynamic equilibrium (...) occurs when the rate of change in a social system at a rate that is commensurate with the system's ability to cope with it. Change occurs in a system in dynamic equilibrium, but it occurs at a rate that allows the system to adapt to it."

To summarize, the Evolution Cycle of the Societal System consists of processes that contribute to the evolution of the societal system. The stages are dynamic equilibrium processes and the processes that shift the system from one stage to the other are shifting processes constituted by different forces.

3.3.1 Genesis stage and formation forces

The genesis stage includes the forces and processes towards a creation of a constellation[5] (e.g. a new regime) or new practices. The genesis stage is characterized by innovation and its dynamics[6].

The theoretical underpinnings of the genesis stage rely on regime formation theory, structuration theory, social entrepreneurship theory, and active society theory. According to regime formation theory, actors' perceptions give rise to new practices and new regimes (Rittberger and Mayer, 1995; Haas, 1995, p.170).

Regimes are established and are operating configurations of political processes, institutional processes and actors' perceptions; similar to what Sabatier (1985) calls "policy systems". More specifically, Young and Osherenko (1995, p.237) conceptualized the formation of the regime as a cooperative action between three different clusters of related factors: (a) power related factors that capture political interplay, (b) interest factors that relate with actors' practices or new practices and/or new knowledge in the system, and (c) contextual factors that capture the organization and function of institutions (Young and Osherenko, 1995, p.240). Contextual factors include "national and world circumstances and events" (Young and Osherenko, 1995, p.251). To summarize, regime formation theory states that a new regime can be formed when innovation in the form of *new practices*, new knowledge and *actors adopting the new practices* are present.

In addition to regime formation theory that deals with policy regimes, structuration theory takes an integrative approach incorporating the role of social agents in the structuration and reformation of structures of the societal system (Giddens, 1984, p.282). The duality of structure, according to Giddens, concerns the dual role of structure of the societal system as the medium and the product of praxis of knowledgeable agents. Social structure not only constrains actors' interaction but also enables it. *Actors and their practices thus form and reform the societal system*. Giddens (1984, pp.89 & 337) specifically states that "social systems only exist in and through the continuity of social

[5] We agree with the definition of De Haan and Rotmans (2011, p.93) of constellation: Constellations being the subsystems of a societal system that have different powers.
[6] The Genesis Stage is not always the first stage in a societal transition.

practices, fading away in time." According to structuration theory, actors' practices and interests are the foundations of a societal structure (Stones, 2005, p.81). From social theory writings, the research on characteristics, role and behavior of social entrepreneurs of Nicholls (2006) provides additional input in identifying what societal conditions may engender the genesis stage. More specifically, Nicholls (2006, p.48, and 133) addresses that social entrepreneurs introduce "a fundamental pattern of change" by their thinking and actions. If social entrepreneurs become empowered–either by self-sustaining mechanisms for achieving critical mass or by provision of support-, "they affect social change because they create a new benchmark for the way a sector or industry must behave" (Young, 2006 cited in Nicholls, 2006, p.67). Consequently niche actors, such as *societal entrepreneurs, have the potential to engender genesis of a new regime;* their presence however is a necessary but not necessarily sufficient condition for a change to come about.

In active society's theory, actors are central to the society and they utilize their assets, power and commitment to their goals to create an active society. More specifically, Amitai Etzioni (1968, p.400-401) addressed the *presence of "a mobilized collectivity"* either from within the system or external to the system as a structural condition for mobilization for social change to take place.

From the above reviewed theories, we induce three forces that drive the system to a genesis stage and we name them ***formation forces***: Presence of new practices, Presence of a niche, and Presence of a societal demand. Formation forces capture the innovative potential of the societal system. More specifically:

> (a) Presence of new practices (societal, technological or organizational) have been addressed by regime formation researchers (Rittberger and Mayer, 1995; Haas, 1995, p.170; Young and Osherenko, 1995) and by structuration theorists (Giddens, 1984)
> (b) Presence of a niche. The presence of knowledgeable actors constituting the agents of change in a societal system is addressed by Giddens (1984). We agree with Giddens (1984) in conceptualizing a niche as the group of knowledgeable actors that act (intentionally or unintentionally) as agents of change when adopting or practicing new practices. Innovation studies also focus upon the societal sphere to indicate agents of change or actors who initiate policy and institutional change. The niche is seen as a locus of new practices (Faber et al, 2006, pp. 78-80 and 102-103) and/or "domain for specialized applications" when considering innovations (Kemp and Rotmans, 2004, p.141; Hoogma, et. al. 2002, p.4).
> (c) Presence of a societal demand. A societal demand is identified as a driving force in socio-economic change theory (Perez, 2002) and in regime formation theory (Rittberger and Mayer, 1995).

3.3.2 Stasis stage and support forces

In a stasis stage, the system undergoes little evolutionary change and it temporarily settles. A societal system at the stasis stage gets settled through processes of legitimization and institutionalization that enable the actors in the system to regulate their interactions, and protect their interests and space.

The theoretical underpinnings of the stasis stage of the societal system rely on structuration theory, institutional theories and innovation theories. Structuration theory offers the theoretical ground on how societal structures are settled or structured. Giddens (1984, p.169) points to the *resources and rules* that act as enabling factors for structuration as well as the constraining factors for system reproduction. The role and importance of rules for structuring of a societal system are also addressed by Mingers (1996) and Arts (2000). More specifically, Mingers (1996, p.474) notes that "structure is seen as similar to a code or *set of rules* which governs possible selections of social action." In line with this, Arts (2000, p.252) addresses *rules* and norms as the media of legitimation whereas *resources* are "material and non-material order of domination", thus addressing the enabling role of resources in achieving a desirable outcome.

Institutional theory researchers find that rules and resources are fundamental to the settlement of every societal system. North (1990) indicates that norms and *rules* constitute both formal and informal

institutions. In line with this, Douglas (1986, p.48-49) states that conventions as emergent informal *rules,* are followed by rules that consequently constitute a societal system.

Innovation theories add to this by offering the basis for those social conditions that catalyze the absorption of change. More specifically, Peizer (2006, p.7) and Hall (1994, p.56) address the importance of *resource provision* for supporting societal structures and change. Financial, material, organizational or legal resources are required for the effectuation of change within an institutional system as a response to the outside forces. In social entrepreneurship writings, provision of support and *exercise of power* are critical for the empowerment and consequently the settlement of new ideas and entrepreneurial practices (Nicholls, 2006, p.67).

From the above reviewed theories, we induce three societal conditions or forces that drive the system to a stasis and we name them ***support forces***: Standardization of practices, Provision of resources, and Exercise of power. Stasis is realized via the support forces. More specifically:

> (a) Standardization of practices is the action of introducing rules and standards. When a practice is standardized in the form of rule, standardization of practices is taking place. Rules are necessary for the settlement of a new system and/or the adaptation and stabilization of an existing system (Giddens, 1984; Douglas, 1986; North, 1990; Mingers, 1996; Arts, 2000).
> (b) Provision (or presence) of resources is the flow or input of any type of resources into the system, such as either funds or subsidies or research input or time (Peizer, 2006; Hall, 1994; Nicholls, 2006).
> (c) Exercise of power concerns the exertion of power in any form to the system. The importance of power is addressed by regime formation theory, with the power factors that entail support for the newly formed regime (Young and Osherenko, 1995, p.240), and by social entrepreneurship writings (Nicholls, 2006).

3.3.3 Metastasis stage and triggers

In a metastasis stage, the system experiences perturbations and shocks. A societal system at metastasis is destabilized and experiences forces and processes that contribute to a societal reorientation or destruction.

The theoretical underpinnings of the metastasis stage of the societal system rely on institutional theories and complexity theory. From institutional theories, Scott (1998) addresses *systemic failures* as destructing forces to the societal system. According to Scott (1998, pp.263-264) systemic failures are characterized by (a) historical origin (the way the system functions and behaves towards change has its origins in the historical pathway of its development), (b) institutional nexus (rigidity of institutional structures and path-dependency), (c) goal view (what is the purpose the system serves), and (d) scientific background incapable to deal with complexity (of problems or systemic complexity experienced by the system). In line with this, Pruitt (1981, p.7) notes that changes in power relations, demands and societal context may lead to a failure of a structure to fulfil its function.

In addition to systemic failures, Scott (1998, p.97) identifies *crises* as a cause of constructive destruction of the societal system. In complexity theory, crises are also seen as essential conditions for the development of the societal system (Geldof, 2005, p.31-32) and necessary for taking "on board the new" (Kuhn, 1970, p.93; Stacey, 1996).

Contextual factors also play a role in the way systems evolve. Contextual factors are indicated by regime formation theory as "national and world circumstances and events seemingly unrelated to the issue area under consideration that play a major role in determining if and when international co-operation to address a particular problem or issue area occurs and in shaping the content of any regime that forms" (Young and Osherenko, 1995, p.251). We refer to these factors as *exogenous events and developments* due to their indirect and implicit impact on the transformation of the system.

From the above reviewed theories, we induce three societal conditions or forces that drive the system to a metastasis and we name them ***triggering forces or triggers***: Systemic failures, Crises, and Exogenous events and developments. More specifically:

(a) Systemic failures are the manifestations of systems incapability to fulfill their desired and/or designed function. Systemic failures are associated with the ineffectivess, inefficiency and/or inadequacy or misfit of an existing system (Scott, 1998; Pruitt, 1981)
(b) Crises are (conceptualized as) events that shock the system and change its dynamics in an abrupt and complex fashion. Crises are critical for the evolution and for the transformation of the societal system (Scott 1998; Geldof, 2005; Martens and Rotmans, 2005; Kuhn, 1970; Stacey, 1996).
(c) Exogenous events and developments are contextual drivers that have a diffused impact on the evolution of the societal system meaning indirect and implicit (Young and Osherenko, 1995). Examples of exogenous events are natural disasters (such as a hurricane, an earthquake) and accidents (such as the Chernobyl accident).

3.3.4 Summarizing with mapping the Forces upon the Evolution Cycle

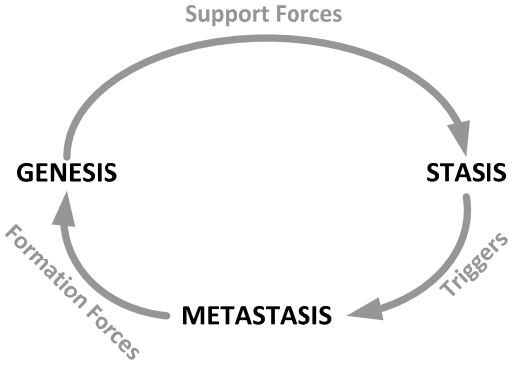


Figure 3.2: The Evolution Cycle and the Forces for transition prevailing in every stage shift.

A societal transition is the outcome of continuous cyclic processes of the evolution of the societal system over time. The evolution of the societal system is conceptualized and mapped as a cyclic process that includes three stages: genesis, stasis and metastasis. These stages are temporary dynamic equilibria and have their own dynamics. Different forces drive the system towards every stage and work on every stage (Figure 3.2)[7]. A brief summary of the stages of the evolution cycle of the societal system and the associated forces driving to them is given below.

Stage	Snapshot of the societal system	Forces
Genesis	The societal system experiences new ideas, new practices and innovation. These may be alternative trends that are not dominant but coexist with existing practices.	Formation forces
Stasis	The societal system undergoes little evolutionary change and it temporarily settles. The support forces have enabled and realized the absorption of new practices in the system which now is at a dynamic equilibrium.	Support(ive) forces
Metastasis	The societal system is at an interim stage and is disturbed by an unexpected event that has severe impacts in the system. The ordinary function of the system is disrupted and unease, in different forms, is experienced.	Triggers

3.3.5 Relation of the Evolution Cycle to the Multi-Phase Framework

The Evolution Cycle of the Societal System describes how the system evolves over time towards its transformation. From the transitions approach, the multi-phase framework also describes how a system transforms (van der Brugge and Rotmans, 2007). More specifically, the multi-phase concept describes the different phases that a system undergoes in a sequence. The system passes from the

[7] Processes and bypasses that complement the Evolution Cycle of the Societal System will be presented in the following Chapters 4,5, and 6.

predevelopment towards the stabilization in a sequence of changing dynamics. The multi-phase framework is a good communication tool for policy makers because it presents the transition and its end-state as attainable and feasible.

Although we understand and value the explanatory capability of the multi-phase concept, we believe that it simplifies the evolution of the societal system in two ways: (a) the ordering of phases in a sequence presumes a beginning and an end of a transition, when this is inconsistent with the open-ended and continuous nature of societal transitions, despite the claim that the sequence can be alternated; and (b) the dynamics that the societal system experiences are not (always) captured by the S-shaped aggregation (Rotmans and Loorbach, 2010a, p.126-127).

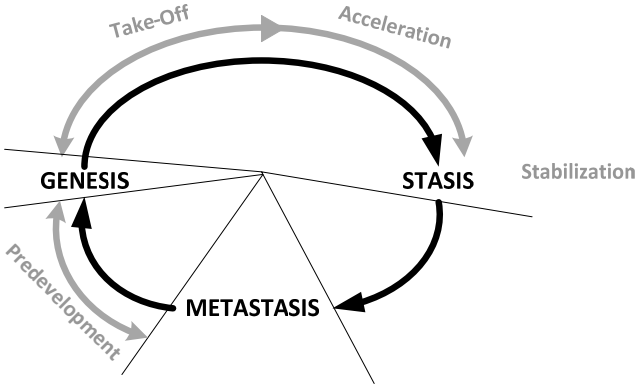
We propose the mapping of the different phases of transitions in a cyclic form that represents the continuum of changes that a system undergoes over the course of a societal transition. We argue that the cycle of system evolution complements the multi-phase framework by representing: (a) the dynamics in a form of loops (which will be explained in the following chapters) that are differentiated for every stage of the system evolution; (b) the different dynamic equilibria that a system experiences; (c) the phases of transitions in a systematic way relating them to underlying dynamics in the form of forces, and (d) the stage where a system may experience collapse or breakdown if disturbances enhance existing dynamics (that in our conceptualization is depicted in the metastasis stage and the associated feedback loops), and (e) the stage that innovations and new practices are fermented as a distinctive stage (the genesis stage) (Figure 3.3). The core assumption of the evolutionary cycle is that dynamics are present at all the stages of the system.

To summarize, the relation of the Evolution Cycle to the multi-phase framework is that: i) the phases presented in the multi-phase model are also included in the Evolution Cycle with two additional stages present at the evolution cycle; and ii) the Evolution Cycle includes dynamic equilibria between phases with slow dynamics. The stages are conceptual constructs that aim at simplifying the complex dynamics a system experiences over the course of a transition.

Take-off phase: "Triggering change and build up of a new regime", "innovations start acting as perturbation of the status quo" ,"regime dynamics collapse when the systems key functions fall out", "build-up of innovation networks based on alternative ideas, concepts, theories, and technology" (van der Brugge and Rotmans, 2007, pp.254-256)

Acceleration phase: "the 'old' regime transforms and consequently the 'selection environment' changes and is primarily based upon selection rules from the up-scaled innovation network" (van der Brugge and Rotmans, 2007, pp.254-256)

Predevelopment phase: "co-evolutionary regime dynamics increase regime interdependencies" "innovations are still isolated and fragmented, improperly embedded and insufficiently developed enough to compete with the existing regime". (van der Brugge and Rotmans, 2007, pp.254-256)



Stabilization phase: "the new regime settles down. Transformation processes turn into optimization processes. Regime dynamics now are equilibrium dynamics in order to enhance efficiency. If this equilibrium is not reached, the new regime can still breakdown." (van der Brugge and Rotmans, 2007, pp.254-256)

Figure 3.3: The Evolution Cycle and the phases of transitions mapped on it.

3.4 Forces Driving Transitional Change

We adopt a systems approach in order to differentiate and distinguish endogenous and exogenous forces. At this point, the systems approach is a conceptual lens used to detect and identify different subsystems and the boundary of what it is defined as the system. Knowledge of structure and delineation of the system are important when investigating what is subject to change. According to systems thinking, every system consists of subsystems, a distinctive boundary from the context, and relations between its subsystems. A fundamental assumption of systems thinking is that the structure of the system influences and determines its behavior.

Systems thinking offers a framework to distinguish *exogenous and systemic forces for transitions*. The delineation of the system from its context is the basis for distinguishing systemic from exogenous forces: systemic are the forces that are exercised and/or act within the system and exogenous are the forces that are present and exercised upon the system (from outside the system).

We consider that change of the system does not only come from outside but also from within. The forces driving transitional change are those which have the potential to transform the societal system and are located within and outside the system. In this way we complement existing views which consider forces external to the system to be more influential than internal forces. For example, Walker (2009) considers forces driving structural change as external to the system and they are the forces that are included in uncertainty analysis.

In the following paragraphs, we will first define every force and second we will identify which forces are systemic and which forces are exogenous. For defining the forces, we build on the primary definitions (as given in the previous Section 3.3) and we further elaborate on the content and their positioning.

3.4.1 Formation Forces

Formation forces represent the innovative potential of the societal system.

Presence of new practices: The presence of new practices refers to technological practices or technology, to organizational practices, to new ideas or services as well as to a merging of existing practices (hybrid). A presence of new practices is conceptualized to be experienced within the system and hence, comprise a systemic force. We conceive that the presence of new practices within the system can have a direct impact on system evolution and change whereas practices exogenous to the system may influence the system indirectly.

Presence of a niche: A niche is a group of knowledgeable actors that act (intentionally or unintentionally) as agents of change when adopting new practices. Accordingly, the presence of actors who adopt a new practice or employ innovative ideas is conceptualized by this force.

Presence of a societal demand: A societal demand depicts the objectives and strong interests of social actors but in an aggregate manner (hence appearing at the meso level) and not as personalized or actor-tailored objectives. An example is the demand for chemical-free food or the demand for recreation space in urban centres. The presence of a niche and the presence of a societal demand are positioned within the societal system. Similar to the presence of new practices, the presence of a niche and the societal demand may influence the system.

3.4.2 Support Forces

Support forces depict the actions of empowerment or blockage of change and the actions of settlement and institutionalization within a societal system. Hence support forces can act upon the transition agents or towards the conventional agents that resist change. For a better understanding of what every force represent in the system, we elaborate on its content and then on its positioning.

Standardization of practices refers to the action of introducing a law-like pattern of a practice/routine that can be a rule or a standard. Standardization ensures that the practice enjoys a universal status and

includes the action of introducing rules and standards. For example, the routine of driving in city streets is standardized by the driving rules and positioning of traffic lights, signs and infrastructure. Laws are standardized rules, and directives are standardized practices. A constitution is a standardized social norm. Standardization of practices is a systemic force since it can take place within the system and specifically at institutions.

Provision of resources is the flow or input of any type of resources into the system. Provision of resources is often called niche empowerment and/or just empowerment. A resource may be capital in the form of investments in a market, funds for research and development, legitimate power, political power, space or other natural resources or commodities. Provision of resources can be both systemic and exogenous.

Exercise of power concerns the exertion of power in any form on the system. Power that is exercised from a societal constellation to another can be either protecting/enabling power or resisting power. At the same time, if power is exercised internally to the constellation, it is referred as a power sink.

The distinction between exercise of power and standardization lies in the objective, especially when talking about the enforcement of a law: when a new practice is legitimized or standardized using legislative actions then it is standardization but when it aims at constraining or enabling actions and practices then we conceptualize it as an exercise of power.

3.4.3 Triggers

Triggers shock or perturb the system and include those forces that are highly uncertain and whose appearance is uncontrollable. For a better understanding of what every force represents in the system, we elaborate briefly on its content and then on its positioning and direction.

Systemic failures are the manifestations of systems' incapability to fulfill their desired and/or designed function. Systemic failures include systemic inefficiencies, ineffectiveness as well as inadequacy or misfit (between demand and supply) of the system. Ineffectiveness of the system concerns the inability of the system to fulfil the demand or objective that it is designed for. Inefficiency of the system concerns the misallocation of resources and the mis-utilization of resources. Inadequacy concerns the misfit of the system to the targeted problem or demand and it is also regarded as a systemic failure. Systemic failures are always endogenous to the system.

Crises are (conceptualized as) events that shock the system and change its dynamics in an abrupt and complex fashion. Examples of crises are riots or experience of societal unease and war. A crisis often occurs "without an apparent advance warning" (Geldof, 2005, pp.31-32) and hence crises are highly uncertain. Crises can take place both outside the system –in its context- and within the system; hence there can be exogenous and/or systemic crises.

Exogenous events and developments are contextual drivers that have a diffused impact on the evolution of the societal system, meaning indirect and implicit. Examples of exogenous events are natural disasters (such as a hurricane, an earthquake) and accidents (such as the Chernobyl accident).

What distinguishes an external event from a crisis is that a crisis is characterised by multiple causality and impact.

Whether an event is considered as a crisis or an exogenous event depends on the system boundaries. If for example we are analyzing the Dutch energy system and its transition, the nuclear disaster in Fukushima, Japan is conceptualized as an exogenous event that may have an influence to its transition. If we are analyzing the Japanese energy system and its transition, the nuclear disaster in

Fukushima is conceptualized as a crisis or systemic failure[8] internal to the system. Or if we are analyzing the security system in the Netherlands (meaning the police and internal security system), the 9/11 terrorist attack in New York is conceptualized as a crisis external to the system that had an influence in the changes that took place in the Dutch security system. This event is conceptualized as a crisis for the American security system as well. An elaboration of the different types of crises can be found in Appendix B.

3.4.4 Relation of the Forces to Conditions for Change

In our earlier work (Frantzeskaki and de Haan, 2009) we elaborated on how Conditions for Transitional Change are related to the Forces Driving Transitional Change. We believe that it is important to elaborate on the analytical link between the conditions and the forces in order to contribute to the theory of transitions in a consistent way.

De Haan (2010) defined three conditions for transitional change: Tension, Stress and Pressure. According to de Haan (2010, pp.56-57, Book II): Tension takes place between a constellation and the landscape (the context of the system). Tension refers to adverse functioning of a constellation in relation to its environment, the landscape. Stress takes place within a constellation and concerns internally adverse functioning of a constellation. Pressure is realized from other constellations and concerns the adverse functioning of a constellation with respect to another constellation. What is considered external and internal to the system obviously depends on the demarcation of the system from its context, the landscape.

For understanding which forces aggregate into specific conditions, the direction of change and the consequent direction of the forces, need to be defined (Table 3.1). Specifically, when change is driven from above (top-down or macro to meso level) the societal system is said to experience tensions. The forces that can be exerted with a top-down direction include: (a) Presence of a new practice, when this new practice is exogenous to the system and it is being imposed on it; (b) Provision of resources can act from the landscape to the system or from a regime to a niche hence has a top-down direction; (c) Standardization of practices; (d) Exercise of power can also act upon the system hence having a top-down direction; (e) Crises that are realized at the landscape can act upon the system with a top-down direction; and, (f) Exogenous events are by definition exerted from the landscape (context) to the system.

Table 3.1: Conditions and forces driving transitional change (adapted from Frantzeskaki and De Haan, 2009).

Forces Driving Transitional Change	Direction of forces	Conditions for Transitional Change
Crises, Exogenous events Standardization of practices Provision of resources Exercise of power Imposition of new practice	Top-down	Tensions
Exercise of power Standardization of practices Systemic failures	Internal	Stress
Presence of a niche Presence of new demand Presence of new practice	Bottom-up	Pressure

When change is driven from within (internal), the societal system experiences stress. The forces that can act in inwards direction include: (a) Exercise of power in the form of self-regulation; (b) Standardization of practices that can be realized within the system at the institutions (hence its

[8] For distinguishing whether it is a crisis or a systemic failure, more information is required about the event and its underlying causes. Given that we refer to this event as an example, we are not at place to search for more details and make a complete analysis of it that will aid at finding under which force to categorize it.

direction is inwards); and (c) Systemic failures that concern the system itself hence always systemic (internal) and with an inward direction.

When change is driven from below (bottom-up or from micro to meso level), the societal system experiences pressure. All the formation forces (presence of a niche, presence of a new practice and societal demand) are forces that act in a bottom-up direction to the system. We have to note that there is no transferability of properties between conditions and forces.

3.4.5 Implications of understanding the dynamics of societal transitions in the form of Forces

Understanding the dynamics of societal transitions in the form of forces (formation forces, support forces and triggers) implies that we focus on the macro-level of aggregation Only the impact of actions and events is considered at the system level and this impact (in the form of forces) is further associated with policy regimes and/or issue related regimes that compete or co-evolve over the course of a transition (Chapter 4 and de Haan, 2010).

Human agency versus the forces

Dissecting the dynamics of societal transitions in the form of forces implies that the impact of events or actor's actions becomes more important than the actor's action. This comes in consistency with our choices of level of aggregation and functionalism for explaining the phenomenon of societal transitions. In this way, we not only understand system components or subsystems as functional systems but also actor's actions as functional towards system's evolution and consequently, transition. Unavoidably, the issue of choice of the ontology of our conceptual framework becomes relevant: which approach underlies the ontology of the forces framework?

Functionalism or structuralism for explaining transition dynamics in the form of forces?

The Forces Framework is a conceptual framework that adopts elements from both structuration theory and neo-functionalism. Starting with structuration theory, practices are seen to produce and reproduce structures whereas structures are seen as both products and constraints of practices. This duality of structure is internalized and represented in the Conceptual Map of the Societal System (discussed in Section 3.5) and is also adopted in the Forces Framework. Formation forces capture the innovation potential of a system with (an explicit) focus on practices. Support forces capture the institutionalization of either (single) practices or niches as determinants that impact on the structure of the system. Considering our macro-level of aggregation we explicitly focus on the way practices impact the evolution of a system. Thus we do not take into account actor-level characteristics such as interest, opportunism or strategic behavior.

Functionalism implies that structures are explained and assessed by their function in the system and that every system has a function. In our research, both the Conceptual Map of the Societal System and the Forces Framework have functionalistic foundations. In relation to forces, the function represents the contribution made by a force to the way a social system develops or operates. Function is perceived in our framework as a property for differentiation of the forces and of the subsystems. Every force has a different function (referred to as impact on the system evolution) hence is categorized as formation, support or trigger. At the same time, every subsystem has a different function in the overall system operation.

3.4.6 Translating empirical information into forces of transitional change

The forces framework offers a way to detect the dynamics of societal transitions. More specifically, the investigation of the forces that drive transitional change will provide policy makers with insights on what drives transitional change, what is the impact of every force on the system, so as to gain insight as to what degree those forces can be influenced and thus what type of means of intervention can be introduced to the societal system.

Having the presented forces of transitions in mind, one might ask: How to detect the presence of the forces identified in the literature when dealing with real life cases? After conducting case studies using the forces frameworks, we can provide a simple heuristic in identifying the forces in real cases.

For the identification of the forces present and influential in societal transitions, the events that take place in the macro-social environment (meaning the macro and meso level of aggregation) first need to be identified and listed. The occurrence of an event manifests the presence of a force that influences the process of societal transition. The conceptual "translation" of an event into a force follows the action criterion: *What is the action realized in the societal context being manifested by the present event?* For example consider a legislative act as an event. If a legislative act concerns the introduction of management guidelines, it manifests standardization action of a type of practices by the authorities; it thus translates into *Standardization of practices*. If a legislative act concerns the establishment of a type of change in formal institutions, it manifests an institutional change; it thus translates into *Institutional change.*

3.5 A conceptual map of the societal system

In order to investigate where change takes place, we conceptualize the societal system to consist of four subsystems: institutions (formal rules and conventions), technology, natural environment and the civil society. These subsystems are placed at the meso-level and they have functionalistic ontological grounds (meaning that every subsystem is only considered when it has a function in the overall system). Knowledge of what constitutes the structure is important in order to determine "order, coherence and organization" of the societal system (Prigogine and Stengers, 1985, p.15).

The *environment* as the source of natural resources and space is an important subsystem of the societal system. The (science and) *technology* includes scientific advancements, knowledge capital and the application of those in the form of technology. The environment and the technology subsystems provide the actors with the means to anticipate and deal with their everyday needs and sustain their life (Blanchard and Fabrycky, 2005, pp.4-5).

The *civil society* consists of the actors living according to shared rules or conventions (Giddens, 1984, p.89; North, 1990). The routines of actors, the everyday practices, are mapped onto the civil society subsystem. The socialized actors are the heartbeat of the societal system (Blanchard and Fabrycky (2005, pp.4-5). The values, norms and ethics of the socialized actors underlie their patterns of behaviour (Sabatier, 1988, p.133) and manifest their practices.

In our conceptual map of the societal system we do not include the culture of the society. In definitions of informal institutions (North, 1990) civil society includes routines of actors, practices as well as conventions, unwritten rules and cultural attributes. More specifically, the culture subsystem includes the values that form the perceptions and beliefs of actors (Michaels, et al., 2006, p.938) as well as the unwritten codes of coordination and ethics that precede rules and constitutions. In our research we choose not to research the impact and influence of culture in societal transitions and not to research the cultural changes that may occur over the course of a transition. The research of cultural change and the impact of culture on societal transitions require different methods (e.g. anthropological research methods) and relates to different research objective than the one we have identified.

The *institutions* (and more specifically the formal institutions) are social constructs and comprise the ground that enables and legitimizes as well as constrains human action and interaction (North, 1990). The market as a special form of formal institution is the testing ground for the efficiency and fitness of a practice, a commodity or a functioning. When we refer to institutions we also include the market as a special form of formal institution. Formal institutions and markets formalize, regulate and standardize human action and interaction via rules.

The conceptual map of the societal system has functionalism as its ontological grounds (mainly Giddens, 1984). Based on structural functionalism, the systems and their subsystems are defined by their function. In line with this, Giddens (1984) proposes that social structures are produced and reproduced by actors' actions, while structures constrain and form actors' actions. Structure is thus the medium and the product of praxis. This comprises the duality of structure (as also previously described in Chapter 2) and it is foundational to the conceptual model.

The civil society subsystem with its practices, informal rules and routines produces and reproduces the rules as mapped in the institutions while, at the same time; institutions regulate, form and constrain cultures and practices of the civil society. The duality of the structures and practices is hence mapped between institutions and civil society. At the same time, the natural environment and technology subsystems influence both the civil society and institutions by the flow of resources, materials and means.

More elaborately: All four subsystems are of vital importance for the societal system. Every subsystem is interlinked with the other subsystems in a way that a change in one affects the others in return. The civil society subsystem is receptive to and nourishes changes of actors' routines, practices and perceptions. The new practices find a ground to diffuse or are aborted. The actions and interactions produce and reproduce institutions; while institutions is receptive to changes in a continuous adjustment of the society to reflect the needs of actors and being capable to accommodate their routinized practices (Giddens, 1984, p.171). This link between the institutions and civil society subsystems represents the duality of structure (Giddens, 1984, p.282) and with our conceptualization we extend the duality by bringing in the role of technology and the environment upon societal development.

Interdependence between the civil society, environment and technology subsystems becomes more evident when looking at the impact of technology on routines and behaviours of actors. Technology provides the means to enable practices and to respond to societal demands (Berkhout, Smith, and Stirling, 2004, pp.64-65) while at the same time influences perceptions of actors. More particularly, technological products modify or completely change everyday practices and interactions of actors e.g. communication practices have changed with the introduction of mobile phones over the last decade. The natural environment also has a great constraining influence on actors' actions and on forming actors' perceptions about interaction with space and time (given the uneven distribution of resources and the climatic zones that define the available resources per geographic area).

The Conceptual Map of the Societal System is used to ground and specify in a systematic way the Forces in every subsystem. The operationalization of the forces using the conceptual map of the societal system is included in Table B.1 in Appendix B.

As we have already presented, a transition is an outcome of the continuous evolutionary change of the system. During the numerous evolutionary cycles, the system experiences changes of smaller magnitude or intermediate changes. The overall progress of change is then captured in episodes of change (inspired by Giddens, 1984, p.244 & 374). We employ the four subsystems to identify the intermediate changes (Section 3.6) and the different episodes of change or, as we call them, the different types of transitions (Section 3.7).

3.6 Intermediate changes over the course of a societal transition

The societal system experiences purposeful and/or emergent intermediate changes that build up into a high-magnitude change, a societal transition. A societal transition is seen as a built-up phenomenon of intermediate changes. The intermediate changes track the course of the transition and are perceived as seeds of transitional change.

We start by identifying what changes in a societal system and its subsystems, focusing on its structure. Three attributes of change can be distinguished for every subsystem: the size, the operation and the (way of) organization. The operation of a subsystem refers to its workings and is directly linked to the outcomes (services, commodities). The (way of) organization refers to the internal regulation of a subsystem. The size of a subsystem is also subject to change e.g. the size of an institutional body is the number of its employees, the size of the market can be the number of firms and the size of the civil society is its population. We identify and categorize intermediate changes in a systematic way in Table B.2 in Appendix B. These intermediate changes can be used as a guiding list and are further grounded in the case studies and empirical examples.

3.7 Types of societal transitions as episodes of change

Adopting a systems approach to investigate societal transitions translates into investigating system change in subsystems. The forces framework is used to investigate the system's behavior over the course of a transition. Our starting conceptualizations on the different types of societal transitions are based on the conceptual tools of the Forces Framework and the conceptual map of the societal system and are the following:

- We define an **institutional transition** as a type of societal transition in which the forces at play have an impact on the institutions and civil society or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions and civil society. In a similar way:
- We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions, civil society and the environment.
- We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions, civil society and technology.

3.7.1 An example for understanding the different types of societal transitions

An example may explain our approach towards unraveling the different types of societal transitions. Take in mind a river basin as a system that includes the basin as the ecological subsystem, the institutions that regulate and protect the river and its related natural elements (e.g. aquifer level) and the communities that use the services of the river in the form of source of drinking or industrial water, transportation, recreation and more. When we detect changes taking place in the ecological subsystem (e.g. rise of water level or drought), which then trigger societal conditions that have the form of changes in institutional functions and organization, then we conclude that the system undergoes a socio-ecological transition. The case of semi-arid river basins in north-eastern Aegean Greek islands like Samos and Kos falls into this type.

When, in a river basin system, we detect changes whcih take place mainly in the institutional subsystem of the system, then the system undergoes an institutional transition. An example of an institutional transition concerns the Rhine River in the Netherlands in respect to flood management. The changes and initiatives for change in their majority concerned institutional or institution-related changes and innovations. Thus the system undergoes an institutional transition or, as put in different water management debates, an institutionally driven transition.

When, in a river basin system, we detect changes which take place in technology, then the system is detected to undergo a socio-technological transition. In highly engineered rivers, technology and technology change has a key role. An example comes from the coastal management of the Elbe estuary as analyzed by Gerrits (2008). In such a highly engineered estuary, the dynamics of sediment transfer from the river to the estuary mouth created a demand for new technological means and institutional innovations.

We thus indicate that societal systems can undergo different types of transitions under different periods of time. Societal transitions as long-term processes of change are perceived as evolving processes of the societal system that can involve different types of change patterns: institutional, social-ecological and/or socio-technological transitions. We therefore detect the dynamics of change using the forces tool, so as to understand the response of the system in the form of different types of transitions.

Given the presented typology of societal transitions, we will explore the dynamics of institutional, social-ecological and socio-technological transitions in the following chapters.

3.7.2 Relation of the typology of societal transitions to the Transitions Approach

Our approach of investigating different types of societal transitions by looking at how the societal system behaves over the course of a transition has implications for the research on transition dynamics and adds to existing transitions literature in two ways:

First, when research has as a point of departure a categorization of types of systems e.g. institutional system, or socio-technological system, then the research focuses on what types of changes take place in the particular systems. It is relevant here to mention that this relates to the choice of system boundary. A boundary is always subjective and placed by analysts mainly to demarcate the subject of research. A boundary, for example, that contains only the civil subsystem and technology subsystem demarcates a socio-technological system (see Figure 3.4). The research then focuses solely on the interactions and changes that take place in the socio-technological system, considering changes in the environment or in the formal institutions as external or irrelevant for the study[9]. Consequently, what is investigated and well researched are only types of changes that fit to the standard response of the specified system. An example here is socio-technological transitions and the respective patterns identified in Geels and Schot (2007) where change of socio-technological systems always includes both technology and society (see also Table 3.2). The types of changes found in socio-technological system are neither comparable nor transferable as examples to other systems; they are tailored and system-specific. In this way, systems that are characterized as socio-technological systems, for example, are only seen to undergo socio-technological changes; hence only tautological explanations are considered. This implies that the change being observed is predefined by the type of the system.

Our research does not follow the limitations of a system-specific view and in turn, extends to the following question: What other types of transitions can take place in socio-technological systems? What about processes of change in a socio-technological system that do not incorporate technological changes/advancement?

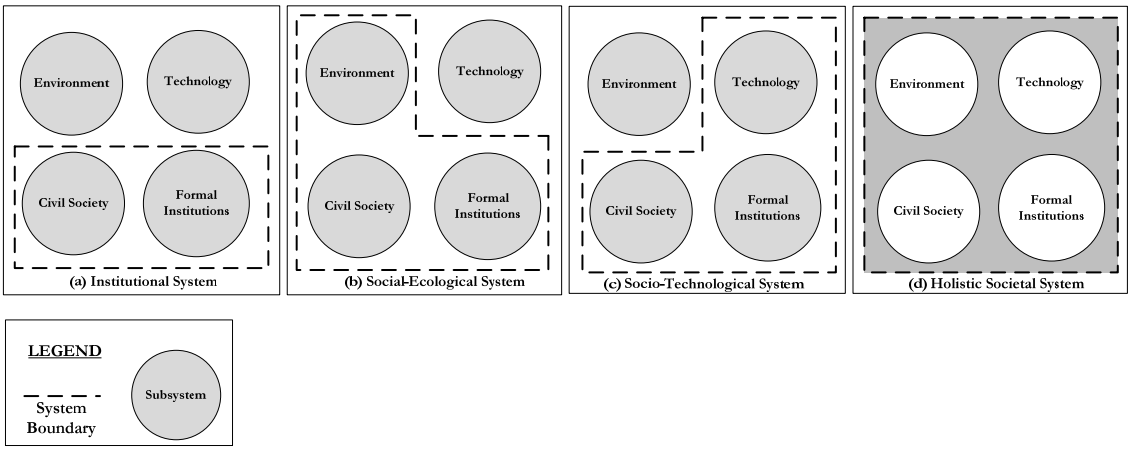


Figure 3.4: Different types of systems as being demarcated by specific system boundary (a) (b) (c) and (d) our holistic approach maps the societal system as including four subsystems.

Second, research on understanding the dynamics that consistently explores how a societal system behaves over the course of a transition and then typifying it, adopts a holistic view and can elaborate on the question: *Is the co-evolution between different elements of the societal system such as economic, technological, institutional and social-cultural elements, generic by nature or does it unfold in a transition-specific pattern?*

[9] The same holds for the studies of social-ecological transitions that "rarely considers the dynamics of technological change in any detail" (Smith and Stirling, 2010, p.1).

Table 3.2: Implications of the typology of societal transitions for research.

	TYPE OF SOCIETAL TRANSITION		
TYPE OF SYSTEM	Institutional	Socio-ecological	Socio-technological
Institutional System	⊗		
Socio-ecological		⊗	
Socio-technological			⊗

Note:
⊗ Type of transition that existing literature covers;
Blank: Type of transition that existing literature does not explore for the respective societal system, but which is also the subject of our research.

3.8 Summarizing the conceptual framework and revisiting the research questions

In this chapter we presented the conceptual framework that we developed. The conceptual framework includes three different conceptual tools:

(a) The **Evolution Cycle of the Societal System**, that maps how a societal system evolves over time
(b) The **Forces Driving Transitional Change**
(c) The **Conceptual Map of the Societal System**, that presents the structure of a societal system and its subsystems so as to understand where change takes place

The conceptual framework is the primary conceptual outcome of our research that we will further ground empirically and theoretically in the following chapters (Chapters 4, 5, and 6). After developing the conceptual framework to be used respond to the first research objective, we realized that we have insights that enable us to revisit the research questions and make them more specific. The main research objective is to understand how societal systems behave over the course of a transition. With the knowledge and insights we gained after developing the conceptual framework, we revisited and revised the research questions as follows:

What are the characteristics and dynamics of transitions?

With our conceptualization, we conceive dynamics of transitions to be produced by, and thus explained by (the act of) **Forces**. Understanding the dynamics in the form of Forces Driving Transitional Change, we revisit the general research question into specific research questions. The new research questions refer to the act of forces upon to the system and to how the forces create/drive a transition. The new research questions also refer to the fitness of the conceptual model for explaining the phenomenon of transitions. The first general research question is revised into:

- ***Are formation forces, or support forces, or triggers alone sufficient to drive a societal transition?***
- ***Can forces alone explain how societal transitions unravel?***

The second general research question is also revised. More specifically:

Is there a generic pattern to be found in the driving forces of the various past and current transitions and system innovations?

With the **Conceptual Map of the Societal System**, we conceive that different types of transitions can be experienced by a societal system. This conceptualization however needs to be further researched and grounded (both theoretically and empirically). The new research questions refer to the different types of transitions and to their relation to different types of systems. The second general research question is revisited into:

- ***Are the different types of transitions (institutional, social-ecological and socio-technological) empirically recognized and corroborated?***
- ***What other types of transitions can take place in institutional systems? What other types of transitions can take place in social-ecological systems? What other types of transitions can take place in socio-technological systems?***

The third general research question is also revisited. More specifically:

Is the co-evolution between different elements of the societal system (such as economic, technological, institutional and social-cultural elements) generic by nature, or does it unfold in a transition-specific pattern?

In our conceptualization of a societal transition, we consider evolution (and co-evolution) to be a defining and creating process towards a transition. More specifically, we conceptualize: A societal transition is (considered to be) a transformative process that results from the continuous cyclic evolution of the societal system over time. The **Evolution Cycle of the Societal System** maps how a societal system or subsystem evolves over time. We need however to understand how co-evolution comes about, and what the impact or relation of co-evolution is to a societal transition. Having this in mind, the third general research question is revised into:

- ***Can the Evolution Cycle of the Societal System capture the complex co-evolution of a societal system that undergoes a societal transition?***
- ***How is co-evolution between different elements of the societal system mapped in the Evolution Cycle of the Societal System?***

The fourth general research question remains. We will provide governance propositions that complement the existing Transition Management Tenets with our knowledge on transition dynamics later in this thesis (Chapter 7).

What do the characteristics and dynamics of transitions reflect to the possibilities to influence them?

CHAPTER 4 - INSTITUTIONAL TRANSITIONS

In Chapter 4 we present the first type of societal transitions, institutional transitions. We define an **institutional transition** as a type of societal transition in which the forces at play have an impact on the institutions and civil society or, using a mechanical analogue of a force as a vector, the forces at play are exerted upon institutions and civil society.

Main Contributions

Three feedback loops are found to complement the Evolution Cycle of the Societal System, which relate to institutional transitions: the self-enforcement loop, the deinstitutionalization loop, and the anarchy loop. These are reinforcing feedback loops and refer to dynamics of the system that are sustained at different stages by the continuum of (the same type of) forces.

Institutional transitions as processes of continuous evolution of the societal system are found to include forces of each of the different types (formation, support and triggers).

The three case studies (the water management transition in the Netherlands, the environmental protection transition in Greece and the energy transition in Greece) are analyzed with the Forces and the Evolution Cycle. In all the cases, institutionalization processes and self-enforcement loops are in place despite the fact that every institutional transition unfolds at a different pace, in a different fashion (different archetypical responses and atypical responses in place) and in a different context.

CHAPTER 4
Institutional transitions

Institutions regulate and delineate the actions, interactions and practices of actors. For societal transitions to be realized, changes in institutions are important. In this chapter, we explore institutional transitions as a type of societal transitions in which the forces at play have an impact on the institutions and civil society. The present chapter unfolds in five sections: In Section 4.1 we introduce institutions and the point of view of our research about institutions and institutional change. Then, we elaborate on the different theories of institutional change and institutional evolution with the objective to ground the Forces Framework to the different institutional theories (Section 4.2). In Section 4.3 we present the feedback loops that are induced from the theory and introduced in this thesis so as to complement the Evolution Cycle of the Societal System (framework). The developed and upgraded conceptual frameworks are now employed so as to analyze the three case studies in Section 4.4. The Forces Framework and the Evolution Cycle are used to analyze the water management transition in the Netherlands in Section 4.4.1, the environmental protection transition in Greece in Section 4.4.2 and the energy transition in Greece in Section 4.4.3. Concluding remarks of the theoretical and empirical exploration of institutional transitions are given in Section 4.5.

4.1 Introducing institutions

Institutions regulate the interaction and transactions of actors by providing the grounds for legitimacy in the form of norms and rules. The existence of institutions is an important precondition for effective and productive social interaction (Scharpf, 1997, p.40). Institutions constrain (North, 1990, p.3; Vatn, 2005, p.12) and shape human actions – viewed as (forms of) conventions (Douglas, 1986, p.47) - while remaining reflexive to changing human needs (Healey, 2006). Action harmful to social welfare is alleviated by institutions and the protection of social and natural capital are maintained (Bromley, 2007). Institutions serve as the established environment where individuals may change their behaviors and their perceptions towards social problems (Douglas, 1986) while producing and protecting actor's interests (Vatn, 2005, p.60).

North (1990, p.40) distinguishes informal constraints that are socially sanctioned norms of behavior, and formal constraints that are political rules and judicial rules. More specifically, formal institutions are systems of rules and include "political (and judicial) rules, economic rules and contracts. The hierarchy of such rules, from constitutions, to statute and common laws, to specific bylaws, and finally to individual contracts defines constraints, from general rules to particular specifications" (North, 1990, p.47). In line with this, Richard Scott (2008, p.64) considers (social) institutions to "involve the collective development and use of both regulative and constitutive rules".

Being socialized within institutions, individuals are provided a frame of values and rules. The societal context, however, plays a role in shaping human values and ethical norms. Institutions are created and influenced by human action and behavior but at the same time, as social constructs (Vatn, 2005, p.6), evolve in time following different paths either of "mutual adaptation, or of purposive design" (Scharpf, 1997, p.41), being subject to change processes "both incremental and discontinuous" (Scott, 2008, p.48).

Institutional change can be simply defined as a change in the system of rules, including either change in one or more rules, or change in the organization of the system of rules (e.g. decentralized versus centralized organization of rules) or in an attribute of the organizations that promote and implement the rules at an operational level (Appendix B, Table B.2).

We are aware that informal institutions (culture, tradition, informal conventions) play an important role in the operation and change of formal institutions given that they comprise the context in which

formal institutions operate. We do not focus on informal institutions because a focus on informal institutions requires research at a micro-level that is out of the scope of the present thesis (see research choices and their implications in Section 2.3.2). We choose however to focus on formal institutions because we believe that changes of formal rules and change in institutional structure bring about changes in practices and at the same time, result in changes in demand (in consistency with a duality paradigm).

4.2 Theories of institutional evolution and change

In order to investigate the process of institutional change, we will first make a literature review on macro-social theories of institutional transformation. Our analysis of the theoretical state-of-the-art of institutional change will yield a list of implicitly and explicitly formulated forces that drive institutional change. We are interested in factors that constitute the context in which institutional frameworks operate. In other words, we aim to establish forces as societal determinants of institutional transitions.

Reference to both theories of institutional change and institutional function is essential for understanding how institutional transitions develop for two reasons: (a) theories and approaches on institutional change refer to the types of change with a small number of them focusing also on what lead to such changes; (b) theories and approaches on institutional function theorize on formation and establishment of institutions at different levels of aggregation. Institution theorists often refer to micro-level changes and arrangements between actors within institutions as well as to meso-level settling of institutions focusing on rules and conventions only. Given that we are viewing institutional transitions as the outcome of the interplay between societal and institutional forces, we decided to consider in our theoretical grounding both theories on institutional change and theories on institutional evolution.

It is important here to specify that we search outside the realm of specific actors and/or actor behavior. This is a point that differentiates our approach from most institutionalist social science researchers who point only at the political interplay and coalition's power exchange when explaining institutional changes (Sabatier, 1988; Pollitt and Summa 1997, pp.13-15). In reviewing the existing frameworks of institutional change, we search for the impact of an event or actor's action on the system, exerted in the form of a force.

There exist a number of frameworks explaining institutional change, such as the ones developed by Scott (1994) and Powell (1991). The reviewed frameworks of institutional change often focus on the subject of change in institutions and what in the context 'causes' it (North 1990; Stark 1992; Van der Steen 1999; Wise 2002; Thelen 2003, 2004; Edelenbos 2005; Portes 2006). In the work of all of these authors, institutional change arises from *within.* Change can be a radical process or it can proceed much more slowly due to the persistence of routines, customs, traditions and conventions. They may occur in response to 'accidents, learning and selection' (North 1990, p.87), may be a result of marginal adjustments, and may include only reformulation rather than replacement of existing institutions (Stark 1992). Thelen (2003; 2004) in her model of institutional conversion, states that newly established institutions are in fact 'updates' of existing institutions. In line with her findings, Edelenbos (2005, p.129) points out that new institutions must be in line with existing institutions, but also notes the need for them to function in a different fashion so as to accommodate societal change.

All of these authors can be said to have adopted a perspective in which *meso changes* (such as reforms in policy regimes), social, political, economic or other, must be explained through *micro-foundations* meaning actor related explanations (Rutherford 1994). Actors are socialized into institutions, but through coordinated action may also revise and regenerate them to fit new circumstances and new societal contexts. Still, this begs the question of which forces are involved in generating this need for institutional transition, which actors decide to go along with in some way. Reasoning along those lines implies searching for *macro-foundations* of the same meso-level changes.

4.2.1 Forces of institutional transitions grounded in literature

The theoretical grounding of the Forces Framework is realized in different theories, namely institutional theory, governance theories, organization theory, political theory, evolutionary economics, social theory on evolution, and transaction cost economics.

Presence of a societal demand

From institutional theory, Wise (2002) considers societal demands to be the main stimuli for institutional change. Aligned with the New Public Management paradigm where institutional change aims at improving institutional performance (see Hood, 1995), Wise (2002, pp.557-558) identifies three drivers of change of public management reforms: demand for greater social equity, demand for democratization and demand for empowerment and humanization of the public service. Those societal demands originate univocally from the clients and employees of the public sector, but the change as such reaches the sector-based policy system from the outside. In addition to this, Lowndes and Wilson (2001, p.643) point at new societal demand as a trigger for new institutional arrangements hence can be seen to initiate institutional changes.

From theory on organizations, Suchman (1995, p.41) also refers to societal demand as the force driving institutional formation when he notes that institutions respond to recurrent problems and arise from shared demands and understanding.

Presence of new practices

From institutional theory, Portes (2006) presents a set of forces of institutional change to give labels to change processes. Portes' forces of change are macro-level developments that have an indirect influence on the generation of institutional change. More specifically, Portes (2006, pp.252-253)[10] presents a number of elements that he calls 'forces of change': charismatic prophecies, technological innovations, cultural diffusion, path dependence and class struggles. We conclude that Portes (2006) points at the presence of new practices (either technological or managerial) to be macro-social determinants.

In the same vein, Eggertson (2005, p.37) recognizes the impact of innovations in bringing about major changes in economic institutions contrary to the conventional process of institutional change that is (also theorized to be) gradual and marginal.

From historical studies and archeology, Tainter (1988) in his explanation of societal collapse, notes that after a society faces stress due to changing circumstances, the *search for new ideas and new ideologies* becomes a priority –if not a solution- in order to tackle the problematic situation. The search for these new ideas and ideologies does not mean that those ideas are adopted by actors. More specifically, he argues that:

> "The system as a whole engages in 'scanning behavior', seeking alternatives that might provide a preferable adaptation. This scanning may result in the adoption by segments of the society of a variety of new ideologies and life-styles, many of them of foreign derivation." (Tainter, 1988, p.122)

Presence of a niche

Departing from institutional theory, Eggertson (2005) highlights the presence of actors who carry new ideas and practices as a force for institutional change in his analysis. What is crucial for institutional change is the practising of new ideas by the actors. More specifically, Eggertson (2005, p. 160-161) refers to such actor groups as new social models that "are the carriers of new ideas and new knowledge about social technologies".

Additionally, innovation studies spot the societal sphere to indicate agents of change or actors who initiate policy and institutional change. The group of actors that adopts or attempts new practices is

[10] The meaning of the term 'forces' in Portes (2006) conceptualization is different from our conceptualization.

named a ‘niche’. The niche is seen as a locus of new practices (Faber et. al. 2006, pp.78-80 and pp.102-103) and/or as a ‘domain for specialized applications’ (Kemp and Rotmans 2004, p.141; Hoogma et. al. 2004, p.4). In line with this, Young (Rowena) (2006, p.67) and Nichols (2006) cast a light on social entrepreneurs as actor groups that can be the “benchmark of change” when they becomeempowered and supported.

