social environmental learning for sustainable natural resource management

theory, practice, and facilitation

marleen maarleveld

Stellingen behorende bij het proefschrift *A social-environmental learning perspective for sustainable natural resource management. Theory, practice, and faclitation*. Marleen Maarleveld, WUR, November 11th, 2003.

1. Focus on rational economic behavior tends to conceal cognitive and institutional fallacies that underlie many social dilemmas in natural resource management. A social-environmental learning perspective is crucial to linking economic and cognitive and institutional factors. (This thesis)

2. People use only a fraction of their potential for social-environmental learning. As a result, focus is often on a particular adaptation. A social-environmental learning perspective contributes to developing people's ability to adapt. (This thesis)

3. The value of grand theories does not lie in the possibility to falsify them, but in their ability to generate ideas.
(Anthony Greenberg in Ellen de Bruin, De grote greep. Experimentele existentiële psychologie werpt zich op levensvragen. *NRC Handelsblad*, Augustus 16-17, 2003)

4. Everybody lives downstream.
(See the hydrological cycle in any introduction to hydrology)

5. If there was one single truth, one would not be able to make one hundred paintings of the same object.
(Pablo Picasso 1997, Picasso's One-liners. New York: Artisan. Picasso's lijnenspel. Weert: Van Buuren)

6. Economics and ecology are often considered to be opposites in natural resource management. However, linguistics show that they have similar roots. Focusing on these linguistic similarities may contribute to realizing sustainable natural resource management.

7. Scan globally, reinvent locally
(Adapted from Nobel Laureate Stiglitz by Louise Fresco, Engagement, *NRC Handelsblad*, December 14 & 15, 2002)

8. Deadline = lifeline

Social-environmental learning for sustainable natural resource management

Theory, practice, and facilitation

Marleen Maarleveld

2003

Promotoren
Professor dr. Cees M. J. van Woerkum
Hoogleraar Communicatiemanagement
Wageningen Universiteit

Professor dr. ir. Niels G. Röling
Hoogleraar Landbouwkennissystemen in Ontwikkelingslanden
Wageningen Universiteit

Co-promotor
Dr. Maria A. Koelen
Universitair hoofddocent Leerstoelgroep Communicatie & Innovatie Studies
Wageningen Universiteit

Promotie-commissie
Professor dr. ir. A.P.J. Mol
Wageningen Universiteit, NL

Professor dr. Danny Wildemeersch
Katholieke Universiteit Leuven, BE

Dr. Jim Woodhill
International Agriculture Center, Wageningen, NL

Dr. Matthijs Hisschemöller
Instituut voor Milieuvraagstukken
Vrije Universiteit Amsterdam, NL

Social-environmental learning for sustainable natural resource management

Theory, practice, and facilitation

Marleen Maarleveld

Proefschrift

ter verkrijging van de graad van doctor
op gezag van de rector magnificus
van Wageningen Universiteit,
Professor dr. ir. L. Speelman
in het openbaar te verdedigen
op dinsdag 11 november 2003
des namiddags te vier uur in de Aula

Marleen Maarleveld (2003)

Social-environmental learning for sustainable natural resource management
Theory, practice, and facilitation

ISBN 90-5808-923-1

Preface

This research was supposed to entail a combination of several laboratory experiments investigating people's behavior in social dilemma situations and, based on the experimental results, the development and application of an intervention design in the area of health or agriculture. Instead, a research journey has resulted in an explorative study of the viability of a social-environmental learning perspective for developing sustainable natural resource management. During the research period I have had a chance to learn more about exploratory, qualitative research, action science, institutional analysis, complexity science, the field of natural resource management, and in particular, water resource management, developing and teaching a course, project management, and more. Throughout, I have met a great number of inspiring people. I have had the opportunity to participate in courses, workshops and conferences in different places in the world. And when I was in Wageningen, the world was around the corner as colleagues and students from all over visited the department. All in all, it has been an incredibly rich learning period. The resulting thesis before you is but the tangible tip of an iceberg. Below the waterline, people, ideas, literature, and interactions provide the foundation. Without this support the thesis would not have crystallized. I would like to make use of this opportunity to thank all who have helped to make it possible to combine a love for people and water into a solid product.

