DRAFT – Do not quote without author's permission

Transformation and Resilience of Water management regimes Integration of water and spatial planning in Rotterdam

Rutger van der Brugge[1]
Rutger de Graaf[2]

1. Introduction

In the Netherlands there is an effort to integrate water management and spatial planning. This paper analyses the integrating developments between these domains on three levels, national, regional and local level. The objective of this paper is to evaluate to which extent the water management system is able to transform itself. This so-called transformative capacity is the systems capability to adapt to changing circumstances through renewal of the water system. Resilience on the other hand indicates a systems ability to adapt, but though retaining essentially the same system[3]. While resilient systems may be able to cope with changing circumstance, predominantly through optimization the functioning of the existing system, increasing transformative capacity leads to a situation in which the functioning of the system is improved by system innovation.

This paper is proposing to develop a framework for understanding the tipping point(s) between transformative capacity and resilience. In the Rotterdam area – the second largest port in the world – located in the Western part of the Netherlands, there are indications that they are very near this tipping point. For the coming period (2006 to 2010) the urban water plan attempts to integrate the urban spatial plans completely. Additionally it argues that in order to achieve the urban spatial plans, the role of water could be decisive, while understanding that this may require quite fundamental infrastructural transformation, but also institutional change. The Rotterdam example will be used to evaluate whether this tipping point is close.

2. Background: Transition theory

Transition theory attempts to explain why and how regimes might transform. Scientific work on societal transitions emerged from various authors (Davis 1945; Boulding 1970; Rotmans 1994; Ness, Drake et al. 1996; Kemp, Schot et al. 1998; Rip 1998; Geels and

[1] Corresponding Author. Dutch Research Institute for Transitions (DRIFT). Faculty of Social Sciences. Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, The Netherlands. Tel: +31 10 408 8777. VanderBrugge@fsw.eur.nl

[2] ·Faculty of Civil Engineering and Geosciences –Department Water Management, Section of Water Resources. Technical University Delft. P.O. Box 5048, 2600 AA Delft, The Netherlands. Tel: +31 15 278 46 73 81. R.E.deGraaf@.TUDelft.NL

[3] The notions of transformability and resilience originate from ecology (i.e. Holling, Walker, Folke, Scheffer). Here, we attempt to translate these concepts to societal systems, more specifically to water management regimes.

Kemp 2000; Rotmans, Kemp et al. 2000; Verbong 2000; Geels 2002; Berkhout 2003; Elzen, Geels et al. 2004; Van der Brugge, Rotmans et al. 2005; Loorbach and Rotmans 2006). Much of the recent work on transitions is descriptive and case study oriented. The majority of these historical cases have focused on the role of technology in changing technological regimes (Kemp, Schot et al. 1998; Verbong 2000; Geels 2002; Elzen, Geels et al. 2004).

Some authors (Loorbach 2004; Rotmans, Grin et al. 2004; Van der Brugge, Rotmans et al. 2005) attempt to broaden the scope towards a general systems approach for societal systems. In this approach transitions are "transformation processes from one equilibrium to another that is qualitatively different" (Rotmans 1994). Case studies from this perspective focus less on the role of technology but attempt to identify qualitatively different phases in the transition process with regard to the co-evolutionary dynamic of institutions, economies, technologies and cultures. (Rotmans 2003). (Rotmans, Kemp et al. 2000) distinguish four phases during transitions:

1. During the *pre-development* phase the system dynamics do not visibly change but under the surface, the system is slowly changing.
2. During the *take-off* phase the structural change of the system begins to show off, manifested by emergent phenomena and changing relations between actors.
3. During the *acceleration* phase the actual structural changes take place. At the systems level, new dynamic patterns are observed as a result of accumulation of socio-cultural, economic, ecological and institutional innovations that reinforce each other;
4. During the *stabilization* phase the new system structures stabilize and a new social order has established.

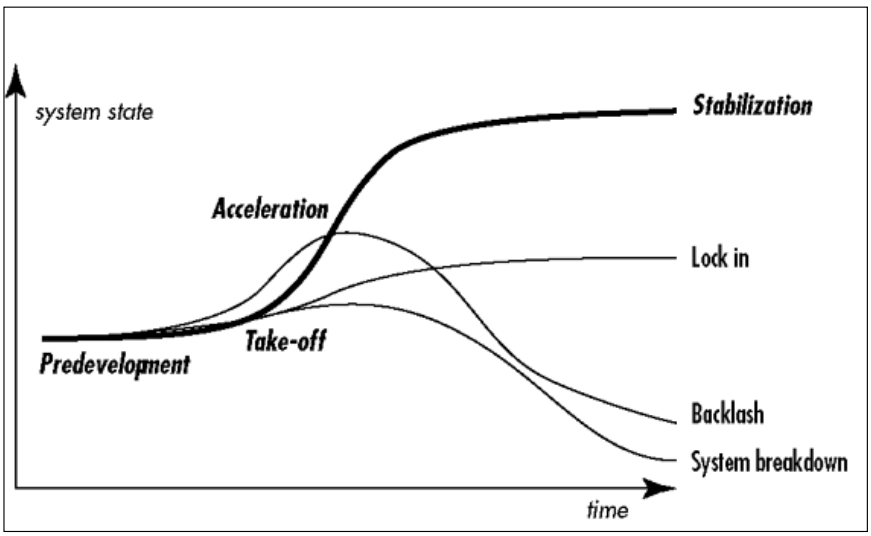

Figure 1. Possible system pathways of a complex adaptive societal system. The transition is the desired pathway in achieving sustainable development. However, the complexity of the interaction processes limits control over societal developments which may lead to less desired pathways, such as the lock-in, the backlash or the system breakdown.