Provision of resources

We have to note here that institutional theorists consider as a given that resources are required for both the establishment and the change of institutions. The majority of institutional theorists refer to costs of institutions in an indirect way when it concerns their operation and as an obstacle when they refer to their change or adjustment.

From political theory, Shepsie (2001, p.324) argues that input (or investment) of resources in institutions make them succeed and is seen as an “insulation” from change.

From innovation studies, Peizer (2006, p.7) and Hall (1994, p.56) address the importance of resource provision for supporting change. Financial, material, organizational or legal resources are required for the effectuation of change within an institutional framework as a response to the outside forces.

Standardization of practices

From institutional theory, Scott (2008, p.131) refers to the development of rules as the way in which power is stabilized, and legitimized - “that is, institutionalized”.

Looking at evolutionary economics, Faber et. al. (2006, pp.76-80) consider the standardization of practices that affects the co-evolution of policy institutions, technology and society. In this way, connections are made between technological opportunities, societal needs and institutional arrangements.

Systemic failures

Starting with institutional theory on systemic failures, Eggertsson (2005, p.41) considers institutions to be imperfect and to deteriorate when they do not perform as expected. Eggertsson (2005, p.41 and 143) refers to “institutional failures” as a cause of “undesirable or unexpected outcomes” and as being the trigger in changing institutions structurally. Reference to systemic failures as stimuli for institutional change has also been made by Kickert (1997a, p.168).

In the same vein, Portes (2006, p.242-243) refers to institutional failures as triggers for institutional change. Inadequate institutional arrangements – conceptualized as institutional failures or broader systemic failures- result in dissatisfied social demands and in a discursive polity (rephrasing Hajer, 2003a; Voss, Bauknecht and Kemp, 2006, p.61), which in turn, may trigger the current system towards change. Lane (1997, p.9) argues that the presence of systemic failures may trigger change of institutional performance and operation.

The experience of a systemic failure seems to trigger an institutional change and to condition the public to accept -if not welcome- an institutional change. In the presence of systemic failures, institutional change becomes easier to realize; a pattern that comes in consistency with the “weak discredited opposition hypothesis” of Williamson (1994).

From social theory, James Scott (1998) considers systemic failures as destructing forces to the societal system. According to Scott (1998, pp.263-264) systemic failures are characterized by (a) historical origin (the way the system functions and behaves towards changes has its origins in the historical pathway of its development), (b) institutional nexus (rigidity of institutional structures and path-dependency), (c) goal view (what is the purpose the system serves) and (d) scientific background incapable to deal with complexity.

Crises

From institutional theory, North (1990, p.87, 89 and 101) considers that discontinuous radical institutional change is the result of revolutions and conquests; along with accidents that result in changes of informal institutions. Such social determinants are considered as societal crises since they shock the system, have acute impacts and are irreversible events.

Eggertsson (2005, p.143 & 159) considers that fundamental structural changes are enabled after a "deep crisis" or an economic crisis.

Osborne and Brown (2005, p.7-8) point at crises to be a source of emergent change and innovation in public service organizations. They argue that crises that come unanticipated –hence "sudden unforeseen"- cause emergent change that is "change (…) that it can never be entirely planned for". Taking a managerial view of crises and provision of public services, they accept that emergent change in public organizations can happen and its cause is limited to two critical factors: crises and politics. This conceptualization is consistent with the managerial viewpoint that almost everything can be anticipated and planned.

In addition to this, Razin (2004, p.636) argues that a crisis, either political crisis or legitimization crisis, seems to function constructively for political actors that initiate or porpose the institutional change as a response to these crises. Crises are also seen to ease the implementation of an imposed institutional transition and to overcome implementation boundaries. This comes in line with the crisis hypothesis of Williamson (1994) that states that a crisis conditions the public to accept a radical institutional reform.

From political theory and governance theory, Boin et al., (2008) (citing Drennan and McConnel, 2007, p.5) defines crises as "episodic breakdowns" (…) "extraordinary in kind and/or scope testing the resilience of a society and exposing the shortcomings of its leaders and public institutions". The impact of crises in policy change and institutional change is not linear: A crisis may trigger an institutional change and/or policy change. In different context, a crisis may be "absorbed politically" and have no impact on existing institutions and policies (Boint et. al., 2008, p.5) whereas it is considered that crises "have the dynamic potential to prompt change" (p.10).

From social theory, James Scott (1998, p.97) indicates crises to cause constructive destruction of the societal system.

From historical studies and archeology, Tainter (1988, p.66-67, 70-71 and 89) reviews a great number of theories that explain societal collapse. From the theoretical approaches he assesses, catastrophes such as crises can lead to collapse when the society does not take action to adapt to changing contexts but cannot cause a societal collapse alone.

From economics, Groenewegen and Kunneke (2005, p.17) consider that revolutionary change in institutions may take place after an external shock to the system. A shock to the system can vary and "institutional change then comes about through a revolution and an institutional crisis".

4.2.2 Early reflections of the theoretical grounding of forces of institutional transitions

Causality of forces?

In this chapter we refer to forces as macro-social determinants of institutional change. This however does not imply that the forces are the causes of institutional change. The forces present in institutional transitions contribute by driving and propelling the transition process. In our theoretical grounding of the different forces, we observe that different theories focus on specific forces to research and describe institutional change. With our Forces framework, we take into account multiple and different forces to explain institutional change without examining which force(s) are more critical than other forces. We consider that the driving forces at play during an institutional transition have a synergistic influence on the transition. We will examine this conceptualization with the case studies.

Can everything be labeled as a crisis?
Institutional theorists and political theory scientists employ the term crisis as an umbrella concept to describe any type of inefficiency or pathology of the system, or simply, any type of unanticipated events. The umbrella view on what can be a crisis is a result of the focus of institutional theorists on the impact those events have in institutions: all events that shock the system and evoke societal demand are considered or named as crises. We disagree on the tendency to label them all as crises. Therefore, we distinguish different types of triggers to capture different events, namely: system failures or institutional failures to describe discrepancies (inefficiency, ineffectiveness), exogenous events to capture events exogenous to the system that influence its operation and crisis that are uncertain events of high impact that shock the system. We argue that systemic failures, crises and exogenous events as triggers of societal transitions evoke societal demand and can propel or hamper a transition process.

Are forces exogenous to the system neglected?
From our theoretical grounding of the Forces Framework in institutional change and evolution theories, we observe that exogenous events are not considered explicitly. What we understand from this early finding is that the overlooking of exogenous events or developments is an outcome of the explicit focus of institutional theory to explain system-based/system-oriented processes and conditions.

4.2.3 Characteristic responses of institutions towards change as found in theory
Institutional change as a process has been investigated and researched by numerous scholars. In their attempt to understand and explain institutional change, they deduced institutional characteristics and responses to change. Those responses are simplified archetypical responses of institution's behavior towards change.

Four archetypical responses have been identified by induction from theory. Institutional inertia and incremental change are well addressed responses of institutions by different theoretical approaches. Adaptive, anticipated change and aligning with a paradigm are responses of institutions that we conceptualized (with induction of special form, as described in the research methodology in Chapter 2, Section 2.4) based on theoretical findings.

Institutional inertia
Institutional inertia refers to the resistance of institutions to change, it is also referred to as institutional friction and it is a behavioral pattern of institutions towards change. A number of scholars have addressed the resistance of institutions and what empowers it.

From institutional theory, North (1990, p.101) refers to institutional inertia when he argues that institutions change so gradually and incrementally that they can be considered as inert to change. More specifically, North (1990, p.7) refers to two mechanisms that shape institutional change: (a) "the lock-in that comes from the symbiotic relationship between institutions and the organizations"; mainly due to the incentives institutions create for those organizations, and (b) "the feedback process" of human action to opportunities institutions create. The first lock-in refers to processes within institutions (at meso-level) that can marginalize institutional change while the second refers to the linkage of institutions with social responses.

Richard Scott (2008, pp.128-130) considers inertia as "a normal state" of institutions. In his analysis, he additionally theorizes on the resistance of institutions and organizations. Supportive arguments that institutions resist change as a normal or regular behavior are also addressed by Bartle (2002, p.4) as "sticky institutions", by Baumgartner, et al (2008, p.4) as institutional friction to challenges and alterations, and by Lowndes and Wilson (2001, p.643) as institutional resistance.

In his discussion of imperfect institutions, Eggertsson (2005) recognizes that (social) institutions are not easily replaced or adjusted mainly due to unawareness of political actors about institutional imperfections and ineffectiveness (p.41) and due to political impotence and vested interests (p.42).

Erakovic and Powell, (2006, p.36) recognize that institutions tend to resist change and decelerate deinstitutionalization processes (destabilization of existing institutions) and refers to adaptation as a change pattern given institutional resistance. In the same line, O' Neil (2000) presents two archetypical responses of institutions to change: institutions respond to disrupts either by resisting change or by using the opportunity to transform (cited by Osborn and Brown, 2005, p.63).

Incremental change

A number of approaches on institutional change state that what is subject to change is only the way institutions are organized and the emergence of new institutional structures is not considered feasible. Among those, Stark (1992) argues that institutional transformations include only reformulations rather than replacement of existing institutions. Thelen (2003; 2004) states in her model of institutional conversion that newly established institutions are built on existing institutions and comprise their "updates". In the same vein, Cocks (2003, p.159) in his analysis of societal change recognizes the slow changing pace of institutions even when their performance is proven insufficient.

Institutional theorists like North (1990) conclude that institutional change is a process of incremental changes that poses high impact on rules, informal conventions and practices. North (1990, p.6, 83 & 101) conceptualizes "gradual" "incremental" institutional change as "continuous marginal adjustments" to both formal and informal constraints that constitute the institutional framework. North does not exclude discontinuous institutional change as a pattern of change. More specifically, discontinuous institutional change is defined as "a radical change in the formal rules" that is the result of revolutions and conquests (North, 1990, p.89 & 101) while accidents, learning and selection are seen as the forces of change for informal constraints (that constitute the cultural heritage of a society) (North, 1990, p.87).

Patterns of resistance to change of informal constraints include the persistence of routines, customs, traditions and conventions (North, 1990, p.83), the transaction costs and the path dependence of institutions.

Adaptive versus anticipated institutional change

Adaptive institutional change includes the change of institutions that aims at revising rules and operation of institutions so as to comply with the changing demands and context; after those changes have become evident to the institutions. Anticipative institutional change includes change of institutions that precedes any major change (e.g. in demands). Anticipative institutional change happens before change in demands or context occurs.

Van der Steen (1999, p.134) distinguishes two different types of institutional change: the reactive or adaptive, and the anticipated or innovative institutional change. Reactive or adaptive institutional change refers to the limiting of available options performed by agents in the face of complex problems. Anticipated or innovative institutional change refers to the action of actors to accelerate institutional reforms when diagnosing or inspecting forthcoming changes. Van der Steen (1999) examines neither the direction nor the order of change as determinants of institutional change.

Aligning with a paradigm

The majority of institutional changes reported in the field of public administration and public management (including journals, books, international conferences and research societies' colloquia) refer to institutional changes realized with the objective to align a specific sector with a (dominant) governance paradigm. Such institutional changes are means to a specified target (that is indicated by the governance paradigm) and are well coordinated.

A well documented and well known governance paradigm is the New Public Management (NPM) paradigm (Hood, 1991; 1996). Apart from the New Public Management paradigm, a number of governance paradigms exist (Box 4.1). Institutional and governance scholars provide an ample number of cases that illustrate how institutional restructuring takes place to align or follow existing paradigms focusing on micro- and meso- level aspects (actor's roles and organizational structuring attributes respectively)[11].

Box 4.1: Governance Paradigms.

New Public Management Governance Paradigm: New Public Management Governance Paradigm (NPM) conveys that public enterprises need to be managed efficienty and effectivelly following a market-based model. More specifically, NPM states (Hood, 1991) that efficiency in public sector will be achieved when institutions reformed towards a market-oriented model (Box, et.al., 2002; Christensen and Pallesen, 2001; Stark, 2002). A well argued analysis of the NPM paradigm is presented by Osborne and Brown (2005, p.4) where NPM is defined as "an approach to managing public services that prioritizes managerial, as opposed to professional, skills and which includes resource and performance management at its heart". Western European countries have adopted the NPM paradigm since conventional management practices in the public sector institutions and infrastructures could not cope with system pathologies. Institutional reforms were realized by political agents mainly to fulfill promises for the betterment of the system. For example, the basic promises of market reforms such as privatization and deregulation include the market opening, the reduction of transaction and operating costs as well as the increase of innovative potential of firms (following Healey, 2006, p.15; Gamble, 1988; Thornley, 1991). The experienced system failures and the shift to NPM paradigm is researched and documented in a number of developed countries revealing the benefits of such a new approach for public sector operation.

Networks Governance Paradigm: According to network governance scholars (Kickert, 1993; Rhodes 1996; Koppenjan and Klijn, 2004; Noteboom, 2006; Klijn, 2008b), the societal system is comprised by integrated networks of actors that "resist government steering, develop their own policies and mould their environments" (Rhodes, 1996a, p.52). Rhodes explored the evolution of the governmental institutions in Britain and the effectiveness of governance practices that made him argue that the shortcomings of other governing practices result from the emerging pattern of society as self-organizing networks. More particularly, Rhodes (1996a; see also Richards and Smith, 2002) reviewed different models of governance (e.g. Westminster model, the minimal state, corporate governance, and more) to conclude that governance as self-organizing networks has comparative advances given that the societal structure evolved in a form of networks. According to Rhodes (1996a, p.15) "governance refers to self-organizing, interorganizational networks characterized by interdependence, resource exchange, rules of the game and significant autonomy from the state." Consequently, new modes of governance need to consider network characteristics and particularities so as to be effective (Rhodes, 1996b, p.658) and so as to sustain the governance networks "if they are to achieve satisfactory outcomes for their participants" (Klijn, 2008b, p.519). Consequently, change of institutions or just policies, is seen as a change in the resource ties or interrelations of a network or networks. For institutions to change, either networks have to mediate and advocate the change or changes in networks have to happen for an institutional change to be realized.

Reflexive Governance Paradigm: Reflexive governance scholars (Voss et. al., 2006; Voss, 2007) conceptualize the societal system as a constellation of interactions between actors and between structures and actors that need to be –when not remain- reflexive to each other's change and interests. According to reflexive governance scholars, the social inquiry reflexively shapes its own constitution that allows only for multi-actor steering by procedures (Van der Meer et. al, 2005). Hence reflexive governance emphasizes the opening of the policy problem definitions to incorporate multiple interests, uncertainties and policy instruments (Voss and Kemp, 2005, p.4; Voss, 2007, p.36-37).

[11] A number of case studies where institutional change took place so as to align the existing institutions and organizations to the New Public Management Paradigm are presented and restructured with the Forces Framework in Appendix C, Table C.1.

Box 4.1 (continued): Governance Paradigms.

Interactive Governance Paradigm: Interactive governance conveys that governance of sociopolitical systems mainly takes place in interactions between actors in all levels of the (societal) system (Kooiman, 1993, p.41). Kooiman (2003) views complexity, dynamics and diversity of interactions to have a dual role: first to be the characteristics of the system and of the interactions that need to be taken into account for governance actions and second, to be the products of interactions and system's governing interventions. A distinctive characteristic of interactive governance is therefore that complexity and dynamics are viewed as inherent to the system. The societal system or more precisely the sociopolitical system is regulated through different forms of interactions between the actors (interferences, interplays and interventions) (Kooiman, 1993, p.38-39).

Deliberative Governance Paradigm: Deliberative governance views the societal system as a cohort of actors where a bottom-up organization and regulation is possible. Hajer and Wagenaar (2003, pp.9-13) present the characteristics of the network society that make conventional governance and policy science methods inefficient, hence suggesting a deliberative approach to deal with the radical uncertainty of networks in society. The deliberative governance framework suggests a sociopolitical system without a single center where actors actively participate in policy analysis/design process (Hajer, 2005), self-organize and regulate their needs and demands in the form of "meaningful and legitimate political actions, agreed upon in mutual interaction to improve our collective quality of life" (Hajer, 2003b, p.191). Actions and mechanisms of this deliberative mode of governance orient the societal system towards "an enhanced conception of democracy" (Hajer and Wagenaar, 2003, p.24). Deliberative governance also refers to new practices of coordinating activities through deliberative forums that constellate "negotiated social governance" (Hirst, 2000, p.19). In the same vein, Healey (2006) presents collaborative modes of governance for participatory policy design set-ups. What collaborative planning as a mode of governance suggests is an active collaboration and involvement of social actors so as to induce social learning and to yield policy designs that are coherent and consistent with social interests (Hirst, 2000, p.33). Institutional and policy change therefore is an outcome of policy and social learning.

From our review of institutional responses towards change, we conclude that for the majority of institutional theorists, societal conditions comprise the context of institutional performance and change. For social theory, institutional change is necessary for institutions to comply with changing demands, preferences, new ideas and practices. Governance theorists focus on dominant paradigms and theorize in multiple levels but not at the same time: some theorists focus on micro- and meso-level analyses while others take a meta-level of analysis (Kooiman 1993; 2003).

From our theoretical exploration of institutional transitions, we conclude the following:

- There are archetypical responses of institutions towards change: inertia or resistance, incremental, adaptive or anticipative responses to change
- Institutional changes when imposed from governments (top-down) are orchestrated towards changing the existing institutions so as to align their operation with the propositions of specific paradigms
- There is lack of patterns on institutional change that take into account both institutional factors and societal conditions. The fields where institutional change is studied are divided between those with a focus on social practices and those with a focus on institutional dynamics internal to institutions that consider other factors (as social demand, social practices) external to change.

4.3 Adapting the Evolution Cycle of the Societal System: Institutional feedback loops as found in theory

Analyzing institutional change as a process where different forces are in place, a number of feedback loops can be derived from institutionally relevant literature. As we already discussed in Chapter 2, the feedback loops are derived by induction of a special form: we infer theoretical constructs (conceptualizations) such as feedback loops from collected theoretical parts found in theory.

We conceive that every feedback loop further enforces the phenomenon in place. We therefore position the (majority) of feedback loops to take place along the different stages of the Evolution Cycle of the Societal System.
Institutional theorists and researchers of empirical cases have addressed a number of processes that explain the behavior of institutions during their evolution and change. We found four processes that add to the evolution cycle of the societal system presented in Chapter 3 as shown in Figure 4.1, which has been adapted to institutional transitions specifically.

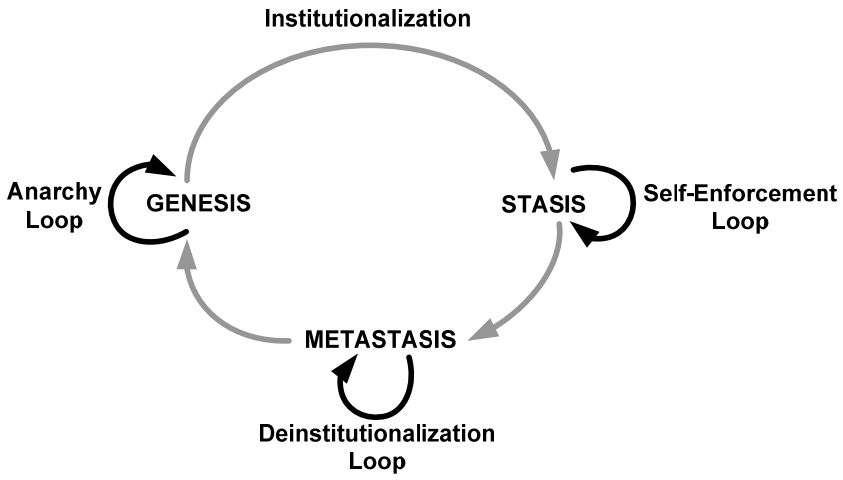


Figure 4.1: The Evolution Cycle of the Societal System including the institutionalization process, and the feedback loops of self-enforcement, deinstitutionalization and anarchy present in the institutional sub-system.

4.3.1 Institutionalization

Institutionalization is conceptualized as the process that includes the interplay of support forces (standardization of practices, provision of resources and exercise of power) until the stasis of new institutions or adjustment of existing ones takes place. Institutionalization is thus the process of settling a system of rules formally. Institutionalization is being observed in two flavors: Formal institutionalization as "the process through which components of formal structure become widely accepted, as both appropriate and necessary, and serve to legitimate organizations" (Tolbert and Zucker, 1983, p.25), and thick institutionalization that refers to a form of institutionalization in which formalization of rules and enforcement occur in a strict way. More specifically:

> "Thick institutionalization takes place in many different ways. Familiar examples are: by sanctifying or otherwise hardening rules and procedures; by establishing strongly differentiated organizational units, which then develop vested interests and become centers of power; by creating administrative rituals, symbols, and ideologies; by intensifying "purposiveness", that is, commitment to unifying objectives; and by embedding the organization in a social environment." (Selznick, 1992, p.235).

We place the institutionalization process as the process that routes the system from the genesis stage to the stasis stage. Institutionalization process is established by the presence and interplay of support forces.

4.3.2 Self-Enforcement Loop

Institutional self-enforcement is a process that feeds back into the stasis of existing institutions. We conceptualize institutional self-enforcement as a feedback loop that contributes to the stasis stage of institutional sub-systems evolution and sets in by support forces. More specifically, institutional self-enforcement refers to the phenomenon in which formal rules reinforce and further facilitate the empowerment of existing institutions. Self-enforcement of institutions is theorized by Greif and Laitin

(2004) who consider institutions to be self-enforced thus persistent to any type of intervention. In line with this, Heritier (2007) in her analysis of theories of institutional change considers that institutions mainly behave as rigid structures that self-sustain themselves making institutional change a complex process.

4.3.3 Deinstitutionalization Loop

The deinstitutionalization loop is a feedback loop that significantly destabilizes an institutional subsystem. Deinstitutionalization is also referred to as institutional decay or destruction and refers to "the process by which the legitimacy of an established or institutionalized organizational practice erodes or discontinuous" (Oliver, 1992, p.564). Deinstitutionalization can be triggered by crises, systemic failures or exogenous events (as addressed by Tainter (1988)). The deinstitutionalization loop contributes to the metastasis stage of the system; it manifests a feedback loop that destabilizes and erodes the system significantly.

4.3.4 Anarchy Loop

When niches as actors with new ideas and innovative practices interact without preexisting relationship and without formal institutional structuring, we refer to it as institutional anarchy. This is conceptualized as the anarchy loop of societal systems in conditions where niches or new practices (formation forces) are in place, which in return stimulate more social innovation and new practices, without any institutionalization taking place.

Scharpf (1997) considers anarchic fields as a form of institutional arrangement that lacks formal institutional organization or is "an institution-free context, in which individual actors will interact with one another in the absence of a preexisting relationship, or of specific obligations between them". The same institution-free context has been also reported by Lindblom (1965) as spontaneous field control (cited by Scharpf, 1997) and Schotter (1981) as spontaneous social order (cited by Scharpf, 1997).

4.4 Cases of Institutional Transitions

Three case studies have an instrumental use in researching dynamics of institutional transitions (instrumental case studies – Stake, 2000, p.437-438). As we already discussed in Chapter 2, the case studies are analyzed with the conceptual frameworks (both the Forces Framework and the Evolution Cycle) to test the analytical potential and fitness of the conceptual models to the phenomenon of transition with a focus on institutional transitions. The research position of the empirical grounding is induction: reasoning is realized from collected facts back to theory. For every case study we followed the research steps that have been described in Chapter 2, Section 2.4. Specific information about the desk research and field research of every case study (including a list of the interviewees) is provided in Appendix A, Cases A1 to A3. The empirical grounding of the Forces Framework in cases of institutional transitions has been realized in published cases found in the literature (Appendix C, and Table C1). The three case studies presented in this chapter concern three different systems that experience institutional transitions. More specifically (Table 4.1):

The first case concerns the institutional transition of the water management sector in the Netherlands (from the 1990s until 2008). The first case study is presented in Section 4.4.1. The second case concerns the emergence of an institutional transition in the environmental protection regime in Greece (for the period of 1986 until early 2000s) in the face of the diversion of the Acheloos river project. The second case is presented in Section 4.4.2. The third case concerns the on-going transition of the electricity sector in Greece in face of the pressure of the European Union's Directives to increase the use of renewable energy supply (Frantzeskaki et al, 2008). The third case is presented in Section 4.4.3.

Table 4.1: Case Studies of Institutional Transitions. Overview of System Boundaries and Dynamics.

CASE STUDY	What System	Time Period under study	Type of Transition	Feedback Loops & Processes
Water management transition in the Netherlands	Water Management System – Rhine River (Social-Ecological System)	1991-2008	Institutional Transition	Institutionalization Process
Environmental protection institutional transition in Greece	Environmental Protection System with a focus on the Acheloos River System (Social-Ecological System)	1973-2010	Institutional Transition	- Self-Enforcement of the Environmental Protection Regime (1985-2000) - Self-Enforcement Loop of Environmental Protection Regime with Thick Institutionalization (2002-2006) - Institutionalization Process of the Water Management Regime (2000-2007) - Self-Enforcement Loop for the Acheloos Diversion Project (1991-2006) - Institutionalization process for the Acheloos Diversion Project (Energy Regime) (2006-2009) - Institutionalization Process related to the Acheloos River Restoration (anti-Acheloos Diversion Project) Issue (1994-2000**)** - Self-Enforcement Loop of the Acheloos river Restoration Issue (anti-ADP) (2005-2010)
Energy transition in Greece	Energy Supply system (electricity) (Socio-Technological System)	1889-2010	Institutional Transition	- Self-enforcement loop - Self-Enforcement with thick institutionalization

In all the three cases, we use the composite concept of institutional change to map all the different types of institutional intermediate changes (operationalization of institutional intermediate changes are presented in Appendix B, Table B.2). A distinction between the different types of intermediate institutional changes for the current cases does not aid our analysis of institutional transitions given that we want to understand what type of forces contribute to the transition and to understand the interplay between the different forces and institutional change in general.

Distinguishing feedback loops in the cases of institutional transitions

The analysis of the case studies follows the steps that have been discussed above: the Forces Framework and the Evolution Cycle are used to (structure and) analyze the institutional transitions and their respective dynamics. The analysis however takes an extra step by searching for how the

transition dynamics in every case can be further mapped as feedback loops. The feedback loops that have been induced by theory in Section 4.3 serve as indicative loops to start with.
The distinction of feedback loops however is not an objective task. The analyst has to assess whether the observed behavior is a feedback loop or not. At the same time, the analyst has to make choices about the force(s) that act upon the system dynamics in such a way that lock the system in a feedback loop and/or break out (from) a feedback loop. The choice of the force that tips a system into a feedback loop is bound to:

(a) *Contextuality:* The criteria for selecting a force over another as the critical force that indicates the entry of a system into a feedback loop are bound to the context. The same feedback loop may be initiated by a different force even in the same system due to the contextual influence.
(b) *The time-issue:* The analyst can define the duration of a feedback loop by interpreting the impact of forces. At the same time, a distinction of a feedback loop depends on the time stretch of a case. If an analyst deals with a long-term case, then behavior of the system can be identified as a feedback loop.
(c) *Break-In and Break-Out from a feedback loop*: We identify the force that brings the system to break-in a feedback loop by examining the impact the specific force has on the existing dynamics of the stage that the system is located. If a force further reinforces the stage dynamics without modifying the existing stage, then the system enters a feedback loop. The Break-Out force can be defined by comparison to the other forces at play and is the last force (chronologically) to have a reinforcing impact on the respective stage; meaning that is the last force that impacts the existing feedback loop. The Break-Out force does not necessarily coincide with the starting of another feedback loop or process.

Note: The break-in and break-out characteristics of the Forces will be used in the analysis of the transition dynamics of the case studies in the following sections and chapters.

4.4.1 The institutional transition of the water management system in the Netherlands

The Netherlands is characterized by its consensus democracy and by its decentralized administration[12]. More specifically, the high-water events in the rivers Rhine and Waal in December 1993 and January-February 1995 (van Baars, 2004, p.1; Petry, 2002; Berben and Tank, 2005, p.77) created a sense of urgency for policy action (NHV-special 6, 2004, p.48) in the water management in the Netherlands.

Organization of the water management system in the Netherlands[13]

The institutional transition of the water management system included a re-arrangement resulting in the empowerment of local authorities; namely the water boards and the municipalities (Hendriks and Tops 2003, p.302). The water management system in the Netherlands is well organized although fragmented in its task sharing between the different administrative bodies. At the national level, the Ministry of Transport, Public Works and Water Management (Ministry of V&W) provides the funding and is responsible for the formulation of policy directions and for the main rivers and primary dikes. Within the Ministry, there exist two directorates: the Directorate General for Public Works and Water Management (Rijkswaterstaat or RWS) that is assigned with supervising water management actions and after 2002, with providing support during policy implementation and the Directorate General for Water established in 2002 assigned with the task of formulation the national policy on flood protection and water management (NHV-special 6, 2004, p.88-89). At the provincial level,

[12] The Dutch water management system experienced the pressure for the adoption of the New Public Management paradigm when realizing that the existing structure of its institutions was inadequate to deal with modern complex problems. This was a response given by three interviewees that has not been corroborated either by other sources of information or from other interviewees.
[13] In 2011, the Ministry of Transport, Public Works and Water Management was merged with the Ministry of Environment, Housing and Spatial Planning to form the Ministry of Infrastructure and Environment. The description of the organization of the water management system refers to the way the Ministries were organized in the period of 2005-2008 that the case study reseach was cnducted.

provinces are assigned with specifying policy directions drawn at a national level to policies for regional level and require approval from the Ministry for their implementation (NHV-special 3, 1998, p.85). At the regional and local level, the municipalities and the water boards are assigned with reinforcing the policies for water management and specifically for the flood defense. The water boards are the competent authorities dealing with flood protection management and maintenance (NHV-special 6, 2004, p.77 and 89-90). At the interorganizational level, the Interprovincial Platform (all provinces are its members), the Association of Municipalities (a board of deputies of all the municipalities) and the Union of Waterboards are the representative administrative bodies responsible for the coordination of the policy processes (aiming at reducing both actors and policy issues) in national arenas. Two temporary organizations were established during the policy design process of flood defense policy in the Netherlands by the Ministry of V&W (a steering committee and an advisory group with two divisions each one for upstream and downstream Rhine area in 2001).

Box 4.2: A brief description of the geography of the Rhine River

"The Netherlands is a low-lying country in the delta region of a number of major European rivers, including the Rhine, the Meuse, the Scheldt and the Eems. The river Rhine is a large European river with a total length of 1,320 kilometres and drains an area of 185,000 square kilometres. The average discharge of the river Rhine is 2,300m^3/s; the maximum reported discharge was 12,600m^3/s in 1926. The source of the river Rhine is in the Swiss Alps.

In the downstream direction, the river Rhine crosses Germany, France and finally the Netherlands, where the river flows into the North Sea.

In the Netherlands, the river Rhine becomes a typical lowland river with a delta. In the delta, the river Rhine bifurcates into several branches: the Waal (the largest branch), the Pannerdensch Kanaal, the Lower-Rhine/Lek and the IJssel rivers.

The name of the bifurcation of the Waal and Pannerdensch Kanaal branches is Pannerdensche Kop. The name of bifurcation of the Lower-Rhine/Lek and IJssel branches is IJsselkop."
(Adopted by Berben and Tank, 2005).

Figure 4.2: The Rhine river and its basin (Source: UNEP 2005 – www.grid.unep.ch)

Analyzing the water management transition with the Forces Framework

The water management transition in the Netherlands is characterized as an institutional transition given that the forces at play have an impact on the institutions and the civil society only. The Forces Driving Transitional Change present in the institutional transition in the Netherlands are presented in a chronological order in Table 4.2.

Table 4.2: The water management transition in the Netherlands.

Year	Event	Conceptualized as:
1991	**Water Board Act:** Policy design tasks were assigned to lower levels of administration (provinces, municipalities and water boards). Transfer of tasks from the government to lower government tiers.	*Standardization of practices (law enforcement)*
1993	High-water incidents in the rivers Rhine and Waal. A flooding in the Meuse valley in the province of Limburg leading to an evacuation of 8,000 people, and a total monetary damage of € 115 million (Van der Grijp & Olsthoorn 2001, p.32).	*Systemic failure*
1993-1994	Public demand/pressure for taking action and minimize the probability to experience another serious flood (referring to the memories and the stories of the 1956 flood).	*Societal demand*
1995	High-water incidents in the rivers Rhine and Waal. Approximately 250,000 people were evacuated from low lying areas at risk in the city of Nijmegen and the estimated economic loss due to the temporary shutdown of companies was 2,000 million euros (Berben & Tank 2005, p.77).	*Systemic failure*
1995	**Delta Act Major Rivers:** The water boards are required to present integral plans for dike reinforcement to the provincial government (Wiering and Driessen 2001, p.290; Dicke 2001, p.166; Van der Grijp and Olsthoorn 2001, p.33).	*Standardization of practices*
1996	**Water Embankment Act:** The water boards had to present the draft plans and the accompanying environmental impact assessment to the provincial government for approval (Wiering and Driessen 2001, p.290).	*Standardization of practices*
1996	**Flood Protection Act:** Aimed to maintain the flood protection standards achieved by the Delta Plan and the reinforcement of the dikes and dunes (Directorate General for Public Works and Water Management 2001; NHV-special 6 2004, p.93).	*Standardization of practices*
1996	Aquatic Outlook Research program. Reported the situation of water management system and infrastructure, and used as input for the NW4 (De Jong *et al*. 1996; Arnold 1997, pp.161-164).	*Provision of resources*
1996	Water Policy Act '**Room for Rivers**': Environmental scenarios on water discharges in the Rhine, its branches, and the Maas (Silva *et al.* 2001, p.9).	*Standardization of practices*
1997-2002	IRMA SPONGE research program (EU Research Program) (Middelkoop 2000; Silva *et al*. 2001, p.9).	*Provision of resources*
1998	Water Policy Act '**The Fourth National Policy on Water Management** (NW4)': Focused on the development of an integrated approach to water at various levels	*Standardization of practices*
2000	Water Policy Act '**A different approach to water, Water Management Policy in the 21rst Century (WB21)':** Apart from directions for policy design on water management, institutional responsibilities were also addressed. Execution and design of policies are left for the water boards, integration and incorporation of spatial planning with water management is appointed to the provincial authorities.	*Standardization of practices*
2001	Establishment of steering and advisory committee for the flood defense policy design in the Rhine River.	*Institutional change*
2001	**Room for the Rhine Branches – Research results (2001):** Research results by governmental institution about policy measures to cope with increasing water levels in the Rhine Branches (Silva *et al*. 2001, p.9).	*Provision of resources*
2002	Establishment of Directorate General for Water	*Institutional change*
2002-2006	FLOODsite research programme (EU program)	*Provision of resources*
2003	Public reactions and opposition in local level: Cases of Lent, Overdiepsche, Oijpolder (Ministry of Transport, Public Works and Water Management 2003).	*Socio-political crisis*
2003	Drawing and submitting of proposals for different actions than suggested by local actors: Cases of Lent, Overdiepsche, Oijpolder (Ministry V&W, 2003).	*Presence of a niche*
2003	Launching of the campaign 'The Dutch Live with Water' for the communication of the recommended policy directions and measures as given in the Room for the River project (www.nederlandleeftmetwater.nl).	*Provision of resources*
2004	Dutch EU Presidency: Initiation of the 'EU Action Program on Flood Management' (Council of the European Union 2004).	*Provision of resources*

Table 4.2 (continued): The water management transition in the Netherlands.

Year	Event	Conceptualized as:
2005	**Ministerial decision on Oijpolder Case**: On May 2005 the States Secretary of the Ministry of WM announced her decision of the exclusion of the Oijpolder of the emergency floodplains' policy alternative.	*Standardization of practices*
2006	Decision and enforcement of Flood Defense policy in the Netherlands '**Room for the Rhine River**'.	*Standardization of practices*
2007	Fourth Assessment Report of Climate Change and related Scenarios by the Intergovernmental Panel on Climate Change (www.ipcc.org)	*Provision of resources (information)*
2007	European Union's flood protection Directive.	*Standardization of practices*
2007	Drawing of the Room for the Rhine River Key Planning Decision.	*Standardization of practices*
2008	**Working Together with Water – A living land builds for its future**. Findings of the Delta Committee, a comprehensive policy act for the water system.	*Standardization of practices*

The experience of a systemic failure such as the ineffectiveness of the flood defense infrastructure (in 1993 and 1995) raised the societal demand for action and triggered the water management institutions to take action that was manifested by the standardization and enforcement of water management practices and by the provision of resources for research. The standardization of water management practices capitalized research inputs (provision of knowledge resources) as well as preceded research programs (by the provision of resources for research). When water management became a hot issue on the political agenda after the Water Policy Act in 2000, the institutional restructuring came as an answer to the request for exclusively specialized bodies for flood protection and water management (assigned to the Directorate for Water) and for policy reinforcement and plans formulation (assigned to the Directorate PW&WM). The co-existence of support forces and institutional changes describe the development of the institutional transition of the water management in the Netherlands.

Institutional changes of the water management system

Opting for more effective and efficient institutional operation, the Dutch Government realized two restructuring changes (considered period 1991-2008): First the redistribution of policy execution and design tasks between the provinces and the empowerment of the water boards was realized in 1991. The institutional change resulted in the clustering in 37 water boards in 2004 (down from 129 in 1990 and 66 in 1998, based on The Water Handbook 2004, p.61) with their own consultancy experts and are able to deal with local problems (The Water Handbook 2004, pp.10 and 65). Second, the establishment of the Directorate General for Water was realized in 2002. This institutional restructuring meant the assignment of policy designing tasks to the new directorate and the redefinition of the role of the Directorate PW&WM to design policies and formulating proposals for plans and projects (NHV-special 6 2004, pp.88-89). We emphasize that our analysis concerns the time period of 1991-2008 and does not take into account the 2011's restructuring of the Dutch Ministries.

The impact of the institutional transition upon the flood defense policies for the Rhine river in the Netherlands

Water management is a task of national importance in the Netherlands given its hydro-morphological characteristics. Water policy is consistent, concise and follows a ladder of increased specification and operationalization of the policy directions on water management. The key water policy, entitled "A different approach to water, Water Management Policy in the 21rst Century" or WB21(2000), includes not only a new integrative approach on how to deal with water but also institutional arrangements for a more effective and integrative water administration. The succeeding policy act, the Room for the Rhine river (2007), includes space-specific measures on coping with future increased water discharge in the Rhine river aiming at keeping "dry feet" for the riparian areas.

In 2008 the Delta Committee delivered officially the findings that formed the policy for the management of the water system in the Netherlands, entitled "Working together with water". The

holistic view of the new policy is evident in the twelve specific policy recommendations that cover all the water system (physical, infrastructure-related and administrative).

Looking at the way national flood protection policies are drafted, two key observations are reported: First, policy options are supported by output of research projects and by societal support (since advisory and steering committees preceded and advised every policy decision). Social acceptance is the fundamental idea behind the constitution of the institutional structures in the Netherlands, known as the Polder model. Water management administration legitimizes and enables the establishment and working of advisory and steering committees that deal with water management issues and deliver advice documents to the Ministry of V&W (commonly reported committees are the Committee Boertien II established after the high waters of 1993 and delivered it advice in 1994 to the Ministry of V&W concerning the river Maas and the Luteijn Committee established in 2002 and concluded in its advice indication on the capacity and the location of possible emergency floodplains to store excess water).

Second, the institutional structure and the policy processes are linked to each other since policy does not only include regulations on water management practices but also directives for administrative tasks complementary to institutional change decisions. What we conclude is that the institutional transition in the water management in the Netherlands shows that policies and institutional changes are coupled.

Does the water management institutional transition resemble any archetypical response?

Incremental and anticipative: The water management institutional transition is characterized as incremental since incremental changes in policies and institutions occur throughout the transformation process. The water management system gently adjusts its institutions so as to conserve the existing consensus model. At the same time, water management institutions are proactive with their policies and take into account scientific input about climate change. What we see is that support provided by research and by social consultation leads to regular updates of the policies regularly without any experienced trigger (neither crisis nor systemic failure) over the last years. Institutions change in an incremental way to anticipate ecosystem dynamics and climate change dynamics.

The role of institutions: For the last decades the water management system experiences ecosystem and societal dynamics, and water management institutions alter their policies and operation to maintain safety in water prone areas with the aid of research findings. The new idea of 'giving space back to the river' instead of further restraining the water banks with high-dikes all along was supported by the 2001 research results (Silva et al, 2001) and institutionalized as a policy in 2006. Water policy in the Netherlands is routed and coordinated by water management institutions that coordinate social dynamics and policy while being proactive to ecosystem dynamics.

Our research findings also agree with van der Brugge (2009, p.153-154) that institutions have changed fundamentally the water management system in the Netherlands. With our analysis we complement that this change happened as a process with incremental changes in place and at an anticipative nature.

Analyzing the water management transition with the Evolution Cycle

Mapping the forces present in the water management institutional transition in the Netherlands on the Evolution Cycle of societal systems, we observe that the water management sector went through two cycles of evolution from 1993 to 2008. In Figure 4.3 we color the first cycle with grey and the second with black. It is shown that the institutionalization processes in the water management sector in the Netherlands are lengthy in time. In addition to this, we notice that the 1993 and 1995 floods in combination with the societal demand for flood-safe cities in 1993 initiated the changes in the water management sector in the Netherlands.

The Dutch water management case reveals that institutional changes were encountered prior to the presence of a societal or socio-political crisis. Provision of resources in the form of research programs

to produce input for the policy process on water management as well as frequent adjustments of the main policy on water management with water acts and other legislative actions are prevalent in the water management system. The analysis of the institutional transition with the macro-societal determinants showed that institutional change comes ***in anticipation to*** changes in the environmental subsystem. The institutional transition thus is policy driven and science driven. Policy-makers and scientific experts constitute a tightly knit group which makes this anticipation possible.

We also cannot distinguish any loop in the water management transition. The different support forces that are present provide support and manifest flow of resources to different policies. What takes place resembles two **lengthy institutionalization processes** with affluent support (1993 until 2003 and 2003 until 2008) towards two stases of the system signaled by two different water policies: WB21 – Different Approach to Water (2001) and Working Together with Water (2008).

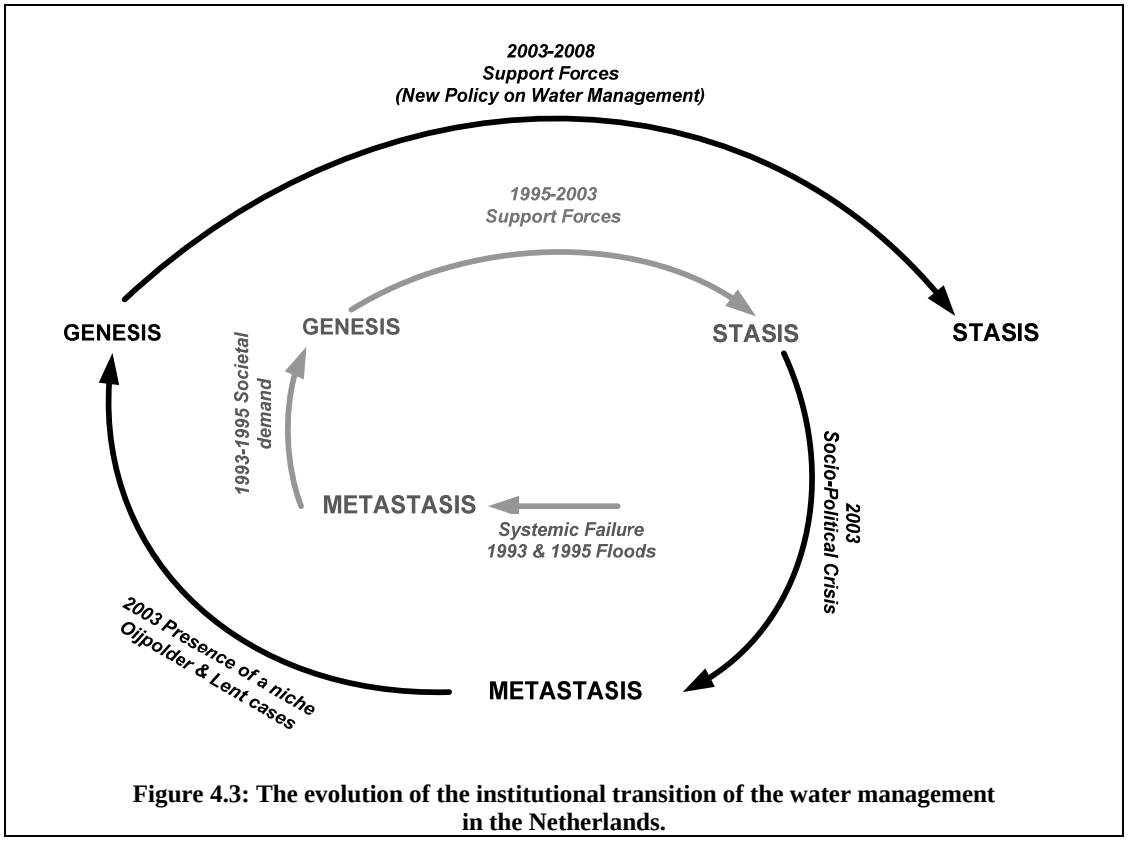


Figure 4.3: The evolution of the institutional transition of the water management in the Netherlands.

4.4.2 The establishment and the institutional transition of the environmental protection system in Greece

In the current case study our focus is on the environmental protection system with its interlinked regimes of water resources management and later the energy regime since the Acheloos diversion project and its impacts on riparian ecosystems and social system has been the major stimulus for the genesis of the environmental protection regime in Greece. In Box 4.3 we describe in brief the characteristics of the Acheloos river and a brief description of the Acheloos Diversion Project is given in Box 4.4 and in Figure 4.3.

The air pollution problem of Athens is considered as another important stimulus for the genesis of the environmental protection regime but its incremental influence in the development of the environmental protection institutions does not classify it as a critical one. Complex problems such as water shortages and environmental pollution were the undercurrent stimuli of the establishment of environmental protection institutions in Greece.

Box 4.3: A brief description of the geography of the Acheloos River.

The river Acheloos flows from Pindos Mountains in the central area of Greece, westwards to the Ionian Sea. The Acheloos river has the highest water discharge in Greece (approximately 4,385m^3/s in his estuary, 2003 estimates) and is the second in length, found in the Greek territory (Green et al, 2010, p.326-327). The river basin of the Acheloos river includes the natural lakes Trichonida, Lisimachia, Ambrakia and Ozeros. Along the length of the valley there are hydro-electric power plants that create artificial upstream reservoirs: Kremasta, Kastraki, Stratos I and II, and Tavropos.

"The Acheloos Valley and the Delta are listed as Special Protection Areas under the EU Birds Directive and were designated for inclusion in the national NATURA 2000 list. In addition, the Acheloos delta forms a complex of wetland habitats which constitute one of 11 Ramsar sites in Greece. The middle and upper reaches of the Acheloos river are the most important Greek habitat for the trout, Salmo trutta, a protected species under Annex II of the EU Habitats Directive. A number of other fish species indigenous to the river are also protected by the EU Habitats Directive." (Pickaver, 2011)

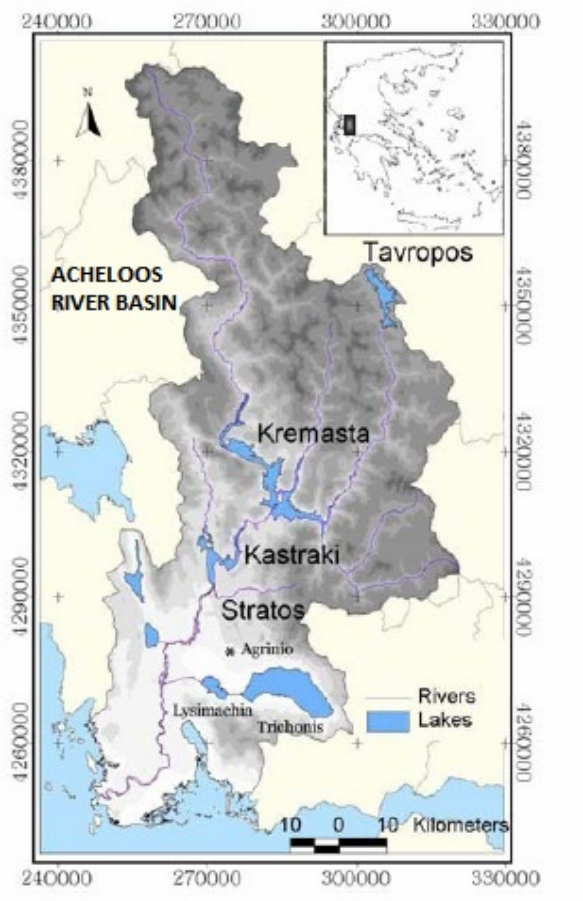


Figure 4.3: The Acheloos river
(Source: Adapted from Nikolaidis et al, 2006, p.47)
(Author's Photo Editing)

Box 4.4: The Acheloos' river diversion project.

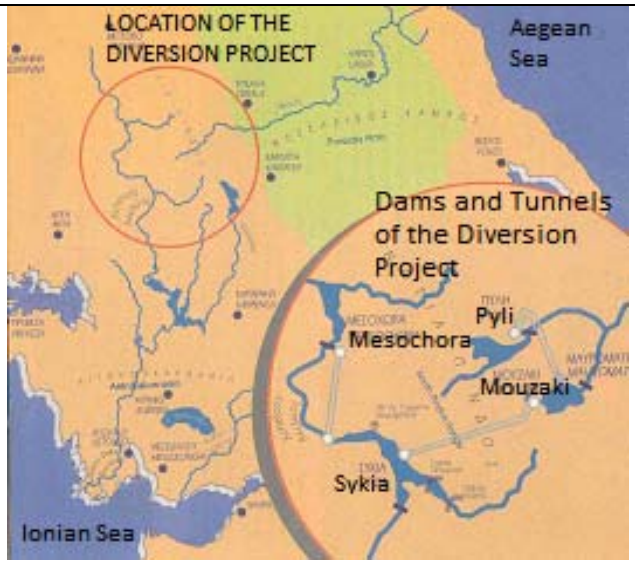
1950-1980: Water shortage problem in Thessaly plain was assessed by the Ministry of Agriculture since 1974 when the underground water table fell significantly due to excessive irrigation for cotton cultivation (after Margaris, Galogiannis and Grammatikaki, 2006, p.239 and 241; see also Mariolakos, 2007, p.148). The farmers of Thessaly claim that water scarcity and respective irrigation problems drive the horticulture of Thessaly into a decline (see Kousis, 2006). The diversion of the Acheloos River is suggested as a promising action to replenish the aquifer of Thessaly plain and consequently revive the horticulture economy of the region is (Gourgounis, 1998, p.164; see also Margaris, Galogiannis and Grammatikaki, 2006). Lack of funds postponed its complete implementation until it was put on the governmental agenda strongly the late 1980s. The first part of the diversion project was realized by the diversion of Tavropos in 1950s and the creation of the artificial lake of Plastiras. The second part of the Acheloos diversion project included "the construction of major dams and associated reservoirs at Mesochora, Sykia, Mouzaki and Pyli together with a diversion channel." (after Margaris, Galogiannis and Grammatikaki, 2006, p.242)

WWF Hellas presents what the diversion project includes the construction of:
" - Mesochora major dam (135 m height) and Mesochora reservoir (228 m^3). The Mesochora dam has already been constructed but remains out of use thanks to the strong opposition by the local community, which will be inundated.
- Mesochora – Glystra tunnel (1 kilometre long)
- Sykia mega dam (150 m height) and Sykia reservoir (502 m^3)
- Sykia diversion channel to Thessaly (17. 4 km length)
- Mouzaki major dam (135 m height) and Mouzaki reservoir (530 m^3)
- Pyli dam (90 m heightt) and Pyli reservoir (47 m3 volume)
- Pyli – Mouzaki tunnel (8 km length)" (www.wwf.gr/en) (2011)

1980-2000: The second part for the completion of the Acheloos diversion raised public reaction. In 1992, the Greek NGOs (the Greek branch of the World Wide Fund for Nature (WWF), the Hellenic Ornithological Society, Elliniki Etaireia and the Hellenic Society for the Protection of Nature (www.eepf.gr) (see www.water-technology.net) began a campaign for the environmental damage of the diversion scheme that raised publicity of the issue and awaken public awareness (see also, Greek NGOs report to DG XI, Brussels, 1993). The public reaction against the diversion of Acheloos river and the diagnosis of potential impacts that are related to the diversion of Acheloos river in Western Greece brought the issue to the Council of State in 1994 (www.water-technology.net). The country's highest administrative court, Council of State cancelled the diversion, suspended all construction works and decided for the requirement of a systematic and comprehensive environmental impact assessment study following scientifically valid methods as well as further study on potential policy actions to deal with development problems in Thessaly (see State Court Decisions 3478/2000).

