Understanding the Development of Water Resources Management in China

Dissertation

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Summary

Throughout the history, the socio-economic development in China has been subjected to water scarcity and flooding. This dissertation aims to understand the development of water supply and demand management and flood management in China during the period of 1949-2009. In this period, both water supply and demand management and flood management underwent a shift in management paradigm from an engineering-oriented approach to a more integrated and sustainable approach, initiated by the central government. However, the wide implementation of management practices in line with the alternative paradigms is expected to be a long-term and complex process. Meanwhile, water resources management is constantly interacting with the external environment (e.g. societal transformation and climate change). All these raise the following question: did fundamental changes really take place in the structure of water supply and demand management and flood management in China? If yes, what triggered and facilitated such fundamental changes to take place and how?

To answer these questions requires a better understanding of the development and interactions of various factors both within and outside water resources management. So far, this field has received little attention in water management research in China.

Insights from sustainability transitions research are particularly useful for answering these questions. "Regime" is the central concept for sustainability transitions research. In this dissertation, a water resources management regime encompasses:

*a whole complex of actors, physical infrastructures, technologies, social practice and various soft factors which are highly interconnected and together form the base for the functioning of the water resources management system, i.e. fulfilling water demand with sufficient quality to both humans and ecosystems, as well as providing protection from water-related risks. These soft factors include the management paradigm, discourses, values, knowledge base, and institutions (*adapted from Pahl-Wostl, 2007b).

A regime transition can be broadly understood as "a long-term continuous process of societal change, during which the structure of society, or a sub-system of society, fundamentally changes"(Rotmans et al. 2001).

The core of sustainability transitions research is to understand how a transition unfolds and how it can be, in part, guided. The two important hypotheses in transitions research are multi-phase perspective (MPP) and multi-level perspective (MLP). They provide a broad framework and a starting point for examining regime transitions, but they need to be further developed and adjusted by including insights from other disciplines and empirical studies. On the other hand, transitions theory has mainly been developed by the European scientific community and current case studies are geographically focused on developed countries in Europe. Studies on

transition in the context of developing countries and emerging economies in other continents are still limited.

Accordingly, this dissertation aims to understand the development course of the water resources management regime in China, i.e. whether, how and to what extent a regime transition took place and how different processes contributed to the start of a transition and the transition phase itself. In order to achieve this, the author has pursued the following two research objectives:

- To develop conceptual frameworks to enable a detailed and precise analysis of regime development.
- To apply the elaborated conceptual frameworks to explore the development of the water resources management regime in China.

Elaborations on the conceptual framework for sustainability transitions research

Two conceptual frameworks were developed based on the existing frameworks of sustainability transitions research and insights from organizational learning, complex adaptive system theory and political science.

- *What needs to be changed and to what extent for a regime transition to take place?*

This question aims to provide clearer criteria for different levels of regime development, i.e. the incremental improvement of established routines, transitions and transformation. To approach to this question, the author linked Van der Brugge's structuration of "regime" and Pahl-Wostl's conceptualization of multiple-loop learning. This is a valuable addition to the MLP and MPP. While Van der Brugge's conceptualization opens the black box of a regime and specifies the precise components of a regime, its combination with Pahl-Wostl's multiple-loop learning allows for the differentiation between different levels of regime development according to the "learning" of different regime components.

- *How is the start of a regime transition triggered?*

Although MPP specifies four different phases of regime development, the boundary between the predevelopment and take-off phases is rather vague. This part of the conceptual framework enables the identification of the moment when a regime transition starts. The author defined a term called "Window of Opportunity for Transition (WOPT)", which was built on Kingdon's "multiple stream model" of policy changes and linked to Van der Brugge's structuration of "regime" and Pahl-Wostl's multiple-loop societal learning concept .

- *How do niches influence regime development?*

In the school of socio-technical regime conceptualization, niches are where radical technological innovations geared to the problem conditions of the existing regimes are created and experimented. In fact, niches also exist in a societal system, such as "shadow networks" (Olsson et al. ,2006), "adaptive network" (Nooteboom (2006), but they are not rooted in technological innovations. Following the line of

organizational learning, on which Pahl-Wostl (2009)'s development of the multiple-loop learning concept based, these networks and associated processes are referred to "informal learning processes" in this dissertation.
Various concepts have been developed to depict the way in which informal learning processes shape regime transitions. In this dissertation, the author limited her focus on how informal learning processes and how a specific actor group ,epistemic communities, who can potentially shape informal learning processes, "find" their way to influence regime development.

Given that regime development eventually unfolds by way of various concrete activities, the author developed a second framework, which drills down into ***three types of governance activities and their co-evolutions during a regime transition***. It was built on a part of Loorbach's transition management work, which groups different activities into three types of purposeful governance activities, i.e. strategic, tactical and operational. These activities facilitate a regime transition towards a desired regime only when they align with each other. The framework further elaborates the adaptive capacity of the regime (polycentric governance, information management, and sufficient resources) that facilitates the co-evolution of these activities.

Deepening empirical basis: three case studies on the development of water resources management regime in China and reflections

The author then applied the elaborated conceptual frameworks to explore the development of two sub-regimes of the water resources management regime in China through three case studies: flood management (Case Study 1) and water supply and demand management (Case Studies 2 and 3).

- ***What needs to be changed and to what extent for a regime transition to take place?***

In Case Study 1, the author investigated whether, to what extent and how a transition towards a regime of Integrated Flood Management (IFM) took place in the period between 1949 and 2009. A transition towards an IFM regime started in Dongting Lake Area, based on the evidence of different levels of learning around several normative criteria of IFM. However, the transition of the whole flood management regime in Dongting Lake area to IFM may still take time, due to the slow reconfiguration of the rest of the regime and the lack of change in other regimes. Strategies to achieve the latter may include, for example, strengthening the overall coordination between these regimes by higher level government. In addition, in decision-making or implementation processes, such as those for cross-sectoral and cross-administrative-boundary collaboration, an increasing involvement of non-governmental stakeholders and experts is needed.
The findings of Case Study 1 challenge the theoretical assumption of a linear sequence of a regime development, i.e. being a step-wise move through single to

double and on to triple-loop learning. The author, therefore, draws a tentative hypothesis: in the regime development process, these different levels of learning do not necessarily take place in a step-wise fashion but occur in a back-and-forth manner.

- *How is the start of a regime transition triggered?*

In Case Study 2, the author explored the moment when the transition(s) of the water allocation regime in the Yellow River Basin started, i.e. whether and how "Windows of Opportunity for Transition (WOPTs)" emerged.

The study identified a series of political and problem windows that had opened in the water allocation regime in the Yellow River Basin since the 1950s. Four WOPTs opened as a result of critical connections between problem windows, political windows containing both paradigm changes and struggles between interest groups, together with solutions that matched both of these windows. These WOPTs triggered the start of regime transitions. However, in some cases, regime states reverted to the original "basin of attraction" after the transitions started, due to the lack of an immediate reconfiguration of other regime components. On the other hand, the study also shows that the emergence of certain other political windows and problem windows did not trigger the start of a regime transition, demonstrating that a transition is less likely to start in the absence of a critical connection of all three streams.

- *Three types of governance activities and their co-evolution during a regime transition*

Case Study 3 investigated a special period during the transition to a Water Saving Society (WSS) in China: a part of a ten-year exploration and experimentation process at the beginning of the transition.

The author identified that three types of governance activities (strategic, tactical and operational) took place during this period. These activities and their partial co-evolutions played an important role in the ten-year exploration process of WSS construction. The author then investigated how the co-evolutions were facilitated or impeded by examining the adaptive capacity of the regime, which is considered to be essential for regime transitions. The results illustrate the fact that measures to enhance the adaptive capacity of the existing regime need to be developed to support the three activities and to facilitate their co-evolutions, for instance, setting up proper incentive systems for local governments to experiment, improving the monitoring system for the experiment and transition process, and enhancing financial and personnel resources for experiment and monitoring.

- *How do niches influence regime development?*

Two types of informal learning processes were investigated in the case studies. The first type has strong links and intensive interaction with the existing regime. They were often led by actors in the formal policy processes. The second type was initiated by actors located outside the formal processes and have weaker links to,

and less interaction with, the existing regime. These two types of informal learning processes influence regime transitions through different approaches.

Among the first type of informal learning processes, policy experiments were found to be a key element in water resources management regime development in China. On the one hand, in our case studies the central government and/or governments at a higher level than the locality where the experiment took place guided and coordinated these experiments. On the other hand, the government at the higher administrative level also created protective spaces for these experiments, for example, by exempting them from existing regulations. This support from the higher level was essential for the innovations to be effectively scaled up and to contribute to regime transitions. At the same time, these case studies also show that sufficient decision-making power was accorded to local government to develop the approaches tailored to local conditions. In this way, local innovation potentials were explored. However, to fully exploit the potential of policy experiments in facilitating the transition, certain barriers still need to be overcome, for example, to enhance the adaptive capacity of the regime.

Last but not least, it is worth noting that the selection, implementation, evaluation and scaling up of the policy experiments are still a part of the political process and are not always transparent. Learning through policy experiments may be vulnerable to the powerful interests of specific groups. This, in turn, calls for a "further elaboration of procedural designs to increase their political robustness" (Voss et al., 2009).

In the second type of informal learning processes – those with weaker links to formal policy processes in the regime – the leaders of the processes actively explored the links. One strategy is to efficiently use both "venues", in which key actors in the formal processes take part and/or policy needs are discussed, and the media, which may draw attention to these key actors. In addition, the actors in these learning processes can also deliberately create or co-organise "venues" in which their ideas from double-loop learning can be represented.

In both types of informal learning processes, one actor group – the epistemic community –can play an important role. The epistemic community contains members from both within the formal processes and outside the processes. Knowledge generated from such a community is not constrained by the prevailing paradigm within the formal processes. It creates a dynamic in the knowledge base of the regime and may result in alternatives being incorporated into the formal policy processes. Such epistemic communities are very valuable for informal learning processes (of both the first and second type) and enable the outcomes of the informal learning processes to effectively influence regime transition.

To recap, what lessons can these case studies deliver for the development of both flood management and water supply and demand management sub-regimes in the studied regions? The studies show that transitions have already started in these sub-regimes and suggest that improvements are needed for further transitions

towards sustainability. These improvements include measures that, for example, enhance the adaptive capacity of the sub-regime, reconcile the transitions of water resources management regime and the development of other relevant regimes, and speed up the reconfigurations of regime components.

The other key question is what these case studies of China water resources management regime can contribute to sustainability transitions research? In general, one can expect that the basic principles of regime development and transition in the two sub-regimes in China are same as those in other countries, namely, how the start of a regime transition is triggered (i.e. how WOPTs emerge), how niches influence regime development (i.e. the features of niches and the linkage necessary for niches to influence the regime). In addition, Case Study 3 demonstrated the three types of governance activities and their interactions after the transition of a water supply and demand management regime started, which provides empirical insights of "partial" transition management in other countries than the Netherlands, where the concept of transition management origins. Furthermore, Case Study 1 indicated the general applicability of the conceptual approach developed in this dissertation to analyse the extent of regime development. However, it revealed that single, double, and triple-loop learning does not necessarily take place in a step-wise fashion. Triple-loop learning can first take place, given the existence of a highly top-down decision-making structure and the urgency of the problem perceived by high-level decision-makers, which is the case in China. Last but not least, the case studies illustrate a special approach how informal learning processes influence regime development in China, that is, policy experiments led by the government. While most experiments studied in sustainability transition research are located at projects and technology levels (e.g. Loorbach, 2007; Van der Brugge, 2009; Berkhout et al., 2010; Geels, 2002), policy experiments in China exhibit another scale and dimension of experiments and may effectively facilitate regime transitions if being deployed properly. The role and shortfalls of such an approach for sustainability transitions still deserves a further systematic research.

Recommendations for Future Research

This dissertation generates some new insights which form the basis for future research:

Further differentiation of the regime components: The elaborated conceptual framework is useful for understanding the changes that take place in regime components and to which extent. In order to provide more practical recommendations for a regime transition, a more differentiated regime conceptualisation is needed.

Further analysis on multi-regime interactions: A water resources management regime does not develop in isolation. More attention needs to be devoted to the interactions between different regimes in investigating water resources management regime development and how to deal with them.

Further drilling down into the actor dimension: Each specific sub-regime of the water resources management regime involves multiple actors who play various roles related to the societal function of the sub-regime. Thus, detailed and systematic studies are recommended to understand how various actors mobilise and apply their resources to facilitate or impede a transition of specific water resources management sub-regimes in China.

Comparison of transitions: The final recommendation is to strengthen comparisons between transitions in the water resources management regime in China and other countries with different policy cultures.

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1. Introduction and Research Objectives

1.1. Water resources management in China

China's total annual renewable volume of water amounts to 2,812 km^3, which is the sixth largest volume in the world (Xie, 2009). Globally, China also has the greatest total length of rivers, with seven major river basins (Hai, Huai, Yellow, Liao, Songhua, Yangtze and Pearl River), of which Yellow River and Yangtze River are among the longest rivers in the world. Despite this abundant total water resource, in 2011 the annual freshwater resource per capita in China was only about a quarter of the world average, i.e. less than 2,000 m^3 (MWR, 2012; Liu and Yang, 2012). There is also a strong geographical split between water availability in southern and northern China: natural water resources are much scarcer in northern China than in southern China. In northern China, 19% of the natural water resources support 46% of the population and generate 44% of GDP (Wang, 2006). For example, in the Yellow River Basin in northern China, the per capita renewable water availability is only 530m^3, which is far below the critical level of severe water scarcity (set at 1,000 m^3 per capita) (Cai, 2008). Over the last decades, climate change has made water scarcity even worse in northern China. In the Yellow River Basin, Ding et al. (2007) have observed a tendency towards a decrease in precipitation since the 1950s. In addition, water scarcity in China has further been aggravated by a deterioration of the water quality, which has been caused by the continuing and extensive pollution from industrial, domestic and agricultural sources (Xie, 2009). At the same time, rapid socio-economic growth in China has led to a dramatic increase in water demand. In 2009, the annual water shortage was estimated to be between 30 and 40 billion m^3 (Jiang, 2009). In addition, over the last decades, competition for water use has significantly intensified between different regions and sectors (Cai, 2008).

Despite the severe water scarcity, China has long been prone to flooding due to its topographic and climatic conditions (CNCID, 2005). China has suffered over 1,000 flood disasters in 2,000 years of recorded history, averaging one every two years. For example, in 1931, the Yangtze River flood inundated 3.3 million hectares of farmland, affected 28.5 million people and caused 145,000 deaths (ADB, 2004). In 1998, the Yangtze River flood affected 223 million people and caused direct economic losses amounting to 166.6 billion Yuan (Zhong and Chen, 2000). In addition, the frequency of disastrous floods in the Yangtze River Basin has also increased from seven times in the 1960s to 34 times in the 1990s (ADB,2004). Continuous and rapid socio-economic development in the flood-prone areas, with the associated increase in population and value of assets, constitute the major reason for the increase in disastrous losses. Over 50% of the total Chinese population and

two thirds of total agricultural and industrial product value are located midstream or downstream of the seven major river basins and these areas are severely exposed to flooding (APFM and WMO, 2009). In the future, it is projected that nearly 80% of China's productivity will located on floodplains (Han and Kasperson, 2011). As climate change has contributed to increased water scarcity, it has also aggravated the flood hazards. Extremes in precipitation levels have increased over the past 50 years in the Yangtze River Basin and are projected to increase in intensity in the future (Gemmer et al. 2013, p.82 and p.85).

1.1.1 Water supply and demand management in China

In order to meet growing water demand, the Chinese government traditionally focused on increasing water supply through engineering measures, such as reservoir construction and moving water from one region to another. Massive investment has been devoted to these measures. For example, since the 1950s, 12 major projects that divert more than 9 billion m^3 of water annually have been completed. Meanwhile, many other projects are under construction, including the South-North Water Transfer project with a planned investment of 486 billion Yuan. This project is expected to transfer 45 billion m^3 of water from southern China to northern China (Liu and Yang, 2012). This type of supply-driven management has largely resulted in inefficient water use. The water productivity in China is very low (about 24.5 Yuan/m^3), which is one tenth of that in high-income countries (Xie, 2009).