Niche-regime interaction

Figure 1 depicts four trajectories of niche regime-interaction. (Berkhout, Smith et al. 2003) define regimes as *dominant cluster of artifacts, institutions, rules and norms assembled and maintained to perform economic and social activities*. According to (Rotmans, Kemp et al. 2000), regime dynamics are determined by shared assumptions, social norms, interests, belief systems and company strategy, summarized as culture, structure and practice. Within the water management literature the concept of water management regimes is not widely used, but refers to a constellation consisting of actors with specific practices and artifacts that are embedded in socio-cultural and institutional structures[4]. Generally, regimes have strong interdependencies between the elements they consist of and share a same logic, therefore enabling and constraining the practice of water resource management in specific ways (figure 2). Existing regime constellations throw up barriers resisting necessary transformative changes for effectively dealing with their water resources. Regimes are thought to be hard to change. (Arthur 1988) emphasizes the effects of learning, returns to scale, uncertainty reduction and network-externalities. (Nelson and Winter 1982) stress the lack of ability to 'reframe' problems due to existence of *technological paradigms* guiding problem perception and solution directions.

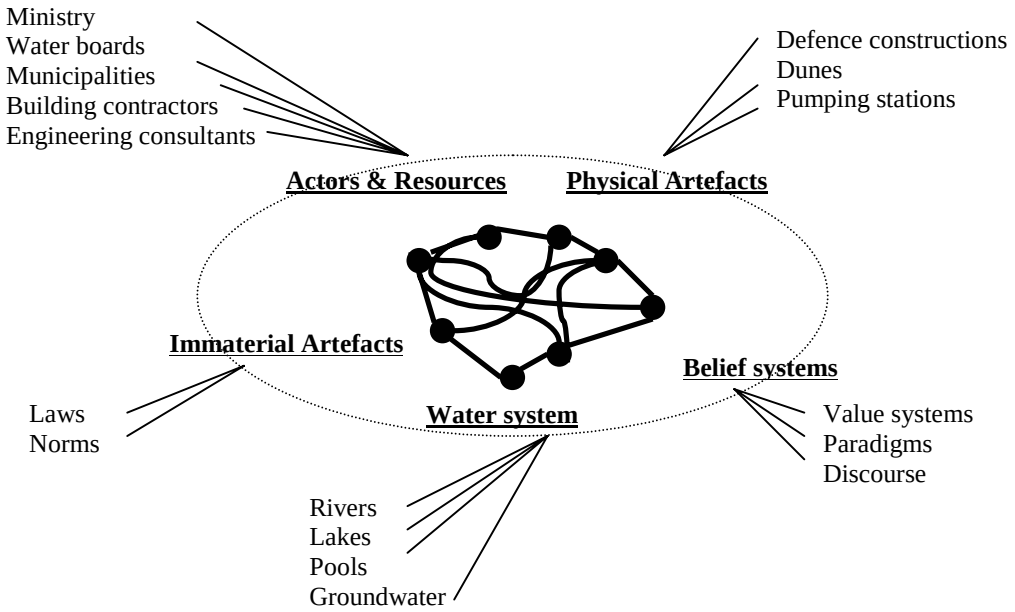

Figure 2. Conceptualization of the Dutch water management regime

[4] The concept of 'regimes' originates from the technological innovation literature (e.g. Nelson and Winter, Rip), pointing out that technologies are always embedded in socio-technical systems. Nowadays, it is widely used in the transition management literature (e.g. Rotmans, Kemp, Loorbach, Schot, Geels) to explain why societal systems are so difficult to transform.

Innovations are often the result of new combinations and can lead to processes of creative destruction (Schumpeter, 1942). (Kemp, Schot et al. 1998) emphasize the importance of giving them time and space (niches) to develop and mature.

Lock-ins occur if the existing regime structures are fixated and more beneficial for individuals than the new emerging structures. For instance, large infrastructural constructions fixate investments. Legislation and subsidies close down (or open up) alternatives and windows of opportunities. There can be backlashes if new alternatives are launched at large scale but altogether are not mature enough and returns are disappointing so that people revert to the traditional manner. Systems break down, or degenerate, when they become too expensive to maintain their internal processes. With the loss of such control variables, there is enough for room for alternatives to emerge. However, it can be possible that there is no suitable alternative developed yet. Another possibility would be that there are competing alternatives.

Transions are trajectories during which regimes transform and head into a new direction[5]. The selection environment is changing and strategies and operations that differ from the earlier selection environment are selected. Radically new innovation networks manage to sustain and mature. This is the result of reinforcing developments at different levels of scale (fig 3).

Transitions involve system innovations that emerge from experimentation in niches and eventually scale up to be incorporated in the regime. System innovations refer to organization-transcending innovations in which relationships between organizations have changed.