2000-2008: The farmers of Thessaly as the critical actors in this policy regime pushed for the diversion project to be re-assessed and put it back to the ministerial agenda. In 2001 funds were allocated for the continuation of the project. The Environmental Impact Assessment study was renewed and gained approval that put the project into a start-up once more in 2003. For such a project to be realized, the environmental protection legislation has been modified partially (see GR 3010/2002). Early in 2004 the project has been stopped once more due to public reactions and lobbying ineffectiveness from farmers. In face of a declining horticulture economy and of irrigation water scarcity, the Ministry of Environment, Spatial Planning and Public Works launched a public information campaign in 2006 to inform the citizens for the benefits of Acheloos diversion plant and to condition public opinion (see press campaign in "To Vima", 16.07.2006, p.19A19; see also Polyzos and Sofios, 2005). What is announced in the 71th International Expo in Thessaloniki in 2007 by the Minister of Environment, Physical Planning and Public Works reveals that the second phase of the Acheloos diversion is on the agenda (since the construction of the Sykia Dam is decided, announced and financed) but the ministry cuts the project in small pieces so as not to raise public reaction (see Ministry of Environment, Physical Planning and Public Works, Ministerial Agenda for the 71th International Expo of Thessaloniki, 2007, www.minenv.gr).

Figure 4.4: The Acheloos Diversion Project (a) and a view of (b) Mesochora Dam and (c) Sykia Dam Constructions.



a: The Acheloos Diversion Project (Author's Photo Editing)
(Source: Hajibiros, 2011 in http://91.121.162.160/hydrodinosaures/greece_ang.htm)

b: A view of Mesochora dam.
(Source: www.eepf.gr/arthra/ektropiacheloou_f116.html)
(Hellenic Society for the Protection of Nature (www.eepf.gr))

c: A view of Sykia dam.
(Source: www.eepf.gr/arthra/ektropiacheloou_f116.html)
(Hellenic Society for the Protection of Nature (www.eepf.gr))

Different regimes tied to one institutional transition?

The Greek case of the environmental protection system turned out more complex than the other two case studies. As we already discussed in the case selection and description in Table 4.1, the system boundary that was initially set was the environmental protection institutions with a focus on the Acheloos River System that is a social-ecological system. The research however showed that for the Acheloos River system, the Acheloos Diversion Project is a common trigger for the development of three regimes in Greece (environmental protection, water management and in the late years, energy) that are interrelated via the environmental protection system (institutions) and via a common political agenda (mainly targeting development of the agricultural sector). We use the concept of *regime* to address *dominant constellations existing in a system* (agreeing with the definition provided by de Haan, 2010). We will analyze the developing dynamics that relate to the Acheloos River System with the starting focus on environmental protection as it was initially designed while analyzing how it involved both water management and energy policy regimes.

The common trigger is the crisis caused by the social resistance and opposition to the Acheloos Diversion Project that tends to re-occur in 1992 with the public reactions that ended in the court, in 1994, in 2004 and in 2009 and 2010. Although the Acheloos Diversion Project was initiated as early as 1964, it officially became an issue for environmental activists and NGOs (Non Governmental Organizations) in early 1990s. Our analysis includes the forces that drive the transition of the environmental protection regime, and the forces that manifest the interplay of the different policy regimes within the specified system.

To present this case in a consistent and systematic way in our effort to detangle the dynamics, we first explain our choices for the selection of specific regimes:

(a) Why the environmental protection regime? The Acheloos river system is a social-ecological system but it has been treated and managed as an infrastructural system hence neither linked nor assed by water management institutions but only by infrastructure development institutions. The diversion project is treated as a common infrastructure project and is being assessed by environmental protection legislation for complying with environmental impact assessment criteria mainly.
The diversion project concerns a river system (the Acheloos river bank and consequently its river basin) that will be diverted via artificial dams and lakes to go through the largest arable plain in Greece (the Thessaly plain). The focus on the diversion project is important since it triggered the introduction of environmental protection legislation in Greece. In our analysis of the dynamics with the Forces Framework we also include critical events directly linked to the diversion project.
The environmental impacts posed by the diversion on the Acheloos river basin were assessed only in 2003. The numerous technical reports, technical studies and official environmental impact studies (even the ones approved in 1995 and 2003 and a number of technical reports of 2005) (TEE-2005, Technical Report by the National Technical Advisory Board, 2005) concerned the environmental impacts of the diversion projects on the project locations only. The function of the technical report in 2003 was to mainly support the Environmental Impact Assessment that was approved in 2003 (GR Decision 131957/2003) and later cancelled by the State Court in 2005 (GR 1688/2005 State Court Decisions).

(b) Why the water management regime? Water management institutions become relevant with the introduction of the EU Directive 2000/60 that states that water management plans need to consider not only the river banks but also the river basin taking in this way an integrated and holistic approach to water. In 2003, the Water Policy Act (GR Law 3199/2003) set the same criteria for water management as the EU Directive 2000/60 (and it is the law that realized the harmonization with the EU 2000/60). With this law, a holistic approach needs to be adopted for the management of water bodies and especially rivers. The environmental NGOs put forward the incompliance of the Acheloos diversion project with the GR Law 3199/2003 and consequently with the EU Directive 2000/60 to the European Council and brought the issue to

the European Environmental Protection Agency. The Acheloos river and its river basin lacked a comprehensive water management plan following the GR Law 3199/2003, and it was also neither protected nor managed as a river system by the Greek Ministry. Independent research, European funded research and National funded research has been conducted about the water quality of the Acheloos river (e.g. Skoulikidis 2003; Nikolaidis et al, 2006); without however relating it with a water management plan at national level. The Greek Ministry of Environment and Infrastructure Development, considered the Acheloos river as a resource that needs to be serviced; hence only focused on its use via the diversion project.

(c) Why the energy regime? The Acheloos river hosts three major hydroelectric dams (Kremasta, Kastraki, Tavropos and Stratos I & II) that are in operation since 1970s-1990s. The hydroelectric dams are placed on the existing banks of the river and use its flow for energy production. The diversion project has been linked with the energy policy regime only recently. A number of local projects that are part of the diversion project have been completed but are either not set in operation or in inefficient operation due to their blockage by the Supreme Court. These include the Mesochora Dam, and the Mesochora Water Tunnel.
When the European Council decided to restrain European funds for the diversion project and to bring the issue of incompliance of the Greek state with the EU directive 2000/60 due to lack of water management plans for all river systems, the Greek state decided to address the Acheloos diversion project as an energy project. What followed is the enforcement of diversion projects (the operation of the Mesochora Dam) by energy policies in an attempt to avoid restrictions of environmental and water management protection policies/laws with the GR Law 3734/2009.

The institutional changes that took place influenced the organization and the monitoring of the environmental impact assessment studies. Different authorities were in charge for monitoring and for policy implementation due to decentralization. We therefore include those institutional changes in our analysis.

We need to note that given our system boundary, we did not consider a number of policy regimes that are related to the environmental protection regime due to their irrelevance for the Acheloos river system (e.g. the waste management policy regime; the chemical substances monitoring and treatment policy regime; and the urban - spatial planning policy regime).

Organization of the environmental protection system in Greece

The Greek institutional organization has undergone a major change from a very centralized to a more balanced system. The Greek institutional structure is characterized by a highly concentrated administrative power in the central government and the ministries. The institutional structure of the environmental protection regime in Greece during the first phase (1970-1980) can be characterized as centralized given that the central, regional and district offices as well as the main administrative tasks were managed by the ministry (see also Georgiou 1994, p.323; Lekakis 1995, p.18). The municipalities and provinces had limited decision power and administrative capabilities due to legal restrictions, lack of personnel and financial dependency on the central government. In this phase, the establishment of the Athens Environmental Pollution Control Project took place as the only institutional change. Environmental protection institutions in Greece were in their infancy since environmental problems were not under consideration for years until the late 1980s due to the late industrialization and urbanization of Greece.

The second phase (1980s-today) is signaled by the inception of Greece in the European Union in the 1980s that put the environmental protection on the political agenda. At the same time, the lobbying of farmer's interests in the political arena was indirectly shown by the drawing of Acheloos river diversion project. The basic promise of the Acheloos diversion project was to cope with water 'imbalances' of the Thessaly region (in line with prior governmental goals for economic development regardless of environmental impacts). The Acheloos diversion project and its anticipated environmental impacts raised environmental awareness among environmentalists and other citizen

groups (NGOs) resulting in a demand for environmental protection. These societal conditions paved the ground for a number of institutional arrangements and restructuring actions.

Analyzing the environmental protection transition with the Forces Framework

The institutional structure in Greece responded to societal demands for environmental management and to pressure from the European Union for harmonization with European legislation on environmental protection and water management (after 2000). This was realized by the government with decentralization and with legislative acts and decisions.

Complex problems such as the water imbalance in the Thessaly plain came to the forefront by a clash of interests between farmers and environmentalists. This clash of interests was generally seen as a conflict concerning the success or failure of the Acheloos diversion project (manifested by crises and systemic failures). The Acheloos diversion project was and is still seen as a promising large-scale infrastructural 'fix' that aims at reshaping the river banks of the Acheloos river and creating water storages (artificial lakes, a complex of water dams etc) so as to mitigate the water imbalance problem of the Thessaly plain in Greece. Due to its large scale, it was anticipated that this infrastructure project would have severe impacts on the morphology and on the environment. It thus raised public resistance during the 1980-1990s that triggered the formation of the environmental protection regime in Greece. This raised strong public reaction during the second phase of the project's implementation and brought the social conflict to the Council of State (in 1994) (Crisis). The Council questioned not only the content of the Environmental Impact Assessment (EIA) of the project but also the policy framework underlying the EIA methodology. A lack of a comprehensive and systematic approach for EIA was revealed. The 3478/2000 State Court Decisions temporarily resolved the social conflict and provided space for re-formulation and complementary work on the Environmental Protection Act in Greece. The social conflict among environmentalists and farmers of Thessaly revived in the early 2000s (Crises & Exercise of power), and the Acheloos diversion was brought back on the ministerial agenda. From 2000 until 2010 the Acheloos diversion project has been an issue that relates to two issue-related regimes and two policy-related regimes that are complex and interrelated. The analysis of the complex dynamics cannot be described by the forces (alone) hence we employ the Evolution Cycle and the related feedback loops to structure and analyze the dynamics in a systematic way.

The forces of the on-going environmental protection transition in Greece are presented in Table 4.3. The institutional transition of the environmental protection in Greece is gradual and on-going. More specifically, the social conflict between the Ministry of Environment, Spatial Planning and Infrastructures and the environmental NGOs is an on-going conflict that is captured by a number of support forces. The on-going conflict manifests itself via resources and power routing to the different regimes.

Table 4.3: The environmental protection transition in Greece.

Year	Event	Conceptualized as:
1950-1970s	Assessed water shortages in Thessaly Plain. (Margaris *et al*. 2006, p.239 and 241; Kousis 2006)	*Systemic failure*
1950s	Diversion of Tavropos and creation of artificial lake of Plastiras (first part of the diversion project) (Margaris *et al*. 2006, p.242)	*Presence of new practices*
1973	Establishment of the Athens Environmental Pollution Control Project.	*Institutional change*
1980	Inception of Greece in the European Union.	*Presence of new practices*
1985	**GR 1558/1985**: Constitution of the Ministry of Environment, Physical Planning and Public works.	*Institutional change*
1983-1987	Development plan for environmental improvement plans.	*Provision of resources*
1985	**EC 85/377**: European Directive that provided policy guidelines for environmental protection policies.	*Standardization of practices*

Table 4.3 (continued): The environmental protection transition in Greece.

1985	**GR 1650/1985 Environmental Protection Act:** Criteria on the assessment of environmental impacts of infrastructure and other human constructs are presented.	*Standardization of practices*
1990	**GR69269/5387/1990 & GR75308/5512/1990:** Ministerial Acts on criteria for assessment on the environmental impacts to complement the Policy Act 1650/1986.	*Standardization of practices*
1991	Approval of the environmental impact assessment study of the Mesochora Dam, Sykia Dam, Pilis Dam, Mouzaki Dam and Mesochora Water Tunnel.	*Provision of resources (Legitimization)*
1990-1994	Public reaction: Numerous conflicts between farmers and environmentalists escalate in court conflicts. In 1990 citizens in Mesochora block the works for the Mesochora Dam and a conflict escalates.	*Crisis*
1992	Greek NGOs begin a campaign for the environmental damage of the Acheloos diversion project. (Greek NGOs report to DG XI 1993)	*Presence of a niche*
1994	The social conflict between farmers and environmentalists is brought to the Council of State.	*Societal demand*
1994	**GR Decision 2759/1994** – Restrictions to the developmental agenda and legislative policies about considering environmental protection and assessment of environmental damages of any development policies	*Exersize of power*
1994	**GR 2759/1994 & 2760/1994 State Court Decisions** – Cancellation of the Diversion Project. Issue brought up by environmental NGOs	*Exersize of power (control power)*
1995	Approval of the environmental impact assessment of the Acheloos diversion project.	*Provision of resources*
1997-2005	**GR 3242/2004, 3250/2004, 3274/2004, 3345/2005:** 'Ioannis Kapodistrias' Decentralization Project.	*Institutional change*
1998	**GR 221/1998:** Constitution of the Environmental Protection Body.	*Institutional change*
2000	**GR 3478/2000 State Court Decisions:** Council of State cancelled the diversion, suspended all construction works and decided for the requirement of a systematic and comprehensive environmental impact assessment study following scientific valid methods as well as further study on potential policy actions to deal with development problems in Thessaly.	*System failure (ineffectiveness to deal with environmental protection) &* *Standardization of practices*
2000	**EC 2000/60**: Water Framework Directive of European Union for the guidelines on policies to achieve good water status for all European Waters.	*Presence of new practices*
2001	Fund allocation for the Acheloos Diversion Project continuation.	*Provision of resources*
2002	**GR 3010/2002:** Environmental Protection Act to update the Act 1650/1986 for the assessment procedure and criteria for infrastructure projects.	*Standardization of practices*
2003	**GR Ministerial Decisions 131957/2003** - Approval of the Environmental Impact Assessment of the diversion project taking into account the modified Environmental Protection Act 3010/2002.	*Exersize of power (Legitimization)*
2003	**GR 3199/2003**: Water Law (Water Policy) on the Harmonization with Directive 2000/60/EC for the protection and management of water bodies.	*Standardization of practices*
2004	Public outcry: The diversion project is stopped once more due to public reactions and ineffective lobbying by farmers.	*Crisis*
2005	**GR 1688/2005 State Court Decisions**: Cancellation of GR 131957/2003 Ministerial Decision that approved the Environmental Impact Assessment for the Diversion Project. **GR 1691/2005 State Court Decisions:** Cancellation of 968/2002, 970/2002, 971/2002 approvals of the Environmental Assessment Studies for projects that belong to the diversion project.	*Exersize of power (Control power)*
2005	**GR Ministeral Decision 49139/2005:** Introduction of the Central Water Management Authority within the Ministry of Environment, Spatial Planning and Infrastructures. **GR Ministerial Decision 1688/2005:** Introduction of Water Management Regional Authorities The new authorities will deal with the implementation of the GR Water Law 3199/2003 at National and Regional Level.	*Institutional Change (Deconcentration)*
2006-2007	Launching of an information campaign for Acheloos river diversion project by the Ministry of Environment to inform citizens on the benefits of the project. Allocation of funds for the continuation of the project. (Polyzos and Sofios 2005; Kousis 2006)	*Provision of resources (information and expected support)*

Table 4.3 (continued): The environmental protection transition in Greece.

Year	Event	Conceptualized as:
2006-2008	Allocation of funds for the continuation of the Acheloos river diversion project.(see Greek Ministry of Environment 2007)	*Provision of resources*
2006	**GR 1186/2006 & 1187/2006 State Court Decisions:** Cancellation of the Sykia Dam works as auctioned due to previously cancelled of the environmental impact assessment that restricts any constructions.	*Exersize of power*
2006	**GR Ministerial Decision 107017/2006 (FEK B1222/05.09.2006)** "Environmental Impact Assessment of infrastructure projects and plans. Harmonization with the EU Directive 2001/42." Update and adapt the existing GR Law 3010/2002 and establishment of new standardized practices that adhere to Strategic Environmental Impact Assessment approach.	*Standardization of practices*
2006	**GR Law 3481/2006** "Legislative changes concerning National Spatial Monitoring and Mapping, infrastructure project licensing and monitoring and additional regulation" (FEK 162A/2006) – The current law legitimized the Acheloos Diversion Project and included policies for its completion and operation of the existing diversion dams.	*Exersize of power*
2007	**Presidential Decree GR 51/2007 –** Introduction of Integrated Water Resources Management practices to complement the Water Law.	*Standardization of practices*
2008	**EC 2008 European Council Decision (C-264/07):** Penalizing Greece for incompliance and non implementation of EU Directive 2000/60 especially Articles 5(1) and 15 (2)	*Exersize of power*
2009	**GR Law 3734/2009**: Law necessary for the further integration of co-generation, PV electricity and Hydroelectricity into the national energy balance by simplifying administrative and financing procedures (mostly regarding to photovoltaic issues), by regulating issues regarding hybrid projects and geothermal energy, biofuels, etc.) This law complies with the Directive 2004/8/EC on cogeneration. The law replaces some articles of the 3468/2006 aiming at facilitating some the integration of some renewable energy technologies (especially PV). Specific regulations are provided for PV pricing, the System Operator and the Centre of Renewable Energy Sources. Also it legitimizes the operation of the Mesochora Dam that is a project belonging to the broader Acheloos Diversion Project.	*Provision of support*
2009	**GR 3053/2009 & 3054/2009 State Court Decisions**: Cancellation of the works on local projects that relate to the Acheloos Diversion Project, cancellation of the approved environmental impact assessment of the diversion project as given in GR Law 3481/2006. (9.10.2009) - The State Court Decision issued the decision based also on question raised by the European Council and WWF Hellas.	*Exersize of power*
2010	**GR 141/2010 State Court Decisions:** Cancellation of works of the Acheloos Diversion Project especially the water tunnel to Thessaly and restriction of the operation of any projects that have been completed. The issue was brought by WWF Hellas.	*Exersize of power*

Institutional changes of the environmental protection system in Greece

The environmental protection institutions in Greece have experienced institutional changes that aimed at improving their response to emerging environmental problems. Institutional transition in Greece was gradually realized through four major decentralizations. First, in 1973 the Athens Environmental Pollution Control Project agency was jointly established by the Greek Ministry of Social Services, the World Health Organization and the United Nations Development Program and had as its main task 'the development of regulation and enforcement protect the environment' (Lekakis 1995, p.19). The agency was merged with the Ministry of Physical Planning, Housing and Environment in 1980. Second, the Ministry of Environment, Physical Planning and Public Works was established by merging the Ministry of Physical Planning, Housing and Environment and the Ministry of Public works and was assigned the task of environmental protection policy.

Third, the most radical institutional restructuring was named the 'Ioannis Kapodistrias' program and was imposed by the central government in 1997 (see www.ypes.gr/kapodistrias). The Kapodistrias

plan[14] established provinces (13 in total) and redefined the spatial boundaries of local authorities (1033 municipalities and 51 prefectures). Local authorities were assigned with the administrative and legislative capability for spatial planning and decision making under the supervision of regional authorities. Fourth, the Environmental Protection Body was constituted as part of the Ministry of Environment, Spatial Planning and Public Works in 1998. This restructuring assigned environmental licensing and monitoring of infrastructure projects to a newly established administrative body. An elaborate presentation of the institutional changes realized in the environmental protection sector in Greece is included in Box 4.5.

Box 4.5: Institutional changes of the environmental protection sector in Greece.

1973 –The Athens Environmental Pollution Control Project agency was jointly established by the Greek Ministry of Social Services, the World Health Organization and the United Nations Development Program and has as its main task "the development of regulatory and enforcement systems to protect the environment" (after Lekakis, 1995, p.19). The agency was merged with the Ministry of Physical Planning, Housing and Environment in 1980.
1985 –The merge of the Ministry of Physical Planning, Housing and Environment and the Ministry of Public works resulted in the Ministry for Environment, Physical Planning and Public Works (National Law 1558/1985) that is the central administrative body for environmental protection policy in Greece.
1997 – The most drastic imposed institutional restructuring is named "Ioannis Kapodistrias" program and was imposed by the central government in 1997 (see www.ypes.gr/kapodistrias). This major institutional transition is continued and enforced by a number of legislative acts, namely Greek National Acts 3242/2004, 3250/2004, 3274/2004, and 3345/2005. It aimed at decentralizing the country's administrative bodies striving for efficiency and effectiveness. The Kapodistrial plan established the regional authorities (13 in total) that are the provinces or peripheries and redefined the spatial boundaries of the local authorities (1033 Kapodistrian Municipalities and 51 prefectures). The mode of the decentralization is delegation since administrative tasks are now allocated to the local and regional authorities irreversibly. Local authorities of both first and second tier have the administrative and legislative capability for spatial planning and decision making under the supervision of regional authorities.
1998 – Within the Ministry of Environment, Spatial Planning and Public Works a new administrative body was constituted (Presidential Decision 221/1998) the Environmental Protection Body so as to deal with the environmental licensing and monitoring of the fulfillment of environmental protection activities when infrastructure projects were implemented.

The water management regime in Greece also experienced a significant institutional change that was initiated in 2003 with the GR Water Law 3199/2003. Within the Ministry of Environment, Spatial Planning and Infrastructures, a deconcentration of administrative power was expressed by the establishment of a Central Water Management Authority at the national level (GR 49139/2005) and a Regional Water Management Authority (GR 1688/2005) at regional and provincial level. The tasks of these newly established bodies include the implementation and monitoring of the GR Water Law 3199/2003 including the design of water policy plans and water management strategies at operational level.

Analyzing the environmental protection transition with the Evolution Cycle
Taking a meta-level view of the Acheloos River System and mapping the forces on the Evolution Cycle of societal systems, we observe that the environmental protection sector went through three cycles of evolution from 1970s to 2010. In Figure 4.5 we present the different cycles without differentiating between the three regimes. We notice that institutional change in Greece has taken place in a **crisis-induced way**: Crisis-Formation Forces-Support Forces is the recurrent pattern and the majority of the forces are support forces rooted in the institutional subsystem.

[14] In 2011, the Greek State restructured the public administration in all levels (regional, local) with the Kalikratis Law. Our analysis does not include the changes that were made by the Kalikratis Law since our study period is from 1950s until 2010.

The institutional restructuring proceeded faster than in the Dutch case due to the concentration of political power in the hands of Greek Government (see Christensen and Pallesen 2001, p.181). More specifically, the systemic failures (water system inefficiency in Thessaly), the crises (as manifested by the social conflict and the public reactions), the societal demand for environmental protection, and the institutional restructuring were complemented with socially embedded forces of the presence of niches (the environmental movement) and the presence of new practices (in the form of the new practices transferred by the European Union due to inception), the provision of resources and the standardization of practices (in the form of funds for research, legitimization, and infrastructure development) constituted the societal determinants present in the course of the institutional transition. Triggers alert the institutional system. Institutional changes and support (support forces) come in response to triggers (Close 1999).

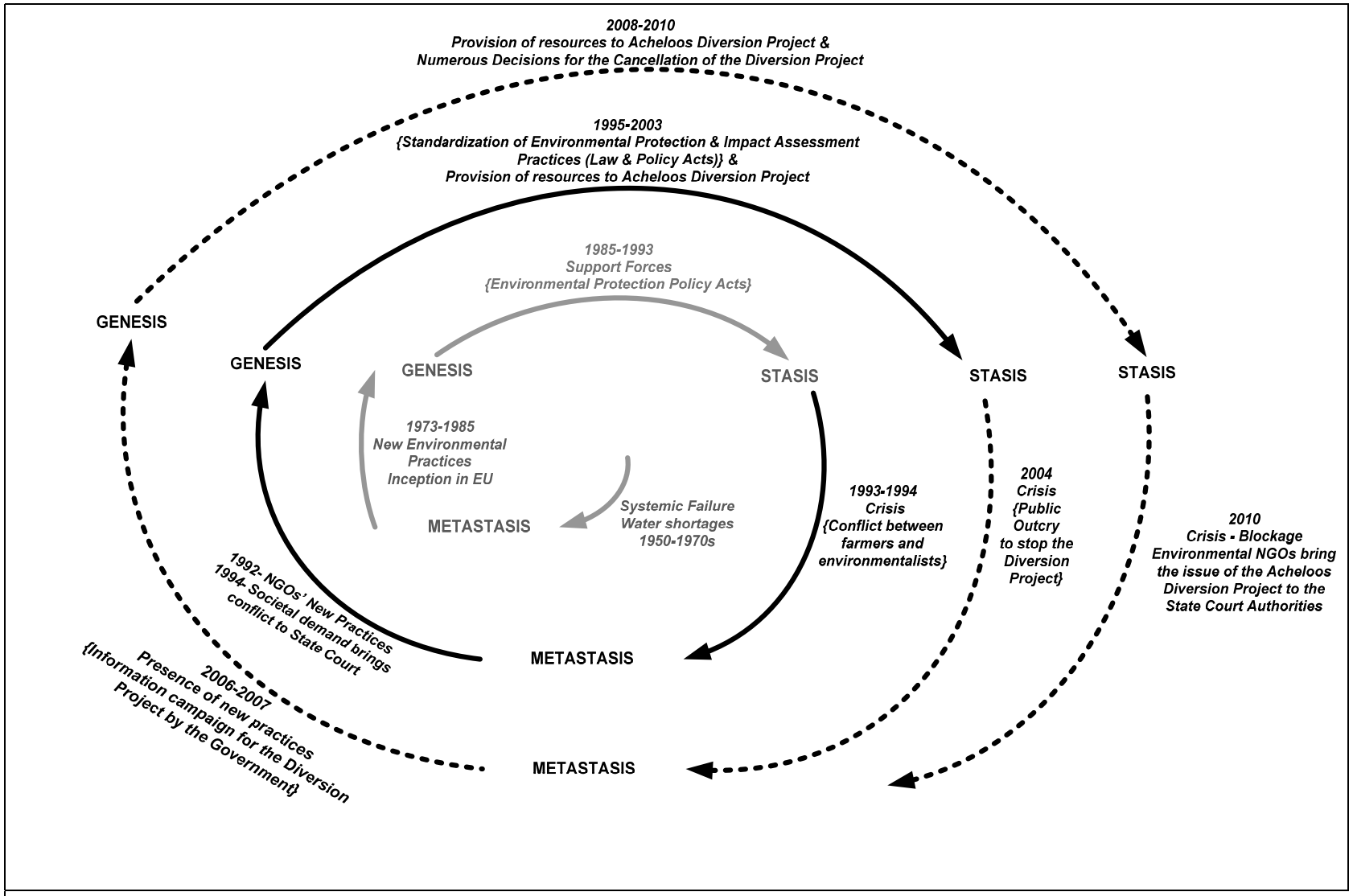


Figure 4.5: The evolution of the institutional transition of the environmental protection sector in Greece (a meta-level view).

Identifying and analyzing the feedback loops of the environmental protection transition

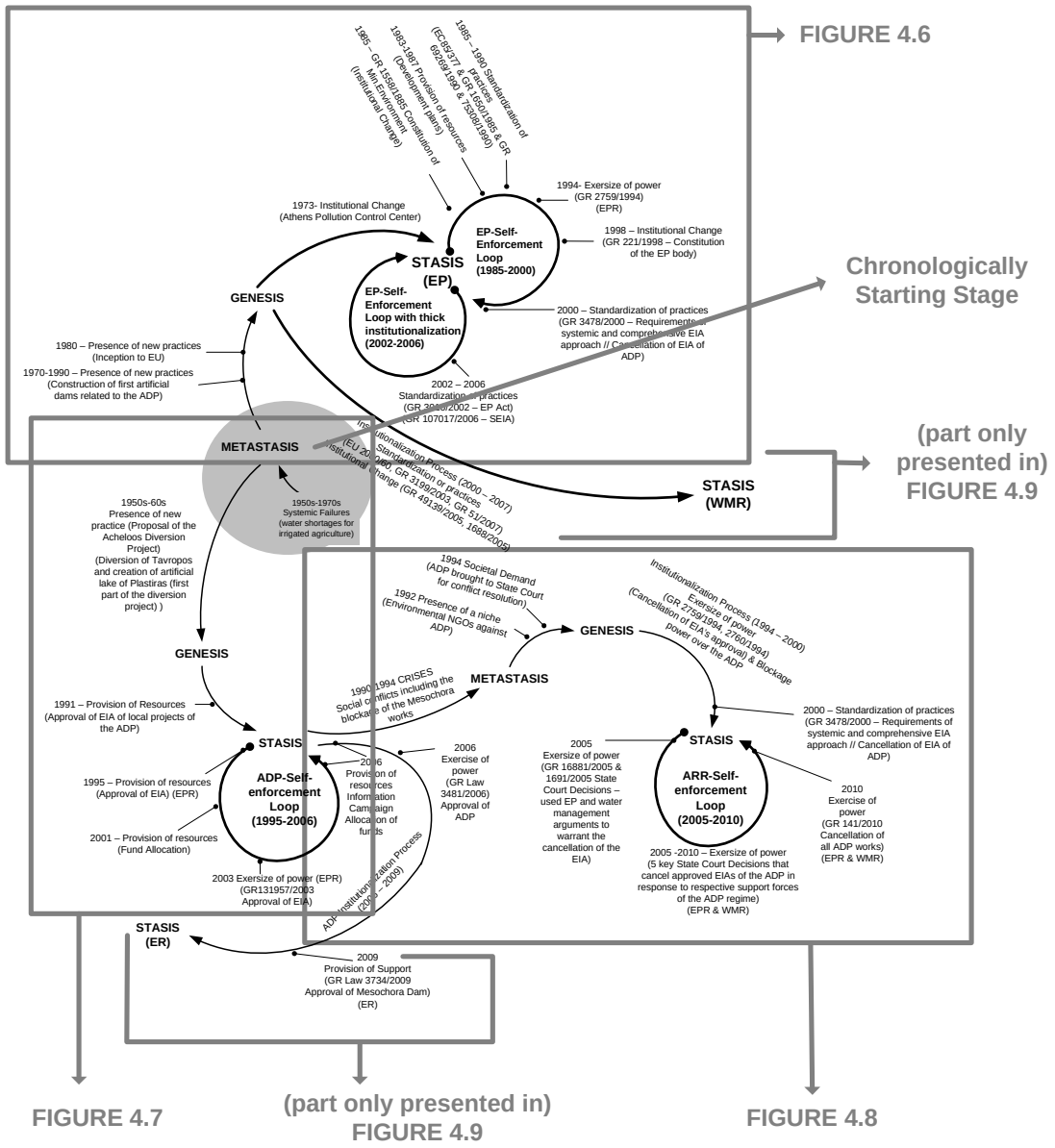
Analyzing the dynamics of the Acheloos river system transition with the aid of feedback loops, we take into account the different regimes that are related to the system. The different feedback loops capture the institutional support and power conflict that continues to revolve around two opposing issues: the completion of the Acheloos Diversion Project and the cancellation of the Diversion Project with the restoration of the river and conservation of its delta wetlands. The feedback loops are issue specific and involve different regimes. We therefore introduce policy regimes that are dominant constellations of a specific policy domain (e.g. environmental protection) and issue-related regimes that are dominant constellations of a specific issue or interest, like the Acheloos Diversion Project Issue Regime and the Acheloos River Restoration Issue Regime.

Note: In this section, we will use a number of acronyms in the Figures and in the analysis. For consistency we list the acronyms here.

ADP	Acheloos Diversion Project
ARR	Acheloos River Restoration
EC	European Council
EIA	Environmental Impact Assessment
EP	Environmental Protection
EPR	Environmental Protection Regime
ER	Energy Regime
EU	European Union
GR	Greek Regulation (Referring to Laws, State Court Decisions and Ministerial Decisions). Detailed description of the Greek Regulation in reference is given in the Table 4.3
NGO	Non Governmental Organization
SEIA	Strategic Environmental Impact Assessment

Presentation Guide: In the following figure we show how Figures 4.6 to 4.8 build up to Figure 4.9 so as to help the reader to understand how the different regimes and their evolution cycles relate to each other. Figures 4.6 to 4.9 present the feedback loops and the different cycles of all the different regimes. These figures have to be considered as a zoom-in on the system's evolution and on the transition dynamics. Figures 4.6 to 4.9 are not related to Figure 4.5. Figure 4.5 is a meta-view of the institutional transition and its dynamics. Figure 4.9 is an overview of all the evolution cycles and feedback loops of all the regimes that co-evolve during the institutional transition in Greece.

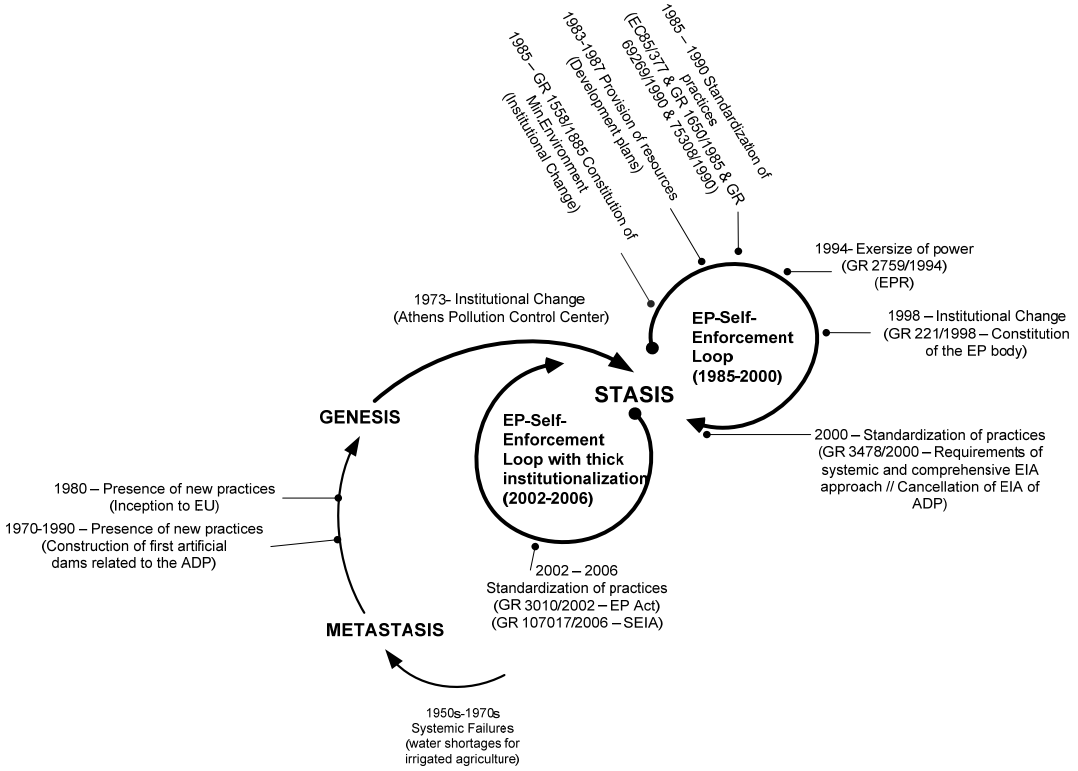
GUIDING FIGURE:



Legend: ADP: Acheloos Diversion Project; ARR: Acheloos River Restoration; EIA: Environmental Impact Assessment; EPR: Environmental Protection Regime; EP: Environmental Protection; EP: Environmental Protection; ER: Energy Regime; EU: European Union; GR: Greek (Law); SEIA: Strategic Environmental Impact Assessment; WMR: Water Management Regime.

Self-Enforcement Loop of Environmental Protection Regime (1985-2000) (Figure 4.6)**:** The presence of support forces towards the settlement of the environmental protection institutions and regime that took place from 1985 to 2000 is characterized by continuous enforcement of the standardized process of environmental assessment. The support forces and the institutional changes support the environmental protection policy that was enforced in 1985 (GR 1650/1985). According to the GR Law 1650/1985 the Environmental Impact Assessment has to precede any project and has to be approved for a project to kick-off. The interplay of the support forces of this time period resembles a self-enforcement institutionalization loop.

The institutional change of 1985 (GR1558/1985) signals the initiation of the self-enforcement loop given that it provided the institutional ground for the environmental regime and critically conditioned the creation of support via the establishment of the Ministry of Environment. The break-out[15] event that signals the termination of this loop is the GR 3478/2000 State Court Decision that quests for a systemic and comprehensive Environmental Impact Assessment study for the Acheloos Diversion Project. The GR 3478/2000 State Court Decision shows that the existing environmental protection institutions do not suffice for on-going and on-the-agenda infrastructure projects hence it asks for a new approach. It has two impacts on the environmental protection regime: it is a systemic failure hence functions as a trigger (by revealing that existing environmental protection legislation is ineffective) and it is a standardization of practices concerning environmental impact assessment approval with a focus on standards hence functions as a support to the environmental protection regime.



Legend: ADP: Acheloos Diversion Project; EIA: Environmental Impact Assessment; EPR: Environmental Protection Regime; EP: Environmental Protection; EU: European Union; GR: Greek (Law); SEIA: Strategic Environmental Impact Assessment

Figure 4.6: The Self-Enforcement Loops of the Environmental Protection Regime in Greece.

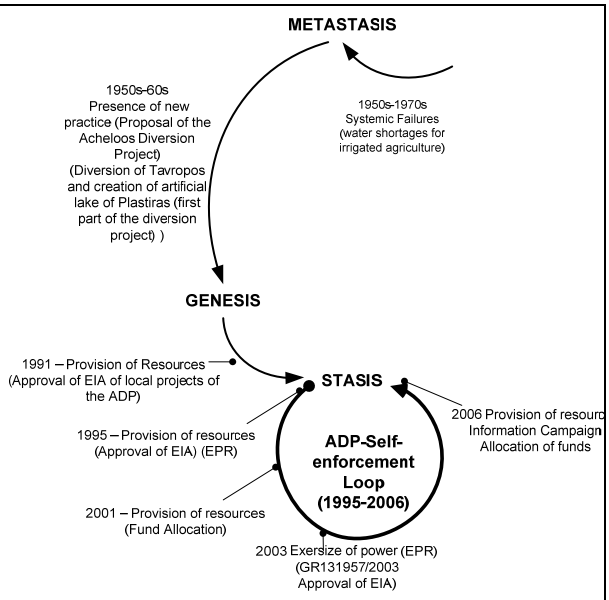
[15] The definitions of break-in and break-out forces are given at the end of section 4.4.

Self-Enforcement Loop of Environmental Protection Regime with Thick Institutionalization (2002-2006) (Figure 4.6)**:** The new environmental protection law enforced in 2002 (GR Law 3010/2002) signals a new self-enforcement loop of the environmental protection regime. The support forces in place enforce the 2002 environmental protection law hence the process resembles a self-enforcement loop. At the same time, the 2002 environmental protection law establishes stricter assessment criteria and increases the categories of projects that require undergoing an EIA procedure; hence we argue that it manifests a thick institutionalization. In line with this, the GR 107017/2006 Ministerial Decision complements the environmental protection law by introducing new standardized practices of Strategic Environmental Impact Assessment.

Self-Enforcement Loop for the Acheloos Diversion Project Issue Regime (1991-2006) (Figure 4.7): The support forces that are at play in this loop enforce the continuation and the implementation of the overall Acheloos Diversion Project (ADP). This self-enforcement loop is issue-related not regime related. Different regimes are at play with a common issue that is the implementation of the ADP. Every support force manifests actions and decisions taken by different regimes to establish the support for the implementation of the ADP. The orchestrated support concerns provision of resources in the form of funds and the exercise of power with the decisions that legitimize the approval of the Environmental Impact Assessment (EIA) of the overall diversion project and after 2000, of the local diversion projects. The support exercised targets the overcoming of the hurdle of the environmental criteria so as to get the approval of the EIA of the diversion project and consequently to proceed towards the kick-off of the diversion project. The approval of the EIA is needed for the ADP to be implemented.

What however happened is that the ADP was partially kicked-off without an approved EIA, and every decision of EIA concerned local projects of the ADP and not the overall ADP.

The break-in force is the 1995 provision of resources as experienced by the first approval of the EIA. The break-out force is the 2006 provision of resources in the form of the information campaign and the fund allocation. The information campaign had as an objective to increase the public support of the ADP by proposing only local projects (the implemented but not operational yet dams). For the first time, the ADP is not in the agenda in its entirety but only parts of it are presented. After 2006, the ADP is being engulfed by the Energy Policy Regime constituting a new support process.



Legend: ADP: Acheloos Diversion Project; EIA: Environmental Impact Assessment; EPR: Environmental Protection Regime.

Figure 4.7: The Self-Enforcement Loop of the Acheloos Diversion Project Issue Regime (1985-2000).

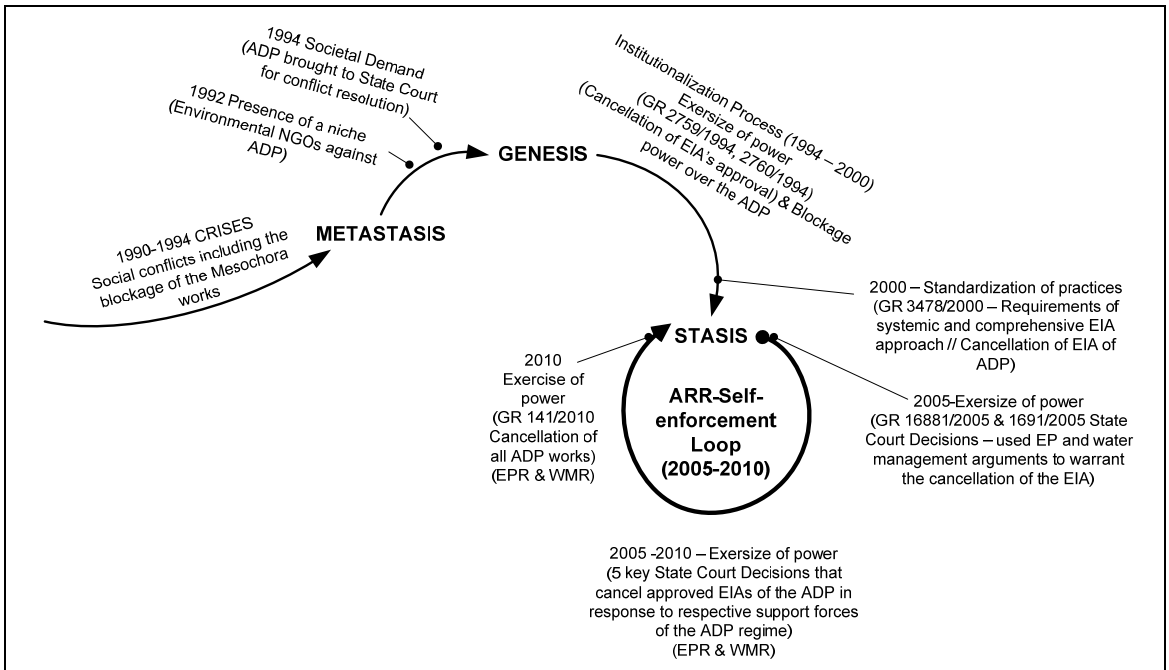
It is expected that after the numerous environmental impact assessment studies conducted, the numerous decisions of approval and counter-decisions of cancellation of the approvals by the State Court Decisions, the ADP will be on-hold and not implemented since it is restrained by the State Court Decisions and by the European Council. What is realized is the construction of the local dams and the main diversion water tunnel (in Mesochora) despite the on-going conflict and deadlock. The Ministry of Environment and the Public Power Corporation (key actor of the *Energy Policy Regime*) kept on financing and installing the local projects with auctions and infrastructure contracts despite

the cancellation of the Environmental Impact Assessment study that needs to be approved for any project to be initiated. The exercise of power and the financial support allocated to the local projects of the ADP are seen as shadow support process that is on-going and becomes evident (hence not avoidable anymore) in 2009 with the GR Law 3734/2009 that addresses the Mesochora Dam as an energy policy plan under the energy policy regime. The involvement of the Energy Policy Regime will be discussed in the following loop.

The self-enforcement loop for the ADP is also set and supported by a shadow regime. The Agriculture Sector Development Regime has lobbied towards the continuation of the ADP for over 60 years. Their actions and power games at micro-level (involving also power politics) are manifested at macro-level with the continuous presence of support forces and the self-enforcement loop for the ADP from 1991 to 2006.

Institutionalization process of the Acheloos Diversion Project Issue Regime (2006-2009) (Figure 4.7)**:** The 2005 State Court Decisions (GR 1688/2005 and 1691/2005) (experienced as exercise of power) showed that the EIA cannot be approved due to incompliance with environmental protection and water management criteria. This force triggers the initiation of an institutionalization process of the ADP (2006-2009) (but it is not its break-in-force). The institutionalization process is constituted by support forces that aim at contributing to the implementation and completion of the ADP. These support forces are exerted by the Spatial Planning Regime (GR Law 3481/2006 – experienced as exersize of power) and by the Energy Regime (GR Law 3734/2009 – experienced as provision of support). The ADP has been considered as a energy project hence supported and legitimized under the Energy Regime in an effort to gain the support towards its implementation/completion.

Institutionalization Process related to the Acheloos River Restoration Issue Regime (anti-Acheloos Diversion Project) (1994-2000) (Figure 4.8): The support forces that were in place from 1994 to 2000 resemble an institutionalization process for the anti-Acheloos Diversion Project. The main actors that provided the support include local NGOs and environmental NGOs. We conceive this process to be the institutionalization of the Acheloos River Restoration issue regime (ARR) since the counter argument to the diversion promises was mainly the preservation and restoration of the river banks and its riparian forests. The institutionalization process was initiated with the Exercise of power in 1994 (GR2759/1994 & 2760/1994) and ended with the 2000 GR 3478 State Court Decisions that cancelled the EIA approval of the ADP. The support forces that constitute the institutionalization process comply with the enforcement of the environmental protection regulation. More specifically, the institutionalization is constituted by support forces that resulted in the cancellation of the ADP due to insufficient evidence concerning the expected impacts of the ADP (because of the scale of the project). We argue that the GR 3478/2000 State Court Decision is a critical event to this process (as well), since it is the last decision that gave support to the cancellation of the ADP based on arguments of insufficient assessment of environmental impacts.



Legend: ADP: Acheloos Diversion Project; ARR: Acheloos River Restoration; EIA: Environmental Impact Assessment; EPR: Environmental Protection Regime; EP: Environmental Protection; EU: European Union; GR: Greek (Law); SEIA: Strategic Environmental Impact Assessment; WMR: Water Management Regime

Figure 4.8: The Institutionalization Process and the Self-Enforcement Loop of the Acheloos River Restoration Issue Regime.

Self-Enforcement Loop of the Acheloos River Restoration Issue Regime (anti-ADP) (2005-2010) (Figure 4.8): From 2005, the ARR Regime included actions and support from both the Environmental Protection Regime and the Water Management Regime. With support we do not mean the support by actors that belong to the two regimes. For example, the break-in-force is the exercise of power (control power) as experienced by the GR 16881/2005 and 1691/2005 State Court Decisions that employed both environmental protection and water management arguments to warrant the cancellation of the EIA of the ADP. The exercise of this power is possible due to the existence and operation of both the Environmental Protection Regime (that in 2002 entered a thick institutionalization with stricter EP standards) and the Water Management Regime (that in 2003 introduced a holistic approach to water with the GR 3199/2003 Law). The succeeding support forces further reinforce the blocking of the works of the ADP (hence we argue of a self-enforcement loop in place). The support forces also indicate a tendency of integration of the Environmental Protection Regime with the Water Management Regime at the operational level of the Acheloos River Restoration Issue (GR 1186/2006, GR 1187/2006, EC 2008-C-264/2007, GR 3053/2009, GR 3054/2009). The support forces include power exercise where the EPR and WMR are interlinked. The break-out-event of the self-enforcement loop is the 2010 Exercise of power (GR 141/2010) over the ADP that requests the cancellation and withhold of all works relating to ADP.

Institutionalization Process of the Water Management Regime (2000-2007) (Figure 4.9)**:** The water management regime became a separate regime from the environmental protection regime after the enforcement of the EU 2000/60 Water Directive. The support forces that are present concern the establishment of the Greek Water Law (GR 3199/2003) (that is the break-in point of the institutionalization process) and the accompanying ministerial decisions (GR 51/2007 Presidential Decree) and institutional changes (GR 49139/2005 and 1688/2005). The institutional changes of the deconcentration of administrative power by the constitution of the National and Regional Water Management Authorities comprise the break-out force of the institutionalization process. The institutional changes signal the settlement of the water management regime; hence we perceive that

the regime entered the stasis stage with these institutional changes. We conclude that the support forces constitute a formal institutionalization process of the water management regime.

The water management regime is researched and is part of our analysis since the ill-management of the Acheloos River basin that does not comply with the GR 3199/2003 Water Law (that brings in the harmonization with the EU 2000/60 Directive) is used as an argument to warrant the blockage of the Acheloos Diversion Project. After the establishment of the water management regime, arguments about ill-management of water resources came forward since they were legitimized.

Tipping Forces

We observe that there are two forces that had a significant impact on setting in motion processes in one regime and/or multiple regimes while diminishing processes in another regime in this case study. These forces can be considered as tipping forces, forces that tip the system towards new state of dynamics[16].

- The GR 3478/2000 State Court Decision event (Standardization of practices) is a critical event for the transition we research. First it signals the break-out from the self-enforcement loop of the environmental protection regime (1985-2000). Second, it is the break-out or termination of the institutionalization process of the Acheloos River Restoration (1994-2000). In this process, we argue that the GR 3478/2000 State Court Decision is a critical event to this process (as well), since it is the last decision that gave support to the cancellation of the ADP based on arguments of insufficient assessment of environmental impacts. This force meant the termination of the institutionalization process and the entry of the system to a stasis stage.

- The 2005 State Court Decisions (GR 1688/2005 and 1691/2005) (experienced as Exercise of Power) showed that the EIA cannot be approved due to incompliance with environmental protection and water management criteria. This force is critical to the transition under analysis for two reasons: First, it signals the self-enforcement loop of the Acheloos River Restoration Issue (anti-ADP) (2005-2010) as its break-in-force. Second, it triggers the initiation of an institutionalization process of the Acheloos Diversion Project (2006-2009) (but it is not its break-in-force).

Forces and Counter-Forces? Loops and Counter-Loops?

The environmental protection transition in Greece was (and remains) a battlefield for both supporters and opponents of the Acheloos Diversion Project. The opponents of the Acheloos Diversion Project use the environmental protection regulation as a manifesto against the diversion project. The supporters of the Acheloos Diversion Project employed the environmental regulation and especially the EIA standards as pre-requirements to a large infrastructure project and strategically supported the perception that the Acheloos river is an infrastructure system and not a social-ecological system. This is manifested by self-enforcement loops mainly constituted by exercise of power and provision of resources. The self-enforcement loops in one regime are counter-balanced by self-enforcement loops in the opposing regime.

In Figure 4.9 we view the feedback loops and institutionalization processes that are in place and explain the complex dynamics of the Greek Environmental Protection Transition with the focus on the Acheloos River System. We view that the present forces set in motion different feedback loops that have different operations in their evolution. What we observe is that forces are involved in feedback loops that reinforce regimes that are in continuous competition; meaning that drivers and counter-drivers (or barriers) are set in place subsequently.

[16] The Forces framework was devised to analyze the case study. The tipping forces are new to the Forces framework and derived from the case study analysis.