As a result of recognizing that water resources were being used inefficiently, in the latter part of the 1980s the Chinese government initiated efforts to manage water demand in order to increase water use efficiency. Measures were implemented in addition to engineering solutions designed to increase water supply (Wang, 2003a). Water saving became a priority of the national development strategy and was institutionalized in the 1988 Water Law (Hu and Wang, 2004). Prior to 2000, the promotion of water saving technologies and infrastructure, as well as the enforcement of regulatory ("command and control") instruments, were the two major measures taken by the government (Wang, 2006). It is self-evident that the deployment of water saving technologies is essential for water saving, but their effectiveness depends not only on their technical features but also on the incentives for water users to deploy them. Neglecting the latter partly explains the low adoption rate of these technologies (Xie, 2009).On the other hand, the government excessively relied on regulatory instruments for controlling water abstraction of specific regions. For example, the central government would order an upstream region to ensure that a certain amount of water would be received by the downstream regions (as described in Zhangye City in Case Study 3: Chapter 6). Or, during a period of water scarcity, the central government would order a specific amount of water to be diverted from one particular region to another, on an ad hoc basis (Wang, 2003b). However, given that multiple actors are associated with water

supply, the excessive reliance on regulatory instruments cannot balance the interests and benefits of all the actors involved. In fact, this approach can even impact negatively on water saving. For example, local governments tried to use as much water as possible to "protect" their allocated volume of water (Wang, 2003b). As a result, despite promoting water saving for almost 20 years, water use efficiency had not significantly improved (Wang, 2003a). In 2000, the central government proposed the "*Construction of a Water Saving Society (WSS)*". This is essentially a large-scale institutional reform, in which a comprehensive institutional framework that includes a broad scope of policy instruments is developed to address water saving along the whole value chain from water abstraction to water recycling and various actors are offered incentives to conserve water (Wang, 2003a; Zhu et al., 2006).

Establishing and managing a water use rights system[1] is the core approach of WSS (Wang, 2001; MWR, 2005c). The government formally recognized water use rights in the Water Law 2002 and issued policy guidelines for developing a water use rights system. In the meantime, several policy experiments were conducted to explore the possibility of transferring water use rights between different sectors in order to enhance the economic efficiency of water use (Speed, 2009; Liu, 2005; Hu et al., 2005: p.138). In addition, over the last decades, regional water use rights allocations to ensure ecosystem water use in river basins has been taken seriously. For example, in the Yellow River Basin, in 2008 the government announced a new strategic goal for water allocation "to ensure the integrity of river ecosystem functions" (Xia and Pahl-Wostl, 2012c).

In order to develop a WSS, the core element of WSS - the water use rights system - needs to co-evolve with various other measures within the on-going water policy reforms. Among others, a proper water pricing system, which can theoretically provide an economic stimulus for more efficient water use (e.g. Jiang, 2012), is considered to be an effective approach to the development of a WSS (Wei, 2011). The price should cover operations and maintenance, wastewater treatment and supply infrastructures and, as a result, should reduce the financial burden on the government. Since the 1990s, Chinese government has issued a series of policies to reform water price in both urban and rural areas. In urban areas, the price of water has increased over time (Zhong and Mol, 2010). In rural areas, reform has varied across different irrigation districts. Measures included increasing the price of water incrementally, changing area-based water fees to volumetric fees and improving fee collection methods (Liao et al., 2008). The reform has encountered various challenges; for example, how to design a policy that can reconcile economic efficiency and social equity (e.g. affordability for low income groups and the acceptance of water price increases by the general public) (e.g. Xie, 2009; Nitikin et

[1] There are basically two types of water use rights: regional water use rights and water use rights for specific products/process in different sectors.

al., 2012; Wang et al., 2012). One particular risk factor is the potential impact of high irrigation costs on grain production, which could threaten food security (Jiang, 2012). Water price reform is not only to do with setting the "right" price but also involves setting up a proper institutional framework for successful implementation (Zhong and Mol, 2010; Ma et al., 2009).

In addition, stakeholder participation is crucial for constructing a WSS and has gained increasing ground in the last two decades. In rural areas, establishing Water User Associations (WUAs) is, in theory, a measure that enhances stakeholder participation. WUAs are one type of the entities to which regional water use rights are assigned (WET, 2007). A WUA refers to a farmer-based, participatory organization that manages the village's irrigation water (Wang et al. 2005) and these were initially introduced in China in the mid-1990s. However, the implementation of WUAs and their impacts on water management practices were mixed. In some regions, WUA was simply a new name - no significant differences to traditional water management practices were made (Wang et al., 2005). In other regions, the WUAs that were supported by the World Bank[2] benefited from a more reliable water supply, a higher degree of farmer participation and more transparent procedures (Wang et al., 2010).

In urban areas, taking the example of water pricing reform, various municipalities have organized formal public hearings for water price increases (Zhong, 2009, 136). Public hearings made sensitive issues such as increasing water prices more transparent and acceptable and tended to result in the government deciding on more reasonable tariffs. However, the implementation of such public hearing still needs to be improved; for example, in the scope and degree of participation, selection of participants, procedures and the execution of the outcomes (Zhong, 2009, 144).

Furthermore, instruments to provide information and to increase transparency also play an important role in the construction of a WSS. These include providing information to stakeholders (for example by organizing various events to raise public awareness about water saving) and mandatory certification of water saving products (MWR, 2002; MWR, 2011).

Last but not least, the deployment of water saving engineering measures and technologies is still a crucial foundation for constructing a WSS (MWR, 2002; MWR, 2011). Policy instruments, such as financial incentives and information provision, are important for incentivising end users to adopt this technology.

In summary, water supply and demand management is in a transition phase towards an integrated approach that aims to ensure and manage society's water demand and, at the same time, to create harmony between the societal system and the water ecosystem. The construction of a WSS, as a central component of water supply and demand management, emphasizes the crucial role of institutions in water saving. It

[2] The World Bank supported the establishment of the first WUA in China and its further development through a series of programmes (World Bank, 2011).

highlights the water use rights system and builds on the existing institutions and parallel water policy reforms such as water pricing reform and stakeholder participation.

1.1.2 Flood management in China

Throughout China's history, vast monetary and human resources have been invested in controlling floods. Flood control primarily centred on engineering structural measures, such as the construction of dams, reservoirs, river regulation works and water detention areas. As a result, since 1949, a massive flood defence system has been constructed in China, which includes more than 85,000 reservoirs, a total of 286,900 km of dykes, nearly 100 designated flood retention zones with a total area of 35,000 km^2 and a total volume of 103 billion m^3 (Han and Kasperson, 2011).

This investment has mitigated the losses that would have incurred; in particular the death toll caused by flooding has significantly decreased (Kobayashi and Porter, 2012; Cheng 2008). Despite the importance of raising dykes, this measure has "reached a point where further expansion has become largely unsustainable" (Han and Kasperson, 2011, p.28). Due to rapid socio-economic development, ensuring that these infrastructures adhere to proper standards has become significantly more expensive and it has become very difficult to achieve cost-effectiveness (Xiang, 2003). Massive aging infrastructures need to be maintained and reconditioned. For example, more than one-third of the reservoirs currently require substantial repairs and huge investment, which is often unaffordable (Xiang, 2003). These aging infrastructures also increase the risk of structural failure, for example, dyke collapse (Liu and Yang, 2012).

Consequently, the Chinese government started to reflect on its purely engineering-based approach to flood control and realized its limitations – especially after a series of disastrous floods that occurred in several major river basins during the 1990s. In 2003, the central government announced a shift from traditional flood control to an integrated approach of flood management. The shift includes the following new elements: 1) "living with floods"; 2) "flood risks should be shared among the whole of society"; 3) "consideration of the negative impacts of structural measures"; and 4) "enhancing society's preparedness for flooding" (E, 2004). It acknowledges that flooding is not totally controllable and the key is to reduce flood risk. It also advocates the need to go beyond the purely engineering-based approach and recommends that an integrated management framework should be built upon an "understanding about interconnected systemic issues and risk awareness" (Han and Kasperson, 2011, p.22). The central government has formulated, enforced and supported policies and programmes with a number of aims, including:

- To reduce the vulnerability of the population in the flood prone areas. For example, the central government issued "Guideline for flood hazard mapping

(interim)" in 2004, initiated a series of pilots and formulated the final Guideline in 2010 (Kobayashi and Porter, 2012; Zhang et al. 2012).

- To manage the exposure of people and assets in flood prone areas. In 2006, three ministries issued a policy document[3] to strengthen the management of flood retention and storage areas (FRSAs). Due to the complex nature of FRSAs, the development and implementation of policies and measures to address FRSA management are still at an early stage (Cheng, 2008).

Meanwhile, various national and international research programmes and projects have been conducted to improve the understanding of flood hazard features and flood risks in China, to develop flood management strategies tailored to the Chinese flood situation, to research FRSA management (e.g. to convert flooding into a useful resource), to develop advanced emergency response systems and decision support systems and to research various advanced structural measures (Cheng, 2008; Xiang, 2005; Porter et al., 2005; Gemmer, 2004).

1.1.3 Concluding remarks

The above sections provide a snapshot of the development of water supply and demand management and flood management in China, especially, the recent changes. It implies that both fields have undergone a shift in management paradigm from an engineering-oriented approach to a more integrated and sustainable approach. A management paradigm refers to a set of basic assumptions about "the nature of the system to be managed, the goals of managing the system and the ways in which these goals can be achieved" (Pahl-Wostl, et al., 2006). It can, therefore, be regarded as the foundation for management practices and for the shift in management approaches.

However, the paradigm changes have not necessarily led directly to the wide implementation of institutions, infrastructures and practice that are in line with the new management paradigm. This is because the new approach has encountered resistance from the existing approach of managing water resources. Firstly, the new approach has encountered the engineering-oriented paradigm that has long been deeply rooted in Chinese water resources management. Secondly, the new approach has often been incompatible with the existing institutions and infrastructure. Thirdly, the development of water resources management has been shaped by various actors and their interactions. For example, since fiscal decentralization at the end of the 1970s, local government has had increasing control over whether and how it chooses to enforce policies issued by the central government. As a result, whether or not the paradigm changes announced and corresponding measures issued by the central government can be effectively enforced at local level remains questionable.

[3] Policy document: Several suggestions on construction and management of flood retention and storage areas (FRSAs).

In addition, various governmental bodies at the same administrative level have overlaps and conflicts of responsibilities in terms of water management. Whether or not this vertical and horizontal fragmentation can be dealt with effectively will determine the successful realization – or otherwise – of sustainable water resources management (Knueppe, 2012). There are also multiple stakeholders outside government, such as water users from different sectors and NGOs. How to address their vested interests poses further complexity to water resources management and its potential shift.

A number of changes taking place simultaneously outside the field of water resources management have imposed pressures on its development. One of these changes is China's rapid socio-economic growth, which has continuously presented water resources management with challenges (for instance, the need to balance water supply and demand and to ensure better flood protection). In addition, the economic system has undergone a transition from a planned economy towards a market economy, which has also increased the role of economic instruments in environmental management. Last but not least, there have been a number of events in the ecosystem, such as floods and droughts, which have added further pressure to water resources management. This pressure has already been aggravated by the impacts of climate change and this is likely to be the case in the future.

In summary, the development of a system such as water resources management constitutes a long-term and complex process: a new component such as the new paradigm must interact with (e.g. compete) the existing components that have long reinforced each other in current water resources management. Meanwhile, water resources management is constantly interacting with the external environment; significant forces include, among others, societal transformation and climate change. These complexities raise the following question: did fundamental changes really take place in the structure of water supply and demand management and flood management in China? If yes, what triggered and facilitated such fundamental changes to take place and how?

To answer these questions requires a better understanding of the development and interactions of various factors both within and outside water resources management (management paradigms, institutions, infrastructure and various practices, innovations and external environment). So far, this field has received little attention in water management research in China.

Sustainability [4] transitions research has contributed to the understanding of fundamental societal changes in different systems (as demonstrated in 1.2). Meanwhile, it provides a useful conceptual and methodological foundation for studying long-term development trajectories. As a result, insights from transitions

[4] Sustainability here implies that the pillars of social equity, economic efficiency and environmental sustainability are all taken into account (Pahl-Wostl, 2007a). In addition, it also concerns inter-generational equity (e.g. Barry, 1999).

research can be particularly useful for answering the questions raised above. In the next section, the author will explain how societal changes are studied in the field of sustainability transitions research.

1.2. Sustainability transitions research

Sustainability transitions research is a relatively young field and a new approach to sustainable development. Its starting point is the recognition that environmental problems are persistent and deeply rooted in our culture, institutional structures and infrastructures and that the solutions require fundamental societal changes (STRN, n.d.; Van der Brugge, 2009). This is conceptualized as "sustainability transitions" (STRN, n.d.). Meanwhile, sustainability is characterized as inter-generational and interdisciplinary (addressing economic, environmental and social dimensions). Sustainability transitions research takes into account a long-term horizon (Rotmans et al., 2001) and draws from different disciplines, such as complexity theory, integrated assessment, innovation studies, governance studies and reflexive modernization. Over the last decade, its community has developed and advanced its theory and methodology, as well as strengthened its empirical basis. Studies cover various areas including energy (e.g. Foxon et al., 2013; Verbong and Geels, 2007; Loorbach 2007), mobility (e.g. Geels, 2002; Nykvist and Whitmarsh, 2008), water (e.g. Van der Brugge et al., 2005), development in general (e.g. Berkhout et al 2011; Næss and Vogel, 2012), waste management (Parto et al. 2006), and the built environment (Truffer et al., 2010). Since transitions research has been mainly developed by the European scientific community, case studies have primarily focused on European countries. Recently, the focus has been extended to developing and emerging countries in Asia (e.g. Berkhout et al 2009; Bai et al 2009; Te Boekhorst et al., 2010; Jupesta et al., 2011). These studies primarily focused on the following two aspects: (1) to explore the long-term historical development of a specific regime; for example, the interactions between the regime and external pressures, the dynamics of innovation processes and the role of specific regime component(s) in regime transition; (2) to explore strategies to shape sustainability transitions; for instance, transition management. However, the field of sustainability transitions research is still relatively young, there is a need to further elaborate on its existing theories and strengthen its empirical basis (STRN, 2010).

In the following two sections, the author will present the major theoretical basis of regimes and regime transitions.

1.2.1 Regime Concept

"Regime" is the central concept for sustainability transitions research, because it defines the system boundary where a transition takes place. However, there is no

single standard definition of a "regime"[5] that is widely accepted (Holtz et al., 2008). In sustainability transitions research, the conceptualization of regime can generally be distinguished between two schools (Holtz et al., 2008).

The first school conceptualizes a regime as a socio-technical system that evolves around core technologies, such as the transition from sailing ships to steam ships (Geel, 2002) or transition from horse-drawn carriages to automobiles in USA (Geels and Schot, 2007). This conceptualization dates back more than 30 years. Nelson and Winter (1977) frame a technology regime as a set of cognitive routines and heuristics embedded in engineers' minds and practices. Rip and Kemp (1998, p.338) widen the concept with a broad scope of "rules" and define the technological regime as "the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures". This broader concept includes more components in the regime and acknowledges the involvement of other societal groups as well as engineers. More recently, the social features of technology advancement have been increasingly integrated into the technology regime concept. This has resulted in the notion of "socio-technical regime", which acknowledges that technological innovations are associated with social features such as cultural and behavioural patterns (Holtz et al., 2008). Despite the inclusion of social features, this conceptualization is still primarily focused on technological development. Such a technology-centred conceptualization of regime may constrain the understanding and management of a regime transition towards sustainability. Whether innovative technologies can contribute to a regime transition towards sustainability depends on whether they are compatible with soft factors in the regime, such as culture and institutions, in a specific administrative geographical boundary. On the other hand, it can be claimed that technological innovation is not necessarily the most important factor to develop the pathway towards sustainability. Sometimes institutions and actors are more significant in making transitions (Pahl-Wostl, 2007a; Van der Brugge, et al., 2005).

Against this background has emerged more recently the second school of regime conceptualization. The transitions research community has shifted its focus towards a system perspective of transitions and elaborates "regime" as a system that fulfils a specific societal function (e.g. Holtz et al., 2008; Van der Brugge, 2009). This conceptualization explicitly includes various soft factors and regards them as equally important as technologies for a regime and for its development. All these components of the regime are associated with the specific societal function of the regime (Holtz et al., 2008).

[5] The "regime" in transitions research has a different meaning than that in political science, where a regime is defined as "a set of explicit or implicit principles, norms and decision-making procedures." (Krasner, 1983 in Van der Brugge, 2009, p.22).

The key functions of water resources management are to allocate water for multiple and competing uses, "taking into account different requirements for water quality and the spatio-temporal variability of both supply and demand" and to "provide protection from water related risks" (Pahl-Wostl, 2007b, p.54). To fulfil these functions, it is widely recognized that both engineering measures and measures taking into account soft factors are equally important for water resources management and its development (e.g. Pahl-Wostl, 2007b; Gleick, 2003). For this reason, in this dissertation, the author has adopted the second school of regime conceptualization.

Accordingly, ***a water resources management regime*** encompasses *a whole complex of actors, physical infrastructures, technologies, social practices*[6] *and various soft factors which are highly interconnected and together form the base for the functioning of the water resources management system, i.e. fulfilling water demand with sufficient quality to both humans and ecosystems, as well as providing protection from water-related risks. These soft factors include the management paradigm, discourses, values, knowledge base, and institutions*[7] *(*adapted from Pahl-Wostl, 2007b).