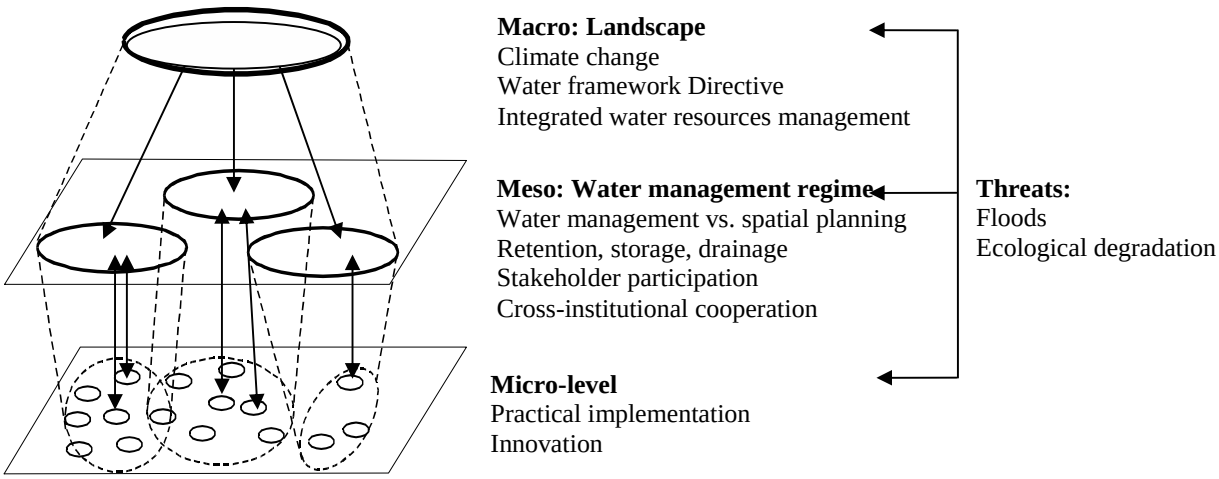

Figure 3 The multi-level concept is based on (Rip 1998; Geels and Kemp 2000). Developments at the macro-level correspond to slow broad societal trends. Dynamics at the meso-level are determined by the regime. The regime is the dominant pattern of actors, artifacts and structures in the social system. At the micro-level, individual persons, organizations, or innovations are distinguished. Translated to the field of water

[5] According to systems theory, this would be regarded as an attractor switch

Transition management

Transition management is a management theory to induce structural change within regimes. Transition management too, starts from the acknowledgment of limited predictive ability and control. It emphasizes the need for small innovative networks that experiment with system innovation. These networks form *niches* in which alternative selection environments are created. The performed experiments are derived from a long-term orientation (sustainability images of the future).

To initiate and coordinate system innovations, (Rotmans, Kemp et al. 2000; Rotmans, Grosskurth et al. 2001; Loorbach 2004; Loorbach and Rotmans 2006) developed an operational transition management model consisting of four activity clusters (Figure 4): (1) the establishment and development of a transition arena; (2) the creating of long-term integrated visions, transition pathways and agendas; (3) mobilizing actors and knowledge development through experimenting and (4) monitoring and evaluating the transition process. Each cycle ends with evaluation of the learning experiences from the experiments, resulting in adjustment of problem structuring and solution. The self-organized expansion of the multi-actor innovation network creates and supports momentum. Important for transition management is the multi-actor component, representing different perspectives about what sustainability means in their specific local context.

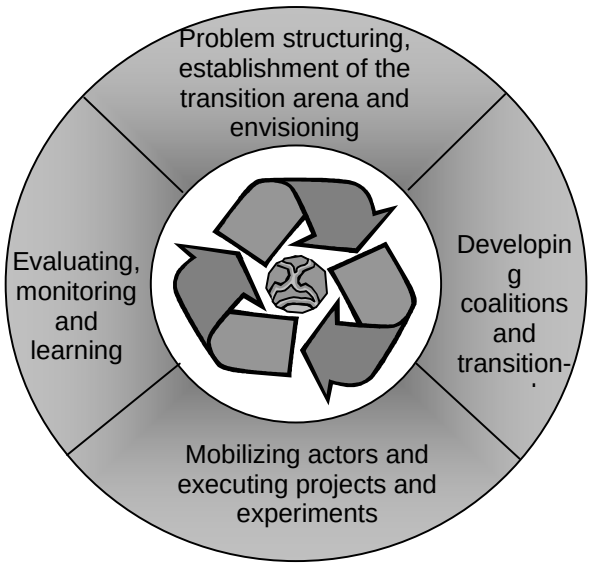

Figure 4. Transition management is a cyclical coordinated multi-actor process at strategic, tactical and operational levels and is organized around four co-evolving activity clusters (1) the establishment and development of a transition arena and envisioning process; (2) developing coalitions, transition pathways and agendas, (3) mobilizing actors and knowledge development through experimenting and (4) monitoring and evaluating the transition process (Loorbach and Rotmans 2006) (Hoogma, Schot, Kemp, 1998) argue that these niches require protection in order to mature and develop. It is important that these system innovations build up resilience in terms of culture, practical experience, institutional structure and financial resources so they are able to cope with distortion. To this end, Van den Bosch & Taanman (2006) propose a triple-strategy of deepening, broadening up-scaling. Deepening refers to in-depth exploration of barriers and opportunities of the innovations at hand. Broadening refers to the learning experiences as a result of placing the innovations into a new context. Up-scaling refers to effort of increasing impact upon the regime by increasing the interlinkages, while retaining it innovative identity

3. Dutch Background: Water management & Spatial planning

Water management and spatial planning have always been closely connected in the Netherlands. Cities were built near river or harbors for trade purposes. Many old towns in the Western part of the Netherlands, for instance Delft, Den Haag and Haarlem, have been built on old sand dunes; higher grounds surrounded by peat and clay soils so to be save from flooding and benefit from favorable drainage conditions. Other cities such as Amsterdam and Rotterdam were built around a dam in a lowland river. First a dam was constructed, after which a drainage canal was constructed to divert the river around the new city. The required collective effort and coordination made institutional capacity, spatial planning en water management essential conditions for such a planned urban development. For that reason, in the past water served as guiding principle for spatial developments and it were the water managers that made spatial development possible by the construction of dikes or draining lakes. Urban expansions were carefully planned and a technical plan was made to ensure that water could be discharged and controlled (Hooimeijer, 2006).

During the 20th century that relation between water management and spatial planning disappeared. New civil engineering technologies, for instance foundation technologies and powerful pumping stations became available. Increased engineering control over the water systems led to heavily modified water bodies within the whole country to such an extent that nowadays water managers tend to say that there are no natural water bodies at all in The Netherlands.