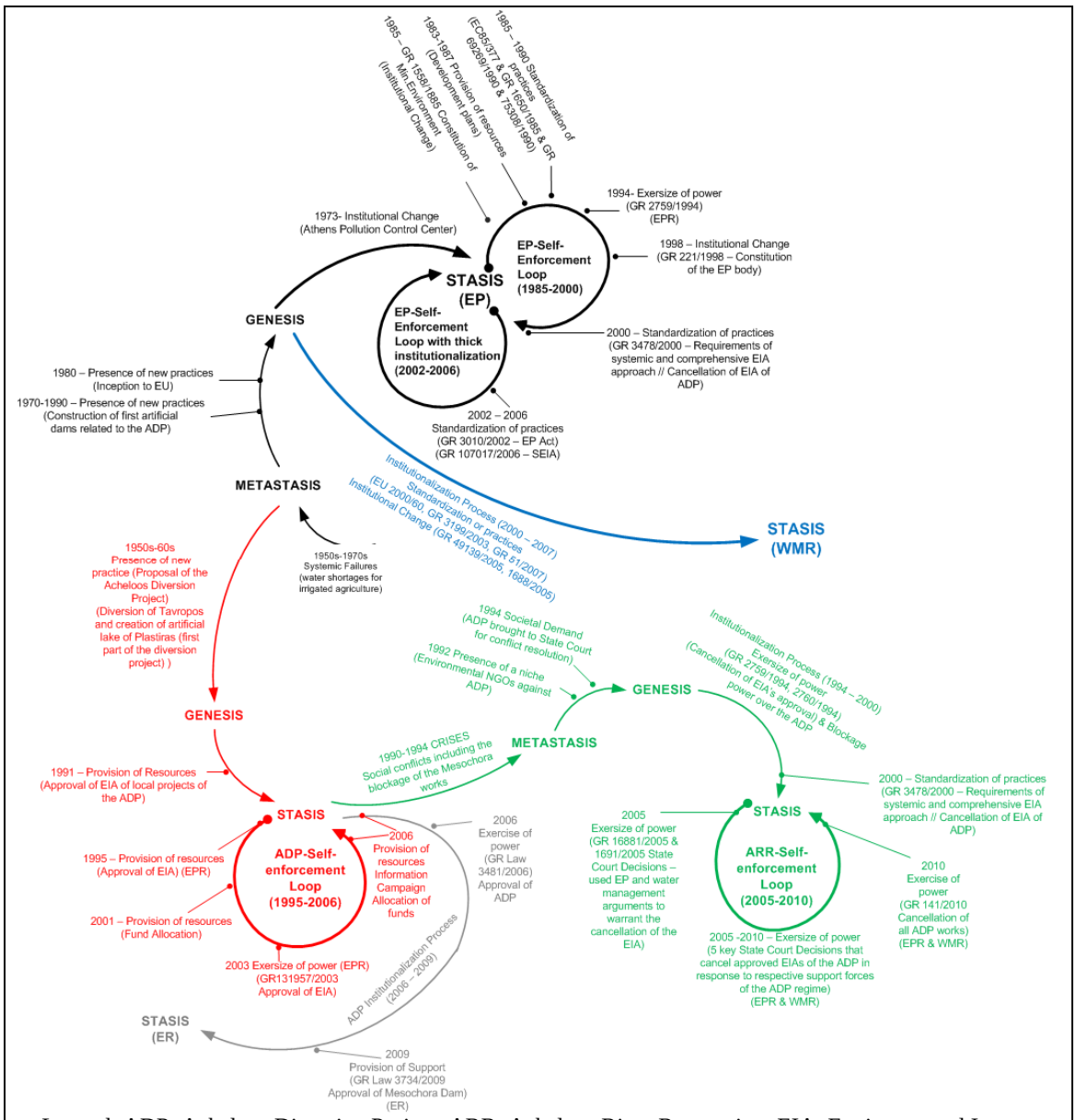
An additional remark is that ***none of the analyzed regimes resemble archetypical responses to change.*** Institutions change and evolve in every regime in an atypical way. What we observe is that we can interpret the evolution of the Acheloos Diversion Project Issue-Regime and Acheloos River Restoration Issue-Regime in three ways:

(a) As competitive or opposing regimes with mirroring self-enforcement loops that manifest power struggle or a battlefield
(b) As co-evolving regimes with the Environmental Protection Regime and the Water Management Regimes given their linkages and mutual influences
(c) As manifestations of (emergent) institutional fragmentation: The newly established regimes of Environmental Protection and Water Management function in the neighborhood of new societal goals like the Acheloos River Restoration and old goals like the Acheloos River Diversion Project. Newly-established regimes tend to fight for support and legitimacy while old regimes tend to persist change and fight back any new development. This constitutes institutional fragmentation where regimes tend to multiply and problems that need to be addressed are related to multiple regimes and consequently become more and more complex (see also Doremus, 2009; Doremus and Tarlock, 2008). In this case, the complex problem of water shortages in the Thessaly plain that was the initial (old but persistent) problem remains unaddressed and its fix –that remains the Acheloos Diversion Project- is now addressed by multiple regimes and complex interests.

Additional remarks of the environmental protection transition in Greece

Pathology fixed?

Looking at the initial trigger of the Acheloos diversion project, that is the water shortages in Thessaly plain, a re-investigation and assessment not only of the water balance of the Thessaly plain but also of the effectiveness of the Acheloos diversion project towards this water balance problem seems due. Climate changes and spatial changes along the river basin need to be taken into account and the diversion project needs to be reassessed along with other alternatives. In 2007 the Greek Minister of Environment announced during the 71th International Expo in Thessaloniki that the second phase of the Acheloos diversion is on the agenda (since the construction of the Sykia Dam is decided, announced and financed) but the ministry cuts the project in small pieces so as not to raise negative public reaction (see Ministry of Environment, Physical Planning and Public Works, Ministerial Agenda for the 71th International Expo of Thessaloniki, 2007, www.minenv.gr). However, the continuation of an infrastructure project of such scale requires reevaluation given that it was drawn in early 1980s and both environmental and technological means have changed over the last decades.



Legend: ADP: Acheloos Diversion Project; ARR: Acheloos River Restoration; EIA: Environmental Impact Assessment; EPR: Environmental Protection Regime; EP: Environmental Protection; EP: Environmental Protection; ER: Energy Regime; EU: European Union; GR: Greek (Law); SEIA: Strategic Environmental Impact Assessment; WMR: Water Management Regime.

Colour Legend: RED: The ADP related forces, loops and processes; GREEN: The ARR related forces, loops and processes; GREY: The ER related forces, loops and processes; BLUE: The WMR related forces, loops and processes; BLACK: The EPR related forces, loops and processes

Figure 4.9: The detangled dynamics of the Acheloos River System Transition.

4.4.3 The on-going energy transition in Greece

The on-going energy transition in Greece has been an institutional transition given that the majorities of changes as well as the majority of the societal macro-determinants are rooted in the institutional component of the societal system. Three distinguishing periods have been defined by directives that restructured the regulatory institutions in Greece. For our analysis of the energy transition we will use this distinction and we will apply both the Forces Framework and the Evolution Cycle to analyze and understand the transition dynamics (Frantzeskaki et al, 2008; also adopted in the analysis of Michalena and Angeon, 2009, p.2019).

Analyzing the energy transition with the Forces Framework

During the electricity introduction phase (1889-1949) the presence of formation forces in the form of market initiatives characterize the energy market that was a liberalized market at the time. System inefficiencies however in the form of high prices of electricity and sudden power cuts were experienced due to the infancy of the system.

Such system failures triggered the demand for a reliable electricity system in the beginning of the nationalization phase (1950-1998). The introduction of a new market player (the Public Power Corporation) signaled the gradual nationalization (market change) of the energy system in Greece (1950-1956). The market monopoly of the Public Power Corporation (PPC) was supported by national laws (standardization of practices) and RES were introduced but developed by PPC exclusively. Provision of resources in the form of public funding was provided by a number of National Laws (GR Law 1892/1990; GR Law 2244/1994; GR Law 1559/1985; GR Law 2601/1998) and development programs for the installation of RES projects during this phase. Standardization of practices concerning the installation of RES facilities was also provided (GR Law 1559/1985; GR Law 2244/1994; Bourodimos, 1990). The liberalization of the energy market in 1999 –following Greece's European obligations- signaled the passing to the liberalization phase (1999-today). Subsequent institutional changes also took place. A crisis in form of riots and reactions of PPC's employees due to fears of loss of jobs temporarily slowed down the implementation of the liberalization of the energy market. During this phase, a number of laws provided support (in the form of either provision of legitimization power, of provision of resources and of standardization of practices) in installing Renewable Energy Sources.

The forces of the on-going energy transition in Greece are presented in Table 4.4.

Table 4.4: Energy (electricity) institutional transition in Greece.

Year	Event	Conceptualized as:
1889	Introduction of electricity in Greece. The General Contracting Company electrified Athens and a Belgian Company (commissioned by the Turkish authorities) electrified Thessalonica.	*Presence of new practices*
1899	Multinational electricity companies enter the electricity market. A *consortium* of an American company with the National Bank of Greece undertook the electricity supply of major Greek cities.	*Presence of new practices*
1929	Local authorities undertake the task to electrify the most remote areas. 250 cities (population>5000 capita) were supplied with electrical power.	*Exercise of power*
1950	400 companies involved in the generation of electricity, constituting a fragmented power generation. Importing of fuel resulted in very high electricity prices, while supplied only specific hours during the day and sudden power outages were quite common.	*System failures (inefficiency & ineffectiveness)*
1950	Presence of different demands due to the development of rural areas and industrial sector: (a) Uniform electrification of the country; (b) Exploitation of domestic resources (lignite and hydropower) at the minimum cost; (c) Need for the allocation of loads into a single interconnected system.	*Presence of societal demand*
1950	Foundation of the Public Power Corporation (PPC) in favor of "the interests of the public".	*Presence of new practices*
1956	Dominance of the PPC as the only provider of electricity and gradual merge of all the existing companies. Development of the PPC into one of the bigger heavy industries of the country and achievement of the country's energy autonomy (even in the most remote areas).	*Institutional change*

Table 4.4 (continued): Energy (electricity) institutional transition in Greece.

Year	Event	Conceptualized as:
1985	**GR Law 1559/1985**: First integration of RES in the Hellenic electricity system by the PPC. A total of 24 MW was installed whereas local government organizations have contributed to a level of 3 MW until 1995 and the private sector was left out of the scene entirely.	*Standardization of practices*
1990	**GR Law 1892/1990**: Public funding for the RES projects by the Ministry of National Economy.	*Provision of resources*
1994	**GR Law 2244/1994**: Sale rates for renewable energy are fixed (interconnected system: 0.07287 Euro/kWh; non-interconnected system: 0.08458 Euro/kWh). It is made obligatory for the PPC to buy that energy.	*Standardization of practices*
1994	**1994-1999 OPE Program I:** Public funding of private investments on RES initiated by the Ministry of Development (Agoris et al, 2004)	*Provision of resources*
1998	**GR Law 2601/1998 on Incentives for Private Investments, Economic Growth and Regional Convergence (and since 2004 Law 3299/2004)**: Public funding for RES projects depending on its location by the Ministry of National Economy.	*Provision of resources*
1999	**GR Law 2773/1999**: Implementation of the **Directive 96/92/EC** for the liberalization of the electricity market. Key points: (a) Favorable pricing regime for RES, (b) Priority access of RES to the grid, (c) Benefit of 2% of municipalities from investments on RES in their region.	*Institutional change (Market Change)*
1999	Fierce objections from local communities were experienced in regions of highly favourable wind potential against the installation of wind parks.	*Crisis (resistance)*
1999	**GR Law 2742/1999**: First national spatial planning law where RES advantages are addressed.	*Standardization of practices*
2000	Foundation of the Regulatory Authority for Energy (RAE) and the System Operator (DESMIE) in response to the Law 2773/1999: a)The RAE is an independent public authority entrusted with the task of monitoring and controlling the liberalization of the electricity market. b) The SO (Presidential Decree 328/2000) has as a task the operation, maintenance and development of the electric power transmission system of the country.	*Institutional change*
2000	**2000-2006 The Operational Programme "Competitiveness" (OPC):** Funding from the 3rd Community Support Framework (2000–2006) for RES and energy saving, substitution and other energy-related actions as high as Euro 1.02 billion. (Hellenic Ministry of Development, 2005)	*Provision of resources (Funding of RES)*
2001	**EC Directive 2001/77/EC:** Introduction of guidelines and indicative targets for the introduction of RES in EU states. An indicative target for Greece to cover a part of its gross national electricity consumption by 2010 from renewable energy sources (RES) equal to 20.1%, with the contribution of large-scale hydroelectric plants included (Hellenic Ministry of Development, 2005)	*Standardization of practices*
2001	Reformation of the PPC into a "Societe Anonyme" in response to the 2773/99 and the Presidential Decree 333/2000. The deregulation of the electricity market actually started in February 2001.	*Institutional change*
2001	**GR Law 2941/2001**: Guidelines for the RES installation in forests and scrublands with special provisions.	*Standardization of practices*
2001	Riots and reactions of PPC's employees associations against the deregulation actions. Fear of loss of working places as a motive of such riots.	*Crisis (Societal unease)*
2002	New organization practices within RAE: Appointment of RAE's Secretariat with meritocracy criteria and transparent procedures. The majority of the rest were academics or executives from the private sector of Greece and abroad from whom only two were ex-administrators of the Public Power Corporation.	*Presence of new practices*
2002	**2002-2006 Operational Program for Energy II**: Public funding for RES from the Ministry of Development and the 2nd Community Support Framework (CFS). The 30% of 42 RES projects of a productive capacity of 576.000GWh were submitted for financing (Hellenic Ministry of Development, 2005)	*Provision of resources (Funding of RES)*
2003	**EC Directive 2003/54/EC**: Amending directive to **the Directive 96/92/EC for the acceleration of the electricity markets liberalization.**	*Standardization of practices*
2003	**GR Law 3175/2003***:* Establishment of a comprehensive set of rules for the rational use of geothermal energy. Law equally necessary to reflect the modifications made by Directive 2003/54/EC.	*Standardization of practices*

Table 4.4 (continued): Energy (electricity) institutional transition in Greece.

Year	Event	Conceptualized as:
2003	**GR Ministerial Decision 1726/2003**: Licensing process of RES facilities to be adapted to the environmental permitting.	*Standardization of practices*
2003	Implementation of the Law 2742/1999 in form of the Regional Frameworks for Spatial and Sustainable Development Plans	*Standardization of practices*
2004	**Supreme Administrative Court (SAC) ruling 2569/2004**: A wind park installation's restriction due to improper siting.	*Exercise of control power*
2006	**GR Law 3468/2006**: Law necessary for the further integration of RES into the national energy balance by simplifying administrative and financing procedures (mostly regarding to photovoltaic issues), by regulating issues regarding hybrid projects and geothermy, biofuels, etc.)	*Standardization of practices*
2006	**GR Ministerial Decision (Ministry of Development) D6/F1/4754/9.3.2006:** Call for expression of interest on investing in RES in the islands of Kefalonia, Zakynthos, Levkas and Ithaka, for the purpose of covering an existing generation capacity margin of 30 MW.	*Provision of resources (legitimization)*
2007	Launching at a public consultation (February 2007) of a draft Law for the Spatial Planning of the RES projects.	*Standardization of practices*
2008	**Decision 49828, 2464/2008**: Framework for the Spatial Planning and Sustainable Development for Renewable Energy Projects and the Strategic Environmental Assessment of the Renewable Energy Projects.	*Standardization of practices*
2009	**GR Law 3734/2009**: Law necessary for the further integration of co-generation, PV electricity and Hydroelectricity into the national energy balance by simplifying administrative and financing procedures (mostly regarding to photovoltaic issues), by regulating issues regarding hybrid projects and geothermal energy, biofuels, etc.) This law complies with the Directive 2004/8/EC on cogeneration. The law replaces some articles of the 3468/2006 aiming at facilitating some the integration of some renewable energy technologies (especially PV). Specific regulations are provided for PV pricing, the System Operator and the Centre of Renewable Energy Sources	*Provision of support*
2010	**GR Law 3851/2010**: Law aiming at implementing mandatory targets for renewable energy sources into the Hellenic energy mix: 20% from RES into the energy mix, 40% from RES into the overall electricity production, 20% from RES into heating and cooling, 10% from RES into transports	*Standardization of practices*

Technological changes are not present in the Greek energy system. The energy technology is imported and adapted to the needs and demands of the energy market. What it is observed is that all changes that take place in the system are placed at the institutional subsystem. Institutions and the energy market undergo changes that aid the institutionalization of the new energy market model (liberalization). We unquestionably characterize the transition of the energy system in Greece as an institutional transition.

Legislative and financial support but lacking of societal support. The overall picture of the electricity system in Greece is characterized by the presence of legislative and financial support for change (OPE I, OPE II, OPC) as well as of an established institutional setting (RAE, DESMIE and advisory bodies). However, societal support of RES is lacking and public participation is discouraged. Lack of societal support is revealed by the societal grounded crises such as riots and resistance to RES installations (see Supreme Administrative Court (SAC) 2569/2004 case). Papadopoulos et al (2008, p.109) also point at the consequences of lacking societal support for RES in Greece: "communities are often unwilling to accept investments (…) and due to the absence of concrete land planning for RES, (…) the resulting legal processes may end at the Supreme Court" resulting in delays of the RES project's kick-off.

What does lack of formation forces mean for the Greek energy transition?

What we observe from Table 4.4 is that support forces dominate and there are only few formation forces present. From one point of view, the missing social determinants (formation forces) can seriously damage the consistency of the system as it is shown that social cohesion and local co-ordination mechanisms may contribute to a sustainable use of natural resources (Agoris et al, 2004; GR Law 3468/2006; Portes, 1998). From another point of view, overlooked societal demands can be an overstatement to start with. What has been observed is a need of information and awareness of the citizens that energy projects can contribute positively to the growth of the economic sectors in Greece

and towards a reliable energy system (Michalena and Angeon, 2009). Especially in developing areas and in islands, the energy infrastructure needs to be updated and renewable energy projects in the mix can safeguard energy provision. What we see is a public defense and resistance to wind parks in numerous sitting places in Greece that end up in the Supreme Court. This Not-In-My-Back-Yard response of the communities can be perceived as a sign that policy making in the energy sector in Greece should not be only law-making and business-as-usual top-down process but can include methods and practices that allow multiple interests to be heard, and take into account that actions for raising awareness and information of the public are needed for acceptance of renewable or any other new practices in the market.

Analyzing the energy transition with the Evolution Cycle

Mapping the forces present in the energy institutional transition in Greece on the Evolution Cycle of societal systems, we observe that the energy sector went through four cycles of evolution from 1880s to 2007. In Figure 4.10 we colored the first cycle with dashed-grey line, the second with grey, the third with black and the fourth with dashed black-lines. We notice that institutional change in Greece takes place in a **crisis-induced way**: Crisis-Formation Forces-Support Forces is the recurrent pattern.

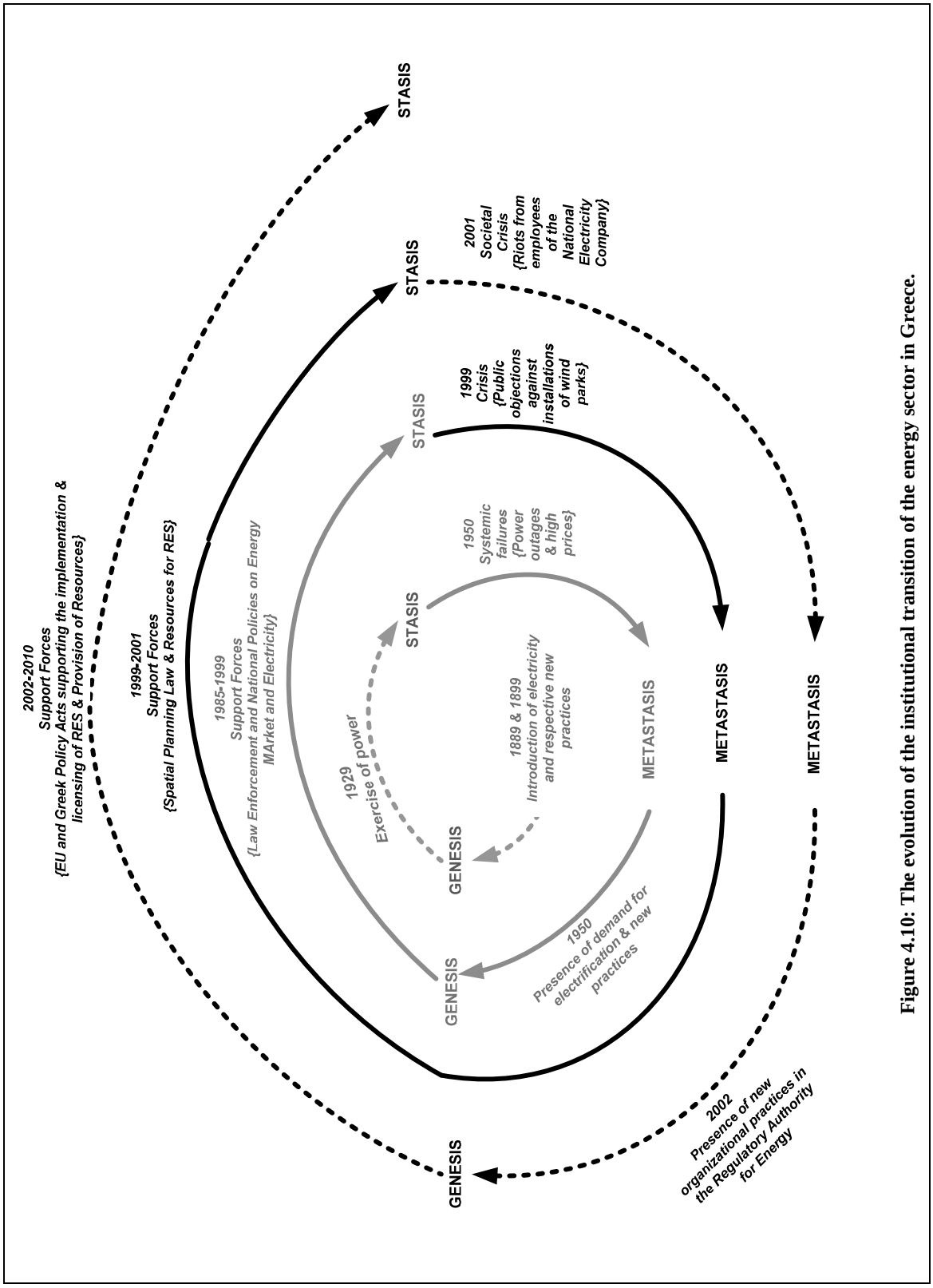


Figure 4.10: The evolution of the institutional transition of the energy sector in Greece.

Identifying and analyzing the feedback loops of the energy transition
In the Greek energy transition we can identify two feedback loops (Figure 4.11):

(a) Liberalization self-enforcement loop initiated by the GR Law 2773/1999 (conceived as an institutional change) (1999-2006), and
(b) Centralized liberalization by a self-enforcement institutionalization loop initiated by the GR Law 3468/2006 (2006-2010) (conceived as standardization of resources).

Liberalization self-enforcement loop (1999-2006): The liberalization of the energy market with the law GR 2773/1999 (institutional change) signals the entry of the energy system into a self-enforcement loop. The support that the preceding laws and funding program provided (GR 1559/1985, GR 1892/1990, GR 2244/1994, GR 2601/1998 and the OPE Program I) paved the ground for the liberalization of the market and the adoption of renewable in the energy system. The GR Law 2773/1999 provided favorable conditions for the development of renewable energy projects by the introduction and establishment of fixed buy-back prices for electricity produced by renewable energy projects (Papadopoulos et al, 2008, p.106). The societal unease due to riots of the employees of the national power company in 2001 and the new organizational practices from the regulatory authority in 2002 insignificantly weakened the institutional loop of self-enforcement that was set in place. All the succeeding events were supportive and enforcing the liberalization loop.

Self-enforcement loop that resembles thick institutionalization (2006-2010): The GR Law 3468/2006 sets the target for the energy policy spotting the percentage of renewable energy production in the energy mix to reach 29% by 2020 and signaled the beginning of thick institutionalization. More specifically, the GR Law 3468/2006 further reinforces the energy market liberalization by setting up stricter and binding legal and market conditions for the introduction of renewables in the market. The GR Law 2773/1999 set the foundations for the liberalization and the GR Law 3468/2006 continues to reinforce the market regime. We argue that the directives and ministerial decisions along with energy plans following the liberalization law further reinforcing it; thus manifesting a self-enforcement loop. The GR Law 3468/2006 however sets stricter and binding conditions for the liberization resembling thick institutionalization.

Crises, societal unease, even the legitimization and financial crisis that Greece is experiencing in 2009-2011 only lead to additional support from the national agencies to implement and establish the liberalization of the energy market. This is perceived by our analysis as a sign of institutional resilience. Shocks in the system are dealt by institutions and do not create disturbances sufficient for the removal or break down of the existing regime. The institutional resilience of the Greek energy system is sustained by the institutional self-enforcement loops.

A context issue: Institutional loops were also maintained due to the top-down approach adopted by the Greek Ministries (Ministry of Development, Ministry of Financial Affairs) when dealing with the energy market. Hence, any practice or institutional change that affects the energy market can only be practiced after a law or ministerial decision is set in force. We can conclude that the laws preceded any development and condition its trajectory making the energy transition as an in-context trajectory.

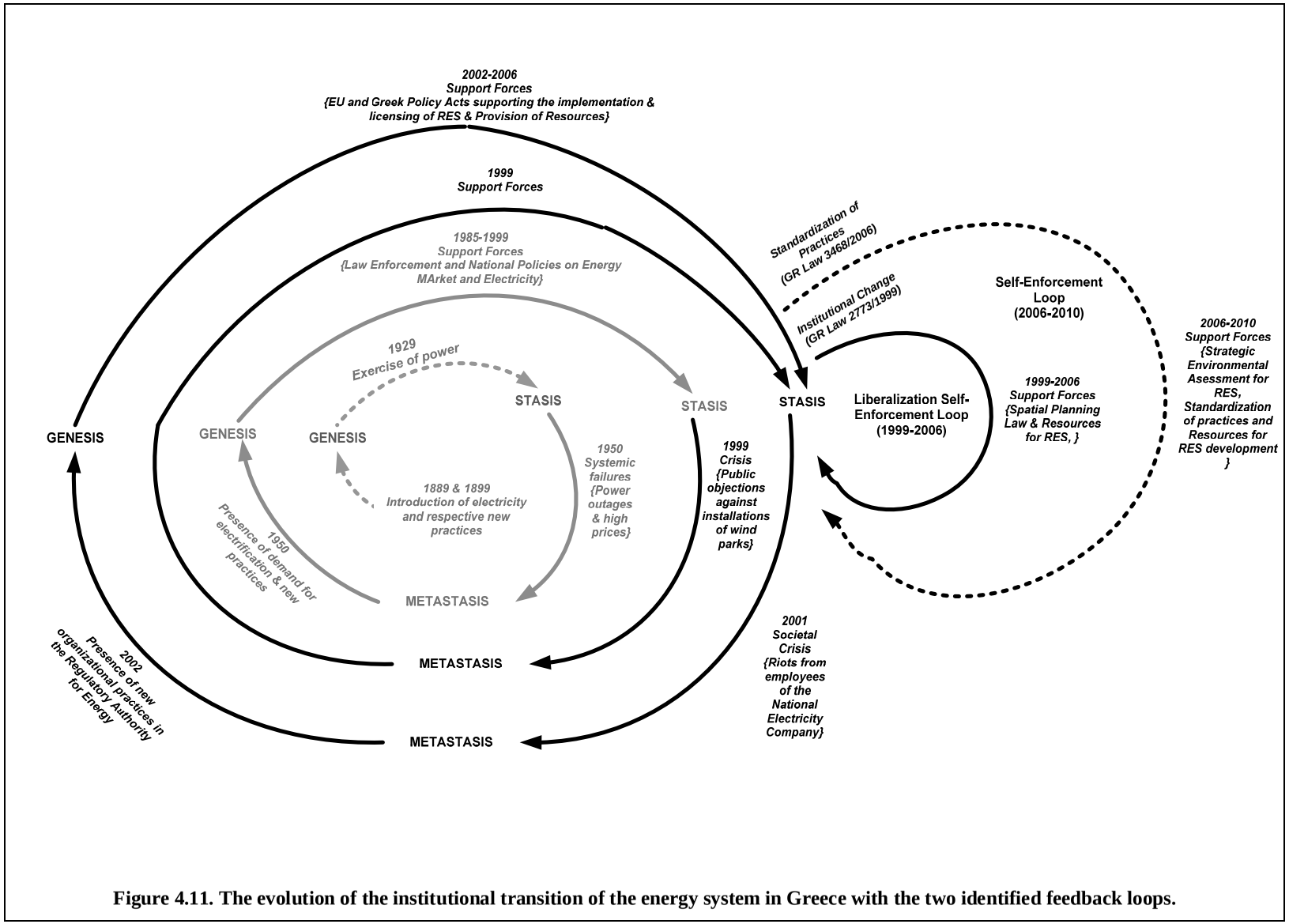


Figure 4.11. The evolution of the institutional transition of the energy system in Greece with the two identified feedback loops.

Additional remarks of the energy transition in Greece

The on-going energy transition in Greece is an institutional transition that shows amongst others that trust in institutions (especially legislative institutions) supersedes reliance on market mechanisms or societal demands. Institutions rule and guide the energy market (pricing, mix and transactions) and the energy supply side. Our concluding remarks additional to our analysis are sixfold:

The energy system in Greece has the tendency to over-institutionalize. The energy market in Greece is regulated to the extent that even the electricity prices and rates of buy-back rates are institutionalized by national law. The policy objectives for the energy system opt for a greater percentage of renewable energy sources in the market. The national laws that constitute the energy institutions favour RES-based electricity. More specifically, GR Law 2773/99 includes the provision of fixed (flat) buy-back rates for RES-based electricity. In this way even the market transactions are bound to regulated conditions and prices.

Role of institutions or, institutional determinism of a socio-technological system. The question of institutional determinism of a socio-technological system arises. Is the energy system in Greece institutionally determined? Do the institutions condition and pave the way of innovation and adoption of innovation in the energy sector? The energy system in Greece as every energy system is a socio-technological system. What we observed is that it undergoes changes in the institutional and market components mainly, thus we categorized the energy transition as an institutional transition. We observe that institutions do not pave the ground for technological innovation or for adoption of any type of technological innovation. Thus we cannot argue that the on-going energy transition in Greece follows the paradigm of institutional determinism (an elaboration of institutional determinism is presented in Chapter 6). What we observe is that the policy regime acts as a determinant and regulator of the market in a restricting manner and does not allow any community-based innovation or any other market innovation to endure.

From our case study, we observed that the Greek literature and Greek energy research scholars have a focus –not to say a preference- to address the successes of wind energy for the Greek energy market; hence neglecting the impact of the existing policies and laws for the introduction of renewable energy (in general) in the energy market. In addition to this, the existing literature only points at the successful stories, and problems or constraints of the existing institutions of the energy system are underlooked/overlooked. Our analysis reveals the role of institutions and the existing pathologies that have been overlooked so far.

Systemic inefficiencies and ineffectiveness are endorsed by existing institutional system. There are different events that evince those systemic pathologies. First, despite the favouring institutional environment for renewable energy projects, the licensing procedure is complex and with inconsistencies hence burdening investments (Papadopoulos et al, 2008, p.107). More specifically, the centralization actions that were introduced with the Law 3468/2006 (allowing for example the Minister of Development to intervene in the financial mechanisms of the RES market) burdened investments. Second, the SAC ruling 2569/2004 resulted in blocking the private investments implicitly, by impeding the implementation of a wind park (creating a negative prerequisite or a "historical precedent") despite the efforts for a favorable investment environment for renewable energy projects by the preceding laws. Third, a call for investment and implementation of RES on islands (D6/F1/4754/9.3.2006) precedes the Spatial Planning Law for RES. As a result, that raises skepticism on the proper sitting of such plants given the lack of Spatial Planning guidelines.

Time inefficient procedures were in place and supported by the existing institutions. These inefficient procedures are cross-checked by our research on the electricity market organization and policy implementation guidelines included in GR Law 3468/2006 and GR Law 2773/1999). First, enforcement of liberalization was delayed that further burdened the introduction of renewable energy sources in the energy system. More specifically, the implementation of the Liberalization legislation (GR Law 2773/1999) took 3 years, a fact that has an indirect negative impact on RES development. Second, the harmonization with the European Directive 2001/77/EC was also time inefficient. The

establishment of a system for issuing warranties of origin for RES was enforced in GR Law 3468/2006, just 5 years after the EU Directive was enforced. Third, there is lack of coordination between spatial planning regulation and energy institutions. Spatial planning institutions did not coordinate in a timely manner with energy institutions for siting legislation. More specifically, the Spatial Planning Law for renewable energy projects that has been initiated as a concept in 1999 (under the GR Law 2742/1999), entered a public consultation in February 2007 and has not been enforced since. Fourth, time inefficiency is also experienced in the authorization processes of renewable energy projects. More specifically, institutions were time inefficient in establishing additional advisory bodies to consult the Ministry of Development (by the GR Law 3468/2006), a fact that may result indirectly in delaying authorization processes. We conclude that the more authorities included in the licensing process due to fragmented procedure, the more time needed for a license to be issued. Such inefficiencies have also been reported by Lazarou, Pyrgioti and Agoris (2007, p.4016) in their analysis of the liberalization of the energy market in Greece: "Numerous RES market representatives complain that RES installation permissions are being delayed, despite the provisions of the current legislation. These delays are mainly due to zone planning and electric network deficiencies, and lengthy evaluation processes by the appropriate state authorities."

Institutions act partially as means of policy integration. The recent Ministerial Decision (49828, 2464/2008) introduces the strategic environmental impact assessment for renewable energy projects. We argue that this ministerial decision integrates environmental criteria into energy planning and is the first legislative action that is taken towards integration of environmental policy with energy policy specifically.

Hide behind the Energy Regime? Energy policy promotes infrastructure projects that do not comply with water law and environmental protection law. The GR Law 3734/2009 establishes how the Hydropower Plant of Mesochora has to be implemented. The law explains in paragraphs 16 until 25 the process that needs to be followed for the reallocation of the citizens of the Municipality of Mesochora in order to proceed with operating the Mesochora Dam. What is interesting is that the Mesochora Dam and the artificial lake that will be created upstream is part of the Acheloos diversion plan that has been stopped by both the Greek Supreme Court and the Court of European Community in 2008 (due to incompliance with the EC 2000/60 – Court decision C-264/07). What we see with the GR Law 3734/2009 is the legitimization of the Mesochora Dam not as part of the Acheloos Diversion but as a critical energy project compliant with the national energy strategy.

4.5 Concluding the exploration of institutional transitions

Our empirical exploration revealed that for the development of institutional transitions, different types of forces are present (formation forces, support forces and triggers). At the same time, we observe that the forces at play have an impact on the institutions and civil society; hence the different systems we researched experience institutional transitions. This corroborates the usefulness and applicability of the Forces Framework in analyzing institutional transitions.

Additionally, we observe the presence of the same set of forces in all the three contexts but a different sequence of those determinants. This is a significant outcome because it partially contradicts propositions of institutional theories concerning the process of change of institutions. What we know from institutional theories (North 1990, pp.89-89) is that institutions are social constructs that depict the particularities of the societal context that they reproduce (Giddens 1984; Douglas 1986; Scharpf 1997). The three cases revealed that even though the departure and end-state of the institutional structures were very different between Greece and the Netherlands, the sets of forces present during the institutional transition are similar. Hence contextual differences are not depicted in the forces being present.

Contextual differences or simply, contextuality is evident in the different feedback loops, the variety of evolution cycles present and the different archetypical responses at every institutional transition. What remains is that in all the cases, institutionalization processes and self-enforcement loops are at

place despite the fact that every institutional transition unfolds at a different pace, in a different fashion and in a different context.

In our view, the perspective that we have presented above is a meaningful complement to the more common focus on explaining institutional change through actors struggling with each other on defining and establishing the rules of the game. Instead of highlighting micro- and meso-processes in the political arena, we consider the societal dynamics (as produced by societal determinants/ forces) to explain institutional transitions. Understanding the functioning of these forces at the macro-level will support policy analysts and policy makers to envisage how wider societal forces impact on their policy regimes and to what extent institutional transitions succeeded in addressing system pathologies. This is complementary to having insight into institutional change as policy actors battling with each other at the micro-level. Institutional transition is a complex process to be conceived as co-evolving societal *and* institutional dynamics.

In Chapter 5 we present the second type of societal transitions, social-ecological transitions. We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment.

Main Contributions

Three feedback loops are found to complement the Evolution Cycle of the Societal System that relate to social-ecological transitions: the institutional over-reliance or over-institutionalization loop, the catastrophe loop and the stewardship loop. Feedback loops refer to dynamics of the system that are sustained at different stages by the continuum of (the same type of) forces.

Social-ecological transitions as processes of continuous evolution of the societal system are found to include different types of forces (formation, support and triggers).

The coastal management transition of the Great Brak River in South Africa is analyzed with the Forces framework and the Evolution Cycle. The transition includes a stewardship loop that shows that the good management practices were regularly adjusted and revised following the ecosystem dynamics without a trigger. In this way the coastal management system has adapted its operation to the ecosystem dynamics. At the same time, the local community with the water managers steward the ecosystem being directly responsible for its health and sustainability.

CHAPTER 5
Social-Ecological Transitions

In this chapter, we analyze social-ecological transitions. We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment. The present chapter unfolds in five sections: In Section 5.1 we introduce social-ecological systems and social ecological transitions. Then, we elaborate on the different theories of social-ecological change and ecosystem change with the objective to ground the Forces Framework to the different theories (Section 5.2). In Section 5.3 we present the feedback loops that are induced from the theory and introduced in this thesis so as to complement the Evolution Cycle of the Societal System (framework). The feedback loops are loops present at the different stages of the cycle. The developed and upgraded conceptual frameworks are now employed so as to analyze the case study in Section 5.4. The Forces Framework and the Evolution Cycle are used to analyze the water management transition in South Africa in Section 5.4. Concluding remarks of the theoretical and empirical exploration of social-ecological transitions are given in Section 5.5.

5.1 Introducing social-ecological systems and social-ecological transitions

A social-ecological system is a (type of) system where nature and society are strongly interdependent. In the resilience approach (Abel, Cumming, and Anderies, 2006; Walker and Meyers, 2004), social-ecological systems are conceptualized and analyzed as complex adaptive systems that are characterized by a tendency to self-organize as a manifestation of their strong interdependency (Levin, 1998). Self-organization of the social-ecological systems affects the way these systems change. In social-ecological systems, changes in one subsystem feed back into processes and conditions of the other subsystem, resulting in interdependent changes (Walker and Meyers, 2004).

Understanding and researching social-ecological systems as complex adaptive systems implies that they self-organize and semi-autonomously maintain their functions (Holland, 1995; Holling, 2001). Changes in social-ecological systems are complex processes and are viewed as quasi-emergent processes of change since "it is neither possible for one state to be deliberately transformed into the other, nor for the process to be fully controlled" (Fischer-Kowalski and Haberl, 2007, p.4). The Vienna school of the socio-metabolic approach towards social-ecological systems defines a socioecological transition as:

> "a transition from one socioecological regime to another. (…) A socioecological regime is a specific fundamental pattern of interaction between (human) society and natural systems." (Fisher-Kowalski and Haberl, 2007, p.8)

Social-ecological transitions will be analyzed in the current chapter. Social-ecological transitions involve dynamics of change in both the ecological and the social subsystems.

5.2 Theories of social-ecological systems and transitions

In order to investigate the process of social-ecological change, we first make a literature review on theories of social-ecological systems' change. Our analysis of the theoretical state-of-the-art yields a list of implicitly and explicitly formulated forces that accompany change of social-ecological systems. It is important here to specify that we do not only consider ecosystem research outcomes but also theories of governance of social-ecological systems. We note that the majority of the approaches focus on ecosystem and societal aspects (e.g. institutions) more than on other aspects such as technology.

Our review of theoretical approaches and published cases on social-ecological systems' behavior (see Appendix C, Section C2, Tables C2) shows that a social-ecological system can respond in three

different meta-level patterns when subjected to change: it can sustain its state by adapting to changes, it can shift to another state by reorganizing or it can decay by collapsing.

Over the course of social-ecological system transitions, the dynamics of the social-ecological system change. The way the dynamics change over time is subject to the underlying conditions of the system. Hence systemic and/or exogenous forces are linked to the different ways that a social-ecological transition develops. Apart from understanding what drives transitions in social-ecological systems, it is also important to understand how sustainability can be achieved in a social-ecological system. What is desirable for the sustainability of a social-ecological system is to maintain a balanced interdependence of the two subsystems: the society and the ecosystem.

Our literature review evoked that different types of forces (formation, support forces and triggers) are present in social-ecological transitions. More specifically, the resilience approach considers three forces when describing social-ecological transitions (adaptation, regime shifting and transformation). The resilience approach considers external (to the system) events or developments, environmental crises and crises in general (referred to as shocks or disturbances), presence of new practices that concern internal developments of technology or societal practices, and institutional changes manifested by changes in governance styles or changes in institutional settings. Different sets of these forces are associated with the different responses of the social-ecological system towards change.

Institutional changes take place during the adaptation and/or regime shifting of social-ecological systems. More specifically, a social-ecological system may undergo a regime shift and/or adaptation when it experiences either a changing context ("loss of resilience – the basin of attraction is shrinking" (Resilience Alliance, 2007, p.19)) or internal developments ("system drivers that move it") or disturbances or shocks. Transformation that is an irreversible change of the social-ecological system is perceived as an outcome of either disturbances and/or of institutional change (Resilience Alliance, 2007, p.49).

In addition to the resilience approach, the vulnerability approach and the ecological-anthropological approach for societal collapses are reviewed. Views from ecological economics are also taken into account.

Scholars of ecological economics consider three forces to be present and important for social-ecological systems' change: disturbances or crises, creation of a niche, and institutional change.
Complementary to the resilience approach writing, based on examples of social-ecological transitions from the vulnerability approach and the ecological-anthropological approach of Diamond, the following forces were indicated as present during the collapses of social-ecological systems: crises (environmental crises, wars, famine etc) that include environmental damage and wars initiated by hostile neighbors in consistency with Diamond's framework (2005) and institutional failures, such as lack of preparedness to deal with crisis, institutional ineffectiveness and inefficient decision making practices, and institutional inefficiencies that extend the notion of "response to environmental problems" of Diamond (2005). More specifically, Jared Diamond's societal collapse approach (Diamond, 2004; 2005) which presents a five-point framework to explain forces causing societal collapse. These include: environmental damage, climate change, hostile neighbors (manifest their presence by the occurrence of wars), friendly trade partners (that is experienced by the pressure for resources used in trading) and the response to environmental problems that includes decision-making processes (politics) and technological means. Collapse is an outcome of the presence of these factors but does not imply that all the factors need to be present at the same time for a societal system to collapse. In addition to this, collapse is conceptualized as a time period when the impacts of these factors converge (Diamond, 2005, p.171).

To summarize the findings from the review of the resilience approach, the vulnerability approach and Diamond's framework as well as views from ecological economics, we recognize six forces which influence the social-ecological system's responses towards change: crises, exogenous events (or

developments), introduction of new functioning, creation of local initiatives, institutional failures, and institutional changes (Table 5.1).

Table 5.1: Forces Driving Transitional Change that respond to the different responses of social-ecological systems to change as derived from resilience approach and vulnerability approach.

Forces Driving Transitional Change in place		***SES responses to change***
Crises, Exogenous events, Presence of a niche (local initiatives), Presence of new practices, Institutional changes	⇨	Adaptation or Regime shifting
Crises, Exogenous events Institutional system failures	⇨	Collapsing

5.2.1 Forces of social-ecological transitions grounded in literature

The theoretical grounding of the Forces Framework is realized in different theories, namely resilience approach, ecological economics, institutional economics, ecosystem theories, regime theory, anthropological studies, and the adaptive governance approach.

Presence of a niche

The role of actors and self-regulation in social-ecological systems are linked. Actors that think and act differently from the mainstream (conceptualized as a niche) are those who recognize and alert the system to existing or forthcoming pathologies and are the carriers of system change.

From the resilience approach, Berkes (1998, p.125) notes that in cases of common-pool resources where local communities sustain good practices towards the ecosystem, collective leadership and self-regulation take place. Such practices of actors can be seen as niches of stewardship for social-ecological systems.

Scholars from ecological economics state that social-ecological systems may overcome disturbances; when institutions are revolutionized or settled (conceptualized as institutional changes) and/or when the system utilizes its social and human capital (we call this creation of a niche). More specifically, social and human capital in the form of groups of people that ask for protection of natural resources and in the form of "regulations and economic incentives" are viewed as prerequisites for the improvement of the ecological subsystem (Pretty and Ward, 2001, p.212-213). The presence of groups/local pioneers that realize and push for change in a social-ecological system is a critical prerequisite for a social-ecological system to overcome a crisis; to handle disturbances or to take protective measures before those disturbances escalate. These groups however need to be inhibited and/or supported in specific ways by local institutions so as to seize their capacity to protect the ecological subsystem and produce capital (Ostrom, 1998; Pretty and Ward, 2001, p.219-220).

Presence of new practices

The introduction of a new idea, a new practice or a new technology is considered to drive transitional change in social-ecological systems by adherents to the resilience approach. When the new practice is a new technology for example, then it might contribute to either conservation (e.g. waste and effluent treatment technologies) or to overexploitation of the socio-ecological system (harvesting technologies concerning agriculture or aquaculture, mining or oil-exploration technologies) (Cumming, Cumming and Redman, 2006).

Provision of resources

Provision of resources can encourage or maintain the existing institutions. Handmer and Dovers (2009, p.197) refer to the phenomenon that "enormous resources will be expended maintaining the status quo" when institutions resist change.

Exercise of power

Regime theorist Young (2009a, p13) refers to exercise of power as a determinant for establishing governance of social-ecological systems' sustainability (referring also to institutional theorists like North, 1990). Exercise of power therefore relates to the operation of institutions as part of the social-ecological system and as a (latent) driver of the social-ecological transitions.

Crises

From anthropological studies, Tainter (1988, p.52-53) calls to explanations of societal collapses that address crises or catastrophes simplistic and reductionist. Despite his criticism of explanations that emphasize solely on the role of crises, Tainter considers crises as a factor that may lead to a collapse. What Tainter (1988, p.53) argues is that a crisis can be accommodated by a society and not necessarily transcend to a collapse. In the same vein, Cocks (2003, p.61) includes disasters and diseases as driving forces in adaptive systems.

From ecosystem research, Paine et al (1998, p.537) refers to disturbances as driver of change for ecosystems. As disturbances they consider any event that disturbs the system. Malthus (1766-1834) mentioned that responses of the ecological system in the form of disasters or diseases can constrain human population growth as a means of defense of the ecological system to anthropogenic activities (Becker et. al., 2005, p.300).

From adaptive governance writings, Galaz et al (2008, p.163 & 174) argue that crises trigger change given that they "can open up space for new interactions".

Crises have been also put in the spotlight by the resilience approach. Crises may precede two different development patterns of the social-ecological systems in particular: collapses of systems (Abel, Cumming and Anderies, 2006; Bruck, 2002) or regime shifting. Crises are also referred as shocks to the system and are changes in controlling variables (Resilience Alliance, 2007, p.20). It is often mentioned that social-ecological systems are disturbed hence forced to change. More specifically, crises can "create space for reorganization, renewal, and novelty" (Folke, et al, 2005, p.455). Disturbances are caused by crises {that are also called disturbance events, cascade events by Abel, Cumming and Anderies, (2006), system disturbances by Nelson, Adger, and Brown, (2007, p.400), surprises, stochastic events by Scheffer et.al., 2001} such as droughts, famine, floods, diseases outbreaks and more. Specifically, crises have severe impacts in the abiotic environment and on the resource base of social-ecological systems (Cumming, Cumming and Redman, 2006) and are uncertain and are "inevitable, sources of change in systems" (Nelson, Adger, and Brown, 2007, p.401). Specifically, Folke, (2006, p.253 and 259) argues that "in a resilient social-ecological system, disturbance has the potential to create the opportunity for doing new things, for innovation and for development".

Systemic failures

Ecological anthropologist Diamond (2005) refers to manifestations of institutional ineffectiveness as *governance failures* and categorizes these into four failure-patterns by Diamond (2005, p.421, 424 and 427): failure in anticipating the problem, failure in perceiving a problem that has arrived, failure in attempting to solve it, and failure of actions taken to solve the problem. We therefore conclude that when a social-ecological system experiences a crisis as a result of a convergence of systemic developments and actors remaining passive/inactive, the crisis may escalate and result in the collapse of the system.

From adaptive governance and regime approaches, Delmas and Young (2009, p.5) refer to *government failures* as triggers for change of governance of social-ecological systems. Government

failures refer to inadequate interventions and to slow response to problems. Galaz et al (2008, p.154) argue that institutional failures – that are "inability of institutions (…) to respond to rapidly changing circumstances"-result in institutional misfits and consequently require system changes. To summarize, government failures are inefficiencies of government's action (in the form of policies and institutions) to tackle environmental problems.

From the resilience approach, Berkes and Folke, (1998, p.354) raised the issue of institutional function when they point out that failures –and collapses- of common pool resources occur not as outcomes of human greed but as outcomes of "*institutional failures*". Institutions that are inadequate or ineffective in dealing with resource problems and/or ecosystem dynamics fail to sustain a social-ecological system's resilience and consequently, sustainability. Folke et al, (2009, p.111) conceptualize institutional failures as manifestations of institutional misfit. Institutional misft can cause "undesirable regime shifts" and can endanger the system due to lack of system back up.

Exogenous events

Exogenous events differ from crises in their origin: they are initiated beyond the system boundary but influence the state and structure of the system in a similar way to the crises. A world war or an accident outside the system can be seen as exogenous events in contrast to a civil war or a pollution incident that are included as crises and belong within the system.

Complementary to the existing theoretical frameworks that describe collapses of social-ecological systems, there also exist extreme cases of unavoidable collapse: when an exogenous effect or a crisis is so severe and causes such irreversible change to the system that action may not be sufficient to deal with it. This type of unavoidable collapse may be an indirect effect of globally interconnected systems where the action at a global level may affect regions that had no role in causing the phenomenon. An example concerns the Atolls islands where the rising sea level causes salinization of the ground that in turn destroys the crops and causes loss of income and loss of area to local communities on the atolls. In this case, the remoteness of the region and the fact that technological solutions are lacking (either too expensive or not feasible or inevitable) can result in the system's collapse.

5.2.2 Characteristic responses and archetypical social-ecological changes grounded in literature

A social-ecological system can respond in three different ways when undergoing change: it can sustain its state by adapting to changes (adaptation), it can shift to another state by reorganizing (regime shifting) or it can decay by collapsing (collapsing).

Adaptation or regime shift

The resilience approach (Gundeson and Holling, 2002; Walker and Meyers, 2004; Walker et.al., 2002; Walker et.al., 2004) elaborates conceptually on all of the three responses to change but more extensively on the first two: adaptation and regime-shift. The resilience approach explains the way social-ecological systems behave when confronted with external pressures or internal stresses. The core argument is that social-ecological systems resist change due to their tendency to self-organize. Resilience is used as an indicator of change in the social-ecological systems and refers to the capacity of the system to accommodate disturbances while maintaining its function and state –remaining resilient-. The level of resilience may be different for every type of change that the social-ecological system experiences (meaning that a social-ecological system can be in a state of high or low resilience). More particularly, when the system adapts to the changing context by "changing within the configuration of system state (…)" and by conserving "the same structure, function and feedbacks and therefore identity" (Walker and Meyers, 2004; Walker et.al., 2004; Walker et.al., 2002), the system undergoes an adaptation.

However, when disturbances are so severe that the system cannot maintain its initial state, it either moves towards a new equilibrium following dominant attractors and sustaining a new system state (perceived as undergoing a regime shift) or it changes in the form of re-constellation or transformation (Scheffer et.al., 2001). The social-ecological system follows dominant system attractors (external and/or internal forces for change) that pull it towards a new state (a new regime). The structure of the

system remains the same ("the defining state variables remain the same") but its function adapts to the new context (to the new regime) due to the "feedbacks in the system that now cause it to continue changing" (Walker and Meyers, 2004; Walker, et.al., 2004; Walker, et.al.,2002). Shifting to a new regime as a response of the social-ecological system brings the system to a partially irreversible state.

In research on climate change policies, Smit et al (2009) differentiate ecosystem adaptation and system adaptation. According to Smit et al (2009, p.73) "adaptation of ecosystems usually refers to human management practices which influence ecosystem changes". Pimm (1984; cited by Smit et al, 2009) refers however to ecosystem adaptation as a reaction of ecosystems to external stresses such as climate change. System adaptation is a holistic response of the system that includes both ecosystem and institutional action towards change.