The composition above is also applicable for various sub-regimes in water resources management. In this dissertation, a sub-regime refers to a regime with a specific societal function that is a part of the function of a larger regime. In the context of water resources management, these sub-regimes could be, for example, a sub-regime fulfilling water demand and supply or a sub-regime providing protection from floods.

1.2.2 Regime transitions

As shown in 1.1, alternative management paradigms have emerged in both water supply and demand management and flood management. To explore whether these changes result in a transition of the regime, how and to what extent, it is important to understand what a regime transition is.

Rotmans et al. (2001) give a broad definition of a regime transition and explain it as a long-term continuous process of societal change, during which the structure of society, or a sub-system of society, fundamentally changes. The "long-term" time

[6] Social practices here refer to activities that actors take to shape other components in the regime, such as construction practice, formulation of institutions.

[7] There are various definitions of institutions. Here the institutions only refer to regulatory institutions, which can be described as "formal legal structures, regulatory frameworks, formalized professional rules of good practice as typically codified in professional handbooks" (Pahl-Wostl, 2009, p. 356).

frame of a transition means several decades, which is much longer than the normal policy cycle of 5-10 years. As noted at the beginning of section 1.2, this feature is very important for sustainability research. Transition embraces a change to the ***deep structure*** of a regime, including the dominant management paradigm, institutions, physical infrastructures/technologies and various practices. Among these, the management paradigm can be regarded as the "label" of the regime, because it defines the boundaries of thoughts and actions (for instance, what institutions to develop and what infrastructures to construct) and has the power to exclude non-compatible approaches (Dosi, 1982; Pahl-Wostl, 2009). In the context of natural resources management regimes, a regime transition must, therefore, be accompanied by a paradigm change[8].

The core of sustainability transitions research is to understand how a transition unfolds and how it can be, in part, guided (STRN, 2010). As elaborated by Loorbach (2007, p. 32), "*transition research is exploratory; it aims at developing and adjusting research hypotheses as an integrated part of the research process*". The two important hypotheses to be tested and elaborated in transitions research are multi-phase perspective (MPP) and multi-level perspective (MLP), which form heuristics to explain the dynamics of the long-term transition processes. These two hypotheses provide a broad framework and a starting point for examining regime transitions.

The multi-phase perspective (MPP) suggests that a transition is gradual and nonlinear and goes through four different phases that shift between two dynamic equilibriums (Rotmans et al., 2001) (Figure 1-1):

- A predevelopment phase of dynamic equilibrium, where the status quo does not visibly change;
- A take-off phase, where the state of the system begins to shift;
- In the acceleration phase, structural changes take place in a visible way through an accumulation of socio-cultural, economic, ecological and institutional changes that react to each other;
- A final stabilization phase where the speed of social change decreases and a new dynamic equilibrium is reached.

[8] Pahl-Wostl (2009) argues that resources management regimes are based on its paradigm. Paradigm change being the precondition of regime transitions may not hold true in other regime tranisitions, for example, technological subsititution such as British transition from sailing ships to steamship (Geel, 2002).

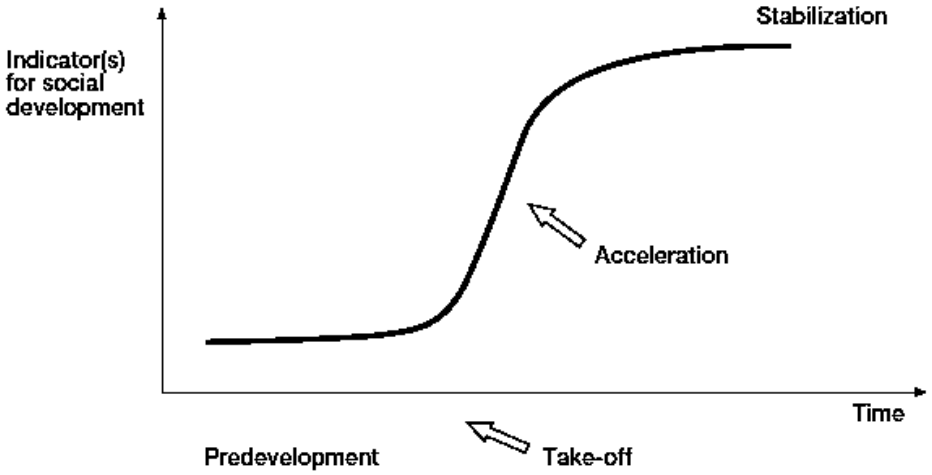

Figure 1-1 Illustration of multi-phase perspective (MPP)
Source: Rotsman et al. (2001) **(Section 1.2.2)**

Such an S-shaped curve is a highly simplified and aggregated model that represents the complex regime development[9] processes. Behind this simple curve, there are many developments within the regime and between the regime and external environment. The multi-level perspective (MLP), as originated from the socio-technical regime school, distinguishes between developments on three different levels (Figure 1-2) (Rip and Kemp 1998; Geels 2002; Geels, 2011):

- A regime at meso-level containing various established components, which creates lock-in and impedes regime-wide radical innovations ;
- Niches at micro-level are the "locus of radical innovations" that create change in the existing regime;
- An exogenous landscape at macro-level, in which regime and niches are embedded, consists of a set of slow-changing components (such as socio-political conditions or slow ecosystem degradation) as well as shocks such as disastrous flooding .

[9] In this dissertation, regime development is a general term, which includes all changes, fundamental or not, in a specific regime.

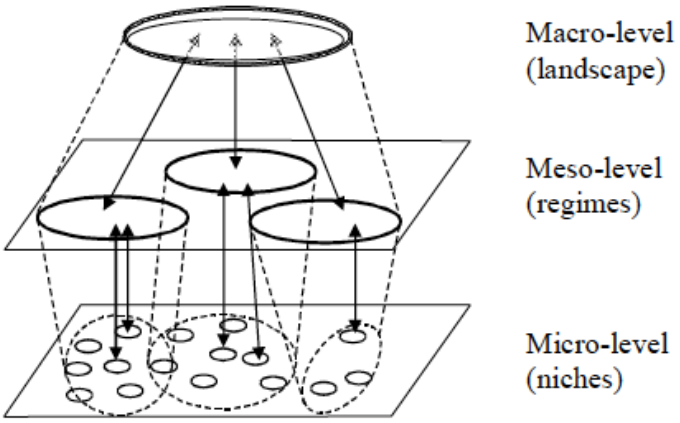

Figure 1-2 Illustration of Multi-level perspective (MLP)
Source: Geels (2002) (Section 1.2.2)

Regimes at meso-level are always associated with a specific societal function. At micro-level, radical innovations take place in niches. The outcomes of these innovations may have the opportunity to shape regime transitions; meanwhile, the existing regime has a partial influence on these innovations. Developments at macro-level reflect the slow socio-economic and ecosystem changes as well as shocks in which the regime and niches are embedded; the regime also impacts on the development of the landscape.

These MPP and MLP hypotheses provide researchers with a good starting point for analysing regime development processes, but they also have their weakness. Among others, their analytical power to specify the "precise constitution of regimes and niches, and their shifting boundaries and inter-sections over time" is limited (STRN, 2010). The regime is treated as a black box (Van der Brugge, 2009, p.87), which makes it difficult to analyse what regime components have changed and to which extent. Besides, MPP and MLP are limited in exploring how a transition took place and how it proceeds, because MLP is a static concept and MPP provides little possibility for investigating in detail the various underlying processes during regime development. These limitations call for a further development of conceptual frameworks that can drill down into various regime components and enable detailed analyses of the dynamics underlying regime development.

On the other hand, as noted at the beginning of the section, transitions theory has mainly been developed by the European scientific community and current case studies are geographically focused on developed countries in Europe. Studies on transition in the context of developing countries and emerging economies in other continents are still limited. Consequently, investigating water resources management regime development in China will broaden the perspective of current sustainability transitions research.

1.3. Research objectives

Accordingly, this dissertation aims to ***understand the development course of water resources management regime in China***. In order to achieve this, the author has pursued the following two research objectives:

Research objective 1: *To develop conceptual frameworks to enable a detailed and precise analysis of regime development.*

In this dissertation, two conceptual frameworks will be developed. One framework enables a better understanding of different stages of regime development and how niches (referred to "informal learning processes" in this dissertation) contribute to the development. Given that regime development eventually unfolds in various concrete activities, the second framework drills down into these different activities and identifies what enables them to contribute to the regime transitions.

The developed conceptual frameworks are presented in Chapter 3.

Research objective 2: *To apply the elaborated conceptual frameworks to explore the development of the water resources management regime in China.*

As noted in 1.2, a water resources management regime covers different sub-regimes. In this dissertation, the conceptual frameworks will be applied to explore the development of two sub-regimes, i.e. the flood management regime and the water supply and demand management regime. This objective will be pursued in Chapters 4, 5 and 6.

2. Method

2.1 Research design

In this chapter, the author will outline the research design, which comprised the following two major parts (Figure 2-1) :

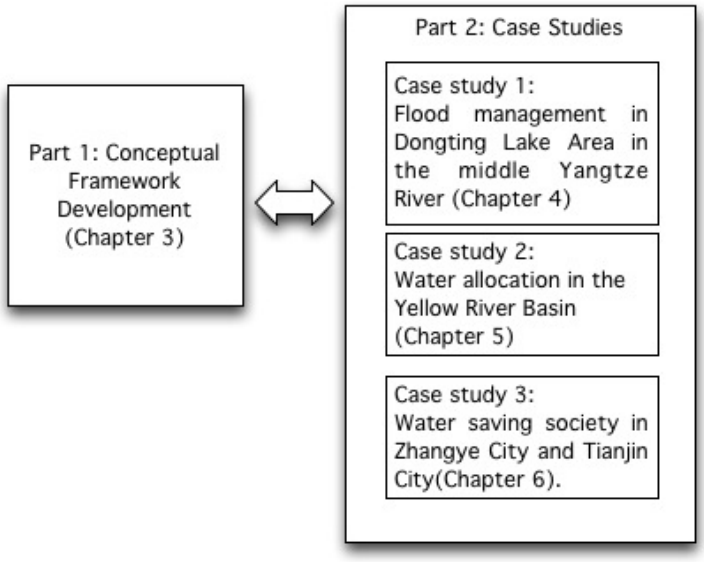

Figure 2-1 Scheme of Research Design (Chapter 2)

2.1.1 Part 1: Conceptual framework development

In this part, two conceptual frameworks were established in order to analyse the development of a water resources management regime, based on the two basic hypotheses and recent developments in the sustainability transitions research field as well as theories in organizational learning and political science (Chapter 3).

As noted above, transitions study is still a relatively new field. It is considered as a "theory-in-development" (Van der Brugge, 2009, p.29), in which insights from different disciplines are integrated in order to specify the regime constitution and to explore the dynamics of regime development in details. The MPP and MLP hypotheses, which are frequently applied in transitions studies, provide researchers with a starting point for analysing the regime development processes, but they are limited in supporting a structured and precise analysis of regime development, for instance, what changes exactly, when and why it happens.

Against this background, the first step in this dissertation was the further elaboration of conceptual frameworks. The frameworks will be able to address: 1) what needs to be changed and to what extent in order for a regime transition to

take place; (2) how the start of a regime transition is triggered; and (3) how niches influence regime development(Conceptual Framework 1: 3.2).
In practice, regime development is manifested in various concrete activities. Consequently, the frameworks also need to (4) enable the exploration of these different activities and their interactions during a transition, i.e. how these concrete activities interact with each other to drive the transition of the whole regime and what features of a regime support the interactions of these activities (Conceptual Framework 2: 3.3) .
In the conceptual frameworks, the development phases or time points of major interest were the start of a transition and the transition phase itself, which correspond to the pre-development, take-off, and acceleration phase of the MPP described in 1.2.2.

2.1.2 Part 2: Case studies

This dissertation explored the development of the flood management regime and the water supply and demand management regime in China at the example of three case studies:

- Case Study 1: Flood management in the middle Yangtze River (Chapter 4)
- Case Study 2: Water allocation management in the Yellow River Basin (Chapter 5)
- Case Study 3: Water Saving Society in China (Chapter 6)

Case study method is "an empirical inquiry that (i) investigates a contemporary phenomenon within its real-life context; especially when (ii) the boundaries between phenomenon and context are not clearly evident; and (iii) in which multiple sources of evidence are used" (Yin, 2009, p.18). Case study research is especially attractive if "a 'how' and 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control" (Yin, 2009, p.13). This is in line with the research aim of this dissertation that is to explore the dynamics underlying regime development. Though often criticized as "arbitrary, subjective and not generalizable"(Yin, 2009, p.13), case studies can generate new theoretical propositions, test existing theories and provide insight into what is important for further in-depth exploration in future studies (Flyvbjerg, 2006). In addition, knowledge gained in case studies in specific areas (e.g. transition in water resources management in China) can contribute to the knowledge accumulation of a specific field (sustainability transitions research) and enables learning, particularly about the context-dependent knowledge (Isendahl, 2010).
In sustainability transitions research, space and scale have not been sufficiently addressed (e.g. Coenen and Truffer, 2012). In most case studies, the country or nation is regarded as the key context within which the studied regimes are located (Hodson and Marvin, 2010; Smith et al., 2010). This approach prevents sustainability transitions research from understanding the "spatial variety and

complex interdependencies that result in geographically specific forms of institutional embeddedness within regions and places" (Lawhon and Murphy,2011, p. 362). The interactions between different administrative geographical scales is *de facto* essential for a regime transition, for instance, if innovations at city level are to be scaled up to national level. Therefore, the case studies in this dissertation explicitly deal with the spatial dimension within a regime, including national, river basin, provincial and city levels.

Single case design (typical case study) was applied in the first two studies. Case Study 1 aimed to explore whether and to what extent the flood management regime has transitioned from traditional flood management towards a desired regime, i.e. Integrated Flood Management (IFM). This study had a long time frame covering 1949-2009. The Dongting Lake area in the middle Yangtze was selected as the single case study, because: (1) it has always been the focus of flood management in China, due to its long history of disastrous floods; (2) there have been many changes in management practices here over the last decades, which may have led to regime transition(s); and (3) there was sufficient literature and documentation regarding flood management in this region, as well as potential access to experts and stakeholders for data collection. In this case study, the administrative geographical scales of the regime included national, provincial, river basin and country levels.

Case Study 2 aimed to investigate how the transition(s) of a water allocation regime started and how different factors facilitated regime development. The time frame of the study stretched from the 1950s to 2009. The Yellow River Basin was chosen as the single case study for similar reasons as in Case Study 1, notably because: (1) the Yellow River Basin is perceived as a typical river basin that suffers from significant water shortages and has experienced several ecosystem crises; (2) there have been a series of changes in the management practices since the 1950s, which may have brought about regime transition(s); and (3) there was sufficient documentation and literature available as well as possible access to experts. Two administrative geographical scales of the regime, i.e. national and river basin levels, were explicitly analysed.

Case Study 3 consists of 2 sub-cases. It aimed to explore the course of the Water Saving Society (WSS) development, i.e. the different concrete activities after the transition started and their interactions, as well as the adaptive capacity of the regime. Compared to Case Study 1 and 2, this study had a relatively shorter time frame: 2001-2005. This was a special period of the long transition process towards WSS, because it was a part of a ten-year experimentation process at the beginning of the transition. The selected period was only the first phase of this experimentation process; the second phase was still going on during the time of this study. As well as the exploration of the WSS experiment in the whole of China, two specific cases were selected to understand the experiment in detail at local level: Zhangye City and Tianjin City. Both of them were WSS pilots designated by the

central government. Zhangye City faced considerable pressure due to the sudden limit of water abstraction imposed by the central government. It was the first WSS pilot in China, which served to answer basic conceptual questions about WSS. Tianjin City has long faced water shortages and was designated as the WSS pilot representing "the receiving areas of South-North Water Transfer project" at a later stage of the first experimentation phase. Choosing Tianjin City as a case study was also partly due to the author's access to local experts. The analysed administrative geographical scales of the regime were at national and city levels.
These studies contained different research objectives related to regime development, which led to the application of different parts of the developed conceptual framework(s) for analysing regime development.