The gross manipulation of the water system was needed to support spatial developments that were needed for economic growth and welfare. Planned urban districts in areas with soft soils were integrally raised with meters of sand and drained by subsurface drainage pipes so that urban planners had a blank sheet in which everything was possible. Clearly, the water system was no longer guiding spatial and or societal functions.

Since the turn of the century the relation between water and spatial planning is again changing. Some say it needs to be guiding again in the spatial development, because climate change induces a serious water threat in The Netherlands. The way this relation is being restored can be illustrated by describing developments at national regional and local levels.

4. Integration of water management and spatial planning in the Netherlands

Integration on macro level: National developments

At a national level a number of trends can be noticed in the Netherlands that illustrate the increasing integration between water management and spatial planning. In the national spatial planning document Nota Ruimte (VROM, 2005) a special water paragraph about water has been included. Moreover, ministries of various domains, namely Transportation, Public Works and Water management and Agriculture, have cooperated to produce this document. Moreover, water is more and more considered as a guiding principle for spatial planning (Rijkswaterstaat, 1998). After the river floods in 1993 and 1995 it was recognized that technical water management measures alone would not be sufficient in the long term to deal with increased river flooding. In the projects 'Room for the River' (Rijkswaterstaat, 1995) the idea is put forward to give rivers enough space to

accommodate for the uncertain effects of climate change and the increased flood risks resulting from urbanization and land-subsidence. From the side of spatial planning the same tendency can be noticed. In 1996 the Ministry of Housing, Spatial Planning and the Environment published a policy document 'Water based spatial planning' (VROM, 1996). In the policy document of the Committee Water management for the 21st century (CW21, 2000) spatial planning is introduced as a strategic tool to solve water management problems. The societal change from 'Fighting against Water' to 'Living with Water' indicates an increasing interest of water in spatial planning. These developments can be regarded as a part of a societal change process, a transition. (Van der Brugge et al, 2005)

Integration on meso level: Regional developments

At regional level the provincial government also takes water into account in regional spatial planning. The principles formulated on national level are further implemented at regional level. In the province of Zuid-Holland, for instance, the water structure influences the spatial plans for developing a green-blue zone. (Province of South Holland, 2002) The plans for development of Delta Metropolis Holland (Regio Randstad, 2001) present a vision in which the Western urbanized part of the Netherlands should not be considered as separate cities. Instead they should be developed as a coherent metropolitan area to make competition with other large cities possible. In this spatial and economic development plan for the Delta Metropolis water plays an essential role. In particular the construction of large water storage areas in the Randstad, measures to decrease land subsidence and improved coastal and river flood defense are important.

Integration on micro level: Local developments

At local level three tools have been introduced to integrate water and spatial planning at local level. The water assessment, the urban water plan and the water paragraph in the local land use plan.

The Water Assessment

The water assessment is a tool to structure the communication process between the local spatial planning authority and the water authority. The assessment is legally obliged for new spatial developments and involves the water authority in the inception phase of a new development. The water authority can influence the spatial plan by using the water assessment. However, the water authority should also be actively involved in the developing phase. Figure 5. shows the process scheme of the water assessment.

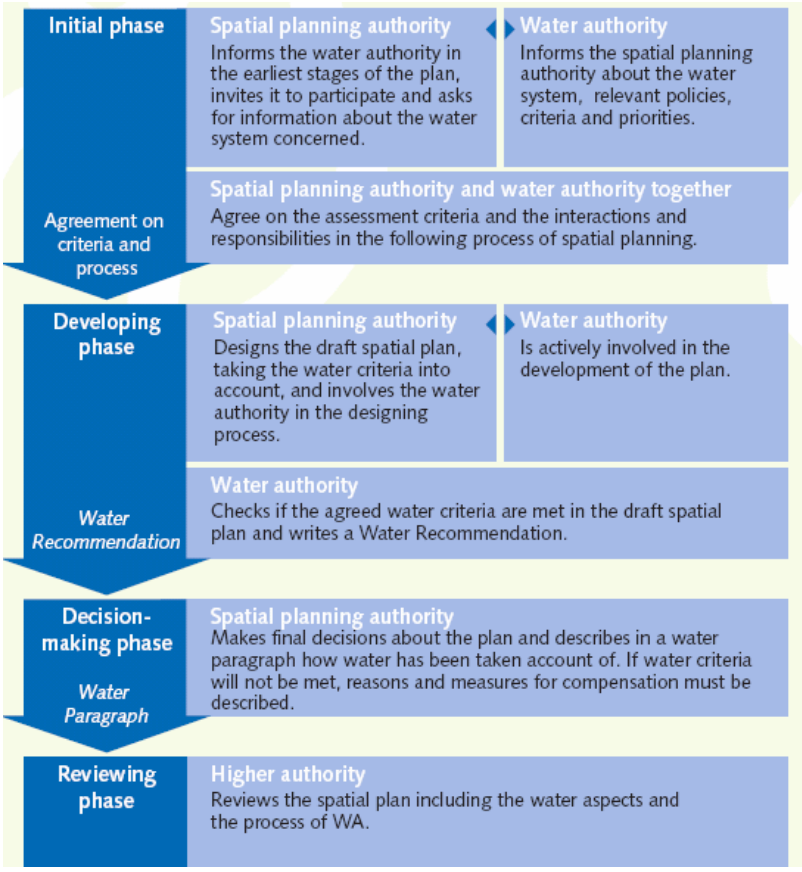

Figure 5. Process Scheme of the water assessment (RIZA,2003)

Urban water plan

The urban water plan is not obligatory. However, in many municipalities in the Netherlands an urban water plan have been made. Mostly the urban water plan is made by various departments of the municipality and the water board. Sometimes, the drinking water company is also involved. The content of the urban water plan is not prescribed. Consequently, involved organisations that make an urban water plan can negotiate on which issues are included in the plan. Most urban water plans in the Netherlands are developed by using an object oriented approach. (Van de Ven et al, 2005). In such an approach water problems are regarded as a technical optimization problem. Other approaches that are used are the guiding principles approach in which water problems are regarded as design problem and the negotiation approach in which water issues are treated as negotiation problems.