Collapse

There are two approaches that elaborate on the collapse of social-ecological systems: the resilience approach and the vulnerability approach. According to the resilience approach, collapse occurs when the social-ecological system cannot accommodate the changes (that means that is pushed beyond its carrying capacity or exceeds its thresholds) and collapse is followed by a reorganization of the social-ecological system (Anderies, Walker and Kinzig, 2006). Given the inherent complexity of social-ecological systems, collapse is an extreme but intrinsic behavior of such systems when experiencing severe disturbances. To corroborate this, Bruck (2002) argues that "societal collapses are a form of cascade, an intrinsic feature of any self-organizing system in which the components are connected" (cited by Abel, Cumming and Anderies, 2006). Disturbances such as overexploitation of resources result in catastrophic shifts that according to Walker and Meyers (2004) "usually result from a complex set of events that lower the resilience of the society, making it unable to recover from an environmental shock".

Summarizing, the resilience approach views the collapse or reorganization of the system as constructive for the social-ecological system: the change that a system experiences during collapsing results in a new system state and not in a destruction of the system. Hence, transformation via collapsing is a drastic change: constructive but not destructive for the system. The view of the collapse as constructive (Berkes and Folke, 1998, p.359) is consistent with the conceptual propositions of the resilience approach that the system remains resilient (hence maintains its function) and that the system has a memory that 'guides' its transformation.

In contrast to the resilience approach, the vulnerability approach states that the social-ecological system is vulnerable to changes and is influenced by change (Metzger, Leemans and Schroter, 2005; Parmesan and Yohe, 2003; Manuel-Navarrete, Gomez and Gallopin, 2007). Vulnerability captures the "extent to which a system is susceptible to sustaining damage" and it is the outcome of the dynamic interplay of social and ecological systems (O'Brien, Sygna and Haugen, 2004, p.195). Eakin and Luers (2006, p.371) defined vulnerability as a "dynamic property of the socio-ecological system". The definition (and conceptualization) of Eakin and Luers (2006, p.376) of vulnerability refers to "system state relative to a threshold beyond which the system is assumed to be damaged, to the system's sensitivity and to the frequency distribution of the stressor (exposure)". What their approach adds is a comprehensive view of vulnerability taking resilience and the thresholds of the system into account.

The conceptualization of collapsing from the vulnerability approach is complemented by that of ecological-anthropological studies (discussed by Diamond (2004; 2005)). Collapses of social-ecological systems include the decay or complete destruction of a social-ecological system as a result of synergies between internal and external dynamics of the system. The collapse of social-ecological systems is considered as the worst-case scenario and research on them focuses on what caused them so as to derive lessons for modern societies to avoid similar destructive pathways.

In line with this, Cocks (2003, p.161 & 184-185) refers to a number of driving forces whose sudden change may cause systems to collapse. Diseases and disasters or catastrophes as mentioned may lead

to collapses (in combination with other drivers) that in his view are not inevitable (in contrast to Tainter's explanations and analysis on collapses).

What differentiates the collapse pattern from the adaptation or regime shifting is the absence of institutional response and of actor's initiatives (that is manifested by the presence of niches or new practices). When a social-ecological system (or societal system) experiences an environmental crisis, the system mainly fails due to lack of preparedness to deal with the crisis incident. Institutions are either not ready or not sufficiently responsive to accommodate and/or to handle a crisis or the system changes and developments overcome institutional capacity. Institutions may also function inefficiently hence contributing indirectly to system collapses. An example of the inefficient institutional capacity to deal with system developments concerns agricultural sector systems where irrigation practices lead to exploitation of water bodies and institutions are incapable of regulating and monitoring the irrigation practices that lead to further overexploitation of the water resources. Cases that fall into this category are the Pitcairn and Henderson Islands (Diamond, 2005, pp.120-136). Similar cases include the over-fishing practices that lead to collapse of marine ecosystems when institutional rules are not in place and the deforestation when institutional rules and mechanisms are not in place to monitor and regulate timber extraction (examples of collapses caused by deforestation are given by Diamond, 2005).

In a nutshell: Social-ecological systems are complex adaptive systems with social and ecosystem dynamics. For such systems to reach a sustainable state, a balanced interplay between the dynamics of both subsystems is essential. Our literature review has shown that social-ecological systems can respond in three different ways towards change: by adapting, regime shifting or collapsing. For each of these patterns of change, different groups of endogenous and exogenous forces (seem to) influence the development of the transition. More specifically, for adaptation and regime shifting, five forces have been identified: Crises, Exogenous events, Presence of a niche (local initiatives), Presence of new practices, and Institutional changes. For collapse, three forces have been found to contribute: Crises, Exogenous Events and Institutional failures.

5.2.3 Early reflections of the theoretical grounding of forces of social-ecological transitions

Role of institutions

As already presented, what differentiates the collapse pattern from the adaptation or regime shifting is the absence of institutional response and of actor's initiatives (that is manifested by the presence of niches or new practices). Institutional response is captured by the presence of institutional changes over the course of a social-ecological transitions. More specifically for the role of institutional change, "regime shifts can be facilitated or inhibited by the governance system" (Resilience Alliance, 2007, p.37). The quest of institutional change for system *adaptation* has also been emphasized by adaptive governance and regime approaches. Lemos and Agrawal, (2009, p.75) acknowledge that social-ecological systems' problems required a shift in institutional forms that led to institutional changes. They identify three trends as causes of the emergence/formation of hybrid instruments for social-ecological systems' governance: globalization (quest for change in global/intergovernmental institutions), decentralization (quest for change in national (regional) institutions and organizations) and marketization (quest for change in the organization of institutions). In line with this, Smit et al (2009, p.73) view adaptation as the outcome of human intervention in ecosystems. Handmer and Dovers (2009, p.197, 201 & 203) refer to three types of institutional responses to environmental problems: either resistance to change or marginal change or adaptation. These three responses comply with the responses as described in the previous paragraphs. Handmer and Dovers (2009) focus on the role of institutions more than the scholars of the Resilience Approach and in this way they complement the ecologically focused responses of the Resilience Approach.

Vatn (2005, p.187-189) argues that institutional change as a reaction to crises is an unintended response of institutions. Specifically, he notes that "the crises – as observed- play the role of motivating institutional change" (p.188).

We conclude that institutional change is seen as a means for a system to adapt to ecosystem dynamics. With this, we understand that institutions and their function also play a role in the change of social-ecological systems. Institutions concern the rules and constraints that society sets to regulate its action. Institutions are settled and reformed following the changing demands and needs of the society but their pace of change is rather slow (Vatn, 2005). An example that shows the importance of institutions (and institutional change) comes from agricultural systems where the introduction of a management scheme by an institution may resolve conflicts in the social system and protects water bodies from depletion in the ecological system (see Bromley, 1982).

The issue of scale

When addressing social-ecological systems, the scale of reference is crucial. At a planetary level, the Earth is a social-ecological system. Governance approaches and global research projects deal with intergovernmental and global level research projects and governance frameworks. Organizations such as United Nations, UNESCO, Intergovernmental Panel for Climate Change deal with social-ecological systems at a global level. In our analysis, social-ecological systems refer to resource focused systems such as a river-basin social-ecological system. This however does not mean that we either eliminate or neglect the interdependency and interconnectedness of one social-ecological system to others. Our reference of a single-resource social-ecological system (e.g. a river system is conceptualized as single-resource when it is researched for the water resources and the riparian forests or the biodiversity of the river basin (and the interrelations of all those elements) are excluded from the analysis) is in line with our delineation of the level of aggregation (Chapter 3) and supported by our strive for understanding transitions and their driving forces at a system level.

5.3 Adapting the Evolution Cycle of the Societal System: Social-ecological feedback loops

A number of ecosystem and environmental institution (and ecological economics) researchers have addressed processes that explain the behavior of social-ecological systems during their evolution and change. We identify three processes that add to the Evolution Cycle of the Societal System presented in Chapter 3 (Figure 3.1) that are shown in Figure 5.1. These feedback loops are complementary to the archetypical responses of adaptation (or regime shifting) and collapse of social-ecological systems.

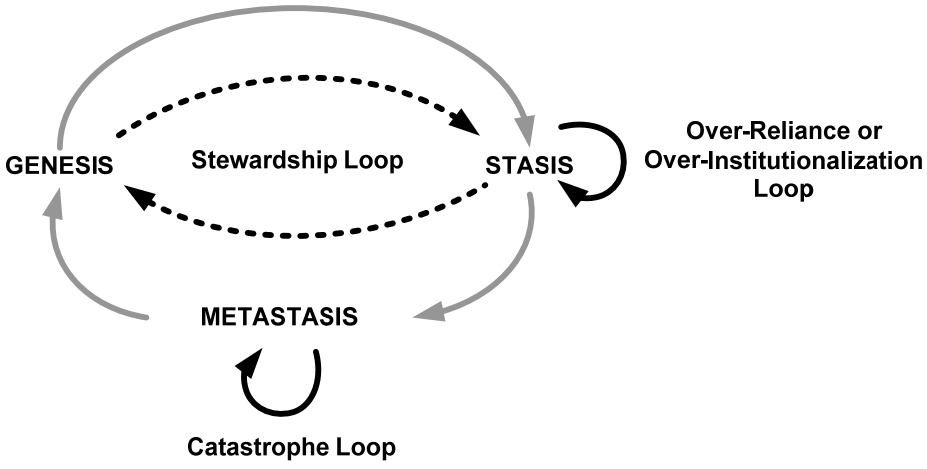


Figure 5.1: The Evolution Cycle of the Societal System including the feedback loops of stewardship, over-reliance or over-institutionalization and catastrophe present in social-ecological systems and social-ecological transitions.

As we already discussed in Chapter 3, the feedback loops are derived by induction of a special form: we infer theoretical constructs (conceptualizations) such as feedback loops from collected notions found in theory. We conceive every feedback loop to further enforces the phenomenon in place. We

therefore position the (majority) of feedback loops to take place at the different stages of the evolution cycle of the societal system.

5.3.1 Institutional over-reliance (or exclusive reliance) Loop

Exclusive reliance on institutions or over-institutionalization is a process of over-reliance on rules for governing social-ecological systems' and changes (Frantzeskaki et al, 2010). Over-reliance on institutions adheres to a highly modernistic approach that supports an "engineered" system (Scott, 1998). Such an over-reliance or exclusive reliance on rules is found when the term "ecological surprises" is used to express that the ecosystem dynamics do not match expected behavior as mapped in management protocols or institutions (in general). In addition to this, it is common among policy practitioners in over-institutionalized social-ecological systems to think that the system can be controlled in every possible way, even to alleviate a potential collapse. Modifications and updates in rules without new inputs about ecosystem dynamics can be perceived as adaptations when social-ecological systems are over-institutionalized.

Examples include floods that exceed the expected water levels, or the increased local sediment deposition in the Elbe estuary owing to altered dynamics (Gerrits 2008), both of which can be perceived as surprises. In short, an exclusive reliance on rules as a mechanism for coping with ecosystem dynamics results in a reduced efficacy of institutions in dealing with the vagaries of nature (Scott, 1998). In the Elbe estuary, policy practitioners (who adhered to the environmental management approach) had a strong technological focus and translated their understanding of the dynamics of the estuary into operational plans and schemes. A diverse and multi-disciplinary team was involved in the realization of the operational plans and schemes. However, the over-reliance on the rules laid out in the operational plans and schemes resulted in the neglect of the ecosystem dynamics. Increased sediment deposition in the Elbe estuary surprised the policy practitioners and forced them to invest in gaining an understanding of the ecosystem dynamics. The ecosystem dynamics of the Elbe estuary provided the signal that the governance of the coupled social-ecological system was proving ineffective.

In our view over-institutionalization has three potential implications (Frantzeskaki et al, 2010). First, rules or practices that are successful in a specific context are transplanted to a different context without modification (Scott, 1998) under the assumption that successful rules will always be successful. Second, an over-reliance on rules can cause policy practitioners to follow the rules blindly and so act in a manner that deviates from the underlying social-ecological governance paradigm while still claiming adherence to this paradigm. For example, local communities and innovators can unintentionally be excluded from the social-ecological systems' governance process (Vreugdenhil and Ker Rault, 2009), even when an adaptive co-management approach is practiced. Third, an over-reliance on rules can lead policy practitioners to believe that the continued implementation of a paradigm can only be ensured by making new rules or modifying existing rules rather than adapting to the response provided by the social-ecological system.

Our arguments here do not state that institutions are not important or that we need to avoid institutional processes. What we note is that over-institutionalization resulting by the adoption of a modernistic approach (Scott, 1998) to an "engineered" system poses risks for socio-ecological systems' sustainability since institutional dynamics are considered paramount to ecosystem dynamics.

5.3.2 Catastrophe Loop

In our analysis of the dynamics of social-ecological transitions, we agree with the conceptualization of collapse of the vulnerability approach. We understand collapse as a pattern of social-ecological systems' change that yields the decay and destruction of the system. We identify a catastrophe loop as the process where different triggers or shocks (crises, exogenous events, systemic failures) are experienced by a societal system and result in its complete destruction (Anderies, Walker and Kinzig, 2006; Abel, Cumming and Anderies, 2006; Walker and Meyers, 2004; Metzger, Leemans and Schroter, 2005; Parmesan and Yohe, 2003; Manuel-Navarrete, Gomez and Gallopin, 2007; Cocks, 2003; Diamond, 2004;2005; Eakin and Luers, 2006). We choose to call this feedback loop a

catastrophe loop so as to show our explicit agreement with the vulnerability approach that a system can be destructed irreversibly. The collapse of social-ecological systems is considered as the worst-case scenario and research focuses on what caused collapses so as to derive lessons for modern societies to avoid similar destructive pathways.

5.3.3 Stewardship Loop

Stewardship as a feedback loop of social-ecological system's behavior concerns the adoption of sustainable practices by local communities when dealing with the ecosystem that are further institutionalized and updated regularly without the trigger of shocks or crises. In this context, the local community stewards the ecosystem and is directly responsible for its sustainability (Ostrom, 1990; Carlsson and Berkes, 2005; Kofinas, 2009); whereas the social-ecological system operates and co-evolves with its context. Such stewardship processes have been studied by adaptive co-management researchers who have worked on deducing institutional arrangements from empirical cases where ecosystem stewardship was realized (Carlsson and Berkes, 2005; Olsson, Folke and Hahn, 2004; Olsson, Folke and Berkes, 2004; Chapin, Kofinas and Folke, 2009; Folke, Chapin and Olsson, 2009).

5.3.4 Early reflections on the Evolution Cycle considering social-ecological transitions

The evolution of social-ecological systems is not a new topic of research. Holling and Gunderson (2002) presented the *adaptive cycles* as sequence of phases: release phase, renewal phase, growth phase, and conservation phase. Given the interactions and scale-issues of social-ecological systems, different adaptive cycles are at place and interact constituting a *panarchy*. Chapin et al, (2009, p.16, Fig.1.6) note that "at any given scale, a system often goes through adaptive cycles of release (collapse), renewal (reorganization), growth and conservation (steady state)."

We find useful to reflect on similarities and differences between the adaptive cycles of the panarchy model (Holling and Gunderson, 2002) and our conceptualization of the Evolution Cycle, due to the resemblance of the two conceptualizations and to the similar research objectives[17] to which they refer.

The similarities (of the Evolution Cycle) with the adaptive cycle model include the alternation of phases with different dynamics and mechanisms, the fact that different types of conditions signal the passage from one phase to another, and the common conceptual basis of understanding the system as a complex adaptive system.

There are however some differences: First, in the Evolution Cycle we consider the social aspects and processes as elementary hence institutions are pertinent. In the panarchy model, the role of institutions is secondary due to the dominant focus on ecosystem dynamics and ecosystem processes. Even though in the theory of the panarchy, organizations, communities and institutions are included, in the empirical cases and examples provided to understand the panarchy at operation, institutions are only associated with environmental policy for eliminating disturbances and variations at the conservation phase (see for example Chapin et al, 2009, p.17).

Second, the Evolution Cycle relates phases and stages with characteristic function in the system evolution and its resulting dynamics to forces of change. The panarchy model does not include either specific mechanisms or conditions to the different phases or adaptive cycles. The processes and conditions that are referred to by Holling et al (2002) are ecosystem specific and not system generic and the way those conditions and processes change over time is related to the different phases (meaning there are not different processes or conditions associated to the different phases of the panarchy).

Third, the Evolution Cycle can describe the dynamics at one scale of operation: the system-related scale that is the meso-scale. What we therefore can address is different forces and different processes

[17] Holling et al (2002, p.5) state that the overall research objective of the research on panarchies is"to understand the source and role of change in systems – particularly the kinds of changes that are transforming, in systems that are adaptive."

(phases, stages, feedback loops) at a single scale. The panarchy model addresses processes in the form of adaptive cycles at multiple heterogeneous scales at the same time.

5.4 Case of Social-Ecological Transition: The coastal management transition of the Great Brak Estuary in South Africa

An analysis of the coastal management and policy transition of the Great Brak Estuary in South Africa with the application and use of the Forces Framework illustrates how to analyze a transition and what to learn from it[18]. The Great Brak Estuary social-ecological transition yielded a new form of institutional arrangements that settled and maintained stewardship of the system's function to the local community (see Appendix A; Slinger et al, 1994; Slinger et al, 2005). In this section we will unfold the transition with the use of the Forces Framework and the Evolution Cycle of the Societal System.

Table 5.2: Case Study of Social-Ecological Transition: Overview of System Boundaries and Dynamics.

CASE STUDY	What System	Time Period under study	Type of Transition	Feedback Loops
Coastal Management Transition in South Africa	Great Brak Estuary (Social-Ecological System)	1988-2004	Social-Ecological Transition	Stewardship Loop (2000-2004)

Analyzing the coastal management transition with the Forces Framework

The decision to construct a dam on the Great Brak River 3 km upstream of the delta of the Great Brak River took place in 1988 (Exercise of power) following an internal study by the Department of Water Affairs and Forestry. The internal study argued that the health of the estuary could be maintained with an allocation of 1 million cubic meters of water per annum and that the dam would reduce the flood risk to the downstream area. After the expression of fear of dam failures and detrimental effects on the living environment by citizens (Crisis – Societal Unease), the authorities instituted the Great Brak Environmental Committee (GEC) (Institutional change). The GEC was assigned the task to investigate the impact of the dam on the estuary and to draw a plan for the optimal use of the allocated water to sustain the river estuary system. The new practice in this context was the first formal acknowledgement of local representation in the environmental management process (Presence of new practices). The GEC commissioned the Council for Scientific and Industrial Research (CSIR) to undertake the environmental impact assessment study in association with the Environmental Evaluation Unit (EEU) from 1988-1990. The study of the potential impacts included surveys of public concerns and perceptions. During the impact assessment, the scientists interacted with local residents, an innovative practice at the time (Presence of new practices). Indirect and informal communications on scientific activities as well as the building of informal ties at an early stage took place.

The environmental impact assessment study revealed that when droughts would be experienced, there would be significant impacts in the estuary. The estuary mouth would close and this problem would persist longer. For dealing with the water related issues arising from the dam construction, the GEC agreed to drawing up a management plan and a monitoring plan, requiring annual reporting and a 10-year revision (Standardization of Practices). The (operational) management plan includes the tasks, responsibilities and procedures for dealing with the water releases. The plan included a rule for adjustment of the water-volume release level within 10 years, so as to enable learning from experience and the adjustment of this level to the system dynamics and behavior. This can be considered an innovation in estuary management (presence of new practices) given that the adjustment of the management plan is agreed as part of the policy cycle. The Great Brak River management plan comprised the first program in which monitoring and policy revision were accepted

[18] The empirical grounding of the Forces Framework also includes published cases found in the literature. Elaboration on the selection criteria for the published cases and on the published cases of social-ecological transitions that have been reconstructed using the Forces Framework are included in Appendix C, and Table C2.

in coastal management in South Africa. The monitoring program of 1990 argued that knowledge gaps about estuary dynamics arising from freshwater flow reduction needed to be researched. The investigation and analysis of ecosystem dynamics on an annual basis and the communication of the results to the public were realized as were opinion surveys about the estuary and the dam.

Box 5.1: A brief description of the geography of the Great Brak River.

The Great Brak river is located on the south-eastern coast of South Africa, east of Cape Town. The Great Brak River is a 28.5 km river with a river catchment of 192 km^2. "The (...) river s subject to droughts and intermittent major flooding" (Slinger et al 1994, p.51).

"The Great Brak Estuary situated on the south-eastern coast of Africa. The active wave climate of Mossel Bay and the periods of low river flow cause the mouth to close from time to time. (...)" (Slinger et al, 1994, p.51-52).

Figure 5.2: The Great Brak river.
(Source: GoogleMaps)

Despite the environmental impact assessment study concluding that there was no increased risk of flooding, a societal crisis appeared in the form of unease when people protested and raised awareness via the media. We need to note that the societal context of that era was characterized by the apartheid and the trend of suppression of the public opinion. The issue of the dam construction raised the attention and united the citizens of the town against the autocratic national authority.

Episodic flood events (1990, 1992 and a large flood in 1993) (Exogenous events) created a sense of urgency that the dam was needed. The episodic floods however were contructive triggers since they resulted in a filling of the upstream reservoir and gave the opportunity of an early test of the system effectiveness. Ecologic triggers (ecological change) such as alterations in the life span of mud prawns, and hypoxic events, also took place. All these ecological responses were collected and interpreted during the monitoring phase. The monitoring group collected and communicated this information to the public (presence of new practices). The residents argued for the sustainability and the health of the estuary (Societal demand). The management plan dealt with the effectiveness of measures targeting the estuary's sustainability. People from the municipality, CSIR, island residents and other citizens involved in the process created an atmosphere of trust. The involved actors communicated their observations and information to the CSIR scientists. Monitoring review reports were published in (2003) and in 2004 the revised management plan was published. The new management plan recommends broader public participation and adaptation of the procedures based on new knowledge of estuary dynamics (Presence of new practices). In 2004 the municipal authorities (under the auspices of the GEC) distributed leaflets so as to inform citizens about the monitoring and operation process.

There are two social trends that also have to be considered in our analysis: First, the societal context in South Africa has changed; making it easier for citizens to be involved in the process. Second, over the years, the visitors to the island region have been asked their opinion about the estuary and the management plan was adjusted accordingly. What has been observed is that perceptions of what a healthy estuary is have changed over the years. The forces of the coastal management transition of the Great Brak River in South Africa are presented in Table 5.3.

The coastal management in the Great Brak River and Estuary was realized via management plans and operational plans that present good practices for integrating societal and ecosystem dynamics. What we observe is that the majority of the forces is rooted in the environment subsystem (ecosystem), the societal subsystem and the institutions. We therefore corroborate that the coastal management transition of the Great Brak River is a social-ecological transition.

Table 5.3: The coastal water management transition in Great Brak Estuary in South Africa
(Source: Slinger et al, 2005).

Year	Event	Conceptualized as:
1988	Decision to construct a dam on the Great Brak River	*Exersize of power*
1988	Societal unease due to protests of citizens against the dam construction that raised awareness via the media	*Crisis*
1988	Formation of the Great Brak Environmental Committee (GEC)	*Institutional Change (Deconcentration)*
1988	First formal acknowledgement of local representation in the environmental management process	*Presence of new practices*
1988-1990	An environmental impact assessment study was conducted by CSIR and EEU	*Presence of new practices*
1988-1990	The process of the environmental impact assessment study included the experience of new practices via daily interaction between citizens and scientists	*Presence of new practices*
1990-today	Monitoring process and implementation process conducted in a public-engaging way	*Presence of new practices*
1990	Water Affairs Department and the industry using water from the dam provided resources for research and analysis of the alternative of constructing a water dam in Great Brak river.	*Provision of resources*
1990	Management plan by the GEC for the Great Brak Estuary & Dam	*Standardization of practices*
1990 1992 1993	Episodic Flood events	*Exogenous events*
1990-1993	Life alterations in cycles of mud prawns, and hypoxic events	*Environmental change*
1990	All these ecological responses were collected and detected during the monitoring phase. The monitoring group collected and communicated this information to the public.	*Presence of new practices*
1990	Residents urged for the sustainability of the estuary	*Societal Demand*
1998	Change of the Water Law	*Institutional Change*
1990-2000	Increasing involvement of people in the monitoring & management process	*Presence of new practices*
2000	Formation of management plan, and operation alignment process that goes on for 10+ years. (annual monitoring, meetings)	*Standardization of practices*
2000	Adaptation to new knowledge and changing dynamics was also considered by the operation plan that requested an adjustment every 10 years.	*Presence of new practices*
2000-2002	Estuary dynamics change due to the synergy of the water circulation regulated by the dam overflow and by the sediment transfer processes	*Environmental Change*
2003	Monitoring review published (10-year report)	*Standardization of practices*
2004	Revised management plan requests participation of actors and draws upon new knowledge of estuary dynamics	*Standardization of practices*

Analyzing the coastal management transition with the Evolution Cycle and with the feedback loops
In our effort to map the coastal management transition with the Evolution Cycle of the Societal System we observe that a stewardship loop is in place, hence we cannot analyze the dynamics in two separate steps as we did in the institutional transition case studies (in Chapter 4). The coastal management transition will be analyzed with the Evolution Cycle taking into account the feedback loop of stewardship early on (Figure 5.3).

We notice that the stewardship loop take place after 2000 (Figure 5.3). The lack of triggers and the alternation of formation forces and support forces (Table 5.2), settle a feedback loop between genesis and stasis stages. We identify this loop as a stewardship loop not only due to the resemblance of the dynamics of the system to stewardship practices, but also due to the function of the feedback loop to the evolution of the system at this period. The stewardship loop (2000-2004) shows that the management practices adopted by the GEC and CSIR were effective and fit in the system and its dynamics. The good management practices were regularly adjusted and revised following the ecosystem dynamics without triggers (e.g crises). In this way the coastal management system has well adapted its operation to the ecosystem dynamics and the local community with the water managers steward the ecosystem being directly responsible for its health and sustainability.

5.5 Concluding the exploration of social-ecological transitions

Our theoretical and empirical exploration revealed that for the development of social-ecological transitions, different types of forces are present (formation forces, support forces and triggers). This corroborates the usefulness and applicability of the Forces Framework in analyzing social-ecological transitions.

We bring forward that theories of social-ecological systems, and their change consider institutions and civil society as elements that influence the ecosystem and our integration of the different understandings brings to the foreground institutional loops and processes that explain how institutional stasis is enforced in social-ecological systems. The identified loops complement the Evolutionary Cycle of the Societal System and are the following: the institutional over-reliance or over-institutionalization loop, the catastrophe loop and the stewardship loop. Especially the stewardship loop shows how social-ecological transformation can take place via reflexive adaptation of practices and formal institutions.

Such a feedback loop is experienced by the social-ecological system of the Great Brak river in South Africa. The stewardship loop shows that the good management practices were regularly adjusted and revised following the ecosystem dynamics without a trigger or shocks or crises. In this way the coastal management system has adapted its operation to the ecosystem dynamics. At the same time, the local community with the water managers steward the ecosystem being directly responsible for its health and sustainability.

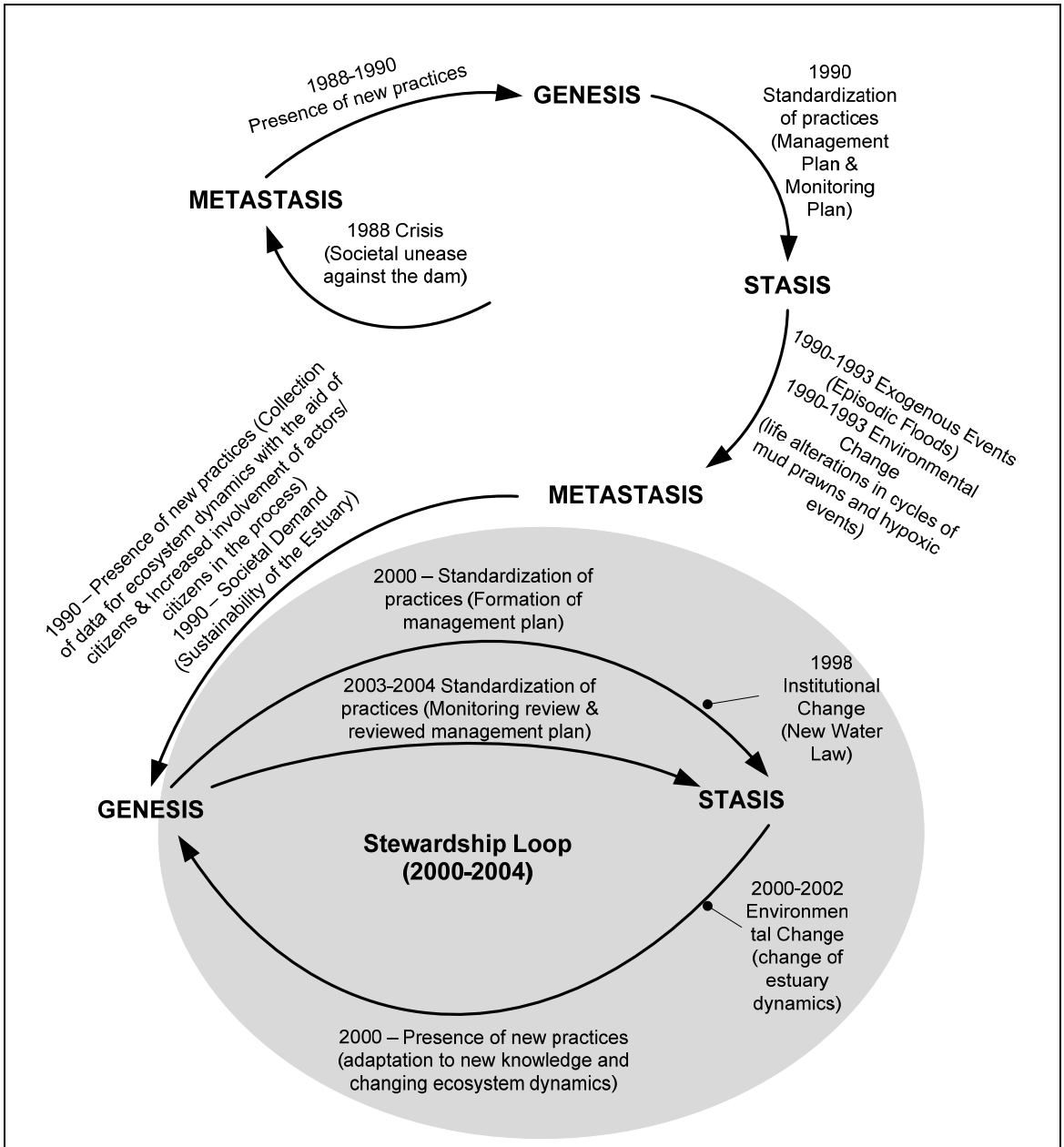


Figure 5.3: The evolution of the coastal management transition of the Great Brak River in South Africa with the identified stewardship loop (pictured in the grey-shadowed area).

Note: For readability, we could not present the evolution of the coastal management regime of the Great Brak River in a spiral form.

In Chapter 6 we explore the third type of societal transitions, socio-technological transitions. We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions, civil society and technology.

Main Contributions

Two feedback loops are found to complement the Evolution Cycle of the Societal System that relate to socio-technological transitions: the institutional restraining loop, and the technological lock-in loop.

A bypass process is also added to the Evolution Cycle as induced by social deterministic approaches, namely the demand-pull bypass

Socio-technological transitions as processes of continuous evolution of the societal system are found to include formation forces, support forces and triggers but exogenous events.

In this chapter, we explore socio-technological transitions. We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions, civil society and technology. The present chapter unfolds in four sections: In Section 6.1 we introduce socio-technological systems and socio-technological transitions. Then, we elaborate on the different theories of socio-technological change and technological change with the objective to ground the Forces Framework to the different theories (Section 6.2). In Section 6.3 we present the feedback loops that are induced from the theory and introduced in this thesis so as to complement the Evolution Cycle of the Societal System (framework). Concluding remarks of the theoretical and empirical exploration of socio-technological transitions are given in Section 6.4.

6.1 Introducing socio-technological systems and socio-technological transitions

Socio-technological transitions are driven by technological performance in face of societal demands and problems. Technological systems and their functions play an important role in the structuring of the modern societies especially after the communication revolution with the introduction of the Internet and the constitution of the network society (see Castells, 1996). In her most recent analysis of technological revolutions, Perez (2009) argues that technological revolutions show historical regularities since one "comes together every 40 or 60 years at the maturity of the previous" and "a major financial collapse marks the beginning of the switch"[19].

6.2 Theories of socio-technological systems and transitions

In this section, we critically review the theories on technological change, innovation and socio-technological transitions. We first realize a categorization exercise of the different theoretical approaches and frameworks into three paradigms that we term: social determinism, institutional determinism, and technological determinism (Table 6.1). In this way, we show the conceptual underpinnings of the different paradigms on socio-technological transitions that co-exist (and precede) with the new field of socio-technological transitions.

Technological determinism: The technological determinism paradigm –commonly addressed as technology-push- positions technology and later science and technology, as the key drivers of societal change and technological innovation. The technology-push view suggests that investment in technology (in the form of research, R&D) is crucial for the advancement of technology, for innovation and in turn, for societal progress (Nelson and Winter, 1977; Freeman, 1974; Klevorick et al, 1995). From innovation diffusion theory, Rogers (2003, p.146) defines technological determinism as "the belief that technology causes changes in society."

Geels and Schot, (2010, p.31) comment on technological determinism and summarize that technological determinism implies that "technology develops according to its own, internal logic, separated from society and that once technology is introduced in society it causes social changes."

The critique of technological determinism includes the neglection of uncertainty in technological processes (both change and maturity), the ignoring of "prices and other changes in economic

[19] Perez (2009) presents five revolutions, namely the industrial revolution, the Age of steam, coal, iron and railways, the age of steel and heavy engineering (electrical, chemical, civil and naval), the age of the automobile, oil, petrochemicals and mass production, and the age of information technology and telecommunications.

conditions that affect the profitability of innovations" (Nemet, 2009, p.701), and the overlooked role of networks (actor-networks) in technological change.

Table 6.1: Technology-Society Paradigms as presented by associated theoretical approaches.

Technology-Society Interrelation Paradigms	Theoretical Approaches	Key References
Technological Determinism (Technology drives societal change)	Innovation studies; Technological and technical change studies (technology-push theories)	Nelson and Winter, 1977; Freeman, 1974; Klevorick et al, 1995
Institutional Determinism (Institutional change precedes and conditions technological change)	New Institutionalism; Functions of Innovations Framework;	North, 1990; Powell and DiMaggio, 1991; March and Olsen, 1989; Hekkert et al, 2007;
Social Determinism (Societal needs and demands drive technological change)	Technological and technical change studies (demand-pull theories); Social construction of technology approach; Theory of techno-economic paradigm	Aschhoff and Sofka, 2009; Rosenberg, 1969; Schmookler, 1962; Pinch and Biker, 1984; Bijker, 1995; Freeman and Perez, 1988

***Institutional determinism*:** New institutionalism scholars propose that the broader institutional context conditions and regulates technological change. Changes in institutions are the preceding events that open opportunities for technological innovations and consequent technological changes (Spar, 2001; Van de Ven, 1993). Van de Ven (1993, 26) in his review of innovation theories argues that within the institutional determinism paradigm, "a larger institutionalized environment enables and constrains organizations to invent and develop only certain types of technologies and practices."

***Social determinism*:** The social determinism paradigm –commonly addressed as demand-driven innovation or demand-pull- positions societal demand (or market demand) as the key driver of technological innovation. According to this paradigm, demand drives firms, scientists and entrepreneurs to work towards new technologies (Rosenberg, 1969; Schmookler, 1962).

The Social construction of technology approach falls under the paradigm of social determinism. The social construction of technology approach views technological development and change as a social process. Technology is being advanced and changed in a trial-and-error processes that includes the testing and adapting to societal needs and problems at the time (Pinch and Biker, 1984; Bijker, 1995). The theory of techno-economic paradigms of Freeman and Perez (1988) (even though it falls under the long-wave theories of technological change) has a conceptual affinity with the social determinism. According to Freeman and Perez (1988, p.58) innovations are responses to existing problems and to side-effects or deficiencies of existing technologies.

Given our literature review we bring forward that: First, different forces are considered critical in every paradigm. This comes in line with the conceptual basis of every paradigm and raises the criticism of a self-fulfilling prophecy. We present the Forces that relate to every paradigm in Table 6.2 as derived by the literature review of the aforementioned approaches associated to every paradigm (Table 6.1). Theoretical approaches that comply with the technological determinism paradigm, address innovations (manifested by Presence of new practices, Presence of a niche, and/or Technological change) and adoption of innovations by a small group of users (early adopters) as critical for the broader technological change. Second, scholars from the same scientific field e.g. innovation studies, can adopt different paradigms. In our literature review, we remained reflective and critical when reviewing the research of different scholars so as to understand the conceptual underpinnings and avoid the field-bias.

Why is it important to understand and consider the underlying society-technology paradigms?

By understanding the propositions of every deterministic paradigm, we understand the assumptions and expectations of the policies proposed by them. For example, scholars who agree with institutional determinism propose regulative measures and institutional conditions to set forth for supporting innovation systems whereas scholars who agree with technological determinism are in favour of technology policy (instruments), R&D funds etc. In addition to this, the societal determinism paradigm proposes that new demand can drive technological change without the need of a system failure or any other trigger. This adds to the Evolution Cycle of the Societal System by creating a by-pass from the stasis stage to the genesis stage that is the demand-pull as theorized by the approaches associated with societal determinism and the empirical grounds they draw upon.

Table 6.2: Forces Driving Transitional Change recognized in the different deterministic paradigms. When a specific paradigm is followed or adopted as a conceptual ground from scholars or as a paradigm from policy actors, those are the forces that are expected to be in place.

Forces Driving Transitional Change in place		***Socio-Technological Paradigm***
Presence of a niche, Presence of new practices (innovation, new technology), Technological changes, Standardization of practices (technology standards)	⇦	Technological Determinism
Presence of new practices (innovation, new technology), Institutional Changes, Standardization of practices (regulation, technology policy), Provision of resources	⇦	Institutional Determinism
Presence of new demand, Presence of new practices (innovation, new technology), Institutional Changes, Exersize of power, Crisis, System Failures	⇦	Social Determinism

The field of socio-technological transitions

The field of socio-technological transitions (Geels, 2002; Geels and Schot, 2007; Raven, 2007) proposes that society and technology co-evolve in a dynamic way. Evolutionary economists also recognize that technology and society co-evolve, their focus however rests on technology-market interactions and neglects institutional and broader societal factors and processes (see critical reflections of Geels, 2002, p.94). The field of socio-technological studies and socio-technological transitions is a valuable effort in bridging this chasm by taking a more inter-disciplinary and inter-related view on technology. More specifically, Geels and Schot (2007, p.404-405) take a dual dynamic as a starting point for the transition pathways that they develop: the evolutionary-economic and the social-institutional dynamics and in this way address that technology changes due to inter-related and inter-disciplinary dynamics.

6.2.1 Forces of socio-technological transitions grounded in literature

In the following paragraphs, we present the forces that are found in different approaches and theories. The forces that are presented here are complementary to the forces that relate to the three deterministic paradigms that are discussed in Section 6.2. We note that not all the reviewed theories relate their analysis to specified deterministic paradigms.

Presence of a niche

Niches in the field of technological change refer to market niches or similar to market space environments. Niches are seen as locus where new technologies are tested and develop initially. Given that niches always involve actors using new technology, they are seen as crucial for technological change.

Innovation studies in general, focus on technological niches as the seeds of broader technological and social changes. Their research effort rests on the events and actions that help a new technology in the form of a niche to be either adopted by the targeted market/regime or to be hybridized (adapted) in another market/regime. Consequently, innovation studies offer insights on the importance of innovations and on the type of support those innovations need so as to enter the market/regime.

From innovation theory, Levinthal (1998, p.242) points at the importance of niches as spaces; where technological innovations are nurtured. He introduced a niche theory of technical change.
From innovation diffusion theory, Rogers (2003, p.283) refers to early adopters of an innovation as the critical group for an innovation to be diffused since they act as channels for further adoption and knowledge about the innovation. The characteristics that Rogers (2003) recognizes in early adopters are in accordance with our definition of a niche as a group of actors who adopts a new practice or idea.

Niches are at the core of the socio-technological transitions' narratives, since "they are crucial for system innovations, because they provide the seeds for change" (Geels, 2005b, p.368)

Presence of new practices
New technology is conceptualized as a new practice or new artifact. The technology change and socio-technological transitions literature refers to new technology as novelty (Geels, 2002, p.103). From innovation diffusion theory, Rogers (2003) argues that technological innovations need to be present and be materialized prior to their diffusion. Innovations in innovation diffusion theory, refer only to technological innovations.

Presence of societal demand
Complementary to theoretical approaches aligned with the social determinism paradigm, innovation diffusion theorist Rogers (2003, p.137) posits the new demand (or need) and the realization of a problem as the starting point to an innovation process. In his technology-focused view, there is no innovation without a preceding need or problem.

Provision of resources
From innovation diffusion theory, Rogers (2003, p.140-141) argues that provision of resources in research for technological advancement is a critical factor for diffusion of technological innovations.

From innovation studies, Van de Ven (1993, p.27 and 29) suggests that provision of resources especially "public resource endowments of basic scientific knowledge and financing mechanisms" contribute to technology innovation and in turn, to technological change.

From technological change theory, Nemet (2009, p.706), and Taylor et al (2006) argue that provision of resources in the form of research and development funds for innovation play an important role in technological change and technological advancement.

From the techno-economic change approach, Perez (2002) argues that resource mobilization is an important factor for technological change.

From socio-technological transitions, Geels (2005b, p.368) argues that provision of resources from a niche market contributes to empowerment of a niche.

Standardization of practices
From infrastructure studies, the cases included in the edited volume of Mayntz and Hughes (1988) refer to the importance of standardization for the development of large technical systems. For example, Salsbury (1988, pp.56-57) refers to standardization as a critical factor for the expansion and development of the railroad system in the United States (e.g. the standardization of time and time zones, the standardization of braking systems, the standardization of the truck gauges).

From innovation studies, Van de Ven (1993, p.27) suggests that standardization of practices and legitimization aid the development of technological advancement and change. Van de Ven (1993, p.31) specifically addresses technology standards as drivers of further technological advancement since they create a performance ceiling that new technologies have to satisfy and to exceed.

From innovation studies, Aschhoff and Sofka (2009, p.1236-1237) argue that regulations as a form of standardization of practices and standards can promote technological change since they can be employed as demand-side instruments. Complying with the demand-pull paradigm, regulations can act as support forces that pull further existing technological innovations to their maturity or advancement.

From institutional economics, Spar (2001) argues that regulations and rules precede technological innovation.

Exercise of power

From socio-technological transition studies, Smith, Stirling and Berkhout (2005, p.1503-1504) note that power exercise can aid the empowerment of a technological niche and/or a technological regime. Exercise of protective and supportive power by networks of actors in new niches or newly established technological regimes is a factor distinguished by Raven (2006; 2007).

In studies of technological change or large technical systems (infrastructure studies), exercise of power is being present at micro level. Actors in the niches or in the regimes exercise power over interests or over resources mobilization in a way that serves their objectives. At the macro level we only observe the outcomes of this power exercise that is manifested by provision of resources or by the standardization of practices in the form of legislation or laws. Technological studies can show us that a force may be present at a micro level of aggregation but its outcomes have a different impact at the meso and macro level hence represented by a different type of force.

Systemic Failures

From studies of large technological systems, Hughes (1983) refers to systemic ineffectiveness in the form of reverse salients[20] to hamper technological system advancement. From technological change approaches, system ineffectiveness or inadequacies can trigger the development of technological updates or new technologies (Hughes, 1987; Freeman and Perez, 1988). From infrastructure research, socio-technological change can be triggered by system failures such as cost overruns in planning and/or in operation, or ineffectiveness to satisfy demands in the form of congestion and/or of energy block-outs (Little, 2004; Mendoca, 2004).

From innovation studies, Nill and Kemp (2009, p.668) note that innovation responds to system and market failures. They argue that system failures have "to do with the facilitating structure, which may be ill developed for innovation in general or unhelpful for certain types of innovation, causing problems of adaptation and problems in the creation of novelty."

From strategic niche management, Schot, Hoogma and Elzen (1994, p.1061) indicated that ineffectiveness of an existing technological system can provide the opportunity of niches to gain space and show their benefits and competencies in dealing with the system pathologies.

Crises

From the techno-economic change approach, Freeman and Perez (1988, p.47) refer to crises as events that influence the establishment of new technologies. More specifically, they argue that "a new technology becomes established as a dominant technological regime only after a crisis of structural adjustment, involving deep social and institutional changes."

[20] Reverse salients "are technical or organizational anomalies resulting from uneven elaboration or evolution of a system: Progress on one frony may produce backwardness elsewhere." (Joerges, 1988p.13 in Mayntz and Hughes). Note that by system in this definition, the author refers to large socio-technological systems.

From energy policy research, Shackley and Green (2007, p.234) used the multi-level framework of Geels and reflected in their analysis that complementary to the regime and niches identified, shocks play a role in socio-technological transitions as well. They distinguish two types of shocks: technological shocks such as "hazardous episodes" – like technological accidents- and landscape shocks such as catastrophes –like climate change, a war-.

Exogenous Events
The theoretical grounding of the Forces Framework in theories of technological change, socio-technological change and transitions, techno-economic change, innovation studies, innovation diffusion studies, and strategic niche management showed that exogenous events are not considered as a driving force for socio-technological transitions.

We need to clarify that exogenous events differ from the landscape pressure as described by Geels and Schot (2007). Landscape pressure is what regime experiences when movements, or other external to the regime developments are recognized by the regime actors, or specifically "Landscape changes only exert pressure if they are perceived and acted upon by regime actors." (Geels and Schot, 2007, p.406). Exogenous events alone are not considered as influential from studies of socio-technological change.

6.2.2 Characteristic responses and archetypical socio-technological changes grounded in literature

The socio-technological transitions field presents five archetypical responses namely pathways of socio-technological transitions. We adopt those pathways and re-construct them using the Forces Framework so as to associate specific sets of forces to every pathway (Tables 6.3 and 6.4). We notice that the pathways presented by Geels and Schot (2007) refer to a 'fight' between niche and regime; hence either competition or symbiosis between the nice and the regime constructs the pathways. Existence of two regimes is not an option.

In socio-technological transitions, Geels and Schot (2007) indicate five distinctive pathways:

Reproduction
Reproduction is a process where "if there is no external landscape pressure (…), then the regime remains dynamically stable and will reproduce itself" (Geels and Schot, 2007, p.406). Using the forces framework to re-construct the theoretical explanation of the reproduction pathway, we conclude that the following forces are at place: Presence of a niche, Systemic Failures, Standardization of practices ("stable rule-sets"), Technological Change ("incremental innovations can boost performance").

Transformation
Transformation (in socio-technological studies) takes place where "if there is moderate landscape pressure ('disruptive change') at a moment when niche-innovations have not yet been sufficiently developed, then regime actors will respond by modifying the direction of development paths and innovation activities." (Geels and Schot, 2007, p.406).

From technological change approaches, Dolata (2009, p.10067) introduces two types of technology-based sectoral change: (a) reactive and crisis-ridden transformation, and (b) anticipative and proactive sectoral transformations. In the analysis and the proposed framework of Dolata (2009), the interdependence between technology and institutional context is prevailing, despite the fact that the argumentative basis complies with the technology-push paradigm. Dolata (2009, p.10073) proposes that "technology-based sectoral change is typified by longer periods of discontinuity featuring a multitude of gradual transformations, where the organizational, structural, and institutional bases of a sector are successively renewed in the direction of a new and dominant design."

Using the forces framework to re-construct the theoretical explanation of the transformation pathway, we conclude that the following forces are at place: External Effects or Presence of a new demand ("landscape pressures"), Presence of new practices, Systemic failures, Presence of niches, Technological Change, Institutional Change, Provision of resources ("new knowledge", socio-institutional dynamics).

De-Alignment and Re-alignment

De-alignment and re-alignment are processes where "if landscape change is divergent, large and sudden (..), then increasing regime problems may cause regime actors to lose faith. This leads to de-alignment and erosion of the regime. If niche-innovations are not sufficiently developed, then there is no clear substitute. This creates space for the emergence of multiple niche-innovations that co-exist and compete for attention and resources. Eventually, one niche-innovation becomes dominant, forming the core for re-alignment of a new regime." (Geels and Schot, 2007, p.408). Using the forces framework to re-construct the theoretical explanation of the alignment pathway, we conclude that the following forces need to be at place: External Effects or Presence of a new demand ("landscape pressures"), Systemic Failures (of the regime), Crisis, Presence of niches, Technological Changes, Standardization of practices ("re-institutionalization in a new sociotechnical regime", p.408).

Technological Substitution

Technological substitution is a process where "if there is much landscape pressure ('specific shock', 'avalanche change', 'disruptive change') at a moment when niche-innovations have developmet sufficiently, the latter will break through and replace the existing regime" (Geels and Schot, 2007, p.409). Using the forces framework to re-construct the theoretical explanation of the substitution pathway, we conclude that the following forces need to be at place: Presence of niches, Crisis, or Systemic Failure, or External Event, Exersize of power ("power struggles" p.410), Provision of resources.

Reconfiguration

Reconfiguration where "symbiotic innovations, which developed in niches, are initially adopted in the regime to solve local problems. They subsequently trigger further adjustments in the basic architecture of the regime." (Geels and Schot, 2007, p.411). Using the forces framework to de-construct the theoretical explanation of the reconfiguration pathway, we conclude that the following forces need to be at place: Presence of niches, Technological Change, Presence of new demand, Institutional Changes, Presence of new practices, Standardization of new practices.

Complementary to the five archetypical pathways/responses proposed by Geels and Schot (2007), niche empowerment is also included as a separate archetypical response of socio-technological systems.

Niche Empowerment

The focus of niches as seeds for change and therefore critical conditions for broader socio-technological change is taken up by Strategic Niche Management scholars who propose different strategies and means to empower niches and innovation {as described by the socio-technological transitions' studies (Geels, 2002; Geels and Schot, 2007)}. Strategic Niche Management is an evolutionary approach that proposes management practices that create a social incubator for new technologies: the creation of a protected space for experiments with new technologies where support is provided (mainly resources and favoring practices). The aim is to nurture the new technology and to further foster and empower it while learning about what changes in policies and organizations are needed for its broader adoption (Nill and Kelp, 2009, p.672; Kemp et al, 2000). Niche empowerment is the objective of Strategic Niche Management instruments, but it can also be a socio-technological transition pathway.

Strategic Niche management puts forward the following two clusters of forces: (a) The forces that need to be present and considered as critical include: The presence of a new practice (mainly a new technology that is socially desirable), the presence of a niche (that is a cradle of innovation), and (b)

the forces that need to be established via management and policies that support and empower niches include: provision of resources (at niche level and later, at regime level), the exersize of power (in the form of control policies for the adoption of the new technology, see Nill and Kemp, 2009, p.672), (the requirement for potential) institutional changes, and social demand (Nill and Kemp, 2009, p.672 put it as “social desirability of the technology”).

Table 6.3: Forces Driving Transitional Change that underpin the different responses of socio-technological systems over the course of a transition as derived from socio-technological transitions literature (Geels, 2002; Geels and Schot, 2007; Nill and Kemp, 2009).

Forces Driving Transitional Change in place		***ST pattern of change***
Presence of a new practice (Technology); Presence of a niche; Presence of new demand; Provision of resources; Exersize of power; Institutional Change	⇨	**Niche Empowerment** (Strategic Niche Management)
Presence of a niche, Systemic Failures, Standardization of practices, Technological Change	⇨	**Reproduction** (Geels and Schot, 2007)
External Effects or Presence of a new demand, Presence of new practices, Systemic failures, Presence of niches, Technological Change, Institutional Change, Provision of resources	⇨	**Transformation** (Geels and Schot, 2007)
External Effects or Presence of a new demand, Systemic Failures (of the regime), Crisis, Presence of niches, Technological Changes, Standardization of practices	⇨	**De-and re-alignment** (Geels and Schot, 2007)
Presence of niches, Technological Change, Presence of new demand, Institutional Changes, Presence of new practices, Standardization of new practices	⇨	**Technological Substitution** (Geels and Schot, 2007)
Presence of niches, Technological Change, Presence of new demand, Institutional Changes, Presence of new practices, Standardization of new practices	⇨	**Reconfiguration** (Geels and Schot, 2007)

Table 6.4: Forces Driving Transitional Change that underpin the different responses of socio-technological systems in a schematic presentation (Geels, 2002; Geels and Schot, 2007; Nill and Kemp, 2009).