2.2 Data collection and analysis

2.2.1 Data collection

Case studies rely on multiple data sources (Yin, 2009) and, as a result, a triangulation approach was employed for data collection.
Data for the case studies in this dissertation was largely collected from literature and document review. One major document type was government-related documents, including government policy documents and reports, government websites, politicians' speeches and books written by policy makers. However, given the often criticised implementation gap of environmental policies in China, the confidence level in the results would be low if the data relied solely on government-related documents. Consequently, other document sources such as media and academic journal articles were also reviewed. The latter, in particular, which included both domestic and international academic articles, provided diverse perspectives on the implementation of certain key policies.
Review of various documents and literatures were complemented by semi-structured interviews for validation and to gain additional insights. The field work was conducted in April 2009 and March 2010. Selected interviewees needed to include actors in specific sub-regimes with a high stake in regime development or with extensive knowledge about regime development. Accordingly, the plan was to interview governmental officials at different geo-administrative levels (given that the relevant sub-regimes include the interactions between these different levels) as well as experts in organizations affiliated with or outside government that are stakeholders and/or have extensive knowledge about the functions the sub-regimes fulfil. However, accessing experts and stakeholders in China proved to be very challenging for the author as an individual researcher from a European university. In particular, it was very difficult to access government officials and to encourage them to express the challenges and problems faced. One of the major reasons for this was that they were afraid that the views they expressed to the author, who came from a

foreign university, could negatively influence their careers. In addition, without a good network, it was difficult for a person from a foreign country to gain access to officials. As a consequence, relatively few officials were interviewed and the information gained from their interviews is relatively limited. The major interview partners in Case Studies 1 and 2 were experts working for organizations affiliated with or outside the government and even reaching these individuals was challenging, due to the author's limited network in China. However, despite all these challenges, the author interviewed several representative actors for each case study. This can be partly attributed to certain interview tactics that the author developed, i.e. who to interview first, where to hold the interviews, whose name to mention when contacting potential interviewees, awareness about other potential actors to whom the interviewees could provide access. For example, in Case Study 1, the initial interviews were undertaken with a senior expert at national level who (1) is a part of the national think tank and often accompanies high-level officials on field work at lower geo-administrative levels and (2) has an extensive network at different levels in this field. During the interview, the author obtained further names of potential interviewees at river basin and provincial levels and gained agreement from this expert to refer to him when contacting these people. In addition, in practice, to mitigate the concerns of officials as mentioned above, interviews were conducted outside the office (for instance, at lunch) and out of working time (an overview of the interviewees' organizations, how the author approached them, the forms that the semi-structured interviews took and interview guidelines are described in Appendix 1).

All in all, despite the low number of interviews, the interviewees covered a broad scope of regime actors, including government officials and researchers in organizations working closely with governmental agencies, as well as experts from NGOs and international projects that contributed to the development of the relevant sub-regimes. The interviewees who proved to be accessible do not represent the whole scope of regime actors and this could reduce the comprehensiveness of the data, but the author attempted to mitigate this issue by undertaking an extensive review of literature and documentation.

2.2.2 Data analysis

Data analysis can generally be classified into qualitative and quantitative analysis. In this dissertation, qualitative data analysis was appropriate because the case studies aimed to understand what changes took place in the water resources management regime, why and how, based on semi-structured interviews as well as by reviewing literature and documentation that generated non-numerical data.

The categorization of data, i.e. how to organize data in a useful way for the study, is an essential step in data analysis. There are two ways of categorizing data: (1) to generate categories based on the data collected or (2) to assign data to pre-defined categories (Kelle and Kluge 1999, p.58 and p.62). In this dissertation, the latter

approach was applied, i.e. the categories for data analysis were created when drafting the guidelines for the interviews and scoping the documentation and literature. This creation of the categories was mostly based on the conceptual framework used for each study (Table 2-1).

Table 2-1 Categories for data analysis in each case study

Case study		Categories
1	Flood management in the Dongting Lake Area in the middle Yangtze River Basin	Management and Transition Framework (MTF) Categories: various events during regime development were classified into two categories: • Critical events • Informal learning processes
2	Water allocation in the Yellow River Basin	Categories: • Problem stream (window), political stream (window), solution stream. • Informal learning processes and epistemic communities
3	Water Saving Society (WSS) in China	Categories: • Strategic, tactical and operational activities • Governance structure • Monitoring • Resources (monetary and personnel resources)

In Case Study 1, two categories were pre-defined: "critical events" and "informal learning processes". Critical events are those events which explicitly influenced Dongting Lake flood management policy-making (e.g. action plans for institutional and infrastructure improvement in the area) at national, river basin and provincial level. Data collection aimed to identify these critical events and the informal learning processes (see 3.2.3) that were linked to these events.

In this case study, the author also attempted to apply Management and Transition Framework (MTF) as a data analytical tool for structuring these different events and their linkages during regime development (Box 2-1).

Box 2-1 Management and Transition Framework (MTF)

Management and Transition Framework (MTF) — A data analysis tool for operationalizing the conceptual framework

MTF is applied as a data analysis tool in Case Study 1 to operationalize the conceptual framework.

The core of MTF is the "Action Situation (AS)", which refers to "a structured social interaction context that leads to specific outcomes". This means each critical event and informal learning process identified can be regarded as an AS. Each AS has a series of input and output features, such as the "institution", "operational outcome" or "actors" (Pahl-Wostl et al. 2010). The "institution" in MTF refers to formal regulations or strategic plans as outcomes of corresponding ASs. The "operational outcome" feature represents the implementation of strategic plans, policies, infrastructural measures and programmes. The "actors" refer to those who participate and lead a specific process, such as strategic planning or pilot projects.

These components and their linkages can help to operationalize the conceptual framework 3.2.1 in the following ways:

- examine whether and to what extent a regime has developed towards a desired regime by comparing the "institution" and "operational outcome" feature of specific ASs with the normative features of desired regime.

- understand how informal learning processes were linked to formal policy processes in the existing regime by drilling down into the "operational outcome" and "actors" feature of the identified informal learning processes.

In Case Study 2, pre-defined categories include: (1) problem stream (window), political stream (window) and solution stream, as defined in 3.2.2; (2) informal learning processes and epistemic communities (3.2.3).
Case Study 3 consists of: (1) strategic, tactical, and operational activities; (2) governance system; (3) monitoring of "information management to deal with complexity and uncertainty", and (4) monetary and personnel resources (3.3).

3. Conceptual Frameworks

In this chapter, the author will elaborate on the two conceptual frameworks which served as the basis for analysing water resources management regime development in China in the three case studies (Figure 3-1). The chapter starts with an exploration of the composition of a regime (Section 3.1), which is the foundation of the two conceptual frameworks. Conceptual Framework 1 (Section 3.2) addresses three questions underlying regime development. Since regime development is eventually manifested in various concrete activities, Conceptual Framework 2 (Section 3.3) depicts these different activities and how they can possibly contribute to regime transitions.

Depending on the research questions raised in each case study, certain parts of the conceptual framework were applied. The concept of regime components and structure was used for all case studies. Conceptual Framework 1 laid the ground for analysing Case Study 1 and 2. The concept of informal learning processes are applied in both case studies. Conceptual Framework 2 were used for investigating Case Study 3. How the two conceptual frameworks were used will be presented in details in Section 3.4.

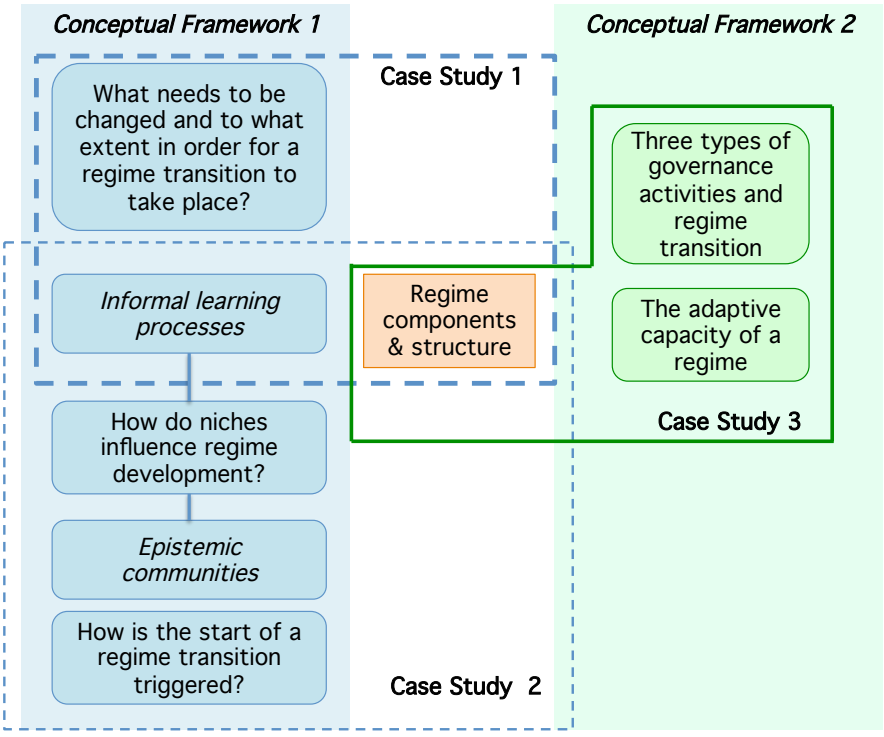

Figure 3-1 Conceptual frameworks and its application in three case studies (Chapter 3)

3.1 What constitutes a regime?

As described in 1.2, a regime contains various highly interconnected components to fulfil its specific societal function(s). For the purpose of analysis, it is useful to distinguish between these different components in a structured way. Based on Giddens' structuration theory and complex adaptive systems[10] theory, Van der Brugge (2009, p.87-p.91) categorizes different regime components into: **regime structure, actors, and process**.

Firstly, the regime **structure** is further classified into three interconnected components (Van der Brugge, 2009, p.89-90):

- The **culture** structure encompasses management paradigms, discourse, values and knowledge base. As indicated in 1.2.2, a regime is centred on its management paradigm, which "generates a kind of 'internal logic' and selective environment which excludes non-compatible approaches" (Pahl-Wostl, 2009, p.355). For example, under the paradigm of traditional "flood control", one perceives that floods are harmful and that they can be fully controlled by human intervention. Such a paradigm manifests itself in management activities (with raising the height of dykes being the dominant measure) and in formulating plans or regulations that pay little attention to the impact of human behaviour on flood risk and preparedness for flooding (Xia and Pahl-Wostl, 2012a).
- The **institution** structure contains regulative institutions, which can be described as "formal legal structures, regulatory frameworks, formalized professional rules of good practice as typically codified in professional handbooks" (Pahl-Wostl, 2009, p. 356).
- The **physical infrastructures** include, for example, irrigation channels, flood defence systems and water saving technologies.

Secondly, a regime involves multiple **actors** with different value systems and resources (such as money, power or skills) who play various roles related to the societal function(s) of the regime. Actors include individuals and the organizations to which they belong; for example, government, non-governmental organizations (NGOs), industrial enterprises etc. The reason why these actors belong to the regime is that their interests and stakes are associated with the fulfilment of the specific societal function(s) of the regime. These actors have different views of how the function should be fulfilled and mobilize their resources to shape regime development.

Third, the **processes** component of a regime connects "the sphere of actors to the sphere of (regime) structures" and is a "cluster of social practices" (Van der Brugge, 2009, p.91). These processes are initiated by actors to shape the regime

[10] A complex adaptive system (CAS) is "a complex, nonlinear, interactive system but the interaction of its various elements follows certain rules" (Pahl-Wostl, 2009, p.357) .

structures. Vice versa, the regime structure components also influence the actors, which leads to the adjustment of their goals, visions, strategies or responsibilities (Van der Brugge, 2009, p.91).
In this section, all components specified in the water resources management regime in 1.2 were systematically categorized. Such categorization clearly differentiates various regime components and is very useful for analysing a regime. However, it is important to keep in mind that, in reality, these components are strongly interdependent on each other and co-evolve in time (Van der Brugge, 2009, p.217).

3.2 Conceptual Framework 1: regime development

The interdependence of various regime components creates a lock-in situation and results in barriers to scaling up radical innovations. Actors in the incumbent regime tend to select specific options (e.g. institutions, physical infrastructure or decision-making processes) and rule out alternative options offered by these radical innovations (Van der Brugge, 2009, p.86; Loorbach, 2007, p.94; Holtz, et al., 2008). As a result, a regime is constantly changing – but often in an incremental way.
Regime development can be depicted as a collection of various regime states at different points in time (Figure 3-2). Regime development during a specific time period is located in a "basin of attraction". This term derives from the domain of complex adaptive system theory. It refers to "a region in state space in which the system tends to remain" (Walker et al. 2004). These regime states in this period, though different, are guided by a single paradigm.
A regime transition can be conceived as the shift of a regime state to a new basin of attraction, i.e. another period of regime development, which is dominated by an alternative paradigm and comprises another configuration of regime components guided by this paradigm.

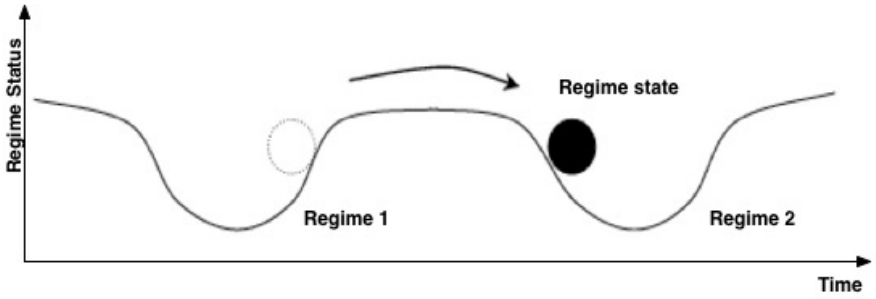

Figure 3-2 Illustration of regime development
(adapted from Van der Brugge, 2009) (Section 3.1)

In order to understand regime development, the author developed a conceptual framework addressing the following three questions:

- ***What needs to be changed and to what extent in order for a regime transition to take place?*** The regime composition depicted in 3.1

served as a sound basis for analysing what actually changes in a regime. This was combined with the multiple-loop societal learning concept (Pahl-Wostl, 2009) to explore the extent of regime change and whether certain regime development can be regarded as a transition (3.2.1). This question will be addressed at the example of Case Study 1 in Chapter 4.

- *How is the start of a regime transition triggered?* To identify the moment when a regime transition starts and to understand how it is triggered, the author conceptualized a term called "Window of Opportunity for Transition (WOPT)", which built upon Kingdon's "multiple stream model" of policy changes (2003), the regime composition depicted in 3.1 and the multiple-loop societal learning concept. This question will be explored in Case Study 2 (Chapter 5).
- *How do niches influence regime development?* Here the author explored how the niches (termed as "informal learning processes"[11] in this dissertation) and a specific actor group – epistemic communities – contribute to the start of a regime transition and to the transition phase itself (3.2.3). This questions will be followed in both Case Study 1 and 2(Chapter 4 and 5)

3.2.1 What needs to be changed and to what extent in order for a regime transition to take place?

To analyse what needs to be changed and to what extent in order for a regime transition to take place, the conceptual framework should first differentiate various regime components. Van der Brugge's categorization of various regime components (3.1) is very useful in this regard.

Meanwhile, the framework should also be able to differentiate between a regime's "normal" incremental improvements and transitions. The multi-level perspective (MLP) as reviewed in 1.2 have frequently been used in transitions studies to analyse the development of a specific regime by constructing narratives demonstrating the interactions between niches, regime and landscape (e.g. Geels, 2002; Nykvist and Whitmarsh, 2008; Verbong and Geels, 2007; Næss and Vogel, 2012). Although these studies provide valuable insights into regime development in different domains with MPP and/or MLP, they do not offer a precise and systematic view of those regime component(s) that need to change, and to what extent, in order for a transition to take place. This is, however, crucial for differentiating between an incremental improvement of established routines and a regime transition.

Pahl-Wostl's conceptualization of the change in a natural resources management regime as societal learning (2009) provides valuable insights here. Her conceptualization is based on the concept of "single, double, triple-loop learning".

[11] Following the line of organizational learning, based on which Pahl-Wostl (2009) developed multiple-loop learning concept, the author used the term "informal learning processes" in this dissertation to refer to niches.

The concept of single-loop and double-loop learning was introduced by Argyris and Schön (1978) in the field of organizational learning. They define the former as "*learning that changes strategies of actions or assumptions underlying strategies in ways that leave the values of a theory of action unchanged* " (Argyris and Schön 1996, p.20). This means that the level of learning only involves a single feedback loop that links detected errors to strategies of actions, without changing the norms and values of the individuals/organizations. Double-loop learning refers to "learning that results in a change in the values of theory-in-use, as well as its strategies and assumptions" (Argyris and Schön 1996, p.21). The "theory-in-use" includes norms, strategies for achieving values and assumptions that link strategies and values. In addition to linking the detected errors with strategies and assumptions, this level of learning also links these errors to the norms and values. Argyris and Schön (1996) claim that double-loop learning is essential for sustained productive organizational learning under rapidly changing and uncertain circumstances. Following this argument, Flood and Romm (1996) and Romme and van Witteloostuijn (1999) articulate a third level of learning: triple-loop learning that addresses the question of how to develop new processes or methodologies in order to reframe norms and values.