Table 1. Three approaches to integrate water and spatial planning in an Urban waterplan (Van de Ven et al, 2005)

	Object oriented	**Guiding principles**	**Negotiation**
Orientation	***optimisation problem***	***design problem***	***negotiation problem***
Planning tradition	***Policy analysis***	***social learning***	***transaction***
Features	***meeting objectives***	***use basic concepts***	***pragmatic / empirical***
Lead	***water experts***	***urban planners***	***decision makers***

Water paragraph in the local land use plan

The local land use plan is the only legally binding spatial planning plan for citizens. The local land use plan defines zones on municipality level where to build and where to develop or maintain other functions such as nature, recreation or water storage. In this legally binding plan a separate 'water paragraph' can be included to make reservations for water storage functions. By using the water paragraph it is possible to achieve a more solid position of water in spatial planning process.

5. Types of change

We here propose a conceptual framework for understanding the way a regime improves the technical system it is involved with. Developments such as described above are of influence in the way we perceive the systems performance and might even change the way we are inclined to in which direction we would want to improve the system. Each type of improvement requires the support of involved stakeholders. The more fundamental change a specific improvement implies the more institutional barriers on is likely to be confronted with. The three types of improvement we consider here are:

- optimization
- development of additional system
- system innovation

Optimization

The first circle is the optimization circle. The regime responds to changes by optimizing the existing system in order to counter the increase. For instance, the regime could decide to improve wastewater treatment facilities as a result of increased pollution from a new factory upstream. By internal or external distortions that will be elaborated in the next chapter, the pressure on the regime may increase until it reaches a 'tipping point'. This tipping point is a critical point in time where the system continues optimizing its technical infrastructure of where it enters the next phase of additional system development.

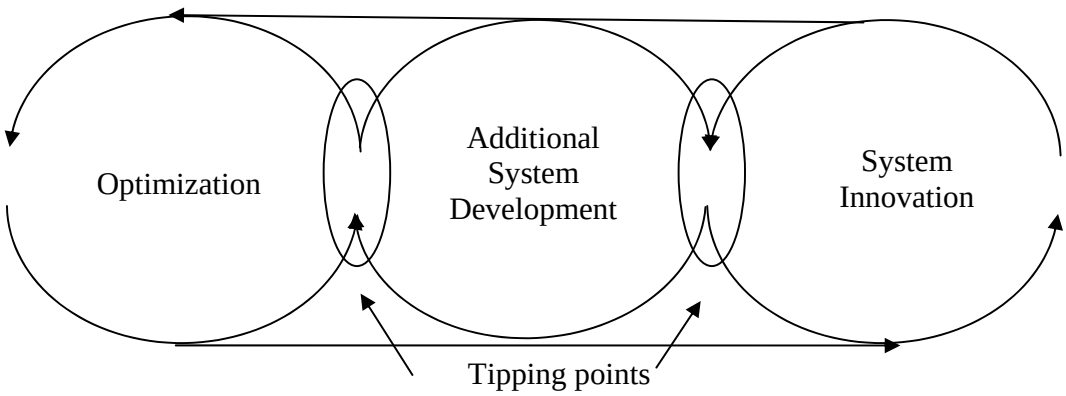

Figure 6. Illustration of conceptual framework of transformative change

Development of additional system
The second circle is that of additional system development. If optimizing the existing technical system is not sufficient, the regime might start experimenting with other technical modules. For instance optimizing sewer capacity will not go on forever. In Rotterdam, the sewer system is already at the top of its performance. Water drainage from city streets thus needs to be done in other ways in the case of extra precipitation. Water managers can experiment and based on learning experiences, knowledge accumulation about what and where and how to implement it, takes place. It can either replace parts of the existing system, or function separately next to the other.

System Innovation
During the third circle the regime is inducing system innovation. System innovations are kinds of innovation that replace the old system since that system was not sufficiently fulfilling the demands of time. Often this will involve a new kind of technology that is the basis of the system. Of course this will take time. In case of storm water management disconnection of paved areas, for instance by separate sewers has become the dominate technology over combined sewer systems in the Netherlands. It is obligated to disconnect 60% of new urban areas from the combined sewer system. Considering the long lifetimes of these types of infrastructure however, it will take decades before the old system is entirely replaced, if no changes occur in the meantime.

Experimenting with system innovation could lead to the regime backlash to the second or first cycle after negative experiences. If transformation proceeds, the system enters a new dynamic equilibrium and starts and continues to optimize the existing infrastructure, because after the third circle we are back in the first one, namely optimizing a dominant technical system. During the second circle basically three things can happen. Some experiments are that promising that they are developed further and are at a certain moment ready to become the new dominant practice. Also optimizing and experimenting may continue because neither the old nor a new technology is ready to win the competition. The third option is that the experiments are that disappointing that the

regime pulls back to the old solutions at the tipping point. The last thing happened with the dual network in water supply. Due to misconnections in the Leidsche Rijn new development near Utrecht the experiment (supplying multiple qualities of water for multiple purposes) was prohibited by the secretary of state and the regime reverted back to the dominant practice, namely supplying one quality of water.