	Socio-technological Pattern of Change					
	Niche Empowerment	**Reproduction**	**Transformation**	**De-and re-alignment**	**Technological Substitution**	**Reconfiguration**
FORCES in place						
Formation Forces						
Presence of new practice	✓		✓		✓	✓
Presence of a niche	✓	✓	✓	✓	✓	✓
Presence of new demand	✓		✓	✓	✓	✓
Support Forces						
Provision of resources	✓		✓			
Exersize of power	✓					
Standardization of practices		✓		✓	✓	✓
Triggers						
Crisis			✓	✓		
Systemic Failures		✓	✓	✓		
Exogenous events			✓	✓		
INTERMEDIATE CHANGES						
Institutional Change	✓		✓		✓	✓
Technological Change		✓	✓	✓	✓	✓

6.2.3 Early reflections from the theoretical exploration of socio-technological transitions

The archetypical responses that are proposed by Geels and Schot (2007) are formed in a hidden (or latent) game theoretic rationale as shown in Table 6.5. What we observe is that for the socio-technological transition field, landscape pressure is a necessary condition for transitions to be realized. Landscape pressure is represented by External Effects (e.g. external to the system development of technology) or Presence of a new demand (Geels and Schot, 2007, p.408 and 413). The majority of the transition pathways take place under the presence of landscape pressure.

From Table 6.5 we also conclude that pathways or even system responses where technology fails (niche loses) are not considered in the literature.

In general, failed transitions have been overlooked by socio-technological transitions scholars. Even though we are aware of system break-downs like abandoned technology (e.g. pesticides like the DDT), such cases or similar cases are not revealed or studied. This is a key difference with the social-ecological transitions' theoretical approaches where the collapses of ecosystems (and social-ecological systems accordingly) are studied intensively to gain understanding and lessons whereas in socio-technological studies the research mainly shed lights on winning technology.

Table 6.5: Positioning the socio-technological transition pathways of Geels and Schot (2007) in a game theoretic canvas.

	Landscape Pressure		**No Landscape Pressure**	
	Regime Wins	*Regime Loses*	Regime Wins	Regime Loses
Niche Wins		De-alignment/Re-alignment Technological substitution	Reconfiguration	
Niche Loses	Reproduction Transformation			

6.3 Adapting the Evolution Cycle of the Societal System: Socio-Technological feedback loops

Scholars of technological change, infrastructure studies and innovation approaches, use mostly cases to illustrate and support their conclusions about technological change and the factors that contribute to it.

We identify one process and two feedback loops that add to the Evolution Cycle of the Societal System presented in Chapter 3 (Figure 3.1) that are shown in Figure 6.1, which has been adapted to socio-technological transitions specifically. These feedback loops are complementary to the archetypical responses presented by Geels and Schot (2007) and Strategic Niche Management.

As we already discussed in Chapter 3, the feedback loops are derived by induction of a special form: we infer theoretical constructs (conceptualizations) such as feedback loops from collected theoretical parts found in theory. Specifically for the socio-technological-relevant feedback loops, we also employ inductions from various reported cases and their discussions that are re-conceptualized and reconstructed as feedback loops. We conceive that every feedback loop further enforces the phenomenon in place and establishes new types of equilibria. We therefore position the (majority) of feedback loops to take place at the different stages of the Evolution Cycle of the Societal System.

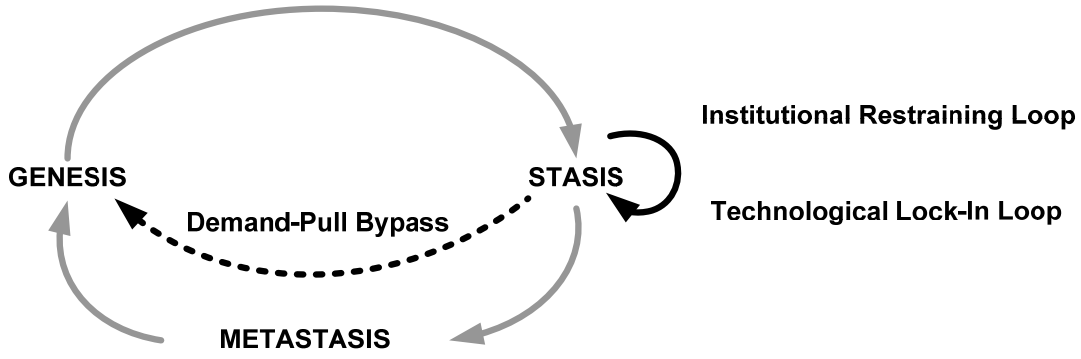


Figure 6.1: The Evolution Cycle of the Societal System including the feedback loops of institutional restraining and technological lock-in as well as the demand-pull bypass present in socio-technological systems and transitions.

6.3.1 Demand-Pull Bypass

As we discussed previously, the societal determinism paradigm proposes that new demand can drive technological change (without the need of a system failure or any other trigger). This adds to the Evolution Cycle of the Societal System by creating a by-pass (process route) from the stasis stage to the genesis stage that is the demand-pull as theorized by the approaches associated with societal determinism and the empirical grounds they draw upon (Aschhoff and Sofka, 2009; Rosenberg, 1969; Schmookler, 1962; Pinch and Biker, 1984; Bijker, 1995; Freeman and Perez, 1988).

6.3.2 Institutional Restraining Loop

Support of formal institutions takes place in a way that further reinforces restraining behavior of existing institutions towards new practices or innovations in general. When formal rules and procedures are followed in a blindfolded manner that restricts any form of innovation either organizational or technological to be evaluated or to be introduced to the system, the system experiences an institutional restraining loop. The institutional restraining loop is a stasis located loop. The institutional restraining loop in socio-technological systems can result in avoidance or even abortion of any technological innovation that threatens the existing institutions.

Examples of such restraining behavior of institutions in socio-technological systems include, the avoidance of electrification of railroads in the United States in 1940-1950s due to the existing labor laws that ensured “full crews” for railways (Salsbury, 1988), and the overprotection of the German institutions of the videotext in 1970s (Mayntz and Schneider, 1988b, p.287).

6.3.3 Technological Lock-In Loop

Technological lock-in as a feedback loop (at the stasis stage) concerns the process when a technology becomes dominant and cannot be overruled or substituted by other technologies –even when the dominant technology is inferior to new technologies- due to continuous support it gains (either institutional support or market support {e.g. increased demand}). Technological lock-in has been an issue for technological studies, socio-technological studies, evolutionary approaches and strategic niche management (van der Laak, Raven and Verbong, 2007). The main difference between the other approaches and technological studies is the realization that for lock-in to occur not only market forces but also institutional and social support are required (see van der Laak, Raven and Verbong, 2007, p.3216).

Unruh (2007) also points at both technological and institutional reinforcing for lock-in to take place. His analysis points at the energy system where he shows how technological and institutional factors constitute what he defines as a carbon lock-in.

> "Techno-institutional lock-in implies that there are systematic forces that make it difficult to change the development path of existing techno-institutional systems. Even with the growing of evidence of substantial environmental risk, these forces can create pervasive market, policy and organizational failures toward the adoption of mitigating policies and technologies." (Unruh, 2007, p.827).

The technological theorist Hall (1994), defines lock in as a pattern of technological system operation. More specifically:

> "Lock-in may arise because of increasing returns to scale in knowledge (…), the costs of acquiring new technological knowledge is costly compared to reusing existing knowledge; and existing complementarities, i.e existing production knowledge is usually a specific asset with complementary assets have been built up (…). Lock in has the technological consequence of confining innovation in many cases to a narrow corridor of developments."(Hall, 1994, p.272)

In the same vein, technology studies argue on technological and market conditions alone when reconstructing lock-in of technologies. What evolutionary approaches of technological and socio-technological systems argue is that a system can break out from a lock-in situation in two ways: (a) when systemic failures occur that degrade the dominant system, and (b) when new technologies due to entrepreneurship are present (Nelson and Winter, 1982; Levinthal, 1998; Dofsma and Leydesdorff, 2009).

> "A co-evolution along a single trajectory can be "unlocked" when the diffusion mechanism of the market no longer co-evolves with the technical means of production. When another selection environment becomes relevant to a previously locked-in system, the new configuration may begin to tilt the system as soon as diffusion at the new interface becomes more important than (…) half of the rate along the trajectory of the system. Because an economic production system is attracted by market opportunities, one can expect a trajectory to be exploited to gain market share. The lock-in can thus be expected to erode as the diffusion rate for the new technology increases." (Dofsma and Leydesdorff, 2009, p. 939).

6.4 Concluding the exploration of socio-technological transitions

Our theoretical and empirical exploration[21] revealed that for the development of socio-technological transitions, different types of forces are present (formation forces, support forces and triggers). This corroborates the usefulness and applicability of the Forces Framework in analyzing socio-technological transitions. From reviewing and revisiting the theories that relate to socio-technological systems and theories of socio-technological transitions, we found two feedback loops that complement the Evolution Cycle of the Societal System that relate to socio-technological transitions: the institutional restraining loop, and the technological lock-in loop. A bypass process is also added to the Evolution Cycle as induced by social deterministic approaches, namely the demand-pull bypass.

[21] The empirical grounding includes published cases found in the literature. Elaboration on the selection criteria for the published cases and on the published cases of socio-technological transitions that have been reconstructed using the Forces Framework are included in Appendix C, and Table C3.

In Chapter 7 we present the research outputs in response to the research questions and the implications of the research findings in terms of theoretical contributions and in terms of governance for societal transitions to sustainability.

Main Contributions

- Transitions can be seen as processes of continuous evolution of the societal system where the system fundamentally changes, unfolding in alternations of slow-fast dynamics. This is in agreement with our theoretical conceptualization of the Evolution Cycle of the Societal System. Stages represent dynamic equilibria characterized by slow dynamics, and process-routes to the stages are characterized by fast dynamics.
- Empirical exploration of the four cases confirms the cyclic character of the unfolding of a transition.
- Different types of transitions as episodes of an overall transition can occur in different sequences and durations. Understanding that a societal system can undergo different types of transitions implies that different forces are critical in different episodes, that different aspects of change have to be taken into account and that different instruments need to be devised for facilitating or initiating a societal transition.
- Governance based on the understanding of transition dynamics implies that governance interventions are devised in a way that considers the dynamics of the system. The governance propositions inform the Transition Management tenet "dynamics of the system create feasible and unfeasible means for governance" and are: (a) governance for societal transitions has to strive to produce both formation forces and support forces, and to reveal triggers for initiating or setting a transition in motion; (b) governance for societal transitions has to employ means that mimic the dynamics of the system in order to internally change the system in a fundamental way; (c) in a system that undergoes a specific type of transition, means that are homologous to the system dynamics have to be employed in order to facilitate the on-going transition, and (d) governance for societal transitions has to consider (and if possible anticipate) the impact of antagonistic or hampering processes and constellations on the societal system.
- The limitations of governing societal transitions are also presented, focusing on the different types of societal transitions.

CHAPTER 7
Synthesis and Conclusions

Chapter 7 presents the synthesis of the research findings. In Section 7.1 we respond to the research questions. Section 7.2 includes a discussion on the theoretical implications of the conceptual models when researching societal phenomena, such as societal transitions. In Section 7.3 we answer the question: what does understanding the dynamics of transitions in the form of forces, feedback loops and tipping forces mean for existing theory on transitions, for existing theory on social phenomena, and for existing theory on governance? Section 7.4 introduces the limitations of governance so as to set the scene and the governance boundaries that need to be considered when attempting to initiate, stimulate or influence societal transitions. In Section 7.5 we present the governance propositions for societal transitions that relate to the aspects of the dynamics that have been brought forward by our research (synergy of forces, feedback loops, types of transitions, antagonistic processes to transitions, tipping forces, system resilience and co-evolution). In Section 7.6 we include a discussion about persistent problems in view of the analysis of the different types of transitions in the different case studies. The last section, Section 7.7, concludes the chapter by elaborating upon the more philosophical aspects of governing societal transitions, referring to both the nature of societal transitions and to the complexity of governance for societal transitions.

7.1 Understanding the dynamics of societal transitions: Responses to the research questions

Our research contributes to the understanding of the transition dynamics by dissecting them with the developed conceptual models. Both the Forces Model and the System's Evolution Cycle proved analytically useful and capable to both map and detangle the dynamics present in the case studies. In addition to this, the application of the conceptual models resulted in further explanations about transition dynamics and societal transitions: the feedback loops present in societal systems' evolution. Based on this we conclude that the conceptual models developed are analytically useful[22] since they can describe societal transitions.

At the same time, the application of the conceptual models revealed additional aspects: the feedback loops and the ways they are created (break-in and break-out forces), the unveiling that different types of change take place towards a fundamental transformation of a system, the way one force can influence different regimes synchronously (tipping forces), and an insightful description of co-evolution of different subsystems and regimes as presented in different cycles and the respective feedback loops.

In the following paragraphs we present a synthesis of our research findings, as responses to the revised research questions (presented in Chapter 3, Section 3.8).

7.1.1 Are formation forces or support forces or triggers alone sufficient to drive a societal transition?

Theoretical and empirical grounding of the Forces Framework showed that, for every transition, forces from all the three clusters are present: formation forces, support forces and triggers. Intermediate changes were also present and played an important role in the development of the transition. This corroborates that all these different forces are required for a transition to be realized.

[22] As Silverman (2005, p.236) puts it, a conceptual model is analytically deep –and of sufficient quality- when it "has mobilized the conceptual apparatus of our social science disciplines and, thereby, helped to build useful social theories".

As we already discussed in Chapter 4, we refer to forces as macro-social determinants of transformative change. This however does not imply that the forces are the causes of societal transitions. The forces present in (every type of) societal transitions contribute by driving and propelling the transition process.

The presence of different types of forces in synergy over the course of a transition shows that:

- formation forces alone do not suffice for driving a transition, or, innovation alone cannot drive a transition
- support forces alone do not suffice for driving a transition, or, policy alone cannot drive a transition
- triggers alone cannot drive a transition, or more specifically, crises alone do not suffice for driving a transition.

On formation forces

Innovation in social practices and innovation in technology (captured and represented by the formation forces) cannot alone drive a societal transition. This contradicts the technological determinism paradigm (discussed in Chapter 6, Section 6.2), which states that technology can drive social change and broader socio-technological transformations. Socio-technological studies neglect landscape pressures and developments when studying the phenomena of socio-technological transitions. We suggest that for understanding what drives societal transitions, a holistic system view is needed so as to also search for driving forces outside the society-technology coupling.

On support forces

Institutions matter when researching societal transitions. Support forces from the institutional subsystem exerted to other subsystems create support to existing regimes and to new practices. Support forces are present in every societal transition and are the expressions of either empowerment of a regime or of a new practice. We found that the legitimacy of changes is established via *standardization of practices*, and that support forces further manifest the regulating function of institutions in the form of *provision of resources*. The (initial) focus of the research society of societal transitions has been on understanding the phenomenon and on deriving policy strategies that can enable innovations to succeed and to breed {e.g. the functions of innovation systems' framework of Hekkert et al, 2007) and the strategic niche management approach of Schot et al (1994) & Hoogma et al, (2002)}. Support alone however does not suffice for a societal transition to be realized.

On triggers, on crises

Our research shows that common conceptions about triggers and especially crises need to be revisited. Crises are not necessarily the critical forces driving transitions and crises are not the only driving forces for societal transitions.

It is a common belief that crises are coupled with change or are seen to create opportunities for change. We argue that crises alone do not suffice for driving a societal transition. We observed that after a crisis or a trigger (such as a systemic failure) different forces follow and lead to intermediate changes. For a system to change more forces need to be present, to act synergistically upon the system regardless of their synchronous or asynchronous presence and impact.

Crises are seen to have a dual role in the evolution of societal systems: as constructive events that can stimulate change or as destructive events that relate to the collapse (or catastrophe) of the societal system or the system's breakdown.

In addition to this, the impact of crises differs based on the context and on the state of the system as such. After researching societal transitions with the Forces framework we can argue that crises are not necessarily and always the catalysts of change; but that the state of the system and the context catalyze the impact of a crisis in a system.

The statement that crises have a mono-directional impact to change relates to their conceptualization as an umbrella concept. For the majority of researchers, whatever causes shocks or perturbations in a system, or is not among the 'expected system's behavior', is termed a crisis. In our research, we realize that there are different types of triggers for societal transitions that shock and perturbate the system: systemic failures, crises[23] and exogenous events. Systems may undergo a societal transition when experiencing triggers other than crises.

In a nutshell: The understanding that different types of driving forces (formation, support forces and triggers) need to be in place for a societal transition to be realized suggests that the couplings of social change with innovation, resources and policy, and crises need to be revisited. For a societal transition, different types of forces need to be in place and they act synergistically even when experienced asynchronously.

7.1.2 Can forces alone explain how societal transitions unravel?

We mapped the evolution of the societal system in a conceptual cycle that includes three stages (genesis, stasis and metastasis). Our theoretical and empirical exploration revealed additional elements to the Evolution Cycle. The complementary elements are derived by induction of a special form: we infer theoretical constructs (conceptualizations) such as ***feedback loops*** from collected theoretical parts. We conceive every feedback loop to further enforce the phenomenon in place. We therefore position the (majority) of feedback loops to take place while the system is in the different stages of the Evolution Cycle of the Societal System.

When coupling the different feedback loops to the Evolution Cycle of the Societal System, we come across (see Figure 7.1):

Feedback Loops positioned at the Stasis stage and settled by support forces:

- **Institutional Self-Enforcement Loop**: Establishment of formal rules and institutionalization processes further facilitate and reinforce existing institutions.
- **Institutional Over-Reliance Loop:** Over-reliance on rules for governing social-ecological systems and changes. Rules are considered the only trustworthy means for explaining system behavior and for engineering the system.
- **Institutional Restraining Loop**: When formal rules and procedures are followed in a blindfolded manner that restricts any form of innovation, either organizational or technological, to be evaluated or to be introduced to the system, the system experiences an institutional restraining loop.
- **Technological Lock-In Loop:** When a technology becomes dominant and cannot be overruled or substituted by other technologies –even when the dominant technology is inferior to new technologies- due to continuous support it gains (either institutional support or market support {e.g. increased demand}).

Feedback Loops positioned at the Genesis and settled by formation forces:

- **Anarchy Loop:** Niches and innovative practices interact without preexisting relationship and without formal institutional structuring.

Feedback Loops positioned at the Metastasis and settled by triggers:

- **Deinstitutionalization Loop**: Institutional decay due to eroding legitimacy of an institutional system (rephrasing Oliver, 1992).
- **Catastrophe Loop**: Decay and irreversible destruction of a social-ecological system.

In addition to the feedback loops, we inferred and therefore include processes that stream the system from one stage to another complementary to the shifting processes that constitute the Evolution Cycle. Those processes are presented below.

[23] Especially for crises, we operationalize and categorize the different types of crises (see Appendix B, Section B3 and Box B.1) so as to be consistent and verifiable when translating an event in the field into a crisis in our empirical exploration of societal transitions.

Processes that stream the system from one stage to another:

- **Institutionalization:** Institutionalization is the process of settling a system of rules formally. Institutionalization routes the system from the genesis stage to the stasis stage and is established by support forces.
- **Stewardship Loop:** Adoption of sustainable practices by local communities when dealing with the ecosystem that are further institutionalized and updated regularly without the trigger of shocks or crises. The stewardship loop takes place between the stasis and the genesis stages and is settled by support and formation forces respectively.
- **Demand-pull bypass:** The process in which demand drives the socio-technological transition (without the presence of any trigger). Demand-pull routes the system from the stasis stage to the genesis stage and is established by formation forces.

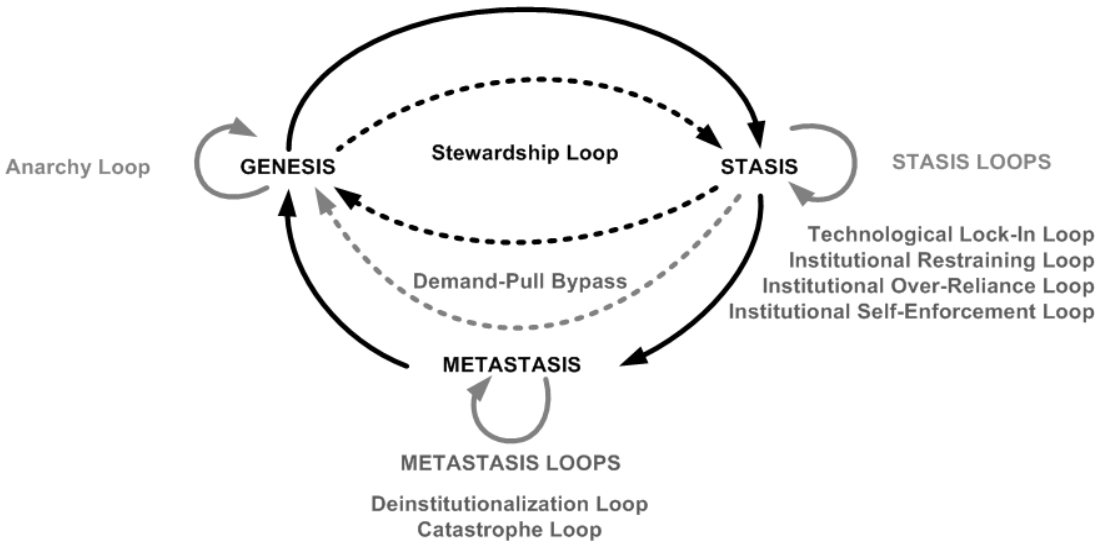


Figure 7.1: The Evolution Cycle of the Societal System including all the feedback loops and processes that explain shifting and dynamic equilibria.

With these we revisit the conceptual proposition of the Transition Approach that a transition is a process of slow and fast dynamics, or more specifically, "the result of long-term developments in stocks and short-term developments in flows" (...) and " the whole picture therefore, forms a hybrid mixture of fast and slow dynamics" (Rotmans and Loorbach, 2010a, p.129).

Additionally, we conclude that there is no stable state of the system hence no stable equilibria. The societal system undergoes continuous change even when it is at equilibrium; that is, a dynamic equilibrium. This implies that the system is always subject to different types of alterations.

In our conceptual model, the Evolution Cycle of the Societal System, the stages represent dynamic equilibria characterized by slow dynamics and the shifting processes (from one stage to the other) are characterized by fast dynamics[24]. Processes like institutionalization, demand-pull bypass and the like are characterized by fast dynamics. The feedback loops show that specific forces may give rise to emergent patterns mapped in the form of feedback loops, creating in this way different types of dynamics. We argue that feedback loops represent special types of dynamic equilibria with slow dynamics.

[24] Fast and slow dynamics refer to the pace of change or speed of change that takes place in the system.

7.1.3 Are the different types of transitions (institutional, social-ecological and socio-technological) empirically recognized and corroborated?

7.1.4 What other types of transitions can take place in institutional systems, in social-ecological systems and in socio-technological systems?

These two research questions could not be answered independently, given that the answer to question 7.1.4 is directly linked to the empirical explorations and the insights that respond to question 7.1.3. We therefore chose to respond to these two questions jointly.

We can think of overall transitions as long-term processes that include different episodes of change, which are different types of societal transitions. Unfolding a societal transition as a long-term process with different episodes of change implies that different aspects of change need to be considered at different times. We defined three types of societal transition:

- We define an **institutional transition** as a type of societal transition in which the forces at play have an impact on the institutions and civil society or, using a mechanical analogue of a force as a vector, the forces at play are exerted at institutions and civil society. In a similar way:
- We define a **social-ecological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and the environment.
- We define a **socio-technological transition** as a type of societal transition in which the forces at play have an impact on the institutions, civil society and technology.

The different types of transitions as episodes of an overall transition can occur in different sequences and durations. Understanding that a societal system can undergo different types of transitions (different episodes of change) has additional implications for the research on transitions and transition dynamics and for the governance of societal transitions.

- Different forces are critical in different types of societal transitions. Critical forces do not only differ between systems and contexts but also between different types of change.
- Given that the main difference between the different transition types is what changes in the system, different aspects of change have to be taken into account and different instruments need to be devised for facilitating a transition.

The case studies that are analyzed in Chapters 4 and 5[25] aimed primarily at applying and testing the usefulness and explanatory potential of the Forces conceptual framework in detangling what constitutes the dynamics of societal transitions. The case studies served also as the empirical ground for understanding how a system can evolve towards a transition.

Our expectations were that every case would relate to a different type of transition. At the same time, we took to heart the criticism that the Transitions Approach and Transition Thinking in general is a context-biased approach – namely, a Dutch approach-; hence we decided to research non-Dutch cases as well.

Our findings did not match our expectations. The water management system in the Netherlands – focusing on the Rhine river and its branches- experienced an institutional transition despite the strong concerns on rising water level in the river. Institutional dynamics prevail.

[25] As we introduced in Chapter 2, part of our research methodology is to test the Forces framework in published cases. The published cases with their re-interpretation using the conceptual framework (especially the Forces Framework) are presented in a separate appendix (Appendix C, Tables C1 for institutional transitions, C2 for social-ecological transitions and C3 for socio-technological transitions).

The same holds for the environmental protection system in Greece. The Acheloos river diversion project appears as an infrastructure fix to a persistent problem of water shortage for irrigation experienced in Thessaly plain. The two social-ecological systems – the Acheloos river basin and the agricultural system of Thessaly plain- are only linked via the diversion project: they are not directly related (they do not even share the same water table). However the diversion project proposes to employ the Acheloos river basin system as a service to the agricultural system. What our analysis shows is that the competitive relation between the quests for sustainability of two different social-ecological systems was experienced as an institutional transition in the environmental protection system and not as a social-ecological transition. The existing data on the Greek case reveal that environmentally related triggers such as recent droughts have not been reported; while changes in resources flow, environmental protection and impact assessment institutions have been established. Institutional dynamics prevail and the system experiences an institutional transition.

The energy (supply) transition case in Greece revealed that the system undergoes an institutional transition. Despite the fact that technological push was present, technological changes and progress in the energy supply technologies were not driving the transition. The change of the energy system has been oriented and driven by the institutional and market changes and not by technology. Institutional dynamics prevailed once more.

As shown in Table 7.1, all three cases showed that different systems can experience the same type of societal transition. We perceive this as a success for our conceptual framework –the Forces framework- that showed its analytical potential by pointing at the forces and the subsystems upon which they act and showing this variation in system's behavior. Our research lacks a case on socio-technological transitions. We have to note here that limited time restricted our search for a case on socio-technological transitions. The published cases presented in Appendix C provided the empirical grounds for our analysis of socio-technological transitions.

Table 7.1: Positioning the case studies in the transition type versus system space.

	TYPE OF SOCIETAL TRANSITION		
TYPE OF SYSTEM	Institutional	Social-ecological	Socio-technological
Institutional			
Social-ecological	- The water management system of the Rhine River in the Netherlands - The environmental protection system of the Acheloos river in Greece	- The Great Brak River Management System transition in South Africa	
Socio-technological	- The energy (supply) system transition in Greece		

Where you can have it all: Social-ecological systems can experience all the types of transitions that we identified. This is not a surprise. The earth is a social-ecological system and that makes us realize that our human interventions, inventions and developments can undergo different pathways but always takes place within the earth system. At a local or regional scale, a river basin system is a social-ecological system, but it can experience all the types of transitions: institutional, social-ecological and socio-technological. It thus requires a very careful and consistent assessment of what changes in a system to realize what type of transition it experiences. In order to achieve this, the analyst should not limit attention to the initially defined system when change takes place outside the initial system boundary; hence a reconsideration of the system boundary is suggested.

For example, the stimuli for change in a social-ecological system may often be an environmental-related event (e.g. a drought). The type of transition that the system may undergo, however, is depicted on the subsystem that experiences fundamental changes/restructuring. The trigger may be a flood in a social-ecological system and the changes may all concern institutions and policies, hence it will be tagged as an institutional change.

7.1.5 Can the Evolution Cycle of the Societal System capture the complex co-evolution of a societal system that undergoes a societal transition?

In our research, we conceptualize a transition to be a continuous process that takes place in different stages. The system adapts to its context and adapts its function via its evolution cycle. The continuous cyclic processes of the societal system result in a fundamental change of the societal system over time. A societal transition is the outcome of the continuous cyclic processes of evolution of the societal system over time.

During the continuous cyclic evolution process, different subsystems of the system co-evolve and change. The Evolution Cycle provides the set of processes (shifting processes, stages and feedback loops) that can describe the evolution of one subsystem or one regime in co-evolution with another subsystem or another regime respectively. For every subsystem or regime different cycles can describe the continuous evolution that is set in place by forces. The driving forces however can set in place different cycles of different subsystems or regimes.

Hence, our conceptualization describes how co-evolution of different subsystems or different regimes can take place. We describe interacting sub-systems or regimes and their respective dynamics during their co-evolution; explicitly stating that the two interacting constellations are altered significantly over the course of a transition. With this we confront the argument made by van den Bergh et al (2011, p.11) (citing Winder et al (2005)) that the Transitions Approach understood co-evolution as non-evolutionary dynamics or, better, “co-dynamics” (implying that the different subsystems or regimes both change but without showing mutual interdependence).

An analysis of the different elements of the system that can co-evolve and how they can be analyzed by the conceptual tools is presented in the following section.

7.1.6 How is co-evolution between the different elements of the societal system mapped in the Evolution Cycle of the Societal System?

We conceptualize co-evolution to take place between different subsystems and between different regimes (more precisely different types of regimes). First, the co-evolution of the different subsystems of the societal system can be mapped with different cycles that can also relate to different types of transitions. This complements (and partially agrees with) the point that co-evolution means “that a complex system co-evolves with its environment (which in turn consists of complex systems)” (Rotmans and Loorbach, 2010a, p.118).

Second, the co-evolution of the different regimes can be mapped with different cycles. It requires however a way to differentiate between the regimes. For the Greek Acheloos River Protection case study we observed that different regimes were in place and co-evolved: the environmental protection regime and the water management regime (Chapter 4, Section 4.4.2). At the same time we realize that the conceptualization of De Haan (2010) of a regime as a dominant constellation in a system can be used to distinguish different types of regimes. In our research we specified two types of regimes: *policy regimes* and *issue related regimes*. Policy regimes are dominant constellations of a specific policy domain (e.g. energy, water) and issue related regimes are dominant constellations of a specific issue or interest that settle with policies from different policy domains. Our analysis of different regimes that co-evolve also shows that forces can set in motion different evolution cycles synchronously.

Due to the level of aggregation that we have chosen, we could not analyze the co-evolution between different practices (e.g. hybridization). The analysis and detection of the process of co-evolution between different practices remains an issue for future research.

7.2 Theoretical implications of understanding transition dynamics for systems resilience

Resilience does not imply resistance to change. Resilience can be perceived as a property of a system that defines its robustness and reliability. From a systems thinking perspective, "resilience arises from a rich structure of many feedback loops that can work in different ways to restore a system even after a large perturbation" (Meadows, 2009, p.76). Especially for ecological subsystems, resilience is desirable and associated strongly to sustainability. What is problematic from a transition perspective is when a system is resilient while being at an unsustainable state, and in this case, resilience is framed as persistence to unsustainability (reformulating Rotmans and Loorbach, 2010a on persistent problems). Within the context of societal system transitions we rethink resilience, and we relate the adaptive and transformative capacity of a system to the different processes that comprise our Evolution Cycle of the Societal System. More specifically:

(a) How resilience is built within the system is represented by the metabolic processes of the system. Metabolic processes are the processes regulating the behavior of the system and are ever present whether or not there are external or internal disturbances. Metabolic processes are systemic and inherent to the system and serve to maintain it in its existing, yet dynamic state and relate to a system's *adaptive capacity*.

    In our conceptualization of the system evolution as a cyclic process (Evolution Cycle of the Societal System), the processes and feedback loops that settle or enforce the dynamic equilibria (the stages) of the system can be considered as metabolic processes of the system (See Table 7.2). Such processes cannot be easily altered or overruled since they are inherent to the system and self-organize.

(b) For system shifts such as societal transitions, transformation processes drive and produce the shift. Transformative processes relate to the transformative capacity of the system and to the ability of the system to shift to another state (hence to change in a radical way).

    In our conceptualization, a societal transition is the result of the continuous cyclic evolution of the societal system in a process of alternating slow and fast dynamics. Looking at the Evolution Cycle of the Societal System, *shifting processes* from one stage to the other are responsible for system shifts. Those processes and by-pass processes relate to the transformative capacity of the system (See Table 7.2).

In this way we relate processes (conceptualized at a meta-level of aggregation) and feedback loops to the adaptive and transformative capacity of the system in relation to ecological, social (civil-society), institutional and technological responses and subsystems.

Table 7.2: Rethinking resilience with the lens of the transition dynamics. Processes and feedback loops that are related to the systemic and post-transformative resilience of a societal system.

	FEEDBACK LOOPS AND PROCESSES OF THE EVOLUTION CYCLE OF THE SOCIETAL SYSTEM	
RESILIENCE	Processes	Feedback Loops
Metabolic Processes (constituting system's adaptive capacity)	Genesis Stage Processes (Dynamic Equilibrium) Stasis Stage Processes (Dynamic Equilibrium) Metastasis Processes (Dynamic Equilirium)	Institutional Self-Enforcement Loop Institutional Exclusive Reliance Loop Institutional Restraining Loop Technological-Lock-In Loop
Transformative Processes (constituting system's transformative capacity)	Shifting Processes Institutionalization Process Stewardship Loop Demand-pull bypass process	

7.3 Additional findings from the analysis with feedback loops as underlying the dynamics of societal transitions

In this section we present additional findings that concern the feedback loops and the implications they have for the analysis of societal transitions. In particular, we answer the question: what does understanding the dynamics of transitions in the form of forces, feedback loops and tipping forces mean for existing theory on transitions, for existing theory on social phenomena, and on governance?

Understanding that dynamics of societal transitions are produced from the feedback loops means that we further understand what it implies for the enforcement of specific stages and what impact specific forces may have on the establishment of and lock-out from feedback loops.

Feedback loops reveal special types of forces: Critical Forces and Tipping Forces

The points of entry to a feedback loop are system dependent. For every system there is a different force that signifies its entry to a loop and its exit from a loop. We consider as critical forces the forces associated with the entry and exit of a system from a feedback loop. For every case study we have identified the critical forces that relate to the different processes and to the different feedback loops (Table 7.2). What we conclude is that there is no homogeneity in the critical forces of the same loops. For example, different forces may signify the entry and exit of self-enforcement loops even in the same system.

Table 7.3: Case Studies of Societal Transitions researched in the present thesis. Overview of types of transitions, feedback loops and associated critical forces.

CASE STUDY	Type of System	Type of Transition	Feedback Loop	Critical Forces
Water management transition in the Netherlands	Social-Ecological	Institutional	Institutionalization Process (2003-2008)	Break-In-Force: Standardization of practices Break-Out-Force: Standardization of practices
Greek Environmental Protection Transition	Socio-Ecological	Institutional	Self-Enforcement of the Environmental Protection Regime (1985-2000)	Break-In-Force: Institutional Change Break-Out-Force: Standardization of practices & Systemic failure
			Self-Enforcement Loop of Environmental Protection Regime with Thick Institutionalization (2002-2006)	Break-In-Force: Standardization of practices Break-Out-Force: Standardization of practices
			Institutionalization Process of the Water Management Regime (2000-2007)	Break-In-Force: Standardization of practices Break-Out-Force: Institutional Change
			Self-Enforcement Loop for the Acheloos Diversion Project (1991-2006)	Break-In-Force: Provision of Resources Break-Out-Force: Provision of resources
			Institutionalization process for the Acheloos Diversion Project (Energy Regime) (2006-2009)	Break-In-Force: Exercise of power Break-Out-Force: Provision of resources
			Institutionalization Process related to the Acheloos River Restoration (anti-Acheloos Diversion Project) Issue (1994-2000)	Break-In-Force: Exercise of power Break-Out-Force: Standardization of practices
			Self-Enforcement Loop of the Acheloos river Restoration Issue (anti-ADP) (2005-2010)	Break-In-Force: Exercise of power Break-Out-Force: Exercise of power
Greek Energy Transition	Socio-Technological	Institutional	Liberalization Self-Enforcement (1999-2006)	Break-In-Force: Institutional Change Break-Out-Force: Standardization of Practices
			Self-Enforcement with thick institutionalization (2006-2010)	Break-In-Force: Standardization of Practices (on-going)
Coastal Management Transition, South Africa	Social-Ecological	Social-Ecological	Stewardship Loop (2000-2004)	Break-In-Force: Standardization of practices Break-Out-Force: Standardization of Practices (on-going)

Tipping Forces: From our empirical exploration of the institutional transition in the environmental protection system in Greece, we observed two forces that had a significant impact on setting in motion processes in one regime and/or multiple regimes while dampening processes in another regime simultaneously (Box 7.1). These forces can be considered as tipping forces, forces that tip the system towards a new state of dynamics since they influence different regimes at the same time in similar or different ways.

Box 7.1: Tipping Forces of the Environmental Protection Institutional Transition in Greece (presented also in Chapter 4).

- **Tipping force - Standardization of Practices (2000):** The GR 3478/2000 State Court Decision event is a critical event for the transition under study. First it signals the break-out from the self-enforcement loop of the environmental protection regime (1985-2000). Second, it is the break-out or termination of the institutionalization process of the Acheloos River Restoration (1994-2000). We argue that the GR 3478/2000 State Court Decision is a critical event to this process (as well), since it is the last decision that gave support to the cancellation of the Acheloos Diversion Project based on arguments of insufficient assessment of environmental impacts. This force meant the termination of the institutionalization process and the entry of the system to a stasis stage.

- **Tipping force- Exercise of Power (2005):** The 2005 State Court Decisions (GR 1688/2005 and 1691/2005) showed that the Environmental Impact Assessment study cannot be approved due to incompliance with environmental protection and water management criteria. This force is critical to the transition under analysis for two reasons: First, it signals the self-enforcement loop of the Acheloos River Restoration Issue (anti-ADP) (2005-2010) as its break-in-force. Second, it triggers the initiation of an institutionalization process of the Acheloos Diversion Project (2006-2009) (but it is not as its break-in-force).

Contextuality and Criticality

By understanding the feedback loops as key elements in the dynamics of societal transitions, we can further dissect what the contextuality and criticality of transition dynamics means from a systems perspective.

The ***contextuality of transition dynamics*** refers to the impact of context on the dynamics, and this impact is fourfold. First, in every context different forces are critical for the transition. Second, the duration and the function of every feedback loop depend on the context and on the system in a synergistic way. A societal system may experience an excess of support forces that settle an institutional loop, but the function that this loop may exert to the system under transition depends on both the context and the system itself. Third, even when the same type of transition is experienced in the same types of systems (e.g. the Acheloos River System and the Rhine River System as social-ecological systems experiencing institutional transitions) contextuality can be evinced by the different feedback loops, the variety of evolution cycles present and/or the different archetypical responses. Fourth, the same feedback loop may be initiated by a different force even in the same system due to the contextual influence. This is also observed in the different self-enforcement loops present in the institutional transitions that we researched (see Table 7.3).

Additionally, in different systems and in different contexts different forces are critical for the break-in and break-out from a feedback loop. A specific critical force or a tipping force is not universal for the system under transition: a force that is critical at a specific time in a system may not be critical later in the system.

7.4 Governance limitations based on knowledge of dynamics of societal transitions

We elaborate on the way that the dynamics of societal transitions can constrain the possibilities for policy makers to initiate, stimulate or influence a societal transition. We start with the presentation and explanation of the governance limitations so as to set the scene and the boundaries that governance approaches have to consider for initiating, stimulating or influencing societal transitions. We draw upon lessons from empirical and theoretical evidence and from case studies for every type of societal transition. The limitations are also categorized into two main clusters: limitations arising from characteristics of the societal system and limitations arising from the dynamics of the societal transitions.

Governance limitations for institutional transitions

Institutional transitions are long-term processes that imply limitations to the degree and type of policy intervention. Public administration research and policy science research have dealt with the inherent characteristics of institutions that relate to limitations for interventions. In this paragraph, we will briefly present the key limitations for orienting institutional transitions:

Late materialization of intervention: Institutions, as social constructs that include formal rules and procedures, take a long time not only to be constituted but also to change. Changes in institutions produce outcomes, in the form of institutional functions and policy developments, which are materialized over the long run and not immediately after institutional changes.

Institutional inertia as inherent response: Institutions change slowly. The pace of change and the types of change that an institutional structure can undergo depend on the starting conditions and setting of the institution (see Douglas, 1986; Lane, 1997). Institutions resist change and more particularly the way they are organized and function cannot be changed without external intervention or pressure from powerful actors. Institutional inertia may be supported by dominant actors, whose goals or functions are linked and related strongly with the existing situation, thus averting change (Scharpf, 1997, p.41-42).

Illusion of control: Institutions as social constructs both influence societal practices and routines and respond by remaining receptive and reflexive to societal demands and values (see also Fisher, 1993). This is addressed and described as the duality of structure by Giddens (1984) and is the core model of structuration theory. Institutions thus change in response to changes in values and demands of the society, and institutional changes may indirectly stimulate or produce changes in routines and practices. This duality, however, does not imply that by controlling or changing the institutions a social control or influence can be maintained. Institutional change has to be in response to and reflexive to societal conditions. Illusion of control of the societal sphere via the institutions may give ground to non-democratic movements or dictator regimes that use institutional changes as instruments in order to capitalize power and their own interests.

Governance limitations for social-ecological systems and social-ecological transitions

Social-ecological transitions challenge not only institutions but also researchers given the immanent complexity and the complex dynamics of change that characterize social-ecological systems. The first two limitations described in the following paragraphs concern the inherent characteristics of social-ecological systems: resilience and vulnerability. The following two limitations relate to the governance practices of social-ecological systems, namely the tendency of over-institutionalization and the contextuality of technology and market fixes.

Resilient or self-sustaining systems that resist intervention: Social-ecological systems are complex adaptive systems that are characterized by their tendency to self-organize (Abel, Cumming, and Anderies, 2006). This inherent characteristic of social-ecological systems limits governmental intervention. However this does not mean that action to protect social-ecological systems is not possible or unnecessary.

Vulnerability of social-ecological systems towards collapse: Social-ecological systems are so interdependent and interlinked that a crisis that is not effectively treated might escalate to collapse. Hence, a crisis in combination with mal-practices or insufficient function of institutions (given the complex dynamics of the system) may lead to the collapse of the system. This implies that inadequate governance (in the form of ineffective policies and/or unfit institutions) may result in a collapse of the system.

Contextuality of technology and/or market fixes for social-ecological systems: Technology and market fixes imply instrinsic limitations for social-ecological systems and social-ecological transitions. A practice that has proven successful in a given context needs to be modified so as to comply with the characteristics of the destination context. An example for such context particularities comes from fisheries management where the adoption of quotas has been successful in Canada and in the United States (see the California Sacramento case as reviewed by Repetto, 2006) but its application is questionable for developing countries in Africa.

Overreliance or exclusive reliance on institutions as an institutional trap: Over-reliance or exclusive reliance on institutions has a twofold limitation. When a system experiences a social-ecological transition, then over-reliance on institutions may mean that ecosystem dynamics are overlooked and ineffectively treated and managed. The other point to this, is when a social-ecological system is under a prolonged institutional transition and ecosystem dynamics are only managed via rule-systems resulting in neglecting ecosystem dynamics (Frantzeskaki, Slinger, Vreugdenhil, and van Daalen, 2010).

In an over-institutionalized system (that over-relies on rules), the stringent focus on safeguarding societal demands results in neglecting the inherent dynamics of the system. When societal dynamics dominate in the form of institutionalization of practices and resources, ecological dynamics are neglected. Another extreme case of over-institutionalization may also be the overprotection of the ecological system at the expense of the social system (Frantzeskaki, Slinger, Vreugdenhil, and van Daalen, 2010).

Governance limitations for socio-technological transitions

Socio-technological transitions unfold in different patterns (Geels and Schot, 2007) but the technological artifacts and systems in every socio-technological transition are indicative for the context and the epoch to which they belong. Technology depicts the societal trends, demands and conventions of the generation by which it is used and vice versa: societal routines and lifestyles are framed and influenced by the technology that existed at that time. Technology and its role in socio-technological system transitions however are confronted by two limitations:

Technocracy: Technological successes and benefits are acknowledged and recognized in modern societies. Technology however is a means to ease and aid humans and not a goal in itself. A monolithic focus on technological performance and belief in technological fixes may restrain the societal system from investigating integrative options to deal with complex persistent problems. What we therefore suggest is to not blindly search for technological fixes while overlooking the societal dynamics (of every system and every problem) but to adopt a holistic view of the system considering both societal and technological dynamics.

Limits of technology: Modern persistent problems such as those brought forth by climate change challenge research and technology systems. Both understanding the problem scientifically and finding technological solutions to address it with are failing. Even though such problems are seen as challenges by researchers and technology developers, the current state of technology is proving insufficient. This is a governance limitation when intervention efforts focus on technology and relating technology fixes only.

7.5 Governance propositions based on knowledge of dynamics of societal transitions

Research on transition dynamics was so far not explicitly connected to nor informed Transition Management practices. Our research resulted in a number of contributions that address both the understanding of the nature of transitions and inform Transition Management.

In this section we will present how our knowledge of transition dynamics can inform governance and complement an existing Transition Management tenet (Box 1.3). We respond to the research question:

What do the characteristics and dynamics of transitions reflect to the possibilities to influence them?

We employ the insights we gained by researching transition dynamics to derive governance propositions for promoting ***sustainability transitions***. Governance interventions are best devised in such a way that they adhere to the dynamics of the system. The governance propositions that we derive from our understanding of transition dynamics inform and operationalize the Transition Management tenet (Chapter1, Box 1.3) (Loorbach, 2010):

"Dynamics of the system create feasible and unfeasible means of governance"

We present the following propositions concerning governance for societal transitions that relate to the aspects of the dynamics that have been brought forward by our research (synergy of forces, feedback loops, types of transitions, antagonistic processes to transitions, tipping forces, system resilience and co-evolution):

Governance takes <u>into account</u>:	
SYNERGY OF FORCES	**<u>Governance Proposition 1:</u>** Governance for societal transitions has to strive to produce both formation forces and support forces and to reveal triggers for initiating or setting a transition in motion.
SYSTEM'S REGULARITIES// FEEDBACK LOOPS	**<u>Governance Proposition 2:</u>** Governance for societal transitions has to employ means that mimic the dynamics of transitions in order to internally change the system in a fundamental way.
TYPE OF ON-GOING TRANSITION	**<u>Governance Proposition 3:</u>** In a system that undergoes a specific type of transition, means that are homologous[26] to the system dynamics have to be employed in order to facilitate the on-going transition.
HAMPERING SUSTAINABILITY & ANTAGONISTIC PROCESSES	**<u>Governance Proposition 4:</u>** Governance for societal transitions has to consider (and if possible anticipate) the existence of and the impact of antagonistic or hampering processes and constellations on the societal system.

[26] Definition of homologous: Homologous: having the same relative position, value, or structure.

In the following paragraphs we elaborate on each governance proposition.

> Governance Proposition 1:
> Governance for societal transitions has to strive to produce both formation forces and support forces and to reveal triggers for initiating or setting a transition in motion.

From our research we concluded that for a societal transition to come about, formation forces and support forces and triggers need to be present. We thus propose that governance efforts need to establish all the different types of forces. Considering the triggers, we propose to have in place means that can reveal and/or anticipate triggers (e.g. monitoring and evaluation, mechanisms that inform policy reflexes).

By focusing the governance efforts on establishing the different types of forces, we imply that shifting processes from one dynamic equilibrium to another are important for societal transitions. This is in line with the management proposition of Transition Management that suggests the following: "managing a complex adaptive system means using disequilibria rather than equilibria" (Rotmans and Loorbach, 2010a, p.143). Our research shows what type of drivers can shift the system from one dynamic equilibrium to another which is required for societal transitions to be on the move.

Before explaining governance propositions 2 and 3 we need to explain that:
- Understanding system resilience in the form of stages and feedback loops may appear to be the underlying explanation of system lock-in. We want to emphasize that these processes explain system evolution even when it happens incrementally on the short term.
- Attempts to change a system that aim at disturbing its dynamics and underlying processes may prove ineffective; especially in systems that tend to self-organize and self-regulate.

Hence, we complement governance efforts that aim at disturbing the system with two governance propositions that focus on using the existing dynamics and self-organization of the system so as to incrementally change it in the short-term, with the objective of radically altering it in the long-term.

> Governance Proposition 2:
> Governance for societal transitions has to employ means that mimic the dynamics of transitions in order to internally change the system in a fundamental way.

We understand a societal transition to unfold as a cyclic process of continuous evolution of different subsystems of the societal system (subsystems) that alternate slow and fast dynamics. The societal system experiences slow and fast dynamics in the form of shifting processes and stages (that are dynamic equilibria) and feedback loops. Our research suggests that when a system is anchored (or entrenched) in a dynamic equilibrium, then the dynamics exerted during the dynamic equilibrium allow only forces that establish them to dominate. When a system is entrenched in a dynamic equilibrium, only marginal changes can be realized by the same type of forces that empower the dynamic equilibria, and efforts for break-out of the equilibirum may prove unsuccessful.

We propose that the governance has to employ means that mimic the behavior of the system, especially when feedback loops dominate behavior. When a system is dominated by a loop, then the same forces that create the loop can change it by feeding into it. For example, in a system with exclusive reliance institutional loops, any attempt to break-out by revealing systemic failures or exogenous events (that can create a shift to a new stage) may prove ineffective. A system that is highly institutionalized cannot easily break out of its existing deep structure. The feedback loops can be the manifestations of the entrenchment of the system into a deep institutional whirl. Hence, only the same type of forces that create the loop can be accepted in and by the system. We thus propose that for such a system, a new policy (for example standardization of practices) or corrective measures that incrementally alter the system can be successfully placed and feed in the existing feedback loops. With this incremental alteration, the system may seek other means and other practices in return and in

this way open up to more changes and alterations that on the long term will result in a fundamentally different system.

We observe such a behavior in the energy transition case in Greece (Chapter 4, Section 4.4.3). Crises and societal unease were unable to change the systems behavior from a purely institutional to a more socio-technological or social-ecological transition. The institutionalization loops are prevailing and dominate the overall function and change process, meaning that change happens only through institutions.

To summarize, for facilitating societal transitions in a system that is entrenched in a stage (dynamic equilibrium) or a feedback loop, the same type of forces that create the dynamic equilibrium can change it by feeding into it. Governance efforts need to focus on how to mimic and/or to feed into the dynamic equilibrium in order to change it and consequently transform the societal system; instead of only waiting for a niche innovation whether spontaneous or deliberatively empowered to replace the existing regime.

> Governance Proposition 3:
> In a system that undergoes a specific type of transition, means that are homologous[27] to the system dynamics have to be employed in order to facilitate the on-going transition.

A (overall) societal transition is a long-term process of fundamental change that unfolds in episodes of change, each one of which has different types of dynamics. Governance efforts need to consider the present episode of change that a system experiences. For example, when a system experiences an institutional transition, governance strategies need to focus on the institutional subsystem and employ means homologous to the forces that drive the transition (e.g. rule-oriented, organizational, or market-oriented). In the same vein, when a system undergoes a social-ecological transition, governance strategies need to address both ecosystem dynamics and social dynamics in a balanced way.

Propositions 2 and 3 suggest that governance means need to not disrupt the dynamics of the system. We must note that these propositions are complementary to governance efforts that aim at shifting the system to a new stage (a new dynamic equilibrium) and/or to a new type of transition (e.g. when a system experiences a social-ecological transition, revealing the potential or benefits of technology may benefit the system and further facilitate the overall transition). We only argue that a governance focus upon means to shift the system may prove ineffective in the face of system dynamics (stages and feedback loops) that are dominant and self-organizing.

> Governance Proposition 4:
> Governance for societal transitions has to consider (and if possible anticipate) the existence of and the impact of antagonistic or hampering processes and constellations on the societal system.

In a societal transition, dynamics that evoke change may be counterbalanced by dynamics that resist it. Counter-forces or processes that burden the transition to sustainable development may be in place, and consequently countervail or hamper any effort towards sustainability. In a complex system such as society, different processes and drivers are in action. These do not necessarily favor sustainability transitions (Frantzeskaki, Loorbach and Meadowcroft, 2012-forthcoming).

For governance efforts to be effective, a broadening of the analysis is required so as to reveal both evoking and hampering dynamics. Broadening refers to focusing the analysis and the influence efforts not only to the regime or system that is to be empowered or supported but also to the counter effecting regimes or niches that are at play in the neighborhood of the regime or system at study. The focus, for

[27] Definition of homologous: Homologous: having the same relative position, value, or structure.

example, on one regime may prove insufficient if hampering processes (hampering loops), or competing regimes (or niche-regimes, de Haan, 2010) are in place.