Pahl-Wostl (2009) maintains that the multiple-loop learning concept is compelling for natural resources management regime, such as water resources management regime, because it is useful for explaining different levels of societal learning that "provide guidance and stability in a social system". In the context of regime development here, single-loop learning refers to an incremental improvement of established routines to better achieve the goals, without questioning the underlying management paradigm. Improving infrastructures, such as raising dykes, under traditional flood control management belongs to this level of learning. By contrast, double-loop learning is defined as "a change in the frame of reference and the calling into question of guiding assumptions" (Pahl-Wostl, 2009, p.359). At this level of learning, reframing, i.e. reflecting on the framing of goals, problems and how goals can be achieved, or paradigm shift, takes place (Pahl-Wostl, 2009). For example, in the flood management regime, the existing management paradigm of "flood control" is questioned and the alternative "Integrated Flood Management (IFM)" emerges. Under the alternative paradigm, various radical innovations including, for example, how to restore floodplains, are initiated and tested. Triple-loop learning enables the scaling up of these innovations by recognizing and removing the constraints to scaling up that are in the existing regime (Pahl-Wostl, 2009). Transformation (also referred to "transitions of the whole regime" (Pahl-Wostl, 2009, p.359) is a result of triple-loop learning in the overall regime structure. This phase corresponds to the "stabilization phase" in MPP. Regime development is assumed to proceed in a stepwise manner moving through the level of single to double and then on to triple-loop learning(Pahl-Wostl, 2009).

To understand which regime components are actually changing during regime development and to what extent (i.e. the level of learning), the author merged the multiple-loop learning concept and the regime structure developed by Van der Brugge (2009). Table 3-1 presents the key features of the three types of learning in different regime components. In the context of water resources management regime, the author claims that double-loop learning in the management paradigm is a precondition for a regime transition. This should be reflected in the cultural structure where the paradigm is questioned beyond isolated groups. However, this alone is not sufficient for a regime to enter the transition phase. As acknowledged in 3.1, a regime often resists change, because it has long been stabilized by the interdependence of all structural components, actors and processes that have co-evolved in the past. An immediate reconfiguration of other regime components needs to start after double-loop learning in the paradigm takes place, without which the regime state is likely to revert to the original "basin of attraction". This means that major actors [12] need to immediately test new institutions or infrastructures/technologies that reflect the alternative management paradigm or to make the existing ones compatible with the paradigm. Accordingly, the author asserts that the water resources management regime enters its transition phase when double-loop learning in the management paradigm takes place, accompanied by necessary double-learning in other regime components.

The author considers a regime to be transformed (i.e. the transition of the whole regime) when triple-loop learning is prevalent in all components of the structure. That is to say, the alternative management paradigm becomes dominant and the rest of the regime has co-evolved into a "new configuration that works" (Rip and Kemp, 1998, p.338).

Both transition and transformation should be accompanied by necessary changes in decision-making or implementation processes where multiple actors interact with each other. This process may also bring new actor groups into the regime (Pahl-Wostl, 2009).

Table 3-1 Different levels of learning in structural components of a water resources management regime

Regime Structure Components	Single-loop learning	Double-loop learning	Triple-loop learning
Culture	● Alternative management paradigm other than the existing one is explicitly dismissed.	● The existing paradigm is questioned beyond the isolated group. ● Ideas and	● Major actors actively promote the alternative paradigm, which makes the alternative

[12] Major actors refer to those who are within or outside the government and have a high influence on, and stake in, regime development.

	● The knowledge base consistent with the existing paradigm is reinforced.	knowledge reflecting an alternative paradigm emerge beyond isolated groups.	management paradigm, discourses and vision become dominant.
Institutions and Infrastructures	● The underlying principles of existing institutions used to justify management practice are strictly followed. ● Physical infrastructures are built or retrofitted according to the established management paradigm.	● Major actors start experiments in the institutional and infrastructure components of the regime that reflect the alternative management paradigm.	● Formulation of regulation framework and wide enforcement of institutional measures in line with the alternative paradigm ● Wide implementation of infrastructure measures in line with the alternative paradigm

3.2.2 How is the start of a regime transition triggered?

While the previous section identifies the key pre-conditions for a transition to start, it is limited in its capacity to analyse how the start of the transition is triggered. In order to address this question, the author further refined the conceptual framework in order to identify the moment when a regime transition starts.

As mentioned in 3.2.1, MLP and MPP lay the ground for analysing regime development. Although MPP, in combination with MLP, helps to analyse different phases of regime development, it is not sufficient for analysing how regime components interact with each other and with the landscape and how this creates the moment when a regime transition starts.

As acknowledged above, an incumbent regime is stable because of the interdependence of various regime components that creates a lock-in situation and sets barriers for radical innovations in niches to break through. In this part of the conceptual framework, the author argues that the start of a transition is triggered by the opening of a so-called "Window of Opportunity for Transition (WOPT)", which provides opportunities for radical innovations to be plugged in. The conceptualization of a WOPT was built on the "multiple stream model" of policy changes developed by Kingdon (2003), the regime composition elaborated by Van der Brugge (2009) and the multiple-loop learning concept in 3.2.1.

Kingdon's multiple stream model contains three separate streams which "have lives of their own", i.e. political, problem and policy streams (Kingdon, 1995):

- The political stream consists of "public mood, pressure group campaigns, election results, partisan or ideological distributions in Congress, and changes in administration". "Political events flow along their own schedule and according to their own rules, whether or not they are related to problems or proposals" (Kingdon, 1995, p.201).

- The problem stream encompasses the attributes of problems, which are associated with actors' values. A problematic condition becomes a problem in the problem stream when major actors are "convinced that something should be done to change it" (Kingdon, 1995, p.114). They translate the conditions into problems by "evaluating conditions in light of their values", by comparisons with others and by "classifying conditions into one category or another" (Kingdon, 1995, p.119). Problems are not, therefore, totally self-evident. Water scarcity and flooding, as presented in 1.1, belong to the "problem" category because they have been given high priority by major actors such as the government.
- The policy stream contains a "wide variety of ideas floating around in the policy primeval soup" (Kingdon, 1995, p.201), which "are developed according to their own incentives and selection criteria whether or not they are solutions to problems or responsive to political considerations" (Kingdon, 1995, p.19).

These streams are constantly evolving. "The greatest policy changes grow out of that coupling of problems, policy proposals, and politics" (Kingdon, 1995, p.19). That is when "an event in the political stream, such as a change of administration calls for different directions, at that point, proposals that fit with that political event, such as initiatives that fit with a new administration's philosophy, come to the fore and are coupled with the ripe political climate. Similarly, problems that fit are highlighted, and others are neglected" (Kingdon, 1995, p.201).

Rather than accepting the long established conceptualization that policies are the outcomes of rational problem-solving processes, Kingdon (1995) believes policy choices result from the opening of a window of opportunity, which is an emergent feature of the convergence of the three independent streams. Actors, their strategies, perceptions and values play an important role in this. There are no single actors who have a determining role as rational planners or have overall control. This is in line with the fact that a regime fulfils its societal function resulting from the interactions between actors and other regime components that are mutually adapted, as emphasized in 3.1. The author extended the "multiple stream model" of policy changes into that of regime development. In the context of a water resources management regime, two elements of a political stream are of particular interest. Firstly, because the interactions between multiple actors who represent their own interests are essential for a regime to fulfil its functions, the struggle for their interests that receives wider attention is regarded as a key element in the political stream. On the other hand, questioning the existing paradigm, i.e. double-loop learning in the cultural structure as described in 3.2.1, constitutes a precondition for regime transition. As a consequence, the distribution of a specific paradigm underlying management practices is regarded as another key element of a political stream. An event in the political stream becomes a "political window" when a struggle for competing interests breaks out and/or the existing paradigm is

questioned beyond isolated groups. This stream containing interests and paradigm is located in the cultural structure as well as the actor and process components of a regime.

Problems arise from interactions between regime components as well as those that take place between a regime and the landscape at macro-level (see 1.2.2) in which it is embedded. An event becomes a "problem" when major actors are aware of, or experience, a significant mismatch between regime components (e.g. when existing institutions are unable to support the wide deployment of specific water saving technologies), mismatch between the regime and the landscape (e.g. when institutions and infrastructure cannot meet the water demand necessary for socio-economic development and for the maintenance of a healthy ecosystem), as well as crises or shocks to the landscape (disastrous floods and droughts)[13]. The latter align with the MLP, which acknowledges that the landscape may add pressure to a regime and lead to instability in the regime (Geels, 2002). The problem stream resides not only in institutional, infrastructural, and processes components, but also in the cultural and actor components of a regime, because it is influenced by the perception and values of major actors. A problem in its stream can only develop into a WOPT if it coincides with a political window.

The author rephrases "policy stream" in Kingdon's model to "solution stream" because options to solve the widely recognized problems can include institutional changes, new technologies or infrastructures and changes to the decision-making processes. These "solutions" may encompasses options that are in line with the existing paradigm (single-loop learning) or radical innovations in niches that follow an alternative paradigm (double-loop learning). This stream resides in all structural components as well as in the process component of a regime. When the solution stream provides options to match both the political[14] and problem windows, three streams join into one "single package". This creates a WOPT and triggers the start of a regime transition. A transition is less likely to be triggered without such a critical connection. If alternatives in the solution stream that suggest an alternative paradigm is developed to address certain problems that do not receive attention from the major actors, such a convergence may not lead to the start of a transition due to the absence of a problem window and a political window containing an alternative paradigm. On the other hand, although the connection of the problem window and the political window may momentarily "shake" the regime, such a

[13] This is a constructivist approach to defining problems, which is in line with the regime development. As Geels (2005, p. 692) maintains, "although processes at different levels can converge and create windows of opportunity for regime change, the actual linkages always need to be made by actors".

[14] Based on the elaboration in 3.2.1, the political windows that can contribute to the start of a regime transition include the situation where the existing paradigm is questioned beyond isolated groups and its combination with the breaking-out of a struggle for competing interests among different actor groups, because questioning the existing paradigm is the pre-condition of a transition.

"shake" is likely to fade if there are no alternatives immediately provided by the solution stream (Kingdon, 1995). Once the three streams have been connected, as maintained in Section 3.2.1, an immediate reconfiguration of other regime components needs to take place, without which the regime state may easily revert to the original "basin of attraction" (De Haan and Rotmans, 2011).

3.2.3 How do niches influence regime development?

3.2.1 and 3.2.2 enable the analyses of the extent of regime development and how the start of a transition is triggered. According to studies on transition patterns (e.g. de Haan and Rotmans, 2011; Van der Brugge, 2009, p.94), in general, regime transitions can be distinguished between top-down pattern and bottom-up pattern. The former refers to the situation where a powerful actor in/outside the regime imposes transition in a top-down manner, such as a large-scale national reform. The latter refer to regime transitions triggered by niches. Given the hierarchical nature of China political system and the importance the Chinese government has long attached to water resources management, it is expectable that transitions of water resources management regime in China are largely driven in a top-down manner. Thus, it is more interesting to explore whether and how the other transition pattern, i.e. the bottom-up one driven by niches, have taken place. In the following section, the third aspect of this framework offers the possibility of exploring how niches influence regime development, i.e. the start of a transition and to the transition phase itself.

In the school of socio-technical regime conceptualization, niches are where radical technological innovations geared to the problem conditions of the existing regimes are created and experimented (Geels, 2011, p.27). Schot et al. (1994) and Kemp et al. (1998) introduced the concept of strategic niche management (SNM) to address how technology niche development can be facilitated through creating "protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures"(Schot and Geels, 2008, p. 538). In SNM, three internal processes for a successful niche development are distinguished:

- The articulation of specific expectations of the technology development that provide direction to learning processes and legitimate protection;
- The building of social networks that contains multiple kinds of stakeholders related to the technology development who will mobilise commitment and resources within their own organisations and networks;
- Learning by these stakeholders containing not only single-loop but also double-loop learning.

While SNM are rooted in technologies and their innovations, the dissertation studied transitions and associated radical innovations in a societal system—water resources management regime. In fact, there are similar "protected spaces" for radical

innovations in a societal system. For example, Olsson et al. (2006) identifies that the emergence of so-called "shadow networks" are essential for the transition of socio-ecological systems. Such networks contain "a willingness to experiment and generate alternative solutions to emerging problems" and "create ways to foster social learning" (Olsson et al. ,2006). Nooteboom (2006) introduces the term of "adaptive network" with similar characteristics, in which self-organising groups of policy makers "break away from the existing policies in the their power networks and develop a joint understanding about new, more effective policies" which can be "contrast with the ones in existing power networks" (Nooteboom, 2006, p. 217). The network members are engaged in a constant learning processes (Nooteboom, 2006). Following the line of organizational learning, on which Pahl-Wostl (2009)'s development of the multiple-loop learning concept based, these networks and associated processes are referred to "informal learning processes" in this dissertation. These processes can be regarded as niches, given its similar characteristics as the niches in the socio-technical regime studies. However, they are not rooted in technological innovations.

Various concepts have been developed to depict the way in which niches shape regime transitions, depending on the features of these niches (its mature extent and its scale) as well as the extent of pressure from landscape (Geels, 2007; De Haan, 2007; Van der Brugge, 2009, p.94). In this dissertation, the author limited her focus on how informal learning processes and how a specific actor group, epistemic communities, who can potentially shape informal learning processes[15], "find" their way to influence regime development.

3.2.3.1 Informal learning processes

Informal learning processes contain the following four major features (Pahl-Wostl, 2009; Olsson et al., 2006):

- Issue-specific: it is formed to deal with a specific problem situation in the existing regime.
- Learning: double-loop learning is at the centre of such processes. Reframing takes place and a range of alternatives that deviate from the existing regime are explicitly tested and explored.
- It provides a space for learning by social interactions. Informal learning processes can contain a "community of practice with joint and shared practices and tangible products" (Pahl-Wostl, 2009, p. 361).
- Informal:
    - The results of these processes are not legally binding.
    - The informal learning processes provide the participants with the possibility to escape from formal organizational constraints.

[15] Van der Brugge (2009) names an actor group who operate in and shape niches as a **niche group.**

Participants are not necessarily under scrutiny of their agencies or constituencies when involved in these processes.

Similar as a regime, each informal learning process encompasses a structure, actors(one or more groups), and processes, as the regime components, depicted in 3.1 (Geel, 2007; Van der Brugge, 2009, p. 96). However, in the "informal learning processes", the institution and cultural structure are "unstable and 'in the making'", and the actor groups are "small and unstable"(Geel and Schot, 2007).
Rather than being engaged in bargaining (as in formal policy processes[16]), the participating actors (actor groups) who may reside inside or outside the regime (Van der Brugge, 2009, p.98; Geel, 2007), think creatively, experiment with new ideas and are willing to learn from each other (Olsson et al., 2006). These learning processes can prepare for, and navigate, a transition by providing a space for double-loop learning that supports the creation of problem and political windows, by developing solutions to connect these windows through the experiment of new regime components after a transition starts (Olsson et al., 2006; Folke et al.,2005; Pahl-Wostl, 2009).
It is worth noting that to effectively influence regime development, it is crucial that such learning processes are closely linked in one way or another to the formal policy processes in the existing regime (Pahl-Wostl, 2009; Olsson et al., 2006). The author distinguishes two types of informal learning processes that influence the formal policy processes in the concerned regime, based on the extent of linkages with the formal policy processes.
The first type contains a strong and important linkage to the formal policy processes. The participants in the informal learning processes are also key actors within the formal processes in the regime (Nooteboom, 2006). This linkage, for example, includes the situation when the informal learning processes are initiated by the key actors in the formal policy processes, such as policy experiment. An extension can be that the participants in the informal learning processes have a good access to and/or exert a strong influence on the key actors in the formal policy processes. The key actors then introduce the innovative ideas they have learnt directly or indirectly from the informal processes to the formal policy processes in which they are engaged.
The second type of informal learning processes initially contains a weak linkage with the formal policy processes, such as radical innovations by NGOs who have limited access to formal processes. Thus, in order to influence the formal processes and transition, the leaders in such an informal learning process shall actively explore the linkages with the formal processes.

[16] Here, the formal policy process includes activities ranging from state/policy assessment, goal setting, policy formulation and policy implementation to monitoring & evaluation in the existing regime (Pahl-Wostl, 2009).