5. A five-step-framework for assessing Resilience and Transformative capacity

In general there are four reasons that might trigger regime change:

1. Changing (exogenous) circumstances
2. Changing (endogenous) ambitions
3. Unsolved problems / Calamities
4. Innovations

With regard to these four broad categories of distortion, regime responses might vary from optimization, developing additional system, system innovation, but also plain denial. The response outcome depends on the distortion itself, but also on regime resilience. Resilience is degree to which a system can absorb distortion until that point, beyond which it is no longer capable of withstanding the pressure and transforms. In order to assess that tipping point we have developed a five-step framework. In the next section we will apply it to the Rotterdam water management regime and will present the first and some very preliminary results.

1. System diagram and actors

The first step is to show make a system diagram in order to understand how the system works. This can be a very simple diagram. Then, actors need to be linked to the diagram to show where they influence the system. Actors have objectives and practices. The last step is to identify thresholds, beyond which the actors are no longer able to reach that objective.

2. What is changing and what is driving that change (distortions)?

Identify the most important elements that are changing in the system. Some elements may be lost, some now elements may emerge. A new system may have emerged, or a merger of actors took place, etc. Identify what is triggering those changes.

3. Resilience ~ absorption (path towards thresholds)

Choose a point in time that is you starting point. Choose that point about when you think the system was in relative equilibrium. Then identify the most important events from that point on to the present. Link those events to how they affected the actors. Were they getting closer to their threshold or further away from the threshold? What is the general direction (ongoing integration with spatial planning)?

4. Resilience ~ resistance

What are the current barriers resisting that general direction? Are there actors who have other stakes; is there lack of know-how; financial risks; or just plain routines?

5. Resilience ~ recovery versus transformation

What kind of distortions can you think of that might happen in the near future? How are they affecting actors? We have identified 5 types of responses that actors may employ after any distortion (resistance, ignorance, implementation, adaptation, innovation). Are there any actors who can take over lost functions?

7. Preliminary Case study results

Rotterdam is the second largest city in The Netherlands. It is famous for its harbor, which is the second largest in the world. It is situated in the west of Holland, in the Delta of the Maas–river. The Rotterdam municipality wants to transform the city to an attractive and competitive area to live and work. For this reason the municipality and the housing corporations are executing huge urban restructuring and renewal plans. This objective should be accomplished by realizing more diversity, for instance more private houses. Upgrading postwar neighborhoods is crucial since social diversity within these neighbourhoods is low. The majority of the houses are owned by social housing corporations.
Both the spatial planners and the water managers now see opportunities to combine the urban planning effort and the water management effort. Urban renewal and reconstruction measures offer possibilities to create room for small ponds, urban channels and a whole divers host of water-related living environments.
Here we report on the preliminary result of the case study. Until now we have done step 1 to 4. Step 5 is yet to be done.

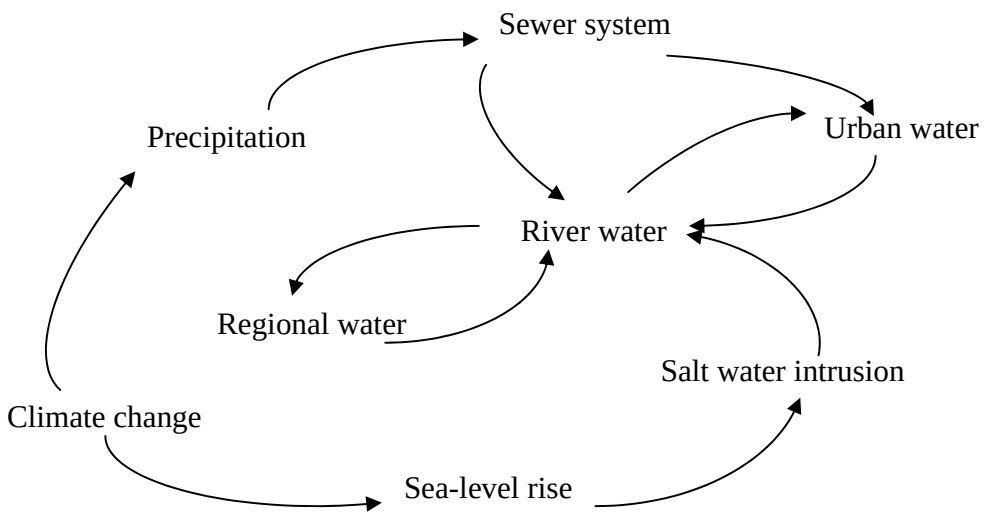

Figure 7. Diagram of the Rotterdam water system

1. System diagram and actors

Water from the regional and urban water system is pumped into the river. Precipitation is captured in the sewer system. Due to climate change there will be increased precipitation during the winter. However, the sewer is close to its maximum capacity. This might lead to an increased frequency of combined sewer overflows to the receiving urban surface water and result in poor quality waters. In case of the water shortage in the regional system the river water is pumped back to the regional water system. Sea level rise and reduced river water discharge in summer due to climate change leads to increasing saltwater intrusion in the river. As a result water shortage problem should be solved with water from other regions. The most promising solution seems to increase the water retention capability, both in the regional as in the urban water system. Increasing this capacity can be done by increasing the amount of surface water and allowing water fluctuation rather than focusing on target level management. This increases the storage capacity of the water system reducing the need to supply water from the river.

One of the very clear thresholds here is the limited sewer capacity. The threat of climate change is now tipping the system to go from a sewer optimization strategy to a developing an additional water retention system. The most important actors for water management and urban planning are indicated in the following table.