Our empirical exploration of the environmental protection transition in Greece reveals that a transition takes place at a battlefield between supporters and opponents of the Acheloos Diversion Project (Chapter 4, Section 4.2). The opponents of the Acheloos Diversion Project that consider the Acheloos River Restoration as a key issue (opposing the diversion) thus using the environmental protection regulation as a manifesto against the diversion project. The supporters of the Acheloos Diversion Project employ the environmental regulation and especially the environmental impact assessment standards as pre-requirements to a large infrastructure project, and strategically support the perception that the Acheloos river is an infrastructure system and not a social-ecological system. This is manifested by self-enforcement loops mainly constituted by exercise of power and provision of resources. The self-enforcement loops in one regime are counter-balanced by self-enforcement loops in the opposing regime.

What we observe is that forces are involved in feedback loops that foment regimes that are in continuous competition; meaning that drivers and counter-drivers/barriers are set in place.

Governance efforts thus need to consider both enforcing and empowering the new practice or the new regime that has the potential to improve the system's sustainability, while at the same time depowering or deinstitutionalizing the antagonistic (to sustainability) regime. Governance efforts that only attempt to empower or institutionalize new regimes may prove insufficient in a 'battlefield' of system transitions.

7.6 Societal transitions and persistent problems: Revisiting persistence and co-evolution

Do problems evolve, persist or co-evolve with the system? Co-evolution takes place between the different subsystems and between different regimes over a long period of time, resulting in a transition. This implies that the system changes drastically (during the evolution) due to the co-evolutionary processes. In view of this, we need to revisit whether the problem that triggered the process of transition has been persistent or has changed over time.

We suggest revisiting two core conceptualizations that consider the relation between persistent problems and societal transitions:

(a) Persistent problems are complex problems that tend to reappear if not dealt with adequately and effectively. This implies that persistent problems are immune to time if not treated.

What we see is that persistent problems evolve over time. This is consistent with our understanding of persistent problems. We conceptualize that persistent problems are rooted in the structure of the system; when the system or different subsystems evolve and transform over time, the problems relating to the structure of the system also evolve. We propose to consider the following: In a context where societal systems co-evolve with other systems or their context (or subsystems co-evolve with other subsystems), problems that are rooted into the structure of the system also evolve over time. This means that persistent problems are not immune to time but tend to co-evolve with the system under study. The evolution of problems further contributes to (and explains) their complexity.

Such an evolution of a complex problem as a result of its co-evolution with the system under study is described in the Dutch water management case and in the Greek energy transition case. The Dutch water management transition undergoes an institutional transition, with a number of new policies and new administrative bodies settling over the course of the transition. The persistent problem that was experienced is the (expected) rising water discharges of the Rhine and its rivers in a spatial context of limited space. The institutional transition set in place new institutions and a new paradigm of giving space back to the river instead of claiming space from the river by constraining it with dikes only. The

persistent problem has co-evolved with the water management system and it appears as a safety problem around both dike-protected areas and inundation areas.

In the Greek energy transition case we observe an institutional transition that included two liberalization loops, one of which still continues now. The persistent problem that was experienced is the dependency of the electricity energy system upon fossil fuels. The institutional transition resulted in new forms of institutions and new rules for the electricity market, setting the scene for new market interactions and mechanisms. The persistent problem has also co-evolved with the energy system and now it appears as an issue of acceptance of renewable energy technologies by the public and by the local authorities (rather than a general dichotomous view of fossil fuels versus renewable energy).

(b) A societal transition as a fundamental change can be or may be the treatment to persistent problems. This implies that after a transition has materialized or a transformative change has taken place, a persistent problem may be lessened or erode.

What we observe in the Greek environmental protection transition case (Chapter 4, Section 4.2.2) is that the persistent problem reappears despite the fact that the system has been transformed. Looking at the initial trigger of the Acheloos diversion project, that is the water shortages in Thessaly plain, we seem due for a re-investigation and assessment not only of the water balance of the Thessaly plain but also of the effectiveness of the Acheloos diversion project towards this water balance problem. Since the initiation of the Acheloos diversion project in 1964, the environmental protection regime, the water management regime and the energy regime have co-evolved and transformed the environmental protection institutional subsystem in Greece. At the same time, the newly established regimes of Environmental Protection and Water Management function in the context of new societal goals like the Acheloos River Restoration and old goals like the Acheloos River Diversion Project. Newly-established regimes tend to fight for support and legitimacy while old regimes tend to resist change and fight back against any new development. Regimes multiplied and the problem that needed to be addressed is now related to multiple regimes and consequently becomes more and more complex. In this case, the complex problem of water shortages in the Thessaly plain that was the initial (old but persistent) problem remains unaddressed and its fix –which remains the Acheloos Diversion Project- is now addressed by multiple regimes and complex interests. To conclude, the persistent problem not only was not lessened but it got more complex and it magnified, even though a transition has been realized.

There is one paradox and one potential explanation that relate to this observation. The paradox is that the regimes that transformed over the years (environmental protection regime, water management regime) are transformed towards a sustainable state (i.e. there are policies and institutions settled in the environmental protection regime that comply with and adopt sustainability values). However, the transition of those regimes to a more sustainable state did not result in dealing with the persistent problem.

Looking at the system as a whole (including all the different regimes), we argue that this may be the case due to the following: (a) the issue related regimes and the on-going conflict between them dominate the system and, consequently, inhibits an overall co-evolution to a more sustainable state that may result in the erosion of the persistent problem, and (b) the system experienced only an institutional transition. The fact that the system has been only partially transformed may explain why the persistent problem has not been resolved. An overall transition of the system may be adequate to deal with the persistent problem or may result in lessening it via its co-evolution.

We need to note that understanding the nature of a problem involves how a problem is perceived by a specific actor or actor group. In our case studies we focus on the perception of the persistent problem held by different regime actors, i.e. we consider the perception of actors of or actors relating to the energy regime in Greece when forming a problem definition. The co-evolution of the problem is therefore bound to data from the in-person interviews as well as to the deduction from the other complementary case study material (see Appendix A).

7.7 Societal transitions and governance of societal transitions: New utopias?
Societal transitions as fundamental changes appear too difficult to steer, too complex to understand fully and too uncertain for predicting the system's end-states.

Is there an ultimum transition? A misconception of a societal transition is due to its characteristic as a "fundamental change". Referring to fundamental change or to structural change, one may assume that every component of the system changes fundamentally at the same time. This however is rarely what is experienced in practice: A societal system undergoes changes in a gradual however incremental way, and in the long-term it may change entirely or partially depending on context particularities. An ultimo transition can be experienced and has been experienced but it takes a very long time to be realized. After such a long-term ultimate change, a societal system has experienced fundamental changes in social practices, technology, institutions, the natural environment, markets and infrastructure as well as cultural aspects. An example concerns the Dutch society in 1910 and today, in 2011; or the Greek society in 1910 and today. Even more specifically, consider the mobility systems or food-production systems in 1910 and today in the Netherlands and in Greece. We argue that ultimo transitions are not utopias or rare phenomena, they are on-going processes of change and their analysis can aid our understanding of the reasons and historical development of existing practices and organization.

Is it then utopic to believe that a transition can be managed, or even steered? From our understanding of the dynamics of societal transitions, societal conditions translated into (the presence of) Forces contribute to the transition. Hence, any intervention that may contribute in setting up or enabling a Force will contribute to the transition. We argue that actions /interventions can be taken in the direction of enabling a transition. We do not believe that there is a unequivocal causal relation between any type of intervention and the direction or type of transition. At the same time, we remain skeptical on bold statements that societal change is emergent, complex and consequently, uninfluencable. We believe that societal transitions are the outcomes of both emergent and coordinated processes, and in this way support the coordinated emergence principle of the Transitions Approach (see Chapter 1, Section 1.4.2).

In addition to this we suggest a rethink of the promises of Transition Management as a governance approach. Transition Management offers a governance approach and the respective management tools (Frantzeskaki, Loorbach and Meadowcroft, 2012-forthcoming) that can influence a domain-specific transition but not the overall transition. For example, the transition arena can initiate a transition in a specific policy domain (e.g. urban water management) but not steer an overall transition. An overall transition is regulated by the coordinated emergence principle, meaning both policy and emergent processes play a role on how a(n) (overall) societal transition evolves. Transition Management offers an approach and guidance for negotiating, initiating and experimenting with incremental changes on the short- and medium term that can revolutionize existing policy regimes. In this way, Transition Management tries to set operational the evolutionary revolution principle of the transition approach (see Chapter 1, Section 1.4.2).

Is a transition to a sustainable system state a utopia? First, we need to consider that sustainability is defined and relates to social values and norms of each generation. Second, societal systems are continuously evolving following a complex process that we conceptualize as a transition. Societal change is the norm and societal transitions have been materialized and evidenced in various systems. An example is the mobility system in Western European countries that experienced the transition from horse and carriage to automobiles or, better, to automobile and public inland transportation. A transition towards a sustainable system state may appear unfeasible or utopic in the short-term but may be realized in the long-term. The question we need to ask is: sustainable based on what generation's values?

In Chapter 8 critical reflections of the research and related future research challenges are presented.

Main Contributions

A reflective view on the research design, research process, and findings is included. Critical reflections concern the relation of time horizon and the level of aggregation, the simplicity and usefulness of the developed conceptual frameworks, the power and value of conceptual models for transitions' research, the understanding of change as a circular or linear process, and the analytic depth of the research exploration.

Reflections on the research findings include critical insights about institutional transitions, social-ecological transitions, feedback loops, and the function of case studies when researching transition dynamics.

The research challenges that have been identified relate to the critical reflections and to the research findings about transition dynamics. The research challenges that relate to the understanding of transitions as long-term processes, unfolding in different episodes of change, include the quest for future understanding of the role of institutions in societal transitions, the role of actors as carriers of change (policy entrepreneurs versus frontrunners versus transition managers) and the role of politics.

The research challenges that relate to the Forces Framework concern the quest for understanding the way forces interact in constituting transition dynamics (cumulative versus synergistic interaction), and the impact on the speed of a transition that forces may have (accelerants versus decelerants of societal transitions).

CHAPTER 8
Reflections and Future Research Agenda

In this chapter we reflect on the research process, research choices and findings. We also present future research topics that can contribute to the Transitions Approach and to Transition Management. First we present a number of critical reflections in Section 8.1 about the research methodology, the conceptual framework, the research findings concerning the institutional transitions, social-ecological transitions, and socio-technological transitions, the feedback loops, and the societal transitions approach. In Section 8.2 the research challenges that can be included in a future research agenda of the Transitions Approach are presented. The new research topics concern both the further understanding of transition dynamics and the research challenges posed by specific forces and specific subsystems (like institutions) when analyzing societal transitions.

8.1 Critical reflections

After completing our research in exploring the dynamics of societal transitions, a reflective view on the research design, research process, and findings is included. The reflection concerns the comments and conclusions derived after taking a retrospective view on the process of the research and a self-critical view on the research outcomes.

8.1.1 Reflections on the research methodology and consequent choices

In our research we adopt a high level of aggregation (which we will refer to as "macro-level") to analyze the dynamics of societal transitions. We conceptualize the dynamics taking place in the societal system, which is an entity that includes both actors and their social constructs (e.g. institutions). Consequently, the dynamics are researched at the system level; which we have called the macro-level.

Zoom in and zoom out in time horizon and level of aggregation: In order to understand how social processes like societal transitions unfold, we need to broaden the time horizon given that social processes take a long time to materialize. The choice of broadening the time horizon for longer than 20 years however is accompanied by the choice of a higher level of aggregation (in order to derive patterns and understanding) due to efficiency issues. Efficiency issues refer to the time aspect of conducting a research on social processes with a long time horizon and to the amount of information required (or collected) for such lengthy processes. In such research conditions (long-time horizon, restricted level of detail and high level of aggregation) the research outcomes often are patterns or frameworks in abstract forms.

> "Many social processes take a long time – sometimes and extremely long time – to unfold. This is a problematic fact for contemporary social science [where] the time horizons of most analysts have become increasingly restricted. Both in what we seek to explain and in our search for explanations, we focus on the immediate- we look for causes and outcomes that are both temporally contiguous and rapidly unfolding. In the process, we miss a lot. There are important things we do not see at all and what we do see we often misunderstand." (Paul Pierson, 2004, p.79).

For our research on societal transitions, we chose to investigate theories and cases that relate to long time-horizon changes that resulted in understanding the phenomenon by mapping it in feedback loops. We do not claim that the feedback loops we have identified comprise a finite set; they are our research findings and are constrained by our boundary choices: level of aggregation, cases characteristics, and research objective.

8.1.2 Reflections on the conceptual frameworks

Do not shoot simple frameworks: Conceptual frameworks are constructed to provide explanations or to be used as tools towards understanding of phenomena. An understandable, coherent and consistent conceptual framework can be considered a well formulated one. It is often the case that such a well formulated conceptual framework appears simplistic and receives the criticism that the understanding or explanations yielded from its use are either "evident" or appear as self-fulfilling prophecies. At this point, we recognize a paradox. Conceptual frameworks, in order to be useful, have to be understandable and coherent so as to aid analysts in recognizing and better understanding the researched phenomena. If the application and use of a framework appears easy for an analyst, it does not mean that the tool is simplistic in its nature. It shows that the framework as a tool for the analysis is useful and applicable. At the same time, the outcomes of an analysis using the conceptual framework cannot always be perceived as evident. What is researched and found with the aid of a conceptual framework must exceed just the testing of the framework itself and must advance understanding of the phenomenon. More specifically, we applied the conceptual frameworks to four different case studies and we not only saw that the model is useful and applicable, but also obtained insights on the dynamics that we could not get without the analysis with our model.

Conceptual models are abstract representations of a phenomenon or a system configuration and aim at aiding the understanding and the analysis of a phenomenon. Conceptual models that refer to complex phenomena such as societal transitions run the risk of becoming as complex as the phenomenon itself or even more complex than the phenomenon itself. The challenge then is to construct a conceptual model that has the analytical capacity to explain the phenomenon while being simple in its application. A conceptual model that explains a complex phenomenon in simple terms or, in a simple way does not neglect or reduce the complexity of the phenomenon.

Is a model only a model? A simple conceptual model is neither simplistic nor neglects the complexity of the phenomenon.

> "A model is a mental construct which is a unit in a body of theory and which aids the social scientist in conceptualizing and generalizing aspects of social behavior or processes through the devices of subtracting detail and generalizing form specifics." (Galt and Smith, 1976, p.27)

Specifically for societal transitions, different conceptual models have been developed to aid the understanding of both researchers and policy makers: the multi-level framework of Geels (2002; 2005), the transition phases' model (Martens and Rotmans, 2005) and the transition cycle model (Loorbach, 2007). These conceptual models map specific characteristics of a societal transition and aid our understanding of them. For example, the multi-level framework of Geels shows how technological change develops from start-up markets or niches to a broader application that is the regime. In its application, the multi-level framework has helped in analyzing in a structured way the diffusion of technological systems in respect to other competitive or supplementary technologies. Its added value to the existing conceptual models for technological change lies in the broadening of the analysis to include social factors such as social demands and avoiding the conventional view of technological change as an outcome of market mechanisms only.

In the same vein, our Forces model shows which determinants contribute to the dynamics of transitions as a heuristic that can dissect and, in turn, analyze the dynamics. From the presentation of these two conceptual models, we understand that every conceptual model serves the need for understanding and explaining a specific aspect of a phenomenon taking into account a specific research scope.

> "Social scientific explanation has a special meaning. It refers to the procedure of identifying some phenomenon as being of interest and then seeking to understand factors which account for its existence, wither in the sense of its origins and development, or in the sense of its fit within its socio-cultural context." (Galt and

Smith, 1976, p.70)

In conclusion, conceptual models are valuable, and useful in aiding understanding and systematizing the analysis. Analysts should consider that conceptual models remain abstract representations of the phenomenon and have limitations. We argue that conceptual models contribute to the research quest for understanding complex phenomena; but overreliance or blind trust in their analytical capacity however must be avoided.

Change as a circular or linear process? In our analysis of societal evolution, we formed a conceptual model that is the Evolution Cycle (see Chapter 3). Conceptual models, apart from being abstract representations of a phenomenon or system, are human-made models. An analyst formulates a conceptual model based on the understanding of the phenomenon and on evidence gathered both from empirical and theoretical observations. There are explanations of social evolution as a linear process such as Parson's explanation (Parsons, 1977) or Sanderson's (2007) or even the famous Kondriatev waves for technological systems that conceptualize (and consequently, analyze) change as a linear process (meaning a sequence of events or causal factors). We are presenting a cyclical model where societal evolution is realized in cycles. Regime theorists also described a cyclical process when describing regime formation and decay (Rittberger and Mayer, 1995).

What we would like to explain here is that social evolution and social change as a quest, related also to how it is viewed in different cultures. Viewing time related phenomena as unfolding as strings of unrelated events, or as cycles of events, or even as cycles that have a repetitive tendency in time, is rooted into culture, as argued also by Trompenaars and Hampden-Turner (1993, p.120-122). This reflection on the conceptualization of societal evolution as either a linear or cyclical phenomenon does not imply that there is an imperative conceptualization; it implies that when explaining social phenomena the conceptual models constructed may also depict cultural reflexes. The value of any conceptual model continues to rely on its explanatory and analytical capacity.

8.1.3 Reflections on analyzing societal transitions

Parathesis or Hyperthesis? When we elaborate on forces and feedback loops that are found in theory and found in cases, we can be confronted with the question: Are those all? The feedback loops and the archetypes (responses to change) that are presented comprise the outcome of our research and more specifically, of our synthesis of both theoretical and empirical exploration of the phenomenon of transformative change. The feedback loops are bound to the research focus we have and to the research approach we adopted. More specifically, the feedback loops relate to both our research focus on explaining what constitutes the dynamics of societal transitions, and our research approach when investigating theories that postulate factors that contribute to change and theories that explain change processes.

We thus make a parathesis: We contend that the presented forces and feedback loops of societal transitions (or, better, of different types of transitions) map how societal transitions unfold, and are products of theoretical and empirical synthesis and grounding. A claim that the presented feedback loops and forces are either paramount or prominent is a hyperbole, or just a hyperthesis. To conclude, we argue that with the produced feedback loops and forces we understand important aspects of how societal transitions develop and how societal systems experience (such type of) transitions. It remains our challenge to either modify or complement them when new findings corroborate or disprove our findings.

> "Social theory is developed as a tool of social research which seeks to provide coherent and relatively simple explanations of events in the real world by, for example, the development of models and causal accounts. Theories are, according to the philosophy of Karl Popper (1963), accepted or rejected via a process of falsification. Science is critical because its task is to disprove rather than prove hypotheses about the real world" (after Turner, 2000, p.6).

Our understanding of societal transition dynamics in the form of feedback loops explains the evolution of the system without using deductive reasoning and hence omitting a mechanistic view of the dynamics. This implies that the feedback loops can explain the dynamics at play without enforcing pattern-like behaviors that give universal explanations or law-like explanations.

> "Deductive-nomological reasoning suggests a mechanical view of the world, in which the same stimulus produces the same effect, ceteris paribus. Theories that view social phenomena as products of either evolutionary processes or intentional action challenge this mechanical view." (Poteete, Janssen and Ostrom, 2010, p.9)

8.1.4 Reflections on feedback loops

The remaining tale of uncertainty: In our analysis of the societal transitions, we used the conceptual tool of the Forces to unravel the dynamics of transitions, and feedback loops. The occurrence and impact of every force on a transition are uncertain. The nature of uncertainty and the degree of uncertainty has not been investigated for every force and for every feedback loop. It remains a topic for future research to investigate the uncertainty bound to every force we identified. Such research on uncertainty however is challenged –if not constrained- by the very nature of the phenomenon of societal transitions. What we argue is that the produced feedback loops provide an explanation of how societal transitions evolve; research on the uncertainties remains a subject for future investigation.

> "The dynamics of society may seem merely a pretentious way of talking about history. It is however with a difference; history conceived not as narrative or chronicle, not even as a connected story or tale, but history conceived as a system that is as a social system with emphasis on regularities and patterns as well as discontinuities and gaps." (Boulding, 1976, p.7)

> "The basic concept of any dynamic system is that of a succession of states. A state of the system is a complete abstract description of the relevant variables of a system as they exist at a moment in time. It is like a frame on a reel of film. The dynamics of a system consist in the first place of the succession of states, as frames succeed one another in a movie." (Boulding, 1976, p.8)

Is the approach apolitical? Analyzing societal transitions from a systems perspective has its advantages and disadvantages. Among the advantages of adopting a systems approach is that it asks for an apolitical approach. What we mean here is that our explanation of the dynamics of societal transitions does not focus on the interests and behaviors of specific actors and how they influenced the decisions taken. We focus on the decision or event isolated from its micro-level context. We considered the events that contribute to every transition without judging whether an event –later translated into a force- is "good" or "bad" for the society or for the transition. This was a consistent choice, given that we aimed at understanding only what contributes to the phenomenon and consequently, adopted a meta-level of aggregation, and a long-term horizon. Hence micro-level attributes were not considered. We are aware that our approach neglected the politics behind policy changes, institutional changes and technological changes. Strategic behavior of actors, especially politicians, opportunism, corruption and other characteristics of the political sphere have neither been researched nor linked to the presence and/or impact of forces on the development of transitions. We are aware that politics play an important role in conditioning change, in power shifts between regimes and niches, and in creating or dampening demands. From transition studies, there are a number of scholars that deal with the politics of societal transitions: Avelino, 2009 about the role of power and empowerment for regime changes and niche domination; Meadowcroft, 2009 about accountability in transitions and transition management; Smith and Stirling, 2010 about losers and winners in transitions and transition management (among other issues); Smith and Kern, 2009 about narratives as forming politics and explaining institutionalization; Hendriks and Grin, 2007 about (politics and) legitimacy of transition management processes; Grin, 2012-forthcoming about leadership and meta-governance). Recently, Meadowcroft (2011, p.73) argues that politics require further research and proposes to research politics in terms of interests, institutions and ideas for understanding their

influence in sustainability transitions. To summarize, an in depth understanding of the impact of politics on societal transitions is a question for future research.

Explaining more than Dutch-phenomena! Considering our conceptual models contributions to the transitions field and to the Transitions Approach specifically, we argue that the Transitions Approach can describe phenomena of transformation and co-evolution in non-Dutch contexts. Our analysis of the Greek cases and the South African case show that analyzing complex processes with transitions thinking yields useful insights about system evolution and transitions, for understanding the fit and the performance of governance practices.

8.1.5 Reflections on (the role of) paradigms

In Chapters 4 and 6 we addressed the different paradigms that are in place and that can have an influence in societal transitions. The expected influence of a paradigm is that the system undertakes changes to align with the paradigm's propositions (as for example occurs in the published cases of institutional transitions that we reviewed in Appendix C, Table C.1 concerning the New Public Management Paradigm). But we do not observe the appearance of the system's response to change as an alignment with a paradigm. This is due to two main reasons that require a critical reflection from the researcher:

(a) A different type of research is required for identifying the extent to which a societal transition aligns with a specific governance paradigm or deterministic paradigm (see Box 4.1 for governance paradigms and Section 6.1 for deterministic paradigms). The research needs to focus on the actors' perceptions and decision discourses for investigating the alignment to a paradigm. Indicative research approaches include a discourse analysis or a focus group with public administrators at the strategic level of their organizations.

(b) Different case studies had to be selected and/or conducted. From our literature review of published cases, we observed that in utility institutions (e.g. energy, mobility) paradigm alignments as patterns of change are very frequent. Examples include the alignment with managerialism in public administration or alignment with the New Public Management paradigm in numerous countries, as shown in Appendix C but not for water management institutions. What we have found is the privatization and deregulation of drinking water sectors as realized and researched in Germany and Switzerland.

8.1.6 Reflections on the Transitions Approach

Do we need universal concepts for a field in social sciences to be successful? It is a well-established war (as Flyvbjerg, 2001 also comments) between natural sciences and social sciences that social sciences cannot win when it comes to predictive outcomes. The impact of context on research findings of social sciences is dominant. More specifically, in natural sciences, concepts relate to proxies and metrics – weight has a specific meaning and proxies are universally accepted – and relate to tangible artifacts and phenomena. In social sciences, concepts often relate to intangibles and represent the understanding of social phenomena. Universal definitions of social concepts that remain unchangeable over time d no juostice either to the field of social sciences or to the phenomena themselves. A novice interdisciplinary scientist may judge a field too early when it comes to precision or universality of the terms that constitute the field's discourse. An example is the concept of institutions: Institutions have received numerous definitions varying from conventions, to rules, to systems of rules, to processes and organizations, to shadow networks and hierarchies. This does not however eliminate the role and value of public administration, institutional economics, and sociological fields such as neo-functionalism or structural functionalism to provide explanations about the role, the importance and the effectiveness of institutions in numerous contexts.

Concepts in social sciences are metrics for giving meaning to social phenomena. The variety of definitions for those concepts is unavoidable and even, desirable in social sciences for the following reasons (that in my understanding prevail): (a) concepts are for giving meaning to social phenomena.

Social science develops and advances via different methods and analytics, hence the explanations provided evolve over time and, unavoidably, the meanings attached to concepts also evolve. (b) For social sciences, the context of study and the research boundaries influence drastically both the method and the output.

8.2 Research Agenda: New topics for transitions research

We propose the below listed research challenges that can, if researched and addressed effectively, contribute to transitions research and the Transitions Approach.

Future research topics from our understanding of transitions unfolding in different episodes:

A societal system can undergo different types of transitions over the course of its evolution. A system can for example, first experience a social-ecological transition and then an institutional transition; provided that we refer to a long-term societal evolution (>25 years). There is no pattern that indicates the sequence of the types of transitions that a societal system can experience. Research outputs from transition researchers (Rotmans and Loorbach, 2009; Kemp and Rotmans, 2009), socio-technological transition researchers (Geels, 2005; Geels and Schot, 2007), socio-ecological transition researchers (Berkes and Folke, 1998; Olsson et al, 2004b) and innovation theorists (Faber et al, 2004; 2006; Freeman and Louca, 2001; Hall, 1994; Hekkert et al, 2007) do not research broad transition patterns but remain at explaining system-bounded changes. The challenges that remain to be investigated when adopting a meta-level view on system transitions mainly concern the understanding of the crossover events or crossover structures. The crossover events or structures (e.g. institutions as a social structure) that refer to those events or structures that enable crossing or traversing from one type of transition to another, have not been identified. Based on our analysis of the different types of societal transitions, we spot potential crossover conditions (events or structures) that need to be further researched: (a) (characteristics of) institutions; (b) entrepreneurs or policy innovators (not market innovators); and (c) politics.

- *The role of institutions in diffusing or mediating transitions*. Institutions have a dual role in social systems (based on Giddens, 1984): they are both the medium and the outcomes of social practices. Hence, a change in practices has to be reflected in the social structures and changes in social structures have to drive changes in social practices. The influence of institutions in forming and reforming social practices can not be explained by direct causality. Institutions function in a complex context, are (slow but also prone) to change and are not immune to imperfections and functional pathologies (Ostrom, 2005, p.243).

Institutions are multi-leveled and diverge across sectors. It is a misconception that institutions are a unitary system of rules, given that institutions diverge across (horizontal) levels (multi-level) and across sectors (multi-dimensional or, multiple vertical levels). Hence, level and function (or sector e.g. energy, water, mobility) influence the way institutions perform over the course of a transition. For understanding the role of institutions in societal transitions a cross-level, cross-sectoral and cross-country analysis and comparison is needed. By examining the role of institutions in transitions, we will examine closely the institutionalization and deinstitutionalization processes that are important for the establishment of new niches or new regimes and for the destabilization of existing regime(s) respectively (when addressing sustainability) (Smith and Stirling, 2010, p.6-7). Thus the role of institutions in diffusing or mediating transitions remains a quest for transition researchers.

- *The role of individuals in societal transitions*. Investigating transitions at a system level does not imply that the importance and role of actors has been neglected from the analysis. Preferences and practices are captured by the presence of niches and by the societal demands. More specifically, for socio-technological transitions the importance of niches is highlighted in all the socio-technological transition patterns (Geels and Schot, 2007). Niches are the cradle of innovation and include small-scale markets in which new technologies are tested. For our approach, niches include groups of actors that adopt a new practice (not only technology). In general, the importance of niches, and consequently of actors, has been addressed by transition research. What however has not been explored is the impact individuals as carriers of new ideas and practices –the so-called policy

entrepreneurs- have on the transition. Policy entrepreneurs are the carriers and advocates of new ideas and new practices and their actions reflect their commitment to an idea or ideal (Huitema and Meijerink, 2009). We therefore believe that investigating the role and impact of policy entrepreneurs in bringing about transitions will contribute to existing knowledge on the development of societal transitions. At this point, we need to clarify that policy entrepreneurs and transition managers differ in two aspects: (a) transition managers are assigned the task to facilitate the policy visioning process in a transition arena (Loorbach, 2010) whereas policy entrepreneurs do not have a specific task assigned to them – meaning that a policy entrepreneur may be a policy advisor, a public administrator or even a researcher-, and (b) the role of transition manager is assigned to a professional whereas the role of a policy entrepreneur is emergent – meaning that in different contexts and sectors different actors may not necessarily intentionally; act as policy entrepreneurs. A transition manager is a role assigned to a professional whereas a policy entrepreneur relates to a behavior or role.

- *The politics in societal transitions.* In the context of societal transitions, politics refer to the power policy actors exercise in decision making (also referred as power dynamics) (see Avelino, 2009), the shifts in priorities within political agendas, as well as the various characteristics and phenomena that can be found in political spheres (corruption, opportunism, lack of transparency and more). The impact of politics in enabling or constraining change requires closer attention.

Future research topics from our understanding of transition dynamics in the form of forces:

- *How do the forces interact? The relation between the forces that influence the course of a societal transition.* In our research we identified a set of forces that are macro-social determinants that produce the dynamics of societal transitions. The relation between these forces has not been investigated. The question that remains is whether there is a synergy or accumulation of forces towards transforming the system. We are aware that such a mechanistic equivalent may not capture to a full extent the complexity of societal phenomena. Methods exist that can assess whether there is synergy or accumulation between the forces when producing societal change (e.g similarity theory).

- *Accelerants or decelerants of societal transitions*. A societal system may experience radical changes of such magnitude and extent that it fundamentally changes to a new system. A societal transition as a process of fundamental change (in all the subsystems of the societal system) is conceptualized as a continuous process in which the system evolves through periods of change towards its transformation. Hence, the time a societal transition may span varies depending on both context and systemic conditions.

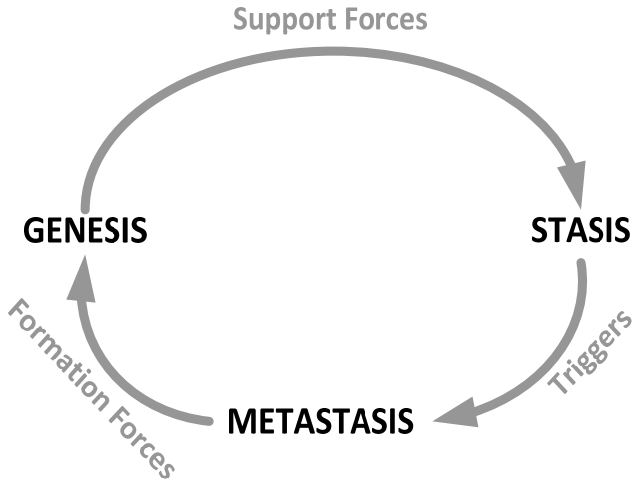
The issue of the time variable in societal transitions has not been thoroughly researched due to two research constraints: First, context particularities of the different systems make it infeasible to derive and define time scales of the different types of changes e.g. technological change or policy change. Second, it is thus infeasible to define how long a transition may take to materialize. In view of these research constraints, we suggest further research on what can prolong and accelerate a societal transition in relation to context (different countries) and to function (different sectors). An example may be the role of societal crises in accelerating or decelerating societal change. From our research, we position trigger events as critical events for the stimulation of societal transitions. The relationship however between the presence of a trigger event (e.g. a crisis) and the response of the societal system with a change –in the form of the time between occurrence of crises and occurrence of a change (intermediate change)- varies between different systems and different contexts.

SUMMARY IN PERSPECTIVE
SAMENVATTING

Om lange termijn duurzaamheid te bereiken is een fundamentele verandering of transformatie van een maatschappelijke systeem van belang. Onderzoek naar hoe fundamentele veranderingsprocessen – maatschappelijke transities – zich ontwikkelen is belangrijk voor het begrijpen van de aard van deze processen en de mogelijkheden om ze te beïnvloeden. Het doel van dit onderzoek is om een bijdrage te leveren aan de kennis over de dynamiek van maatschappelijke transities.

Allereerst conceptualiseren we maatschappelijke transities als continue cyclische processen waarin een maatschappelijk systeem van het ene naar het andere dynamische evenwicht overgaat. Drijvende krachten (Driving Forces of Transformative Change) dragen bij aan deze overgangen. Het voorgestelde raamwerk van deze krachten bestaat uit: (a) Formatiekrachten, die het innovatieve potentieel van het maatschappelijk systeem representeren en onderverdeeld worden in: Aanwezigheid van een niche, Aanwezigheid van een maatschappelijke vraag, Aanwezigheid van nieuwe werkwijzen; (b) Ondersteunende krachten, die de veranderingen versterken of blokkeren en gerelateerd zijn aan institutionalisering binnen een maatschappelijk systeem. Ondersteunende krachten zijn: Standaardisatie van werkwijzen, Voorzien van hulpbronnen, Uitoefenen van macht; en (c) Triggers, krachten die een schok op het systeem uitoefenen en die zeer onzeker zijn en niet beheerst kunnen worden. Crises, Systeemfalen en Exogene gebeurtenissen behoren tot de categorie van Triggers.

De krachten geleiden het systeem van het ene naar het andere stadium waarbij er evolutionaire veranderingen optreden. We beschrijven de manier waarop het systeem in de tijd verandert door middel van een evolutionaire cyclus (Evolutionary Cycle of the Societal System). Deze bestaat uit drie stadia, de dynamische evenwichten: (a) Genesis, (b) Stasis and (c) Metastasis. Als een systeem zich in zo'n stadium bevindt zijn de veranderingen relatief langzaam,, terwijl de overgangsprocessen tussen deze evenwichten gekarakteriseerd worden door snelle veranderingen. Drijvende krachten kunnen ook terugkoppellussen activeren waardoor een systeem in een bepaald stadium blijft.



De Evolutionaire Cyclus van het Maatschappelijk Systeem en de Drijvende Krachten van Transitionele Verandering.

Het maatschappelijk systeem wordt geconceptualiseerd als bestaande uit verschillende onderdelen die niet synchroon veranderen. We onderscheiden hierbij verschillende typen transities: institutionele transities, socio-ecologische transities en socio-technische transities.

- Een **institutionele transitie** wordt gedefinieerd als een type transitie waarbij de krachten invloed hebben op instituties en de burgermaatschappij

- Een **socio-ecologische transitie** wordt gedefinieerd als een type transitie waarbij de krachten invloed hebben op instituties, de burgermaatschappij en de natuurlijke omgeving.

- Een **socio-technische transitie** wordt gedefinieerd als een type transitie waarbij de krachten invloed hebben op instituties, de burgermaatschappij en technologie.

Wij bestuderen verschillende typen transities om te verklaren hoe de verandering van het systeem verloopt in de tijd. Tijdens de analyse worden dezelfde vragen gesteld voor de verschillende typen transities: wat zijn de drijvende krachten? Wat zijn de patronen die naar boven komen tijdens een transitie? Alvorens deze vragen te onderzoeken is er een literatuuronderzoek uitgevoerd om het krachtenraamwerk en de evolutionaire cyclus in te bedden in de literatuur. De literatuurstudie bevestigde onder meer dat de verschillende typen transities onderscheiden kunnen worden.

Het conceptuele raamwerk van de krachten en de evolutionaire cyclus zijn vervolgens gebruikt om vier verschillende cases volgens een instrumentele case study aanpak te reconstrueren en te analyseren. Dit empirische onderzoek van de vier cases bevestigt de bruikbaarheid van de conceptuele raamwerken en het cyclische karakter van het verloop van een transitie. De eerste case was een institutionele transitie van de Nederlandse watersector van 1991 tot 2008. De tweede case was een institutionele transitie in het natuurbeschermingsregime in Griekenland van 1973 tot 2010. De derde case betrof een institutionele transitie die nog steeds gaande is in de elektriciteitssector in Griekenland over de periode van 1986 tot 2010. De laatste case ging over een socio-ecologische transitie in het kustwater management regime van de Great Brak rivier in Zuid-Afrika over de periode 1988 tot 2004.

In de keuze van de cases is rekening gehouden met de mogelijke kritiek dat de transitie-aanpak en het transitie-denken in het algemeen een context-afhankelijke aanpak is; namelijk een Nederlandse aanpak. Dat is de reden geweest dat er ook niet-Nederlandse cases bestudeerd zijn.

Het onderzoek van de cases liet zien dat de conceptuele raamwerken bruikbaar zijn om de transitie-dynamiek in de cases te verklaren. Daarnaast heeft het onderzoek van de cases nieuwe inzichten opgeleverd doordat gebruik gemaakt is van de ontwikkelde conceptualisaties:

(a) in iedere case waren krachten van ieder cluster aanwezig gedurende de transitie. Voor een maatschappelijke transitie moeten dus verschillende typen krachten aanwezig zijn.

(b) het bestuderen van de dynamiek met behulp van de krachten en terugkoppellussen laat zien dat een systeem karakteristiek gedrag vertoont gedurende de evolutie. Het gedrag van een systeem kent terugkerende kenmerken, zelfs bij andere soorten triggers of problemen. Het water regime in Nederland bijvoorbeeld ondergaat langdurige intsitutionaliseringsprocessen gevolgd door stagnatie in de Stasis fase.

(c) door de dynamiek van systeemtransities te begrijpen als processen met krachten en terugkoppellussen wordt de ‘black box’ van de context van transities geopend. Wij concluderen dat afhankelijk van de context, andere mechnismen en krachten essentieel zijn, en dat een grondige analyse van de invloed van context nodig is om het verloop van transities in de tijd te begrijpen.

(d) de invloed van krachten kan verschillen wanneer een terugkoppellus actief wordt of wanneer een terugkoppellus inactief wordt. Voor ieder systeem blijkt er een verschillende kracht die van betekenis is voor het activeren van een lus en het uitschakelen van een lus. We beschouwen deze krachten als

zogenaamde kritieke krachten. Uit de cases blijkt dat niet steeds dezelfde soorten krachten kritiek zijn voor dezelfde soorten lussen. Daarnaast waren er zogenaamde overgangskrachten (tipping foces) zichtbaar. Dit zijn krachten die een belangrijke invloed hadden op het in beweging zetten van processen in het ene regime en/of meerdere regimes en tegelijkertijd de processen in een ander regime dempen.

(e) de bevindingen wijzen er op dat een aanvullende karakterisering van de definitie van een regime gewenst is. De regime definitie van Holtz et al (2008) is breed en omvat alle elementen van een maatschappelijk systeem, daarbij expliciet makend dat technologie, instituties en omgevingsaspecten ook in een regime-analyse mee moeten worden genomen. De Haan (2010) maakt onderscheid tussen niches en regimes, waarbij regimes dominant zijn over andere entiteiten in het systeem. De vraag is: dominantie van wat? Bij het analyseren van de case studies vonden we een onderscheid tussen beleidsgerelateerde regimes en issue-gerelateerde regimes. Beleidsgerelateerde regimes houden verband met een dominante constellatie op een beleidssector (b.v. energiebeleid of waterbeleid). Issue-gerelateerde regimes houden verband met een specifiek onderwerp. Issue-gerelateerde regimes ontwikkelen zich door krachten of elementen uit beleidsregimes en kunnen meerdere beleidssectoren en meerdere niveaus omvatten.

(f) Van tevoren was niet bekend wat voor soort transities er plaats vonden in de cases. De verwachting was dat in iedere case een verschillend type transitie had plaatsgevonden. Dit bleek echter niet het geval. Het water management systeem in Nederland onderging bijvoorbeeld een institutionele transitie hoewel het om een socio-ecologisch systeem gaat. Hetzelfde geldt voor het natuurbeschermingssysteem in Griekenland waar institutionele veranderingen de overhand hadden. Ook bij de energietransitie in Griekenland was sprake van een institutionele transitie. Hoewel er een technologiepush aanwezig was, waren het niet de technologische veranderingen die van belang waren voor de transitie. De veranderingen zijn gedreven door institutionele veranderingen en niet door technologie.

Tot op heden is in de literatuur over het management van transities niet expliciet rekening gehouden met onderzoek naar de dynamiek van transities. Uit dit onderzoek volgen een aantal inzichten doe toegepast kunnen worden voor het bevorderen van transities naar duurzaamheid. WE formuleren deze in de vorm van stellingen die het uitgangspunt voor transitiemanagement dat: “dynamics of the system create feasible and unfeasible means for governance” verbijzonderen..

(1) Bij het bevorderen van maatschappelijke transities moet gestreefd worden naar het produceren van zowel formatiekrachten als ondersteunende krachten en moet aandacht besteed worden aan triggers voor het initiëren of het in beweging zetten van een transitie.

(2) Bij het bevorderen van maatschappelijke transities moeten middelen gebruikt worden die de bestaande dynamiek van transities benutten om het systeem intern op een fundamentele manier te wijzigen.

(3) In een systeem dat een specifiek type transitie ondergaat, moeten middelen die homoloog[28] zijn aan de dynamiek van het systeem toegepast worden om de transitie te faciliteren.

Stellingen 2 en 3 geven aan dat pogingen om een systeem te veranderen door de bestaande dynamiek te verstoren ineffectief kunnen werken; in het bijzonder bij systemen die zelf-organiserend en zelf-regulerend zijn.

(4) Bij het bevorderen van maatschappelijke transities moet rekening gehouden worden met (en zo mogelijk geanticipeerd worden op) de aanwezigheid en de invloed van processen en constellaties die veranderingen in het maatschappelijk systeem kunnen tegenwerken.

[28] Definitie van homoloog: overeenstemmend, gelijknamig.

Krachten die een transitie naar duurzaamheid tegenwerken kunnen ervoor zorgen dat maatregelen om de transitie te bewerkstelligen niet effectief zijn. Het is daarom nodig om zowel rekening te houden met het versterken van de nieuwe werkwijze of het nieuwe regime die de duurzaamheid van het systeem potentieel kan verbeteren en tegelijkertijd de macht van het antagonistische (tegen duurzaamheid) regime te verkleinen of het te deïnstitutionaliseren.

Het onderzoek laat zien dat er een aantal vraagstukken zijn die nader onderzoek vergen. Deze hebben onder andere betrekking op onderzoek naar:
- de rol van instituties bij de diffusie of het faciliteren van transities, en daarnaast naar de institutionaliserings- en deïnstitutionaliseringsprocessen die van belang zijn voor het tot stand brengen van nieuwe niches en nieuwe regimes en voor de destabilisering van het bestaande regime(s).
- de rol van actoren als dragers van veranderingen ('policy' entrepreneurs versus voorlopers versus transitiemanagers)
- de rol van de politiek bij het bevorderen of beperken van veranderingen.

Met betrekking tot het raamwerk van de krachten zijn er nog vragen over de manier waarop de krachten interacteren in relatie tot de transitiedynamiek (cumulatieve versus synergetische interactie) en de invloed die de krachten kunnen hebben op de snelheid van een transitie (versnellers versus vertragers van maatschappelijke transities). Als laatste is nog van belang om onderzoek te doen naar hoe een maatschappelijk systeem van het ene type transitie naar het andere type overgaat op weg naar een (volledige) transformatie.

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Greek Energy Legislation

The below listed Greek legislation of the energy sector is presented in a chronological order and complements the legislation as presented in Chapter 4. We need to mention that the Greek Legislation and any Legislative Decision are cited with the code-number and date in Chapter 4 and do not require additional referencing. We however choose to reference complementary sources for consistency. The legislation is chronologically ordered.

GR Law 1559/1985 (1985) "Regulation of issues of alternative forms of energy and specific issues of power production from conventional fuels and other provisions" (Official Gazette A 135).

GR Law 1892/1990 (1990) "Modernization and development and other provisions" (Official Gazette A 101).

GR Law 2244/1994 "Regulation of power generation issues from renewable energy sources and conventional fuels and other provisions" (Official Gazette A 168).

GR Law 2601/1998 (1998) "Private investment aids for the country's economic and regional development and other provisions" (Official Gazette A 81).

GR Law 2773/1999 (1999) "Liberalization of the Electricity Market- Regulation of energy policy issues and other provisions" (Official Gazette A 286).

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The below listed Greek legislation of the environmental protection regime and the water management regime is presented in a chronological order and complements the legislation as presented in Chapter 4. We need to mention that the Greek Legislation and any Legislative Decision are cited with the code-number and date in Chapter 4 and do not require additional referencing. We however choose to reference complementary and key sources for consistency.

GR Law 1650/1986/16.10.1986 (Number of Governmental Documentation 160 A) "On environmental protection"

GR Ministerial Decision (legislative action) 69269/5387/25.10.1990 (Number of Governmental Documentation 678) "Categorization of plants and activities, content of Environmental Impact Assessment Study, identification of content of Specific Environmental Studies and respective complementary legislative actions in consistency with the National Law 1650/1986".

Greek Presidential Decision 221/1998 "Constitution of specific Environmental Protection Service in the Ministry of Environment, Spatial Planning and Public Works"

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GR Law 3199/2003 (FEK A'280/9.12.2003) Protection and management of water bodies – Harmonization with EU/2000/60 Directive

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GR Law 3345/2005 “Financial issues of Provincial Authorities and regulation of administrative processes”
GR Ministerial Decision 49139/2005 Establishment of Central Water Authority/Organization located at the Ministry of Environment, Spatial Planning and Infrastructures (FEK B’1695/2.12.2005)
GR Ministerial Decision 47630/2005 Constitution and composition of Central Water Authority for Regional Administrations (FEK B’1688/1.12.2005).
GR State Court Decision 3478/2000 (in Greek)
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GR Ministerial Decision 107017/2006 (FEK Â’1225/5.9.2006) Environmental Impact Assessment procedure, and criteria concerning programs and projects in agreement with the European 2001/42/EU
GR Presidential Decree 51/2007 (FEK A’ 54/8.3.2007) Establishment of actions and processes for a holistic protection and management of water bodies in consistency with the European Directive 2000/60/EU

ACKNOWLEDGEMENTS

This thesis is dedicated to Stamatis Vasiliadis
for his unforgettable advice

Sustainability sounded and still sounds like a very vague and complex issue to understand, and an even more complex issue to research. Now think of marrying it to transitions, processes of transformation that are as complex as you can imagine. This couple of maximum complexity was and still is my research playground. I still remember the first article I read about transitions, and I can spend the space of another thesis to tell you how differently I read it now. During my four years of my PhD and the extra year I took to condense my research into this book format, there are some people who stood by me. I would like to take the opportunity to thank the people who supported me: people who supported specifically my PhD research, and people who supported me during my PhD at the Faculty of Technology, Policy and Management at the TU Delft. I would also like to express my thanks to my friends and family who in one way or another contributed to my work.

I would like to thank my promoters Wil Thissen and Els van Daalen who gave me the opportunity to undertake a PhD on sustainability transitions at the TU Delft. Wil was a critical but inspiring promotor when it came to my research and a very supportive professor when it concerned my other activities like education, organization of conference panels, writing research proposals, organizing and realizing a summer school and two workshops. I especially thank Wil for the learning opportunity I had to edit a special issue together and to learn from him how to remain critical while being polite and constructive as a reviewer and as an editor. Els was my supervisor during the last five years. I am thankful for all the time she devoted to my ideas, papers and the present thesis. She especially helped me to learn how to write complex ideas in a simple way. Els was very supportive, acted as the most critical reviewer in all my papers and proposals, and supported my interest in education and research for education. I am also thankful to her for translating my propositions and summary in Dutch.

I would like to thank Jill Slinger for being a good colleague, a hard-working co-author, and a friend that supported me and injected me with positive energy during difficult times. I would like to thank Peter Bots for his support during the first months of my PhD at Delft, and for being a patient teacher when I was an impatient first year PhD student. Special thanks goes to Martin de Jong for working together, for being persistent with me, for both being supportive and for nudging me when needed.

At this point, I would like to thank Jan Rotmans for addressing the most difficult questions during our KSI meetings as a Theory-Building group and for being a source of inspiration, a guru on transitions. I would also like to thank John Grin for his help during the first year of my PhD and for helping me to take the step forward on distilling and reflecting upon my findings during the last year of my PhD research.

I would like to thank my thesis committee members Prof. John Groenewegen, Prof. John Grin, Dr. Jill Jaeger, Prof. Martin de Jong, Prof.Jan Rotmans, Prof.Hans de Bruijn for accepting being in my committee, and for their feedback and comments on the content and messages of my thesis.

Special thanks to Hans de Haan (Fjalar) for being a committed research colleague that made the marriage of our conceptual frameworks successful. I am looking forward to working together again in Melbourne, Australia. I would like to thank Derk Loorbach for working together on Transition

Management, and for pushing me to be courageous and brave about my research findings of my thesis and about my research ideas on sustainability transitions.

During my PhD, I was very lucky to share a 'vague research posting' and an office with Yucel Gonenc. I thank Gonenc for being a constructively critical colleague and a wonderful office-mate to share stories, and treatments when feeling home-sick.

My PhD research was conducted under the auspices of the KSI Research Program. The KSI group of PhD students was an extraordinary group of peers that I would like to thank, and especially, Rutger van den Brugge, Roel van Raak, Flor Avelino, Anna Katherine Ellersiek, Bonno Pel, Karolina Safarzynska, Jos Timmermans, and Suzanne van den Bosch. I would like to thank the people who directly or indirectly contributed to this thesis with their comments on draft chapters, and journal papers, including Florian Kern, Heleen Vreugdenhil, Rutger van den Brugge, Gonenc Yucel, and Miriam Cuppen. A special thanks to Keith Fortowsky for editing and proofreading my thesis, and for being an overseas friendly reviewer to the multiple versions. I am looking forward to start working together on Keith's PhD now.

For my PhD, I contacted three case studies. For these case studies I would like to thank all the interviewees, informants and experts that I consulted especially those associated with the Greek case studies (even though I have to preserve their anonymity). Considering the energy (supply) case in Greece, I have to note that such an analysis would not be possible without the insights and experience of Evanthie Michalena, who is an advisor at the Energy Regulatory Authority in Greece and a researcher with Sorbonne University in France. Considering the South African case, I would like to thank Jill Slinger and Suzan Taljaard for providing me with data and for allowing me to re-construct their case study.

My colleagues at TU Delft were a good team especially as educators/teachers. I especially thank Alexander de Haan for giving me the opportunity and for trusting me to participate in his teaching team in Epa1111 course from 2007 to 2010. I appreciate all the freedom, the time and the energy you shared with me; not only when co-teaching the course but also when re-designing the course. I learned a lot working and teaching with you. I would like to thank the people who worked together during my teaching experience at TU Delft, including Olga Di Ruggero, Gwen Kolfschoten, Renate Klaasen, Marleen Brummelink, WG Phaff, Jill Slinger, and Bert Enserink.

For the last one and a half years I joined the Dutch Research Institute For Transitions (DRIFT), at Erasmus University Rotterdam, a very vibrant research group. My DRIFT colleagues were my loud support during finalizing my thesis. I would like to thank my DRIFT colleagues for being true sustainability believers and the most unconventional action researchers on sustainability transitions, including Derk Loorbach, Flor Avelino, Julia Wittmayer, Shivant Jhagroe, Katinka Wijsman, Chris Roorda, Frank van Steenbergen, Suzanne Maas, Caroline Hoogland, and Josee van Eijndhoven.

In addition to nice colleagues and nice friends that are also colleagues, I also had the resourceful support from my friends. First, I would like to thank my very best friend Sofia Liasi, for believing in me, in my abilities, for supporting me all the time, and for being an always reliable and loving friend. I would like to thank my best friend Sara Haijiamiri, for all the sharing of the challenges and dilemmas during our PhD's and for all the strategic advice and positive energy that we exchanged; even though being so far away. I would like to thank my best friend Maria Apostolaki, for being my constant motivator and a friend who finds the best translations of my work in my native language, Greek. I would like to thank Heleen Vreugdenhil, for being an excellent colleague, and a very good friend. I would like to thank Christos Strydis for making difficult times sound 'easy to overcome' with his unlimited humor. I would also like to thank Dimitris Theodoropoulos for all the funny stories.