3.2.3.2 Epistemic communities

An epistemic community, according to Haas (1992), is "the network[s] of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area". The members of the communities have "(1) a shared set of normative and principled beliefs,...; (2) shared causal beliefs,...; (3) shared notions of validity -...; and (4) a common policy enterprise – that is, a set of common practices associated with a set of problems to which their professional competence is directed ..."(Haas, 1992, p.3). First of all, the community members' "expertise and competence in a particular domain" are highly valued by the society or key policy makers, which results in their access to the formal policy processes (Haas, 1992, p.3). If double-loop learning takes place in the communities, epistemic communities can be regarded as a key actor group for informal learning processes. They constitute the strong linkage between informal learning processes and the formal processes in the regime as elaborated in the first type of informal learning processes (3.2.3.1). Their members do not necessarily come from specific disciplines, but they have shared causal beliefs and notions of validity. This means "if confronted with anomalies that undermined their causal beliefs, they would withdraw from the policy debate" (Haas, 1992, p.18), which distinguishes them from interest groups. In addition, as opposed to bureaucratic knowledge bodies who "operate largely to preserve their missions and budget", epistemic communities apply their knowledge to "a common policy enterprise" that consists of practices associated with issues that are subject to their normative objectives (Haas, 1992, p.18).

As noted above, environmental problems are persistent. Meanwhile, regime development is associated with the interdependence of different regime components. In this way, policymakers face increasing complexities and uncertainties in their decision-making. As a result, they turn to specialists for support (Haas, 1992), which results in the introduction of epistemic communities or links them to the formal policy processes. Lindemann's case study (2006) on the transition of European water management demonstrates that epistemic communities have contributed to regime formation by scientifically assessing the problems at hand, providing integrated evaluation of different strategies and developing new management and governance concepts.

However, policymakers do not always recognize their limited understanding of complexity. It is often at the time of crisis, shock, or rapid change, i.e. when a problem window opens, that they seek advice from an epistemic community. Under these conditions, the community that is called upon may become particularly influential and may succeed in imposing their own ideas – ideas that are not initially recognized by policymakers (Haas, 1992). The communities may eventually trigger the opening of WOPTs by reframing the problems at hand (cause-effect relationship), redirecting various policy interests (contributing to the political

window) and by putting forward their proposals, e.g. an alternative management paradigm as well as institutional and technological solutions in line with an alternative paradigm (contributing to double-loop learning in the institutional and physical structure of the regime and the solution stream that connects the problem and political window). Where a problem or political window is absent, the epistemic communities may actively exploit these gaps and thus facilitate the opening of WOPTs. Due to their highly valued expertise, they can greatly influence various formal policy processes, such as the introduction of alternatives or the selection of policies (Haas, 1992). Sometimes information generated by an epistemic community may create a shock "capturing the attention of the public and policymakers and pressuring them into action" (Haas, 1992, p.14). In other words, they trigger the opening of problem windows. After WOPTs open, given the complexity and uncertainty of a regime transition, policymakers may seek advice from epistemic communities to define measures that facilitate the "reconfiguration" process. In this way, epistemic communities also contribute to the regime transition towards the desired regime.
However, it is worth noting that despite their potential for facilitating the start of a regime transition and the transition itself, epistemic communities may also impede a regime transition. The reason for this is that the effects of their involvement in policymaking are not easily reversed. Their proposals can easily gain orthodoxy once they are adopted (Brouwer et al., 2009).

In summary, the framework elaborated in 3.2.1, 3.2.2, and 3.2.3 supplements the multi-level perspective (MLP) and multi-phase perspective (MPP) by offering the possibility of detailed analyses of those regime components (C: culture, Ph: physical infrastructures, I: institutions, A: actors, P: processes) that actually change, to what extent they must change (DL: double-loop learning and/or TL: triple-loop learning) for a transition or transformation to take place, how the interaction between regime components and between the regime and the landscape trigger the start of a regime, and how niches (i.e. informal learning processes) and actor groups contribute to the start of a transition and the transition towards a desired regime (Figure 3-3).

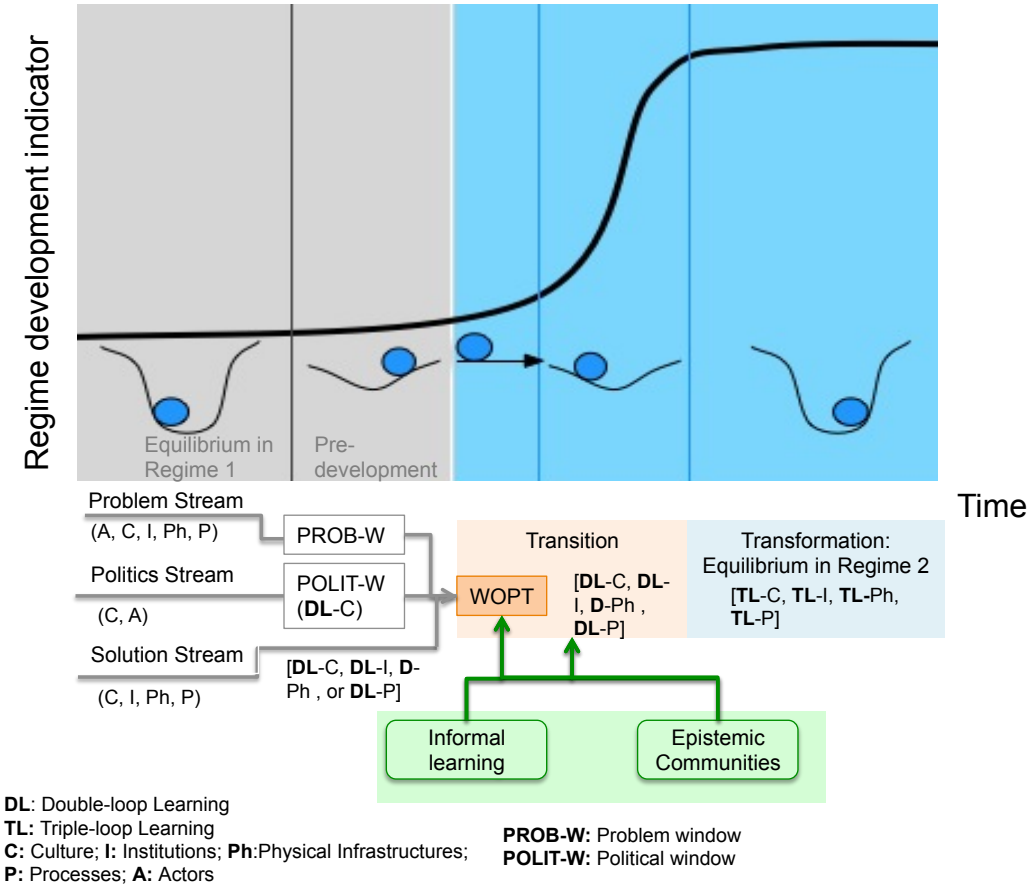

Figure 3-3 Conceptual framework 1 based on 3.2.1, 3.2.2, and 3.2.3 (Section 3.2)

3.3 Conceptual Framework 2: three types of governance activities and their co-evolution during the transition phase

In practice, different levels of learning that are associated with different levels of regime development are manifested in various concrete activities. The conceptual framework 1, as described above, is limited in its power to systematically analyse these different concrete activities during a transition; for example, how a new vision emerging in the cultural structure translates into the formulation of specific institutions and the wide application of specific technologies and infrastructures. Because of this, the author developed a separate conceptual framework that focused on the activities **after a transition starts**, i.e. ***how these activities interact with each other to further facilitate regime transition.***

3.3.1 Three types of governance activities and regime transition

This framework shares the conceptualization of a regime as defined in the first framework and was founded in part on Loorbach's transition management work

(2007)[17] . He groups different activities into three types of purposeful governance activities[18] . These are strategic, tactical and operational activities and their features are illustrated in the following section.

The most important strategic activity is double-loop learning in the cultural structure of a regime. A shared understanding of the system and problems is achieved among major actors, which creates a sense of urgency to act and serves as a basis for reframing the management paradigm and developing a shared alternative vision (Loorbach, 2007, p.116- p.119). In the context of water resources management, the conceptualization of what constitutes sound water resources management in a specific region belongs to this type of activity.

Tactical activities, such as agenda-building and coalition-building, aim to translate visions and make these concrete (Loorbach, 2007, p.119- p.121). One example is the formulation of the action plan for creating a Water Saving Society.

Operational activities embrace all those short-term activities with high innovation potential (Loorbach, 2007, p.122), where double-loop learning takes place in the institutional and infrastructural structure as well as in the process component of a regime[19]. Policy experiments and technological innovations belong to this type of activity.

These governance activities may pull in different directions and will not necessarily reinforce each other. Loorbach (2007, p.112) claims that only when multiple actors within each type of governance activity "direct their action towards shared overall goals, can they reinforce each other and influence transition processes", i.e. impact regime transition "more rapidly, more efficiently and in a more directed way". To put it into concrete terms, tactical activities translate the alternative paradigm and vision developed within strategic activities into a shared agenda. These tactical activities aim to overcome the barriers in the existing regime (Loorbach, 2007, p.119- p.121). Meanwhile, they guide the operational activities to ensure systematic learning. Operational activities scale down the alternative paradigm, visions and agendas developed in the course of the strategic and tactical activities (Loorbach, 2007, p.122).

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[17] Loorbach (2007, p.27) presents transition management as "a new mode of governance based on complexity thinking but with the explicit aim of redirecting and accelerating transitions to a more sustainable society".

[18] The term "governance activity" emphasizes that policy-making is a result of interactions among diverse societal actors. This emphasis is essential for study and management of a regime, because actors and the processes, where actors and the regime structures interact, are central pillars of a regime and its development.

[19] This type of activity belongs to the informal learning processes. However, the latter has a broader scope. Informal learning process also include double-loop learning in the cultural dimension (such as problem conceptualization, developing new management paradigm or visions) as well as double-loop learning in different regime components before a transition starts.

3.3.2 The adaptive capacity of a regime and its role in pushing co-evolution of the governance activities

The co-evolution of these activities does not take place naturally. Therefore, in addition to Loorbach's framework, the author identified the important features of a regime that drive such co-evolutions.

As noted in 1.2.2, when an alternative management paradigm or regime components representing an alternative paradigm emerge, the interdependence of various regime components creates a lock-in situation and results in barriers to scaling up radical innovations. A regime needs a specific capacity to renew and reconfigure its different components to deal with changes such as the emergence of a new paradigm. This capacity is referred to adaptive capacity, which enables the regime to cope with the pressure to change by altering or, if required, converting regime components and, at the same time, by sustaining its crucial societal functions (Smith, 2005; Folke et al., 2002; Pahl-Wostl, 2009). There are two major "coping" strategies: one is short-term reactive adaptation that reinforces existing regime configuration; the other is proactive adaptation that is associated with learning and flexibility and that supports innovation (Fabricius et al. 2007; Pelling and High, 2005). In the regime transition context and this dissertation, the adaptive capacity refers to the latter, the "proactive" adaptive capacity. Regime transition requires a high adaptive capacity. In other words, a high adaptive capacity is likely to propel the co-evolution of the governance activities above. However, this feature of the regime and its role in regime development has received little attention in sustainability transitions research (Van der Brugge, 2009, p.232). In this part of the conceptual framework, the author attempted to link the adaptive capacity of a regime and the co-evolution of these different governance activities to explore how the former may facilitate the latter.

Considerable studies have been devoted to understanding what determines the adaptive capacity in the domain of governance (e.g. Smit and Pilifosova, 2001; Pahl-Wostl 2009; Smith et al., 2005; Armitage and Plummer, 2010). However, there seems to be no consensus on a specific set of indicators that enhance the adaptive capacity of regimes. In the context of water resources management, Pahl-Wostl, (2007b, 2009) and Pahl-Wostl et al.(2007) claims that a combination of a polycentric governance system and information and knowledge management to deal with increasing uncertainties and complexities is key for building up the adaptive capacity of a water management resources regime. On the other hand, resources (e.g. money, power or skills) actors can mobilize is fundamentally important for the adaptive capacity of a regime (Smith, 2005). The list of these factors that enhance the adaptive capacity is not exclusive. This dissertation will first focus on exploring these factors, which are closely related to the co-evolutions among the three activities.

Polycentric governance[20] system

A polycentric governance system enabling a higher adaptive capacity is supported by the complex adaptive system (CAS) theory (Pahl-Wostl, 2009). A CAS has the ability to adapt to a changing environment, which results from its multi-level modular system structure and decentralized control. It implies a certain degree of redundancy, which is claimed to result in a high ability to maintain functional integrity in changing environments (Pahl-Wostl, 2009). A key aspect of multi-level governance of polycentric nature is that it contains an institutional setting where organizations at multiple levels can "exercise considerable independence to make and enforce rules within a circumscribed scope of authority for a specified geographical area" with their local knowledge and social capital (Ostrom, 2001, p.2). Polycentric governance aims to find the right balance between bottom-up and top-down control (Pahl-Wostl, 2009; Folke et al., 2002).

The polycentric system can support the three activities and their co-evolution in two ways. Firstly, such a structure creates an environment that encourages lower administrative units and/or non-state actor groups to engage in double-loop learning in operational activities (Imperial, 1999; Andersson & Ostrom, 2008). Secondly, such a multi-level structure contains explicit mechanisms addressing cross-level issues (Lebel et al., 2006) and the interactions between three types of activities. In such a system, methods for assessing and comparing innovations in a specific system are developed, which enables further application of the innovations elsewhere in a tailored manner (Ostrom, 2009).

However, innovations and natural resource programmes often require local government to bear substantial costs. In a polycentric system, local governments are given decision-making autonomy within their administrative boundaries and they may prefer to invest in other more economically profitable activities. Therefore, the governmental entities at the higher level providing sufficient positive incentives is important for local governments' commitment to prioritizing natural resource programme and to innovations (Andersson & Ostrom, 2008). In this way, polycentric governance is likely to be more effective, which leads to a high adaptive capacity.

[20] Governance is often regarded as being an opposite of the term "government" that implies the hierarchical control model. In political science, governance recognises the roles, the plural interests and the interactions of multiple actors (including both state and non-state actors), the increasing importance of a diverse mode of governing (i.e. bureaucratic hierarchies, markets and networks) and multi-level interactions across administrative boundaries (Pahl-Wostl, 2009; Voss, 2007). Governance includes a wide range of processes that coordinate and steer actors' behaviour by formal and informal rules (Pahl-Wostl, 2009).

Information management to deal with complexity and uncertainty

Monitoring, as a core of information management, is a cross-cutting activity that generates interactions among the three governance activities (Loorbach, 2007, p.128). They take place within each of these three activities:

- Operational activities: monitoring the progress of experiments on institutions as well as on infrastructures and evaluating what works and why;
- Tactical activities: monitoring and evaluating the processes (coalition-building) as well as the strategies (e.g. examining whether the different single experiments contribute to the whole transition strategy and exploring the synergies between different experiments);
- Strategic activities: monitoring and evaluating the development of problem definition and overall vision;

Information and knowledge from monitoring of operational activities feeds into monitoring of tactical activities, which further feeds into monitoring of strategic activities. Reversely, information and knowledge generated from monitoring of activities at higher levels can also re-shape the direction of activities at lower levels.

On the other hand, according to the adaptive management approach, in an ideal "experiment" the novel policies or technologies themselves and the way to implement them are "conceptualized as hypotheses to be tested and constantly refined" to address the uncertainties faced by new policies (Berkes et al. 2003; Lee, 1999). In the context of a regime transition, the "experiment" can encompass all three types of governance activities, i.e. visions, strategies, agenda and small-scale experiments. They are treated as hypotheses and subjected to testing. Monitoring in a regime with a high adaptive capacity should support such "hypotheses testing". This requires the identification of uncertainties at the outset of a transition.

Monitoring can only shape the three governance activities and their co-evolution when findings from monitoring are integrated into formal policy processes (Pahl-Wostl, 2007a; GWP, 2006). This means that mechanisms, such as deliberated monitoring plans and indicator systems, should already be institutionalized in the tactical activities as a transition starts.

Resource availability

As depicted in 3.1, various actors within a regime mobilize their own resources (such as money, power or skills) to take purposeful actions for shaping regime development. It is essential for regime actors to have sufficient resources in order to build up the regime's adaptive capacity to respond to changes such as the emergence of an alternative paradigm and vision (Smith, 2005). In other words, regime actors need sufficient resources to push the co-evolution of the three types of activities towards the desired regime. The financial resource is one of the most important resources. A regime with a high adaptive capacity requires financial resources derived not only from the public purse but also from private funding

sources (Folke et al. 2005; Smit and Pilifosova, 2001). In addition, actors must be equipped with sufficient knowledge about the new visions and actions required in order to increase the adaptive capacity of the regime in transition (Smit and Pilifosova, 2001).

In summary, Loorbach's (2007) conceptualization of the three governance activities, which serves as a foundation for this conceptual framework, opens the black box under the smooth curve of the take-off and acceleration phases in the MPP. Meanwhile, the alignment of the three governance activities reflects the interactions between a regime and niches in the MLP after a regime transition starts and adds insights about how different concrete activities within a regime and niches can be partially managed in a way that facilitates a regime transition towards a desired regime. Last but not least, the framework highlights the important role of a regime feature, i.e. its adaptive capacity, in compelling the alignment of the three activities and, as a result, the regime transitions.