Table 2. Actors and their objectives in Rotterdam

Actor	Objective
Municipality of Rotterdam	Competitive economy. Attractive location for a diversity of people and companies.
-Municipal works of Rotterdam	Safe and effective collection and transportation of wastewater and stormwater. Realisation and design of infrastructure.
-Developing corporation of Rotterdam	Improved economic development of Rotterdam area
-Urban Planning Agency Rotterdam	Design of attractive public space. Planning of urban renewal.
Waterboards	Water quality of urban and regional water system. Effective treatment of municipal wastewater. Flood protection.
Drinking water company	Cost effective and reliable supply of safe drinking water
Housing corporations	Providing social housing possibilities Quality of neighbourhoods
Local distict government	Living quality of districts

2. What is changing and what is driving that change (distortions)?

Considering the opportunities to combine the urban planning effort with the water management effort, an increased cooperation between urban planners and water management expert can be noticed. There are attempts to integrate the urban water plan

completely with the urban plan. This restores an old Dutch tradition of cooperation between these disciplines. The municipality of Rotterdam is the first in the Netherlands to fully integrate these fields again. Important drivers of this renewed cooperation are climate change and the need to realize water retention in the urban environment. Realizing this is extremely hard because space in metropolitan areas is both scarce and expensive. Combining this task with urban renewal might be the only opportunity to realize the required water storage effort. From the urban planning side water is considered to be an important asset to make the city a more attractive location for businesses and people by realizing waterfronts and building near water.

3. Resilience ~ absorption (path towards thresholds)

In the year 2000, before the report WB21, integration of water and spatial planning started by making the first Urban Water Plan of Rotterdam, Waterplan1. Waterplan 1 was initiated by the Municipal Works of Rotterdam and made by a project team of various actors including the water boards. This was the first step towards integration of spatial planning and water management. In 2005 the ambitious report "Rotterdam Water city 2035" aim to enhance living quality in the urban area. In this plan the south of Rotterdam will be transformed to 'Waterway City', an extensive network of waterways integrated into an urbanized environment, each household having garden access to the waterway network. The network is connected to the river delta and new recreation areas with small lakes on the south side of Rotterdam. This report was the contribution of Rotterdam and the waterboards for the International Architecture Biennale in Rotterdam. This contribution was the result of extensive cooperation between urban planners and water experts. This cooperation has been taken up further in 2006 where complete integration of urban water plans and spatial plans is realized.

4. Resilience ~ resistance

Although the integration of water management and spatial planning is proceeding rapidly, literature and stakeholder research at local district level (De Graaf, 2006) still indicated a number of obstacles for fully integrating urban renewal and water management.

- Agreements about finance were lacking

Although many plans have been made including cost estimations of water management measures, it is not clear who is responsible to pay for these measures. As a result distribution of costs becomes subject of long negotiations and many measures get never implemented.

- During decision making, water related stakes did not have enough weight.

The strong competition of urban functions for means and space often result in a relatively small share for water. Other functions such as recreation and parking space are often considered to be more important by inhabitants and local district government than water storage that is design to accommodate the once in 100 years rainfall event.

- Spatial fit

Rotterdam is in the transformation from 4 storey high social housing blocks to one family houses. The space demand of the latter type is much larger. Therefore in practice urban renewal does not lead to more space for water. On the contrary less space for water becomes available.

- Heterogeneity of actors & many different objectives

The number of actors that is involved in both urban planning and water management is high. As a result the policy making and decision making process is highly complex. Moreover, involved actors such as the municipality and waterboards are not single actors but consist of multiple stakeholders. The municipality includes the Municipal Works, The Urban Planning Agency and the Development Corporation. The Waterboard consist of water quantity, water quality and flood control managers. These stakeholders have different objectives and perceptions. This makes the process even more complex and unclear.

- Crucial actors missing

Crucial actors for the integration of water management and urban planning are not involved in developing the urban water plan of Rotterdam. The most significant ones are the housing corporations, the local district government and the drinking water company. Considering the large opportunity of urban renewal at local level for implementing additional water storage involvement of these actors is crucial for realizing the urban water management ambitions of the municipality of Rotterdam.

8. Discussion

In Rotterdam there is an increasing cooperation between water managers and urban planners. We argue that by connecting the water management regime to the rapidly transforming urban planning regime the transformation capacity of the urban water management system will increase. Opportunities created by the urban transformation in Rotterdam can be used to implement an additional or even new urban water infrastructure. Water can make an important contribution to urban planning objectives such as a high quality living environment and being a favourable location for companies and people. However, research at local level still shows considerable obstacles for realizing improved water systems in urban renewal projects. The resilience of the combined urban planning and urban water management regimes still seems high.

However, we do have the impression that the water management regime in Rotterdam is close to tipping point. The municipality and the water boards have defined the required water effort to achieve a robust water system that is able to handle climate change and they are currently working on the implementation in the Water plan 2, designing indeed projects that may grow into an additional system next to the sewer system.

Unfortunately there was no time yet to assess the resilience of transformation capacity of the Rotterdam Water management regime. However, we would like to emphasize that resilience and transformation capacity are not properties of individuals but of the whole system. Change of one individual could either have consequences for small parts of the system, or perpetuate through the whole system. Therefore it is really important to understand the relationships between actors and when this might change and how. Relationships may change, but differently under different kinds of distortion. This is what we would like to investigate in step 5.

This casestudy on transformation capacity and resilience for the water management system in Rotterdam is currently going on. Further steps will include developing new technical concepts and scenarios to make concrete scenarios for the urban water system. Based on these scenarios the measures proposed in Waterplan 2 will be evaluated. Carrying out this research leads to more insight about when water management regimes approach tipping points, going from optimization to the development of additional systems or system innovation. These insights are useful for transition management strategies to sustainability.

9. References

Berkhout, F., A. Smith, et al. (2003). "Socio-technical regimes and transitions contexts." SPRU Electronic Working Paper Series.