I am very lucky to be surrounded by friends that I love and upon whom I can rely, and I would like to thank them for supporting me *even without understanding what I am researching*, including, Karine Vasileiadi, Apostolia Takirdiki, Eleni Koulouki, CKai Yang, Yiannis Sourdis, Sebastian Isaza,

Manuela and Aleja, Daniele Ludovici, Anna Pourisheva, Simona Triantafulidou, Catherine Chiong Mezza, WG Phaff, and my friends who are in Greece, including Toula & Stefanos Strydis, Kassiani Tsagkaraki, Katerina Arvanitaki-Tsitra, Sofia Chlampea, Ilias Kesisoglou, Dimosthenis Manias, Maria Kontopuraki, Roula Petraki, Maria Noidou, Yannis Koutentakis, and Spyros Dervisis. I would also like to thank my professors from TU Crete, in Greece who pushed me to study abroad and advised me to pursue a PhD, including Theocharis Tsoutsos, Vassilios Gekas, Nikolaos Nikolaidis, Eleftheria Katsivela, and *especially*, Nikolaos Kalogerakis.

I would like to thank my parents, my father Evagelos and my mother Maria, for supporting me during my first year of my PhD and for all the nice treats, cookies and gifts that they sent me all these years. I would like to thank my family for making my visits back to Crete memorable and for encouraging me to progress, including, Antonis & Filio Deiktakis, Ritsa & Damouls Votzakis, Vicki & Kostas Kompitsaki, Stelios E. Frantzeskakis, Lampros I. Frantzeskakis, Nikos & Anthi Frantzeskakis, Yannis Frantzeskakis, Maria & Ioannis Archontakis, Maria & Omiros Frantzeskakis, Eleni & Manolis Frantzeskakis, Nikos & Anthi Frantzeskakis, Toula & Michalis Xatzidakis, my godparents Anna & Nikos Zimbragoudakis, my grandmother, Eleftheria Deiktaki and my god-daughter, Elena Kornaraki.

I want to thank my parents in law, Daniela Rovelli and Massimo Galuzzi for their understanding, love and care during the last years, and all the pricessless advice about balancing work and life.

Last but not least, I want to thank my partner in life, Carlo Galuzzi, for standing by me and for supporting me day and night. Carlo, I want to thank you for being my caring partner and a workaholic who truly understands me! The completion of my thesis was only possible due to your support, patience and love. This thesis is partially dedicated to you.

Niki Frantzeskaki

Delft, 2011

APPENDICES

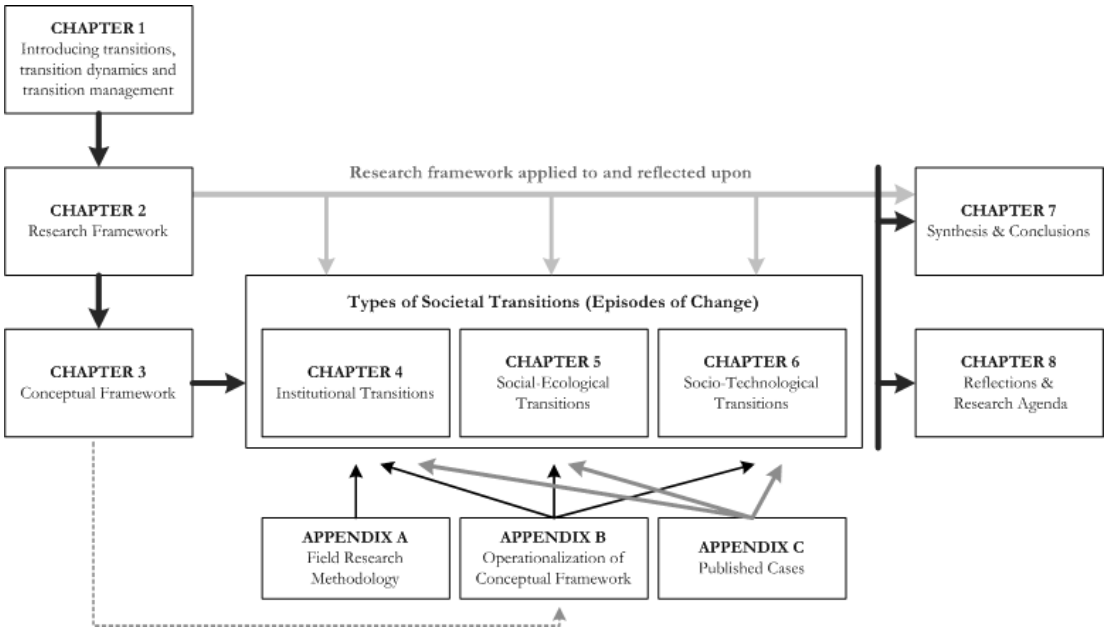

Figure A.0: Thesis Organization and relation of Appendices to the Thesis Chapters.

APPENDIX A
Case Studies: Field Research Methodology

A.1 CASE: Greek Energy Transition

Field research: During my research for the energy transition in Greece, I interviewed policy advisors for energy planning employed by the Ministry of Development in Greece and DG Energy (at that time) and one energy policy researcher working at the Technical University of Crete during their attendance to the European Union organized event "EU Sustainable Energy Week 2008" that was held in Brussels (www.eusew.eu). They accepted my request for an interview under the condition that I will preserve their anonymity. Therefore I do not include their names or any other information that can picture them. At the same time, I chose not to include in my research information provided about the politics behind energy planning in Greece. The information included in the case study was also cross-referenced by literature and by existing legislation; while information about the politics behind decisions and policies was not considered.

Considering the energy (supply) case in Greece, I have to note that such an analysis would not be possible without the insights and experience of Dr. Evanthie Michalena, who is an advisor at the Energy Regulatory Authority in Greece and was a researcher with Sorbonne University in France. The case study of the energy (supply) transition in Greece primary relies on energy legislation and ministerial decisions, on insights of Dr. Michalena and on published research in scientific publications. Dr. Michalena acted during my case study research and reporting as an expert hence my interaction and cooperation with her represents an ***expert consultation*** for my research.

The method for the selection of the interviewees was a snowball method. I have to note that more interviews than the ones included in Table A.1 were conducted but the given information was neglected during the research due to over-focus on politics. The period that I conducted the field research was January 2008-March 2009.

Table A.1: Interviews for the Greek Energy Transition Case.

Interviewee	Position	Date and Place of Interview
NGO Representative	Greenpeace Greece	11-October-2007, Brussels
Energy Policy Advisor	Energy Planning Division, Ministry of Development, Greece	28-January-2008, Brussels
Energy Policy Advisor	Legislation Enforcement Group, Ministry of Development, Greece	28-January-2008, Brussels
Energy Policy Advisor for Islands	DG Energy, EU	29-January-2008, Brussels
Policy Researcher	Technical University of Crete, Greece	29-January-2008, Brussels
Energy Planner	Energy Agency of Cyclades	30-January-2008, Brussels

A.2 CASE: Greek Environmental Protection Transition

Field Research: Concerning the Acheloos case in Greece, I have to comment on the limitations our research findings have due to lack of transparency and openness in the public sector in Greece. During my research on the Acheloos case, I put effort in contacting researchers and policy advisors working at the Ministry of Infrastructure, Spatial Planning and Environment via e-mail and via the phone. To my disappointment, researchers working at the Ministry were unavailable throughout the 18 months of my research on the Acheloos case (January 2007- June 2008). Representatives from environmental NGOs and specifically, Greenpeace Hellas, and WWF provided me with available information and suggested information routes with the agreement that I preserve their anonymity (Table A.2). The results of my research excluding the analysis and interpretation have been communicated and assessed at early stage by an Environmental Legislation Professor who requested to keep her anonymity. The Environmental Legislation Professor acted as an expert, hence her advice can be considered as ***expert consultation*** on the environmental transition case.

Desk Research: The desk research for the Acheloos River System with a focus on Environmental protection legislation was extensive and included various sources. More specifically, desk research on the set up of environmental protection legislation and the organization of environmental protection institutions was carried out using diverse sources of data and information such as journal articles, communication letters for legislation adjustment, press releases and governmental documents. More specifically, my case study on the Acheloos case has been based on data found in published studies on the Acheloos diversion project in articles, in the national law and ministerial decisions, in websites of the Greek environmental NGOs (Arkturos, WWF, Greenpeace and local NGOs). The desk research was also complemented with additional information and additional data and included the months from January 2010 until January 2011. We therefore include additional information to the case that consequently extended the study period up to 2010.

Table A.2: Informants for the Greek Environmental Protection Transition Case.

Informant	Position	Date and Contact Mean
NGO Representative	Greenpeace Greece	January 2007 – e-mail communication
NGO Representative	WWF Hellas	October 2007 – in-personal communication, Brussels, Belgium
NGO Representative	WWF Hellas	October 2007 – in-person communication, Brussels, Belgium
NGO Representative	Arktouros	November 2007 – e-mail communication

A.3 CASE: South African Water Management Transition

Considering the South African case, I would like to thank Jill Slinger and Suzan Taljaard for providing me with data and for allowing me to re-construct their case study for my PhD research.

A.4 CASE: Dutch Water Management Transition

Field research: Sixteen semi-structured interviews were conducted during the last rounds of the Room for the River policy design in 2005. Interviewees included policy experts and project planners from water boards, municipalities, provinces and the ministry as well as with actors resisting the plans. The method for the selection of the interviewees was a snowball method. I have to note that more interviews than the ones included in Table A.3 were conducted; however when the interview transcripts were communicated to the interviewees for cross-checks, a number of them refused to be included in the research sample due to “sharing too much information” during the interview. Given the code of contact and ethics followed during the field research, we had accepted their request for declining inclusion. The period that I conducted the field research was January 2008-March 2009.

The results of my research excluding the analysis and interpretation have been communicated and assessed by a Senior Policy Advisor at the Directorate Water Policy whose anonymity I will preserve.

The Senior Policy Advisor acted as an expert twice during the research (09-August-2005 in-person interview and January 2009, e-mail communication), hence her advice can be considered as ***expert consultation*** on the water management transition case.

Table A.3: Interviewees of the Dutch Water Management Transition Case

Interviewee	Position	Date and Place of Interview
Public administrator Municipality of Nijmegen	Association of Municipalities (Vereniging Nederlandse Riviergemeenten)	17-May-2005, Nijmegen
Public administrator Province of Gelderland	Province of Gelderland	17-May-2005, Arnhem
Water Director	Ministry of Transport, Public Works and Water Management (Ministerie van Verkeer en Waterstaat (V&W))	25-May-2005, Arnhem
Water Management Researcher	State Institute for Inland Water Management and Waste Water Treatment (RIZA) (Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwaterbehandeling (RIZA))	26-May-2005, Arnhem
Policy Researcher	Rijkswaterstaat Oost Nederland (Directoraat-Generaal Rijkswaterstaat / Directorate General State Water Management)	27-May-2005, Arnhem
Public administrator	Waterboard Rivierland Sfdelingshoofd Planvorming	30-May-2005, Lienden
Heilig Landstichting Representative	Heilig Landsticting (NGO)	30-May-2005, Lent
Adviebgroep Dyickteruglegging Lent Representative	Adviebgroep Dyickteruglegging Lent (NGO)	30-May-2005, Lent
Gedupeerden Waaldykverlegging Representative	Gedupeerden Waaldykverlegging (NGO)	30-May-2005, Lent
Senior Water Policy Adviser	Directorate General for Water Ministry of Transport, Public Works and Water Management (RWS)	07-June-2005, Den Haag
Water Policy Researcher	WL | Delft Hydraulics (now Deltares)	08-June-2005, Delft
Senior Political and Legal Counsel	Directorate General for Water Ministry of Transport, Public Works and Water Management (RWS)	07-June-2005, Den Haag
Water Policy Advisor	Directorate General for Water Ministry of Transport, Public Works and Water Management (RWS)	07-June-2005, Den Haag
Senior Advisor on Research and Spatial Planning	Waterboard Noorderzijlvest	19-July-2005, Den Haag
Senior Policy Analyst	Directorate General for Water Ministry of Transport, Public Works and Water Management (RWS)	09-August-2005, Den Haag
Water Policy Researcher	WL | Delft Hydraulics (now Deltares)	17-August-2005, Delft

APPENDIX B
Operationalization of the Conceptual Framework

Table B.1: Forces for Transitions systematically operationalized using our conceptualization of the societal system.

	Forces Driving Transitional Change		
	Formation Forces	**Support(ive) forces**	**Triggers**
Market	F1 – Presence of a niche Presence of new market Presence/Introduction of new infrastructure	S1- Standardization of practices Standardization of transaction practices	T1 – Systemic failures Market externalities Infrastructure inefficiencies Infrastructure ineffectiveness Infrastructure inadequacy
	F2 – Presence of a (new) demand Presence of new market demand	S2 – Provision of resources Investments on new market Investments on new infrastructure	T2 – Crises Depression Inflation / Deflation
	F3- Introduction of new practice Opening of new market Imposition of new market	S3 – Exercise of power Control over the market by government Protection of a new market	T3 – Exogenous events
Institutions	F1 – Presence of a niche Presence/creation of new institution Presence/creation of hybrid institutional form	S1- Standardization of practices Standardization of organization practices Standardization of interaction practices	T1 – Systemic failures Administrative inefficiency Administrative ineffectiveness
	F2 – Presence of new demand Demand for a new institution Demand for a new organization practice Demand for new decision-making process	S2 – Provision of resources Legitimize new institution Provision of resources on the new organization	T2 – Crises Political crisis Legitimization crisis
	F3- Presence of new practice Introduction of a new practice for the organization of institutions Imposition of a new institution	S3 – Exercise of power Legitimization of new institution Control of new organization	T3 – Exogenous events
Civil society	F1 – Presence of a niche Presence of a new social movement Presence of local initiatives on new practice	S1- Standardization of practices Standardization of routines Standardization of interaction practices	T1 – Systemic failures Inadequacy of routines and habits (in face of new realities) Values and action inconsistency (Do not practice what you preach)
	F2 – Presence of a (new) demand Societal demand	S2 – Provision of resources Provision of resources on the social movement	T2 – Crises Societal unease (e.g. riots) War
	F3- Introduction of new practice Introduction of a new practice of social functioning Imposition of new social practice	S3 – Exercise of power Control over the social movement Increase number of supporters (backing)	T3 – Exogenous events

Table B.1 (continued): Forces for Transitions systematically operationalized using our conceptualization of the societal system.

	Forces Driving Transitional Change		
	Formation Forces	**Support(ive) forces**	**Triggers**
Technology	F1 – Presence of a niche Creation of pioneers/ entrepreneurs	S1- Standardization of practices Patents and/or patents applications	T1 – Systemic failures Technological inefficiency Technological ineffectiveness Technological inadequacy Knowledge gap / deficiency
	F2 – Presence of a (new) demand Demand for a new technology Demand for a new knowledge	S2 – Provision of resources Research programs on technology by universities and research centers Research programs on technology by industry	T2 – Crises Technological accident
	F3- Presence of a (new) practice Presence/introduction of new technology Presence/introduction of new knowledge	S3 – Exercise of power Control over the technology with legislation	T3 – Exogenous events
Environment	F1 – Presence of a niche Presence/creation of new resource pool Presence of new habitat	S1- Standardization of practices Following a natural law Regulation of practices based on ecosystem's thresholds/limitations	T1 – Systemic failures Resource depletion Space limitation Controllable response to pressures Uncontrollable response to pressures
	F2 – Presence of a (new) demand Demand for (new) resource Demand for space Demand for conservation of a resource	S2 – Provision of resources Utilization of/Making available a new resource Provision of space for habitat or ecosystem functioning	T2 – Crises Diseases outburst Famine Forest fire
	F3- Presence of a new practice Introduction of new (non exploited) resource sink	S3 – Exercise of power Control over the use of a resource by government Protection of a resource by governmental center Protection of a resource by non-governmental center	T3 – Exogenous events Earthquake Natural disasters (e.g typhoon)

Table B.2: (Examples of) Intermediate changes categorised along the four components of the societal system.

Societal System's Component	Subject of change		
	Attributes' change	**Function change**	**Change in organization**
Market / Infrastructures	-Change of market price -Change of market size -Change of infrastructure's size (expansion/development/abandonment)	-Deregulation -Regulation	- Privatization - Nationalization
Institutions	-Enlargement/Shrinkage of institutions (changes in number of personnel)	- Top-down - Bottom-up	– Centralization - Decentralization
Civil society	–Demographic changes	- Change of societal routines	– Change of beliefs, perceptions and norms
Technology	–Change of the number of research outcomes (number of patents, licensed products, artefacts) -Change of the research capacity –Modification/ change of the design properties of an artefact	-Change of the function of a technological artefact -Technological innovation	
Environment	-Change of the availability of a natural resource (depletion/ creation/ investigation) -Change in population size of animal species (fauna change)	- Land-use changes (e.g conversion of forest area to grassland, deforestation, reforestation, urbanization)	-Change of natural or biological metabolism (from acidic environment in lakes to have alkaline or from eutrophic to have oligotrophic and visa versa)

B3. Operationalization of Crises using the Four Components of the Societal System

We classify and analyze different types of crises according to their origin (Frantzeskaki, 2009). These different crises include: political crisis (where political leaders do not suffice causing an outburst of preceding political unease), legitimation crisis (that follows a dissatisfaction of the current regime), market crisis (where market collapses and/or recession, deflation), societal crisis or unease (expressed as riots and massive protests), wars (civil war, deliberation war, colonization), science and technology crises, and environmental crisis (such as an epidemic or loss of habitat or biodiversity).

Institutional Crises:

Political crisis: Political crises involve malfunction of political representations and institutions. A political crisis may influence the change in perceptions that is captured by policy change. More specifically, "a phase of public policy making during which dominant representations no longer succeed in interpreting the development of a social field in a way that satisfies the actors concerned and can therefore no longer successfully structure and legitimate the action of the State. It is in this sense that a political crisis produces problems." (after Muller and Surel, 1996, p.93; Surel, 2000, p.505).

Legitimation crisis: "A legitimation crisis occurs when people lose confidence in the old regime." (after Wilson, 2000, p.264). According to Wilson (2000, p.264) legitimation crises are the results of enablers or stressors of change.

Economic crisis: A sudden collapse of a market, a recession, a deflation, or a sudden change of a price of a commodity that is fundamental to economic activity such as oil and water. The OPEC or Oil Crises of 1970s is an example of such a crisis. A famine is conceptualized also as a structural crisis given that it concerns resources and infrastructures.

Societal Crises: Crises that take place in the civil society component are named societal crises and involve crises in the informal institutions and in the civil society and refer to practices and perceptions of actors that are at unease. A working list of such crises is presented below:

Societal crisis or unease: A societal crisis is present when groups of citizens are protesting against governmental action (decisions, legislative acts, etc.) when their values, interests are violated or misrepresented or hurt from the current power regime. Riots, strikes, local or national protests are symptoms of such crises.

War: A war is an event that poses irreversible and high impact changes to all the components of the societal system. A war is conceptualized as a crisis that starts-up from the civil society and has a strong action-reaction character. A war has a build-up effect and can be seen as a convergence of various other forces. There are different types of wars that are listed below:

(a) **Civil war**: The fighting parties have the same national origin but opposing beliefs (political beliefs, religious beliefs and more).

(b) **Independence/ liberation war**: One party fights so as to re-gain or sustain national independence by claiming / redefining national geographical borders.

(c) **Imperialistic war/ colonization**: One party uses military force to expand its territory

Looking back in history, the Roman Empire used imperialistic wars as a mean to fulfill their ambition for sovereignty.

Environmental crises: They involve disturbances and diseases that have their source in the natural environment. Examples of first-order environmental crises concern natural phenomena with a random outbreak or occurrence such as volcanic eruptions, earthquakes droughts, floods, diseases outbreaks, hurricanes etc. Second-order environmental crises concern events that have their causes in the interaction of societal and environmental systems and their appearance in the environment such as biodiversity loss, forest fires, or resource depletion. Third-order environmental crises concern the complex phenomena that take place at a meta-level and are outcomes of interactions between socio-

ecological systems and natural phenomena. Third-order environmental crises include complex phenomena such as climate change.

Science and technology crises: For example the inability of the current science and technology system in addressing the problems brought forth by climate change. In that both understanding the problem scientifically and finding technological solutions to address it with are failing.

Scientific crises in the pure sense of the word are possible in the sense of failing scientific doctrines like described by Kuhn (1973), although the societal impact might be low. Scientific crises are an example of where a crisis can be a constructive force as they might lead to a so-called paradigm shift.

A technological crisis, so it appears, is not possible since when a technology fails to meet its expectations it will most probably not be embedded in a larger infrastructure (see also Geels, 2002; 2005; Hall, 1994) and if it already is and then fails it would, per definition be a structural crisis.

Box B.1: Role of crises in societal transitions

Crises as constructive events for introducing transitions: Crises can be constructive for the introduction of changes in a societal system. This comes as a conclusion from our theoretical exploration of institutional transitions. From post-modern sociology (Scott, 1998) and neo-institutionalism theory (Scharpf, 1997; Giddens, 1984; Stacey, 1996), crises are viewed as constructive for introducing change. More specifically, crises from a highly modernistic point of view have a constructive function for the social system (Scott, 1998, p.97). In addition to this, Cocks (2003) views crises and triggers in general as "recurrent determinants of historical change". From our theoretical exploration of social-ecological transitions, we conclude that crises are seen as shocks of the system and stimuli for change from scholars of ecological economics and environmental researchers (Frantzeskaki, Van Daalen and Slinger, 2008; Frantzeskaki et al, 2010). More specifically, crises are uncertain and are "inevitable, sources of change in systems" (Nelson, Adger, and Brown, 2007, p.401). Crises are referred as shocks to the system and are changes in controlling variables (Resilience Alliance, 2007, p.20). It is often mentioned that social-ecological systems are disturbed hence forced to change (Abel, Cumming and Anderies, 2006; Nelson, Adger, and Brown, 2007, p.400; Scheffer et.al., 2001; Cumming, Cumming and Redman, 2006). Additionally, according to Zinmeister (1998) and Walker and Meyers (2004) environmental crises "may be the final driving force to trigger a regime shift". These crises disturb and shock the system in such a drastic way that it results in either irreversible changes (collapse or system renewal) or reversible changes that require significant effort and support for the system to recover (Folke, 2006). Summarizing, crises in socio-ecological systems may precede two different development patterns of the socio-ecological systems in particular: or regime shifting {by "creating the opportunity for doing new things, for innovation and for development" according to Folke, (2006, p.253 and 259)} or collapses of systems (Abel, Cumming and Anderies, 2006; Bruck, 2002).
Martens and Rotmans (2005) have also referred to crises as influential events in the process of creating a transition vision. Boin (2004, p.172) argues that crises "mark the transition from one stable pattern into one of many alternative futures". In policy process and policy change literature, crises are events that perturbate the system and create a context that favours –if not asks for- changes. More specifically, crises are seen as events necessary for taking "on board the new" (Kuhn 1970 p.90; Stacey 1996). Sabatier (1988) in his advocacy coalition framework, positions "external perturbation i.e the effects of systemic events" as one of the processes that can yield policy changes apart from actor groups' interactions and coalitions. In the same vein, Kingdom (1984) includes crisis and other events that can shock the system as events that can open a window of opportunity for new ideas, changes or simply, new ways of dealing with issues (Boin, 2004, p.173).

Crises as destructive events: Crises can also lead to the destruction of a societal system. More specifically, research on social-ecological systems suggested that collapse of the system may occur after the experience of a crisis. In particular, the vulnerability approach and the ecological-anthropological approach of Diamond (2004, 2005), indicate –amongst other forces- that crises such as environmental crises, wars, famine and more, to contribute to the collapse of systems. Malthus also mentions that responses of the ecological system in the form of disasters or diseases can constrain human population growth as a means of defense of the ecological system to anthropogenic activities (Becker et.al., 2005, p.300).

References of Appendix B

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APPENDIX C
Published Cases

A prelude to cases' reconstruction

The idea of using published cases as complementary empirical material comes from the incentive to have different types of empirical material for testing the conceptual models outside the transition research field. The published cases with their re-interpretation using the conceptual framework (especially the Forces Framework) are presented in separate tables (Tables C1, C2, and C3).

The criteria to select among the numerous and different published cases are listed below:

(a) Content relevance: Empirical cases should report on transformation either in a broad context (maybe can be called transition) or in a specific subsystem e.g. institutional reforms.

(b) Source validity: Published material is only included so as to be able to cross check the source of information. Cases reported in journal papers, books, conference papers or doctoral dissertations are acceptable since their validity can be checked.

(c) Indifference on context and time: The cases can refer to transformations in any country – hence indifference on context – and to transformation that takes longer than 20-25 years – hence time-span indifferent-.

(d) Type of cases' data: The published cases should present the data in a form that complies with them as primary or secondary data of good quality. This means that the presentation of historical data should be separate from interpretation in order to be useful and meaningful for the published cases to be re-constructed with the Forces Framework.

(e) Finalized transition: The end-state of the system under analysis should be clearly described and demarcated so as to be considered as a finalized transition in the given time horizon.

(f) Non-KSI-cases: We choose to review and reconstruct published cases that do not adopt the Transitions Approach so as to avoid interpreting secondary data and to avoid the 'self-fulfilling prophecy': analyzing a case that is already considered and analyzed as a transition. Empirical cases (published cases) are important to be reviewed so as to include different perspectives on what influences change (departing from other school of thoughts).

For every type of societal transitions, we specify complementary selection criteria to the criteria listed above when needed.

C1. Published Cases of INSTITUTIONAL TRANSITIONS

The cases presented in the table below are published in journals and books and are used to test the Forces Framework in published cases of institutional change. The cases presented here are the ones found to have the level of detail and the level of information for forces to be identified. Another criterion that is critical to our selection of cases concerns the time period (time span) of the institutional change: we search for cases that describe institutional change and/or evolution for more than 4 or 5 years that is the regular election cycle. We search for cases that describe institutional evolution that span longer than 10-years. Given those criteria, we found a relatively small number of cases to assess the Forces Framework (relatively small in comparison to the number of published cases). This fact may appear contradictory to the vast amount of publications of cases on institutional change published in public administration and governance journals. The main reason is that the majority of the empirical material published focus on the impact of one specific factor or attribute (e.g. conflicts between policy regimes or budgetary problems) on the process of institutional change, considering all other factors external to their analysis.

We present here a number of published cases so as to show that apart from the cases included in Chapter 4, the Forces Framework has been applied in additional empirical material so as to assess its applicability, comprehensiveness and consistency. We do not claim that these are the only cases found in published material that can be analyzed with the Forces Framework. We argue that after the search and desk research of one year, these are the cases that matched our criteria (level of detail and level of information).

Table C.1: Published cases of institutional transitions reconstructed and analyzed with the Forces Framework.

Empirical example of institutional transition	Forces Driving Transitional Change	Type of Institutional changes	Notes about archetypical responses
Public management institutions' transition in Ukraine 1990s-2000 (Condrey, et.al., 2001)	Systemic failures (administrative ineffectiveness at local level due to centralized form of institutions, lack of autonomy of local authorities, p.273); Crisis (national economic crisis, p.275); Societal demand (demand from civil service officials for a professionalization of the civil service); Standardization of practices (laws concerning civil service practices)	Decentralization (laws that assign some responsibilities to regional level authorities)	*Adhering to NPM paradigm (explicitly mentioned in referenced sources)*
Mobility infrastructure transition in Finland 1970-2000 (De Jong, 2008)	Systemic failures (cost overruns); Presence of new practices (private contractors with innovative practices; introduction of Public Private Partnership practice); Crisis (Economic crisis – late 1990s)	Deconcentration of the Road Agency (Split into the Road Administration and the Road Enterprise); Liberalization of road management	
Mobility infrastructure transition in Sweden 1970-2000 (De Jong, 2008)	Systemic failures (cost overruns); Presence of new practices (private contractors with innovative practices; introduction of Public Private Partnership practice); Crisis (1990s-Economic crisis in forms of a recession);	Liberalization of road management (1990s)	

Table C.1 (continued): Published cases of institutional transitions reconstructed and analyzed with the Forces Framework.

Empirical example of institutional transition	Forces Driving Transitional Change	Type of Institutional changes	Notes about archetypical responses
Mobility infrastructure transition in Norway 1990-2007 (De Jong, 2008)	Systemic failures (cost overruns); Presence of new practices (private contractors with innovative practices; introduction of Public Private Partnership practice; Introduction of NPM paradigm from other Nordic countries)	Liberalization of the public Road Enterprise (2002)	*Adaptation to context changes*
Mobility infrastructure in Germany 1970-2000 (Denkhaus and Schneider, 1997)	Systemic failures ("accumulated debts"; "rising infrastructure capacity requirements" p.78); Societal crisis (opposition from various actors); Provision of resources (1993 – regionalization fund); Standardization of practices (compliance of reforms with EC Directive 91/440 and EC Law 1893/91)	Privatization (1993)	*Adaptation to context changes*
State-owned enterprises in New Zealand (Aberbach and Christensen, 2001; Christensen and Laegreid, 2001; Steane, 2008; Erakovic and Powell, 2006) []Note 1]	(Economic) Crisis; Systemic failures ("not sustainable economic system"); Standardization of practices (Erakovic and Powell, 2006);	Liberalization (1984); Privatization of state-owned enterprises (1984-1994); Deregulation of domestic markets;	*Adhering to NPM paradigm (explicitly mentioned in referenced sources)*
Public service systems in Norway (mid-1980s-2000) (Christensen and Laegreid, 2001)	Exogenous event ("stronger felt globalization process" p.87)	Devolution; Administration reforms;	*Adhering to NPM paradigm (explicitly mentioned in referenced sources)*
Public management institutions' transition in Switzerland 1970-2000s (Schedler, 2003)	Systemic failures (such as administrative ineffectiveness to deal with local problems and serious financial problems); Presence of niches (presence of pioneers within the administrative staff)	Decentralization changes (Devolution via "managerial reforms" of the way of functioning of local authorities and meso-level authorities)	*Adhering to NPM paradigm (explicitly mentioned in referenced sources)*
Public mobility sector transition (rail revolution) in the United Kingdom 1920s-2000 (De Bruijn, et.al., 2004b, pp.23-36)	Systemic failures (1989-Infrastructure inefficiency); Provision of resources (1993-Research funds); Crisis (societal unease, resistance via boycotts and creation of negative social image of the liberalized system); Systemic failures (1999- Paddington accident, 2000-Hatfield accident, systemic inefficiencies present such as cost overruns, administrative ineffectiveness due to "fragmentation enhanced by subcontracting" (p.26))	Centralization (1921); Nationalization of the railways (1948); Liberalization and privatization of railways (between the period 1993-1999);	*Anticipation*

Table C.1 (continued): Published cases of institutional transitions reconstructed and analyzed with the Forces Framework.

Empirical example of institutional transition	Forces Driving Transitional Change	Type of Institutional changes	Notes about archetypical responses
Public management institutions' transition in Italy 1980s-2002 (Capano, 2003)	Systemic failures (administrative ineffectiveness); Standardization of practices (a series of legislative actions from 1992 to 2001 – presented in detail in Capano, 2003, p.790, Table 1)	Decentralization changes (1990s)	*Adaptation*
Public management institutions' transition in Thailand 1980-2000 (Mutebi and Sivaraks, 2007; Cheung, 2005)	**S**ystem failures (inefficiencies and increased transaction costs); Crisis (1997-Asian economic crisis); Presence of societal demand (pressure coming from market actors/business interests for change in public management routines/practices); Standardization of practices (2002- the Ministerial Restructuring Act and the Public Administration Act) [Note 2]	Decentralization (delegation: ("decentralize responsibilities and finances from the central government to subnational governments") [Note 1] Privatization of state enterprises (1999- Public Sector Management Reform Plan)	*Adaptation*
Public management institutions' transition in Israel (local level institutions) 1970s-2003 (Razin, 2004)	Systemic failures (over-fragmentation, budget-related problems); Crisis (1998- local political opposition towards change in local authorities management); Crisis (1985-Economic crisis in form of hyperinflation, 2001-2004-War and economic crisis, 2003- Fierce opposition of citizens to a proposal for reform) [Note 3]	Decentralization of local authorities (1970-1980s); Privatization; Centralization of local authorities (2003- Reduced Amalgamation Law);	*Anticipation*
Public management institutions' transition in China 1980-2000s (Cheung, 2005)	System failures (system inefficiencies to manage growing logistics); Crisis (1997-Asian economic crisis);	Decentralization; Liberalisation (fiscal liberalization)	*Adaptation*
Public management institutions' transition in Singapore 1980-2000 (Cheung, 2005)	System failures ("fiscal deficit", inefficiencies); Crisis (1997-Asian economic crisis);	Centralization (1995 – Public Service Initiative); Privatization	*Adaptation*
Public management institutions' transition in Japan 1980-2000 (Cheung, 2005)	Crisis (1997-Asian economic crisis);	Privatization of Japan National Railway, the Nippon Telegraph and Telephone;	*Adaptation*
Public management institutions' transition in South Korea 1980-2000 (Cheung, 2005)	Crisis (1997-Asian economic crisis); Societal crisis (conflict within the organizations: "split between new political elites and the bureaucratic mandarins" p.268)	Decentralization reforms	*Anticipation*
Public management institutions' transition in Taiwan 1980-2000 (Cheung, 2005)	Crisis (1997-Asian economic crisis); Societal demand ("rise of indigenous business power who demanded a share of the public enterprises", p.270)	Privatization (1990s); Decentralization (1998 -deconcentration: "abolition of provincial layer", p.270)	*Adaptation*

Notes Table C.1:

[Note 1]: *The New Zealand example is one of the best cases when presenting the optimal implementation of NPM. However, all the analyses include only the political process and the steps of the liberalization and not information on the social context and impact. Hence, we cannot elaborate on societal determinants for New Zealand albeit its particularity when talking about NPM.*

[Note 2]: *An extensive presentation of the key laws and legislation is given by Mutebi and Sivaraks, 2007, p.1089-1091.*

[Note 3]: *This case concerns a lock-in of an over-decentralized system that suffers from legislative inconsistencies and fragmentation of decision making centers. Attempts to transition the system towards efficient public management are on-going.*

C2. Published Cases of SOCIAL-ECOLOGICAL TRANSITIONS

The cases presented in the table below are published in journals and books and are used to test the Forces Framework in cases of social-ecological change. The cases presented here are the ones found to have the level of detail and the level of information for forces to be identified. Another criterion that is critical to our selection of cases concerns the time period (time span) of the institutional change: we search for cases that describe institutional change and/or evolution for more than 4 or 5 years that is the regular election cycle.

We search for cases that describe institutional evolution that span longer than 10-years. Given those criteria, we found a relatively small number of cases to assess the forces framework (relatively small in comparison to the number of published cases). This fact may appear contradictory to the vast amount of publications of cases on environmental change published in environmental management, ecosystem research, ecological economics and impact assessment journal sources. The main reason is that the majority of the empirical material published focus on the findings of research projects and programs that last approximately 4-5years and to cases that refer to either solely policy changes or ecosystem changes.

The last years (since 2000) there are new approaches on social-ecological systems' research that investigate either their mechanisms towards resilience (the resilience approach of the Resilience Alliance) or the co-evolutionary approach founded by Berkley center of environmental research (Noorgaard) or their metabolism (the Vienna School of Social-Ecological Transitions, Fisher-Kowalski). These schools of thought adopt a long-time scale when analyzing social-ecological systems and our analysis draws from their cases' pool.

The information provided in these cases has been re-conceptualized and reconstructed using the framework of the Forces Driving Transitional Changes so as to indicate which forces were present during the change of these social-ecological systems and which forces link to every response to change of the system. What is observed in the cases is that apart from formation and driving forces (as stated in the reviewed theoretical approaches), support forces are also present when regime shift takes place. The presence of support forces is an indication/manifestation of the sufficient function of formal institutions.

We present here a number of published cases so as to show that apart from the case included in Chapter 5, the Forces Framework has been applied in additional empirical material so as to assess its applicability, comprehensiveness and consistency. We do not claim that these cases are either exhaustive or that they are the only cases found in published material that can be analyzed with the forces framework. We argue that after the search and desk research of one year, these are the cases that matched our criteria (level of detail and level of information).

Table C.2: Published cases of social-ecological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-ecological transition	Forces Driving Transitional Change	Type of changes	Notes about archetypical SES responses
Regime shift and reorganization of the water management system of the wetlands Everglades, Florida, USA 1970-2000 (Lebel, et.al., 2006; Gunderson and Light, 2006; Gunderson et al, 2006; Vedwan et.al., 2008; De Bruijn, et.al., 2004b, pp.9-21)	Crisis (Nutrients pollution- Algae blooms in the Lake Okeechobee; extensive flooding); Presence of niches (NGOs and state agencies for the restoration of Everglades; Everglades coalition); Presence of new practices (new practice for nutrients management for the lake); Standardization of practices (water management policies; Everglades restoration plan in 2000); Provision of resources (fund for restoration; Kissimmee Restoration, Everglades Restoration Removal projects)	Institutional changes (Deconcentration - New institution etc. South Florida Water Management District)	*Adaptation*
Regime shifts in two subsystems: hunting and fishing The James Bay area – Eastern subarctic Canada 1900s-1998 (Berkes, 1998)	Crises (exploitation of fish stocks; over-hunting of caribou); Provision of resources (signing of agreement); Presence of a niche (local people/stewards spread their local knowledge on good hunting practices); Presence of of new practice that is institutionalized (management practices such as quota and breeding seasons p.113); Presence of new practices (new practices of rotation/pulse fishing and population thinning in fisheries)	Market change (monopoly in fur trade market)	*Adaptation*
Regime shift of the socio-ecological system of Aboriginal pastoral societies Western New south Wales, Australia 1975-2004 (Abel, Cumming and Anderies, 2006)	Crises (diseases; drought of 1895-1902; economic recession); Presence of niches (national organizations for Aboriginals); Exercise of power (protecting power in the form of granting citizenship to Aboriginals, legislation in 1980s and 1990s); Provision of resources (forgiveness of pastoral debt; investments in infrastructure and communications and elsewhere)	Institutional changes (Market changes in the form of price changes of wool)	*Adaptation*

Table C.2 (continued): Published cases of social-ecological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-ecological transition	Forces Driving Transitional Change	Type of changes	Notes about archetypical SES responses
Regime shift in agricultural system: from large scale commercial cattle ranching to wildlife ranches South East Lowveld, Zimbabwe 1970s-2004 (Abel, Cumming and Anderies, 2006)	Provision of resources (human and social capital); Various Crises (severe droughts 1983-1984, 1991-1992, 2001-2002; HIV-AIDS casualties; civil war; outbreaks of disease such as FMD); Presence of new practices (wildlife ranching 1980s, tourism); Standardization of practices (wildlife legislation 1975); Provision of resources (subsidized activities related with protection of wildlife)	Institutional changes for agriculture (agrarian reform, 2000)	*Adaptation*
On-going transition: Lake Victoria, East Africa - Papyrus wetlands 2000-2006 (Kiwango and Wolanski, 2008)	Crisis (Environmental damage due to waste discharge in the lake (bad practice) lead to eutrophication); Presence of new practices (new infrastructure – building of new dams like Kiira dam)	Environmental changes (Land-use changes :papyrus wetland's land used for crops and agricultural use)	*Developing trend to replace wetlands' area with agricultural crops – this may lead to increased eutrophication of Lake Victoria and collapse of artisanal fisheries*
Agricultural sector regime shift: from agragarian to an industrial socio-ecological regime, Austria 1830-2000 (Krausman and Haberl, 2007; Krausman, Schandl, and Sieferle, 2008)	Crises (WWI , WW II, economic crisis of 1930; oil crises in 1970s); Presence of new practices (Energy supply infrastructure – energy conversion infrastructure + Railways + steam engine; intro of new crops (legumes, root crops); new agricultural practices- fertilization, use of pesticides; new agricultural machinery); Presence of niches (from coal to steam engine to internal combustion engine in energy and in industry; adoption of new agricultural practices); Societal demand (growing demand for human and animal labor + demand for food due to population growth)	Environmental change (land-use changes- Deforestation); Market change (Agricultural output); Population change (population growth)	*Adaptation*

Table C.2 (continued): Published cases of social-ecological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-ecological transition	Forces Driving Transitional Change	Type of changes	Notes about archetypical SES responses
Agricultural sector regime shift: from agragarian to an industrial socio-ecological regime, Austria 1830-2000 (Krausman and Haberl, 2007; Krausman, Schandl, and Sieferle, 2008)	Crises (WWI , WW II, economic crisis of 1930; oil crises in 1970s); Presence of new practices (Energy supply infrastructure – energy conversion infrastructure + Railways + steam engine; intro of new crops (legumes, root crops); new agricultural practices- fertilization, use of pesticides; new agricultural machinery); Preence of niches (from coal to steam engine to internal combustion engine in energy and in industry; adoption of new agricultural practices); Societal Demand (growing demand for human and animal labor + demand for food due to population growth)	Environmental change (land-use changes- Deforestation); Market change (Agricultural output); Population change (population growth)	*Adaptation*
Agricultural sector regime shift: from agragarian to an industrial regime United Kingdom 1830-1995 (Schandl and Krausmann, 2007; Krausman, Schandl, and Sieferle, 2008)	Crises (WWI , WW II, economic crisis of 1930; oil crises in 1970s); Presence of new practices (new crops; innovations in agriculture; new crop rotations; motorized automobiles; fossil fuel energy in agriculture production)	Institutional change of the land use; Demographic change (population growth); Institutional change (regulation change – abolishment of corn laws); Market change (Food market change- Increase in food imports + Decline of energy prices)	*Adaptation*
Agricultural sector regime shift: modernization of Dutch agriculture and livestock systems The Netherlands 1900s-2000 (Grin, et.al., 2004)	Crisis (agricultural crisis; social crisis of hunger after WW II; Presence of new practices (new knowledge and technology for agriculture – OVO; specialization and separation practices towards animal holding / breeding and crop production; use of machinery); Provision of resources (financial measures; land redistribution); Crisis (pollution from manure; 1997-classical swine fever epidemic; 2000 BSE outbreak; 2001 foot and mouth disease; 2002 MPA affair); Exercise of power (via legislation aiming at reducing pig farming); Provision of resources (1998 - 348 Programm;); Presence of niches (establishment of projects of new livestock systems); Societal Demand ("need to transform identities" (p.144) in organic pig raising project)	Institutional changes (new institutional arrangements with an involvement of Ministry of Environment and Spatial Planning in issues of Ministry of Agriculture; 1990s privatization of Direction of Agricultural Research organization);	

Table C.2 (continued): Published cases of social-ecological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-ecological transition	Forces Driving Transitional Change	Type of changes	Notes about archetypical SES responses
Agricultural sector regime shift: from industrialized to "organic" agriculture USA 1950s-2000 (Carolan, 2006)	Crisis (social crisis between farmers and agrochemical companies like Monsato); Presence of a niches (organic movement led by J.I.Rodale from 1950-1971; creation of sustainable agriculture organizations); Standardization of practices (1980-Report for organic farming practices from US Dept. of Agriculture); Provision of resources (1982 Farm Bill; research funds, LISA program, SARE program)	Institutional change (deconcentration of institutions by establishing new institutions for sustainable agriculture); Environmental changes (land-use changes)	
Agricultural sector regime shift: Nisuros Island, Greece 1930s-2001 (Petanidou, Kizos and Soulakellis, 2008)	Crisis (biodiversity loss; erosion; war and Italian occupation); Presence of new practices (farming in low lands; mechanization of agriculture and animal husbandry; irrigation; use of fertilizers and pesticides); Presence of niches (mining; tourism)	Environmental changes (land-use changes); Demographic changes (emigration); Institutional changes – Market changes (agricultural system change)	*Adaptation*
Agricultural sector regime shift: from meadows to industrialized crop cultivations(regime shift) Turkey 1950s-2000 (Tanrivermis, 2003)	Crisis (Groundwater pollution by nutrients; soil erosion); Presence of new practices (fertilizers in agriculture); Provision of resources (subsidies for use of fertilizers 1970s); Standardization of practices (environmental legislation for pesticides, fertilizers etc; 1983- the Environment Law; 1998 - Pasture Law of 4342)	Demographic changes (population increase); Environmental changes (land-use changes); Institutional changes (establishment of various ministries)	

Table C.3: Published cases of socio-technological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-technological transition	Forces Driving Transitional Change	Notes about archetypical responses
Railroad network, USA, 1830-1970 (Salsbury, 1988)	Presence of a new demand (1830s) (trade, and people's commuting); Presence of niches (numerous small railway companies spread locally and regionally); Provision of resources (1830s-1950s) (Investments in railways and railroads, Western Railroad); Systemic failures (1840s – series of disastrous wrecks due to mal-operation of the railway system); Presence of new practices (1850s – New administrative methods by Western Railroad); Presence of new demand (1840s – demand for signaling system for the railways); Presence of new practice (1844 – new technology – Morse's experimental telegraph); Provision of resources (1850s- railroad companies invest in telegraph company - mutual support, pp.44-45); Standardization of practices (1883 – Standardization of time – standard time and time zones by the Railroads); Technological change (1830-1840s – America-built and designed locomotives and engines); Presence of new practice (1969-1970s) (System building strategy at place, pp.52); Technological change (1868 – air brakes); Presence of new demand (1969) (Demand for moving goods along long distances – fast freight lines); Standardization of practices (1890-standard gauge for all lines); Presence of a niche (1970s – placement of air brakes in some rail cars and freight cars); Presence of new demand (1900s – demand for equitable rail tariffs, p.59-60); Standardization of practices (Standardization of tariffs for freight transport and internal accounting methods); Standardization of practices (1918 – Congress formally establishes standard time) ; Labor Laws (1920s); Systemic Failures (1920-1930s – ineffective management, p.63); Technological changes (1930s-1940s – steam motive power, light weight metals, Centralized Train Control systems); Crisis (1970s – Financial collapsing of the Penn Central Railroad system).	NOTES: - Co-Evolution: The railroad network supported and co-evolved with the telegraph network/system - The technological changes of the 1930-1940s were not adopted at that time by the system, but quite later.

Table C.3 (continued): Published cases of socio-technological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-technological transition	Forces Driving Transitional Change	Notes about archetypical responses
Energy System Transition 1965-1995 California, USA (de Vries, 2005; Van Est, 1999; Nemet, 2009)	Institutional change (1965 – Establishment of the State Power Plant Committee – Deconcentration of California State Resources Agency); Crisis (1969 – Oil spill in Santa Barbara); Standardization of practices (1970 – National Environmental Policy Act – NEPA); Standardization of practices (1970 – California Environmental Quality Act – CEQA); Presence of new demand (1970 – demand for energy supply by urban and industrial users); Provision of resources (1970-1972 Resources for research on energy sources including nuclear power plants when Rand was contracted); Exercise of Power (1973 – Legislative power with the veto to the siting bill); Crisis (1973 – Oil Crisis : Arab oil export embargo); Institutional Change (1975- Energy Research and Development Administration – ERDA: Deconcentration); Standardization of resources (1974 – Warren-Alquist siting bill); Institutional Change (1974 – California Energy Commission : Deconcentration & Specialization); Presence of new demand (1976 – Public opposition to nuclear energy : demand on no-nuclear energy); Institutional Change (1976 – Establishment of the Office of Appropriate Technology – Devolution of CEC and CPUC); Provision of support (1974-1977 – Federal Wind Energy Program fund); Institutional Change (1976 – Private Energy Producer Act : Deregulation and Deliberation of the energy market / solar/wind tax credit); Provision of support (1978 – Solar Legislation : Legislative support of solar energy alternative and industry); Standardization of practice s (1978 – National Energy Act); Provision of resources (1979 – Mello Bill for wind resource development); Provision of support (1970s – Public Utilities Regulatory Policies Act and the Energy Tax Act : Legislative Support of renewable energy industry and financial incentives for private investments, Van Est, p.44); Crisis (1979 – Three Mile Island near meltdown); Introduction of new practices (1979 – First USW Wind park with a trial-and-error process); Exercize of power (1980 – Additional Rules that forced utilities to purchase RES power : Power exersize by legislature to the utilities supporting RES market); Introduction of new practices (1983 – CPUC required contracts by the Energy Producers for their energy production – ISO 4 contracts); Standardization of practices (1986 – CPUC approved rules for the energy market competition); Provision of resources (1987 – research support for conducting a feasibility study for RES); Standardization of practices (1990 – Assembly Bill 3995 – values for cost and benefit assessment of environmental impacts and resource diversity); Technological Change (1991- 33M-VS wind turbine); Institutional Change (1992 Energy Policy Act – Deregulation : wholesale competition in electricity generation and price through a competitive auction, Van Est, p.65); Crisis (1995 – Legitimation crisis – Illigal bidding by the Commission CPUC)	NOTE: Observation of a self-enforcement loop – 1976-PURPA Acts until 1983 Deukmeijan Administration in California with power politics against existing laws and bills that promoted renewables Entry Point : 1976 Institutional Change with the PURPA Acts Exit Point: 1983 Change of Administration – Political Change

Table C.3 (continued): Published cases of socio-technological transitions reconstructed and analyzed with the Forces Framework.

Empirical Example of Socio-technological transition	Forces Driving Transitional Change	Notes about archetypical responses
Railroad system France, 1832-1937 (Caron, 1988)	Presence of a new practice (1829-1832 First experiments on passengers transportation with locomotive with a tubular boiler); Presence of new demand (1832- Demand for passengers transportation); Provision of resources (1832 – First state subsidy for railways); Provision of resources (1843-1960 slow expansion of rail lines); Presence of a new demand (1850s up to 1870s – demand for freight transport that was increasing); Systemic failures (1830s failures of the system, p.77); Presence of a new practice (1840 – Experiment with privatization of the Paris-Rouen and the Paris- Orleans lines); Crisis (1846 – Financial crisis with the railways shares); Technological Change (1849 – The Crampton locomotive) ; External Event (1859 – Rail Accident in Saint-Germain); Systemic Failures (1842 and 1846 accidents caused due to faulty lines and poor conditions of the railways, p.86-87); Presence of a new demand (1840s-1850s Demand for long-distance communication of the railway operators); Presence of new practice (1845 – Electric telegraphy) ; Provision of resources (1845-1846 Lay down of the telegraphy lines); Organizational Change (1850s establishment of the administrative organization of the networks, p.87-88); Standardization of practices (1850s – administrative standardization); Systemic failures (1871, 1872, 1878, 1882 Accidents due to system inefficiency to deal with increased traffic); Presence of a new demand (1870s – demand of new material and technologies by the railways like metal bridges); Presence of a new practice (1870s electrification of large areas, p.97); Standardization of practices (1870s electrification of signaling); Systemic failures (Accidents 1876, 1879, 1880, 1881 due to signaling failures, p.97); Presence of new practices (1880s two new technologies were proposed and adopted: the electric semaphore and the continuous brake); Standardization of practices (1921 New Convention on Networks for common fund); Crisis (1930 global financial crisis); Institutional Change (1937 – Nationalization of railways);	NOTE: The railway system in France pushed for innovations and technologies in metallurgic industry (metallic bridges), and in energy system, as for example promoting the use of electricity (p.97).
Railroad System Germany, (1815-1920) (Heinze and Kill, 1988)	Presence of a new demand (1800s – demand for routes – streets, waterways); Provision of resources (1805-1807 investments in traffic infrastructure – highway building); Presence of a niche (1800s local tradesmen and manufacturers wanted railroad for trade and communication transits, p.115); Provision of resources (1830s Railway projects in all major German cities, p.115); Presence of a new demand (1840s – demand for carrying of coal); Presence of a new practice (1849- First coal cargo train to Berlin); Presence of a new demand (1940s – demand for transit of cargo between cities without the need to be transshipped); Standardization of practices (1846 – standardization of technical equipment and technologies by the 17 Prussian railway companies, p.126); Provision of resources (1850s – provision of new infrastructures such as new lines, second and third tracks, switches and connections); Provision of resources (1960s – 1870s – expansion of the railway network by the different states of Germany); Institutional Change (1871 – Reichsgrundung – Unification); Crisis (1870-1871 French-German War); System failures (1870-1871 during the war, system ineffectiveness in the form of delays in troop and material transports, p.127); Presence of a niche (1875 and 1876, nationalization of all important railways by Bavaria and Saxony states respectively – that were acting as niches); Institutional Change (1920 – foundation of the Deutche Reichbahn as the national railway company – Nationalization of the railways);	NOTE: “It can therefore be said that there was no general or even national interest in a railway system when its building began.” (p.115) Private interests were expressed but did not invest in the railway system.

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- **RESHARE** (FP7 project) (www.reshare.nu) (2010)

- Participate and contribute to the **FP7 project: Tender RTD12/0801** "Monitoring the FP7 contribution to sustainable development" as member of the TU Delft team (2009)
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