3.4 Analysing case studies

The conceptual frameworks elaborated above enable a detailed analysis of regime development and lay the ground for analysing the three case studies in the dissertation. Depending on the research questions raised in each case study, certain parts of the conceptual framework were applied (As shown in Figure 3-1).

3.4.1 Case Study 1: Flood management in the middle Yangtze River

The three types of learning as depicted in Section 3.2.1 were used to investigate whether and to what extent the regime transition towards integrated flood management (IFM) in the middle Yangtze River (Dongting Lake area) took place in the period between 1949 and 2009[21].

Firstly, to explore whether and to what extent the transition has occurred, the author applied part of Conceptual Framework 1 (3.2.1) and specified the expected features of regime components of the desired regime, i.e. Integrated Flood Management (IFM). Secondly, the author paid special attention to informal learning processes (3.2.3.1) to explore their contributions to regime development.

3.4.2 Case Study 2: Water allocation management in the Yellow River Basin

The objective of this case study was to investigate (1) whether and how "Windows of Opportunity for Transition (WOPTs)" emerged, triggering transitions of the water allocation regime in the Yellow River Basin, and whether a transition towards the new

[21] The study was conducted in 2010, meaning that only data until 2009 was available.

regime continued; (2) how informal learning processes and epistemic communities have influenced regime development, during the period from 1950 to 2009.
Accordingly, the analysis was based on part of Conceptual Framework 1 (3.1, 3.2.2 , and 3.2.3.1).

3.4.3 Case Study 3: The process of innovation during the transition to a Water Saving Society in China

This case study aimed to gain an insight into the process of innovation during the transition towards a Water Saving Society (WSS) in China by investigating (1) the development course in the experimentation period of WSS (2001-2005), i.e. whether the three types of governance activities depicted in 3.3 existed and whether their co-evolution took place; (2) how high the adaptive capacity of the existing water resources management regime, which facilitates the co-evolution of these activities, is. For this purpose, Conceptual Framework 2 as outlined in 3.3 was applied.

4 Paper 1: Understanding the Development of Flood Management in the Middle Yangtze River

This chapter has been published as:
Xia C, Pahl-Wostl C. (2012a) Understanding Transition in flood management of Yangtze River Basin - an in-depth case study of Dongting Lake area at the middle Yangtze. Environmental Innovation and Societal Transitions, 5, 60-75. DOI: 10.1016/j.eist.2012.10.001.

5 Paper 2: The Development of Water Allocation Management in the Yellow River Basin

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6 Paper 3: The Process of Innovation during the Transition to a Water Saving Society in China

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7 Conclusions and Outlook

This dissertation aims to understand the development of the water resources management regime in China, with a special focus on its two sub-regimes: the flood management regime and the water supply and demand management regime.
This dissertation contributes to sustainability transitions research in two ways: (1) by developing two conceptual frameworks for analysing regime development; and (2) by strengthening the empirical basis for sustainability transitions research by exploring the development of the water resources management regime in an emerging economy such as China.

7.1 Elaborations on the conceptual framework for sustainability transitions research

Sustainability transitions research is still a relatively young field. Multi-phase perspective (MPP) and multi-level perspective (MLP), which have frequently been used in this field, form broad and heuristic frameworks to explain the dynamics of transition. However, they lack the analytical power to understand, for example, what specific components in a regime have changed, to what extent, and how these components interact with each other to trigger the start of the transition. Therefore, further elaborations on theory and analytical methodologies in sustainability transitions research are needed. Accordingly, in this dissertation, two conceptual frameworks were developed based on the existing hypotheses of sustainability transitions research and insights from organizational learning, complex adaptive system theory and political science.
"Regime" is the main analysis unit in the two frameworks developed. In this dissertation, a regime is understood as a system that fulfils a specific societal function. The first framework enabled detailed analyses of regime development:

- *What needs to be changed and to what extent for a regime transition to take place? (3.2.1)*

This question aims to provide clearer criteria for different levels of regime development, i.e. the incremental improvement of established routines, transition and transformation (or a transition of the whole regime).
To approach to this question, the author linked the following two concepts: (1) Van der Brugge's structuration of "regime" (2009), which categorizes regime components into structure, actors and processes; and (2) Pahl-Wostl's conceptualization of multiple-loop learning (2009): single-, double- and triple-loop learning. This is a valuable addition to the MLP and MPP. While Van der Brugge's conceptualization (2009) opens the black box of a regime and specifies the precise components of a regime, its combination with Pahl-Wostl's multiple-loop learning

(2009) allows for the differentiation between different levels of regime development according to the "learning" of different regime components. In Case Study 1, the author further elaborated on what constitutes a desired regime (i.e. Integrated Flood Management). This step was essential when examining what has changed, and to what extent, towards the desired regime.

- *How is the start of a regime transition triggered? (3.2.2)*

Although MPP specifies four different phases of regime development, the boundary between the predevelopment and take-off phases is rather vague, i.e. when a transition starts and how. This part of the conceptual framework enables the identification of the moment when a regime transition starts. The author defined a term called "Window of Opportunity for Transition (WOPT)", which was built on Kingdon's "multiple stream model" of policy changes (1995) and linked to Van der Brugge's structuration of "regime" (2009) and Pahl-Wostl's multiple-loop societal learning concept (2009).

- *How do niches influence regime development? (3.2.3)*

In the school of socio-technical regime conceptualization, niches are where radical technological innovations are nurtured and experimented. There are similar "spaces" for radical innovations in a societal system. They are termed as "informal learning processes" in this dissertation. Here the author explored how these informal learning processes and how a specific actor group, epistemic communities, who can potentially shape informal learning processes, "find" their way to influence regime development.

Given that regime development eventually unfolds by way of various concrete activities, the author developed a second framework, which drills down into ***three types of governance activities and their co-evolutions during a regime transition***. It was built on a part of Loorbach's transition management work (2007), which groups different activities into three types of purposeful governance activities, i.e. strategic, tactical and operational. These activities facilitate a regime transition towards a desired regime only when they align with each other. The framework further elaborates the adaptive capacity of the regime (polycentric governance, information management to deal with complexity and uncertainty and sufficient resources) that supports the co-evolution of these activities.

The two conceptual frameworks offer the possibility of analysing regime development in a more precise way. In this dissertation, these frameworks were applied to explore water resources management regime. However, the regime composition and structuration, which is the foundation of the two frameworks, is very broad. Thus, the two frameworks can be used to analyse any system that contains a complex of cultural, institutional, physical infrastructure components, actors, and social practices that fulfil a specific societal function(s) and faces persistent problems, such as energy, mobility, or built environment.

7.2 Deepening empirical basis: three case studies on the development of water resources management regime in China and reflections

The author applied the elaborated conceptual framework to explore the development of two sub-regimes of the water resources management regime in China through three case studies: flood management (Case Study 1) and water supply and demand management (Case Studies 2 and 3). Depending on the research questions to be answered in each case study, different parts of the conceptual frameworks were applied. The spatial dimension of a regime was also explicitly dealt with in these case studies.

In this section, the author explains how the conceptual frameworks were applied in the case studies and reflects on what lessons the case studies can provide for sustainability transitions research and water resources management transition in other countries.

7.2.1 What needs to be changed and to what extent for a regime transition to take place?

In Case Study 1 (Chapter 4), the author investigated whether, to what extent and how a transition towards a regime of Integrated Flood Management (IFM) took place in the period between 1949 and 2009 with the framework developed in 3.2.1. A transition towards an IFM regime started in Dongting Lake Area, based on the evidence of different levels of learning around several normative criteria of IFM. Double and triple-loop learning took place in certain regime components within specific criteria. For example, the central government imposed a new paradigm for overall flood management and also formulated and enforced institutions to carry out infrastructural changes to restore the floodplains. However, the transition of the whole flood management regime in Dongting Lake area to IFM may still take time, due to the slow reconfiguration of the rest of the regime and the lack of change in other regimes that are key for the transition of the flood management regime. In addition, as articulated in 3.2.1, both double- and triple- loop learning should be accompanied by necessary changes in decision-making or implementation processes. We found that processes for cross-sectoral and cross-administrative-boundary collaboration have not been fully developed to support triple-loop learning of the regime structure change towards IFM and need to be improved, for instance, developing formal mechanisms to facilitate cross-sectoral collaboration, strengthening the river basin commission' s power over the enforcement of flood management strategic plan of Dongting Lake. Besides, both double- and triple- loop learning will benefit from an increasing involvement of non-governmental stakeholders and experts from other disciplines in strategic planning, which leads to

a better understanding of the ecological and socio-economic implications of flood management measures.

In addition, the findings of Case Study 1 challenge the theoretical assumption of a linear sequence of a regime development, i.e. always being a step-wise move through single to double and on to triple-loop learning, elaborated in 3.2.1. During the development of the flood management regime in Dongting Lake, triple-loop learning around the criterion "exploring measures that take advantage of the flood regulation service of a floodplain" (both institutions and infrastructures) took place, mainly due to the following facts: (1) the central government perceived the urgency of the problem; (2) the availability of solutions in line with an alternative paradigm, and; (3) the decision-making structure in Chinese flood management is hierarchical. Such triple-loop learning occurred rapidly, without an explicit discussion on the existing management paradigm. We can, therefore, draw a tentative hypothesis: in the regime development process, single, double, and triple-loop learning does not necessarily take place in a step-wise fashion but actually occur in a back-and-forth manner, which is shaped by various factors such as the political nature of the geo-administrative boundary of a regime and the availability of WOPTs. On the other hand, this poses a question whether explicit double-loop learning linked to the management paradigm is a precondition for the start of a transition. At the time of crisis or rapid change, might a transition start directly with triple-loop learning in the institutional and infrastructural dimension that implies an alternative paradigm? If the answer is yes, one thing is clear: such a transition is likely to last (i.e. not revert to the original "basin of attraction") only when it is followed by an immediate elaboration and an explicit promotion of the alternative paradigm beyond the isolated groups and a reconfiguration with other existing regime components.

7.2.2 How is the start of a regime transition triggered?

In Case Study 2 (Chapter 5), the author explored the moment when the transition(s) of the water allocation regime in the Yellow River Basin started, i.e. whether and how "Windows of Opportunity for Transition (WOPTs)" emerged. The conceptual framework developed in 3.2.2 was applied here.

The study identified a series of political and problem windows that had opened in the water allocation regime in the Yellow River Basin since the 1950s. Four WOPTs opened as a result of critical connections between problem windows, political windows containing both paradigm changes and struggles between interest groups, together with solutions that matched both of these windows. These WOPTs triggered the start of regime transitions. However, in some cases, regime states reverted to the original "basin of attraction" after the transitions started, due to the lack of an sufficient reconfiguration of other regime components. Currently, the water allocation regime has started its transition towards a more sustainable regime. To prevent the regime from reverting to the original "basin of attraction", this study recommends that the reconfiguration of various regime components needs to

accelerate. This raises the question what is a sufficient reconfiguration to prevent the reversion of the regime state and why sufficient reconfiguration takes place in some cases but not in others. These questions deserve further attention for research. For the latter, for instance, a more systematic study of "proactive" adaptive capacity of a regime (for this, 3.3.2 provides a good starting point). On the other hand, the study also shows that the emergence of certain other political windows and problem windows did not trigger the start of a regime transition, demonstrating that a transition is less likely to start in the absence of a critical connection of all three streams.

7.2.3 Three types of governance activities and their co-evolution during a regime transition

Case Study 3 investigated a short period during the transition to a Water Saving Society (WSS) in China (Chapter 6). This was a special period during the long-term transition, because it was a part of a ten-year exploration and experimentation process at the beginning of the transition. The analysis was based on the conceptual framework developed in 3.3.

The author identified that three types of governance activities (strategic, tactical and operational activities) and their partial co-evolutions took place, which played an important role in the ten-year exploration process of WSS construction. This period started with activities at the strategic level, which addressed the necessity, theoretical background, and definition of the WSS. These activities were translated into guidelines and plans of WSS construction and stimulated the formulation of complementary institutions at the tactical level, which further guided the activities at the operational level. The strategic activities also provided rationales for the experiment of WSS construction at the operational level. Reversely, the theories about WSS and water rights developed at the strategic level were validated by the first pilot at the operation level. However, regular feedbacks from the activities at the operational level to those at the tactical level were still lacking.

The author then investigated how the co-evolutions were facilitated or impeded by examining the adaptive capacity of the regime, which is considered to be essential for regime transitions. The results illustrate the fact that measures to enhance the adaptive capacity of the existing regime need to be developed.

- ***Polycentric governance system:*** the governance structure of the WSS experiment process was found to be polycentric. However, local governments have to bear the substantial costs of innovations and learning oriented-experiment. Therefore, proper incentive systems should be set up to stimulate learning according to the specific country context. In countries like China, where the central government plays a relatively strong role, positive incentives can include a combination of political incentives (e.g. linking innovation to the performance evaluation system of local officials) and

economic incentives (e.g. subsidising or awarding grants for specific innovations).

- ***Information management to deal with complexity and uncertainty***: monitoring operational and tactical activities took place and thus contributed to the co-evolutions between these two types of activities. However, learning within and co-evolution among each activity still require improvements to be made. A comprehensive monitoring system needs to be in place at the beginning of the experiment. Such a system, containing a comprehensive indicator system and regular monitoring and evaluation, should be able to monitor and evaluate all three governance activities and address the uncertainties associated with innovations. Equally important, mechanisms enabling the monitoring and evaluation results to be fed back into the formal policy processes should be institutionalized.
- ***Resource availability:*** there was a lack of financial and personnel resources for local WSS experiments and for facilitating the co-evolutions between different governance activities. Sufficient financial and personnel resources should be put in place to design, monitor and adjust the local experiments and to make an effective impact on transitions. This requires exploring different financial sources and mechanisms as well as capacity building for staff.

7.2.4 How do niches influence regime development?

In this dissertation, three kinds of niches, termed as informal learning processes, were analysed: policy experiments initiated by the government, pilots initiated by actors outside government, and research projects initiated by actors both within and outside the government. Some informal learning processes were related to a specific issue within the existing regime and were led by actors in the formal policy processes. They have strong links (both in terms of participants and urgent needs as elaborated in 3.2.3) and intensive interactions with the existing regime. The others were initiated by actors located outside the formal processes and have weaker links to and less interaction with the existing regime.

These informal learning processes, with their different levels of links and interaction with the formal policy processes, influence regime transitions through different approaches.

Among the first type of informal learning processes that contains strong linkages to the formal policy processes, policy experiments were found to be a key element in water resources management regime development in China. In our case studies, policy experiments were conducted at different administrative geographic scales, ranging from municipal level (Water Saving Society (WSS) pilots) to county level (flood insurance in a county of Hunan province) to irrigation district level (water use rights exchange experiments in Inner Mongolia).

Since they were initiated by the government to explore ways of reconfiguring the new regime components and the existing regime components, these processes had intensive interaction with the formal processes in the existing regime. On the one hand, in our case studies, the key actors, i.e. the central government and/or governments at a higher level than the locality where the experiment took place guided and coordinated these experiments. In Case Study 3, the central government coordinated the overall WSS experimentation process, i.e. conceptualizing WSS and setting up mid-term objectives and plans for WSS development in China, systematically selecting pilots with different water conditions, socioeconomic backgrounds and political importance, and facilitating the dissemination of lessons from local experiments. In Case Study 2, in order to support water rights exchange experiments, the central government, the River Basin Committee and the Autonomous Region government formulated policies that guided and regulated water use rights exchange experiments. On the other hand, the key actor in the formal policy processes also created protective spaces for these experiments, for example, by exempting them from existing regulations. In Case Study 2, water rights exchange experiment started before the legal framework allowing such an exchange was set up. This support from the higher administrative level in terms of responsive coordination and guidance created an institutional framework for these policy experiments and was essential for them to effectively scaling-up and contribute to regime transitions. At the same time, the Zhangye pilot in Case Study 3 demonstrates that, despite coordination and guidance from the central government, sufficient decision-making power was accorded to local government to develop the approaches tailored to local conditions. In this way, local innovation potentials were explored. However, to fully exploit the potential of policy experiments in facilitating the transition, certain barriers still need to be overcome, as articulated in 7.2.3.

Last but not least, it is worth noting that the selection, implementation, evaluation and scaling up of the policy experiments are still a part of the political process and are not always transparent (Voss et al., 2009; Mei and Li, 2013). Learning through policy experiments may be vulnerable to the interests of specific powerful groups. Mei and Li (2013) claim that having specific actors as coordinators may be a "double-edged sword", as these actors could facilitate the transition but also impose an undesirable direction on the transition. In addition, radical experiments such as that in Zhangye, undertaken without any ex ante assessment, may bring long-term negative impacts on the whole local socio-ecological system or even external impacts on other locations (Xia and Pahl-Wostl, 2012b). These, in turn, call for a "further elaboration of procedural designs to increase their political robustness" (Voss et al., 2009).