Berkhout, F., A. Smith, et al. (2003). "Socio-technical regimes and transitions contexts." SPRU Electronic Working Paper Series.

Berkhout, F., Smith, A. en Stirling, A. (2003). "Socio-technical regimes and transitions contexts." SPRU Electronic Working Paper Series.

Boulding, K. E. (1970). A primer on social dynamics: history as dialectics and development. New York, Free Press.

De Graaf, R.E.(2006). Waterstad in Praktijk: Kansen en obtakels voor water bij stedelijke vernieuwing in de Rotterdamse wijken Zuidwijk en Pendrecht

Davis, K. (1945). "The World Demographic Transition." The Annals of the American Academy of Political and Social Science 235: 1-11.

Elzen, B., F. W. Geels, et al., Eds. (2004). System Innovation and the transition to sustainability: Theory, Evidence and Policy. Cheltenham, Edward Elgar Publishing, Ltd.

Geels, F. W. (2002). Understanding the Dynamics of Technological Transitions: A Co-evolutionary and socio-technical analysis. Centre for Studies of Science, Technology and Society. Enschede, Universiteit Twente: 426.

Geels, F. W. and R. Kemp (2000). Transities vanuit sociotechnisch perspectief. Maastricht, MERIT.

Gemeente Rotterdam, Waterschap Hollandse Delta en Hoogheemraadschap van Schieland en de Krimpenerwaard (2005). Rotterdam Waterstad 2035. Episode Publishers

Hooimeijer, F.L. (2006). The Relation between design and technology of Polder Cities. Proceedings of the International Symposium on Lowland Technology 2006,pp. 579-584. eds. S. Hayashi, H. Araki and K. Hokao.

Kemp, R., J. Schot, et al. (1998). "Regime shifts to sustainablilty through processes of niche formation: the approach of strategic niche management." Technology analysis and strategic management 10: 175-196.

Loorbach (2004). A multi-level framework for transition management. SEEON Conference, Seeon.

Loorbach, D. and J. Rotmans (2006). Managing transitions for sustainable development. Understanding Industrial Transformation. Views from different disciplines. X. Olshoorn, Wieczorek, A. J. Dordrecht, Springer.

Ministerie van Verkeer en Waterstaat, 2001, *Anders omgaan met water, waterbeleid voor de 21e eeuw.*

Ministerie van Verkeer en Waterstaat, 1998, *Vierde Nota Waterhuishouding.*

Nelson, R. R. and S. G. Winter (1982). An evolutionary theory of economic change. Cambridge, Massachusetts, Belknap Press of Harvard University Press.

Ness, G. D., W. D. Drake, et al. (1996). Population-environment dynamics : ideas and observations. Ann Arbor, University of Michigan Press.

Provincial Government of South Holland, Projectbureau Groenblauwe Slinger (2002). The Green-blue Meander. City and countryside in balance *Toward a green-blue lifeline running through South Holland's western urban area*

Regio Randstad (2001). van Randstad naar Deltametropool

Rip, A. e. R. K. (1998). Technological Change. Human Choice and Climate Change. S. Rayner, and E.L. Malone. Columbus, Ohio, Battelle Press. Volume 2: 327-399.

RIZA Projectbureau Watertoets (2003). Handreiking Watertoets 2. Samenwerken aan water in ruimtelijke plannen

Rijkswaterstaat (1995) Ruimte voor Rivieren (room for rivers). Ministry of Transport,
Public Works and water management. The Hague, The Netherlands

Rotmans, J. (1994). Transitions on the move. Global Dynamics and Sustainable Development. Bilthoven, The Netherlands, Rijksinstituut voor Volksgezondheid en Milieu.

Rotmans, J. (2003). Transitiemanagement: Sleutel voor een duurzame samenleving. Assen, Netherlands, Koninklijke Van Gorcum.

Rotmans, J., J. Grin, et al. (2004). Multi,- Inter- and Transdisciplinary Research Program into Transitions and System Innovations. Maastricht.

Rotmans, J., J. Grosskurth, et al. (2001). Duurzame ontwikkeling, van concept naar uitvoering,. Maastricht, International center for Integrative Studies.

Rotmans, J., R. Kemp, et al. (2000). Transities & transitiemanagement: De Casus van een emissiearme energievoorziening. Maastricht, ICIS / MERIT.

Rotmans, J. and D. Loorbach (2006). Transition management: reflexive steering of societal complexity through searching, learning and experimenting. The transition to renewable energy: theory and practice. J. C. J. M. van den Berg and F. R. Bruinsma. Cheltenham, Edward Elger.

Van der Brugge, R., J. Rotmans, et al. (2005). "The transition in Dutch water management." Regional Environmental Change Volume 5(1).

Verbong, G. (2000). De Nederlandse overheid en energietransities: Een historisch perspectief. Eindhoven, Stichting Historie der Techniek.

Van den Bosch, S. Taanman, M. (2006) How Innovation impacts society. Patterns and mechanisms through which innovations contribute to transitions. Paper presented at the conference

Van der Brugge, J. Rotmans, D. Loorbach (2005). The transition in Dutch water management. Regional Environmental Change, vol.5, p.164-176

Van de Ven, F.H.M., S.P. Tjallingii, P. Baan, P.J. van Eijk, M. Rijsberman (2005). Water in Drievoud, benaderingen voor stedelijke waterplannen. Eburon, Delft

VROM (1996). Ruimtelijke Ordening op Waterbasis, acht bouwstenen voor beleids innovatie von het Studieprogramma Ruimte Water Milieu

VROM, LNV, VenW en EZ, Ministeries van (2005). Nota Ruimte. www.vrom.nl