In the second type of informal learning processes – those with weaker linkages to formal policy processes in the regime – the leaders of the processes actively explored the linkages. One strategy is to efficiently use both "venues", in which key actors in the formal processes take part and/or policy needs are discussed, and the

media, which may draw attention from these key actors. For example, WWF's "Partnership for a Living Yangtze" in Case Study 1 was not initially linked to the formal policy processes of floodplain restoration in the Dongting Lake Area. However, by joining CCICED, which is a central government think tank for environmental issues, and using the media effectively, WWF was able to influence the transition. In addition, the actors in these learning processes can also deliberately create or co-organise "venues" in which their ideas derived from double-loop learning can be represented (Meijerink and Huitema, 2010). One example is the Yellow River Forum in Case Study 2, which was co-organised by the YRCC (the key actor in the formal policy processes) together with external prominent national research institutes and international organizations.

In both types of informal learning processes, one actor group – the epistemic community –deserves a special attention. The epistemic community contains members from both within the formal processes and outside the processes. The Science and Technology Committee (STC) of the YRCC in Case Study 2, which consists of senior experts from various prominent research institutes and organizations inside or outside the YRCC, is a community of this kind. The STC has regular meetings with YRCC decision-makers, in which these decision-makers consult experts with regard to management problems and key projects. Knowledge generated from such a community is not constrained by the prevailing paradigm within the formal policy processes. It creates a dynamics in the knowledge base of the regime and may result in alternatives (such as a new paradigm and vision, alternative institutions and infrastructures and new processes) being incorporated into the formal policy processes. Such epistemic communities are very valuable for informal learning processes (of both the first and second type) and for facilitating the outcomes of the informal learning processes to effectively influence regime transition.

In summary, these different types of informal learning processes and, more importantly, the way in which they interact with the existing regime have offered a complementary alternative to the traditional top-down imposition of alternative paradigms. In this way, they have influenced regime transitions in the sub-regimes in water resources management in China. In this sense, the empirical studies also contributed to a better understanding of how informal learning processes influence regime development in sustainability transitions research.

To recap, what lessons can these case studies deliver for the development of both flood management and water supply and demand management regimes in the studied regions? The studies show that transitions have already started in these sub-regimes and suggest that improvements are needed for further transitions towards sustainability. These improvements include measures that, for example, enhance the adaptive capacity of the regime, reconcile the transitions of water resources management regime and the development of other relevant regimes, and speed up the reconfigurations of regime components.

The other key question is what these case studies of China water resources management regime can contribute to sustainability transition research? In general, one can expect that the basic principles of regime development and transition in the two sub-regimes in China are same as those in other countries, namely, how the start of a regime transition is triggered(i.e. how WOPTs emerge), how informal learning processes influence regime development (i.e. their features of and the linkage necessary for them to influence the regime). In addition, Case Study 3 demonstrated the three types of governance activities and their interactions after the transition of a water supply and demand management regime started, which provides empirical insights of "partial" transition management in other countries than the Netherlands, where the concept of transition management origins. Furthermore, Case Study 1 indicated the general applicability of the conceptual approach developed in this dissertation to analyse the extent of regime development. However, it revealed that single, double, and triple-loop learning does not necessarily take place in a step-wise fashion. Triple-loop learning can first take place, given the existence of a highly top-down decision-making structure and the urgency of the problem perceived by high-level decision-makers, which is the case in China. Last but not least, the case studies illustrates a special approach how informal learning processes influence regime development in China, that is, policy experiments led by the government. While most experiments studied in sustainability transition research are located at projects and technology levels (e.g. Loorbach, 2007; Van der Brugge, 2009; Berkhout et al., 2010; Geels, 2002), policy experiments in China exhibit another scale and dimension of experiments and may effectively facilitate regime transitions if being deployed properly. The role and shortfalls of such an approach for sustainability transitions deserves a further systematic research.

7.3 Recommendations for Future Research

7.3.1 Further differentiation of the regime components

In comparison with previous frameworks, which treated a regime as a black box, the conceptualization of a regime as developed in this dissertation and based on Van der Brugge (2009) is very useful for understanding the changes that take place in regime components and to which extent. However, in order to provide more practical recommendations for a regime transition, a more differentiated regime conceptualization is needed. This means, for example, that it is necessary to further categorize different types of policy instruments in the institutional structure and different types of technologies/infrastructures in the infrastructural structure. Such differentiation will enable a detailed and comprehensive assessment of the interactions between different regime components, such as the interaction between economic instruments and regulatory instruments, regulatory instruments and

infrastructures for monitoring or economic instruments and the incentives for specific actor groups.

7.3.2 Further analysis on multi-regime interactions

A water resources management regime does not develop in isolation. For example, as shown in Case Study 1, the flood management regime was also shaped by its interaction with the regional planning regime. The lack of reconfiguration within regional planning partly impeded the transition towards IFM in FRSAs. Such multi-regime interactions are also essential for studying the water supply and demand management regime, because this sub-regime also interacts with other regimes including the energy regime (the water demand of the energy sector is high in the Yellow River Basin) and regimes that are centred on different sectors in urban development (these sectors are water users and have a stake in water demand and water saving for the construction of a Water Saving Society).

It is, therefore, recommended that more attention should be devoted to the role of these types of interactions between different regimes in investigating water resources management regime development and how to deal with them. They may compete with each other or together destabilize the existing regime (STRN, 2010). For example, methodology can be developed for analysing multi-regime interactions in order to understand how these interactions result in WOPTs and either contribute to, or impede, the regime transition.

7.3.3 Further drilling down into the actor dimension

Each specific sub-regime of the water resources management regime involves multiple actors who play various roles related to the societal function of the regime. They create institutions, infrastructures and the culture of a regime – and benefit from them. Their paradigms, vested interests, power relationships, actions and interactions with the regime structure constitute the complexity of the regime. These factors were not explicitly covered in the current dissertation.

As a result, the third recommendation is to conduct detailed and systematic studies on how various actors mobilize and apply their resources, such as knowledge, power and network, to facilitate or impede a transition of specific water resources management sub-regimes in China (for example, by creating a political window and developing and selecting an option from the solution stream). Such understanding is an essential basis for developing strategies that systematically facilitate the sub-regime transition.

7.3.4 Comparison of transitions

The final recommendation is the strengthening of comparisons between transitions in the water resources management regime in China and other countries with

different policy cultures (e.g. with different government roles or a different share of alternative governance modes).

In a specific sub-regime of the water resources management regime, potential comparison topics can be focused on what facilitates and impedes the start of the sub-regime transition and the transition phase itself in different countries by investigating:

- The adaptive capacity of the sub-regime: what different regime architectures (polycentric, horizontal and vertical integration) of the specific sub-regime exist in different countries? Has the regime architecture evolved over time to facilitate the sub-regime transition?
- What kind(s) of informal learning processes exist in the sub-regime development in different countries? Which one(s) are more effective in triggering the regime transition and/or facilitating the transition and how?
- How did different regime components underlying sub-regime development in different countries interact with each other to shape regime development, for example, how did actors and the resources they can mobilize interact with the evolving policy mix in the sub-regime?
- What was the role of certain types of the sub-regime structural components, for example, the power and resources of various actors, in the development of the sub-regime in different countries?
- Did co-evolution among three governance activities take place to facilitate the sub-regime transition in different countries? If yes, why and how did this take place? Otherwise, why did it not take place?

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Appendix 1: Interviewee

Name and affiliation	Why being selected	How the author approached them	Forms of semi-interviews
Case Study 1			
Prof. Cheng, Xiaotao, China Institute of Water Resources and Hydropower Research (IWHR)	He is a well-known expert in the field of flood management in China and belongs to the think tank of Ministry of Water Resources. He also has extensive knowledge about flood management of Yangtze River and Dongting Lake.	Through the contacts ASEM-WaterNet	Personal visit at his office
Mr. HWZ * Senior Engineer Changjiang (Yangtze River) Institute of Survey, Planning, Design, and Research (CISPDR)	He is an senior expert working at CISPDR, which is a think thank for Yangtze River Basin Commission. He has been involved in the strategic planning process of flood management of Yangtze River and Dongting Lake .	Through Prof. Cheng, Xiaotao	Personal visit at his office
Mr. LXC * Institute of Water Resources and Hydropower Research, Hunan Province (HNIWHR)	He is an senior expert in HNIWHR, which is a think thank for Hunan Provincial Water Bureau. He has been involved in the strategic planning process of Dongting Lake flood management .	Through Mr. HWZ	Personal visit at his office
Mr. ZH * Hunan Provincial Water Bureau.	He is an official at Hunan Provincial Water Bureau and has been involved in strategic planning process of Dongting Lake flood management.	Through Mr. LXC	Personal visit at his office
Dr. Zhang,Cheng WWF	He is a programme officer at WWF who was involved in "Partnership for a Living River".	Direct contact	Personal visit at his office
Case Study 2			
Mr. XYP* Yellow River	He is an official at Yellow River Basin Commission	Contact through a senior	Personal visit at his

Conservancy Commission (YRCC)	and has been actively involved in river basin allocation.	researcher in Chinese Academy of Science	office
Dr. ZWG and FXF* Yellow River Institute of Hydraulic Research	They are experts in water allocation and water rights experiment in the Yellow River Basin. Their institute is affiliated with YRCC.	Through Mr. XYP	Personal visit at their office
Mr. CXG Yellow River Water Affair Bureau	He is an official at Yellow River Water Affair Bureau and has extensive practical experience in water allocation.	Through Mr. XYP	Personal visit at his office
Case Study 3			
Dr. Zhang Xuehua	She is a senior researcher in the water management field at Tianjin Polytechnic University and has been engaged in water-related projects in Tianjin City.	She is a visiting scholar at USF.	Personal visit at her office
Ms. CJ Tianjin Water Resource Bureau	She is an official at Tianjin Water Resource Bureau, who has been involved in water saving policy-making in the city.	Through Dr. Zhang Xuehua, a visiting scholar at USF	Lunch
Mr. YJS Hangu District Water Resource Bureau	He is an official at Hangu District Water Resource Bureau and has been involved in WSS pilot in Hangu District.	Through Dr. Zhang Xuehua, a visiting scholar at USF	Personal visit at his office

* these interviewees do not want their names published.

Appendix 2: Interview Guideline

A2.1 Case Study 1

In Case Study 1, two groups of interviewees have been approached. The first group is the governmental official and experts in organisations affiliated to government agencies. The second group is non-state organisation(s) that contributed to informal learning processes.

A2.1.1 Governmental Official and Experts in organisations affiliated to government agencies

Objectives:

To identify the "integrated flood management (IFM)" feature of flood management and critical events and informal learning processes in Dongting Lake Area after 1998 .

Interview Questions:

I. Introduction

II. IFM features

Based on the document review, I understood that there was significant changes in flood management after 1998. Could you elaborate on the following aspects in the current flood management practice?

Measures	New features after 1998	Which policies (national, river basin, and provincial) have been essential for the implementation of measures in this aspect? *	Were there pilots of this measure implemented (pilots organised by the government or other organisations) **	What were the major barriers for implementing this measures?
Adjustment of land use and development on floodplains to reduce				

society's exposure to flooding				
Enhancing society's preparedness for floods and reducing its vulnerability				
Social equity is promoted via cost and benefit sharing mechanisms among various stakeholders				
The adverse impacts of flood control structural measures on ecosystems are taken into account Integrated approach				

*: This question aimed to identify critical events in the formal policy processes that pursue the new paradigm and approach of IFM, i.e. whether double- or triple- learning took place.

**: These questions aimed to find out whether there are informal learning processes to pursue the new paradigm and approach of IFM. Following sub-questions are posed to understand the details of these informal learning processes.

- What were the objectives of the pilot or programme?
- Who led and participated in the pilot or programme?
- Were the outcomes of the pilot or programme fed back and integrated to decision-making on flood management in Dongting Lake Area?
    - If yes, how were the outcomes feedback into the decision-making process?
    - What do you think were the major factor(s) enabled such an integration?

III. Actors

- What are the major agencies and organisations involved in flood management in Dongting Lake Area?
- Who of them lead and participated in strategic planning of flood management in Dongting Lake Area?
- What are the form of participation of these agencies and organisations in strategic planning?
- Are there difficulties for collaboration in strategic planning? If yes, what?

A2.1.2 Interviewee: WWF

Objectives:

To obtain a better understanding of the WWF programme "Partnership for a Living River" (this was identified by the first group of interviewees to be important programme). This Programme can be regarded as an informal learning process.

Interview Questions:

I. Introduction

II. General Background of the Programme

How was the Programme initiated ?

III. How has the Programme contributed to the "Converting Reclaimed Farm Lands into Lakes" in Dongting Lake Area?

	1	2	3	4
Action				
Major outcomes				
Actors (institutions and organisations) and their roles				

		Critical event 1***	Critical event 2	Critical event 3	Critical event 4
Were the outcomes of the action feedback and integrated to... (critical event)?	Action 1				
	Action 2				
	Action 3				
	Action 4				
If yes, how?	Action 1				
	Action 2				
	Action 3				
	Action 4				

*** these critical events were identified by the first group of experts and governmental officials.

A2.2 Case Study 2

A2.2.1 Objectives

The interview aimed to identify key recent changes in water allocation regime in the Yellow River Basin , informal learning processes that were associated with the formal policy processes, and whether and how the epistemic communities contributed to the regime development .

A2.2.1 Interview Questions

I. Major Changes in water allocation regime in the Yellow River Basin

- What are the major differences among the "Yellow River water allocation scheme (1987)", "Administrative Measures of Yellow River Water Diversion (1998)", and "Yellow River Water Diversion Regulation(2006)", in terms of efficiency, equity, and environment?

  This questions aims to get a basic understanding what have been improved in terms of sustainability in water allocation. This also served as a complementary data collection to literature review.

	Yellow River water allocation scheme (1987)	Administrative Measures of Yellow River Water Diversion (1998)	Yellow River Water Diversion Regulation(2006)
Efficiency: How the efficiency of water allocation was achieved?			
Equity: The compensation mechanism between up- and down-stream regions as well as between sectors;			
Environment: How is environmental water need addressed; Consideration of water quality during water allocation; Consideration of groundwater during water allocation.			

- Were there other major formal policies related to water allocation developed recently? If yes, what?
- What are the major barriers to implement these key policies?

II. Informal learning processes and epistemic communities

- Were there major research projects/activities or experiments related to these key policies?
- If yes:
    - What were the objectives of the research project/activity or experiment ?
    - Who led and participated in the research project/activity or experiment ?
    - Were the outcomes of the research project/activity or experiment fed back and integrated to decision-making on water allocation in the Yellow River Basin?
        - If yes, how were the outcomes fed back and integrated into the decision-making process?
        - What do you think were the major factor(s) enabled such an integration?

- Were there expert groups/committees/organisations who have contributed to these key policies?
- If yes:
    - Who were they?
    - Were the activity outcomes of these expert groups/ committees/ organisations fed back and integrated to decision-making on water allocation in the Yellow River Basin?
        - If yes, how were the outcomes fed back and integrated into the decision-making process?

A2.3 Case Study 3

Data on the national policy experiment process, i.e. the strategic and tactical governance activities, were mainly collected based on desk research. During the field trip, two interviews were conducted in Tianjin, given the availability of the network.

A2.3.1 Objectives

Tianjin is one pilot in the first experiment period. The interviews aimed to explore major measures, the availability of financial and personal resources, monitoring processes, and incentives of decision-makers at the local level.

A2.3.2 Interview Questions

I. Introduction

II. Background

- Could you give a brief introduction of the Water Saving Society(WSS) pilot implementation in Tianjin?
- What are the major measures?
    - Did the local(municipality and/or district) government promote water use rights actively? If yes, how?

III. Actors

Who were engaged in developing the strategic plan of WSS pilot in Tianjin/Hangu District? (the role of the central and municipal government, the river basin commission, and non-state actors)

IV. Monitoring

- Was there a middle-term evaluation during the pilot period?
- If yes:
    - When and who conducted the evaluation?
    - What were evaluated?
    - Was the evaluation results used to adjust the pilot process?

V. Political Incentives

- Is the promotion of WSS related to the performance evaluation of local officials?
- If yes, how?

VI. Financial resource:

- Where did the funding of WSS pilot come from?
- What financial incentives were available for different counties and districts within the city?
- Was it sufficient?

VII. Personal resource:

- Please describe the organisational structure of WSS pilot implementation in Tianjin/Hangu District.
- How many staff work on the WSS pilot implementation?
- Are there additional staff allocated to the WSS pilot?
- How is the understanding about WSS and water rights among the staff who have led and implemented the WSS pilot?