From the start there have been my supervisors and colleagues of the Department of Communication & Innovation Studies. I would like to thank Niels Röling, Cees van Woerkum, and Maria Koelen for giving me space and inspiration and their confidence and patience to allow my chaotic curiosity to develop into this thesis. Fanny, Monique, Stephan, Paul, Annemarie, Noelle, Hedwig, Luc, Elroy, Joyce, Irene, Natasha, Dominique, Rhodora, Julia, Jasper, Tesfaye, Bart, Joke, Sjoukje, Regina, Maarit, Mieke, Martha and other members of the department family- I cannot thank you enough for making Wageningen a great base camp to explore from, experiment, and relax, whenever and wherever! With regard to getting to that base camp, I would also like to thank the Utrecht-Wageningen carpool who delivered me, and the thesis, safely and promptly in Wageningen.

With regard to scientific explorations abroad, I would like to thank the NWO for enabling me to visit the Ostrom's Workshop in Political Theory and the Wageningen Foundation and University for support to participate in international meetings and courses. I thank the Ostroms and their workshop colleagues for a very interesting and hospitable semester. I never realized a place like Bloomington could be so much fun.

With regard to explorations in the waterworld, there are a number of people that I would like to thank. First of all, Rob Janmaat, for introducing me to the interesting aspects of watermanagement in Gelderland. I would like to thank Jan Feringa, Bert Meijers, Coen Volp, Ton Heeren, Rob de Groot, and colleagues for allowing me to join them in watermanagement in Gelderland for some time! It has been a valuable input for this research, and you have also taught me the value of regional government including the people who work there. I would also like to thank all the other water experts who took the time to share their insights, in particular the members of Thales. I have been introduced to a world of innovative thinkers like Erik van Slobbe, Govert Geldof en Paul Berends.

Changing jobs while the research was not yet finished, has allowed me to explore the world of land management and to try to bring into practice what I had been reflecting on for this research. The department of Innovation and Knowledge Management has proven a supportive environment for finishing the job in addition to the job. Adri, Wim de H., Theun, Jeroen G., Joost, Warmelt, Rob, Marlies, Manoesjka, Jook en Brigitte, I thank you for your help and support.

With regard to explorations outside the scientific domain and water and rural worlds I would like to thank my parents, family and friends. You have had to wait quite some time for this project to finish. I would like to thank you for your patience, but even more for all your support. Nicolet & Ge, Alex en de Rotterdammers, Natasja & Xavier, Hugo & Natascha, Hedi, Angelo, Annemarie M., Hester, bedankt! And Rob, I thank you for giving the final deadlines butterfly wings. Chaos theory's butterflies not only bring about far away meteorological effects, but can also cause quite a stir much closer to home than one expects.

I hope you will all enjoy the result! Thank you again for your support and contributions.

Content

PART I

SCOPE AND GOALS OF THE STUDY

1 Social-environmental learning for sustainable natural resource management?

A sustainable future can be found in the ability to adapt - not in any particular adaptation

Abstract
This chapter introduces the aim of this dissertation: to investigate the value of a social-environmental learning perspective for realizing sustainable NRM. Current dilemmas in water management are discussed to illustrate the need for more sustainable NRM. The complex and dynamic nature of NRM, such as water resource management, makes it a never-ending story that calls for continuously modified understanding and innovation. Developments in NRM research and practice indicate that facilitating social-environmental learning may lead to such ongoing adaptation of insights and behavior. By focusing on developing the learning capacity of resource users and managers, a social-environmental learning perspective may help to facilitate sustainable NRM. A number of research questions and objectives are formulated to learn more about why and how this may be the case.

1.1 The need for sustainable natural resource management (NRM): The example of water resource management

Fresh water is one of the natural resources essential for natural and human life. Rivers, lakes, aquifers, rain, and other elements of the hydrological cycle generate ecological goods and services that are crucial for maintaining and developing natural and human activities (Constanza & Folke 1996; Gordon & Folke 2000). Spatial views show that there is an abundance of water on earth. However, natural causes and, increasingly, human behavior influence the availability of fresh water resources. For example, less than 0.08% of the world's water resources are currently available as fresh water for human use. Most water resources are salty (97.5%). The larger part of the remaining 2.5% is locked up in ice caps and glaciers, located in areas too remote for human access, or available at the wrong time and place, and in the wrong amount (World Water Commission for Water in the 21st Century 2000).

Next to natural causes, human decisions and actions increasingly influence the availability of fresh water resources. A growing population, together with water management for the agri-

cultural, industrial and urban development required to support its needs, has led to water scarcity, pollution and extremities in water flows. In addition, unequal access to water resources, fragmented, sectoral policy management, conflicts, and lack of political and public awareness of the seriousness of these issues threaten the world's water resources and the livelihoods dependent on them. A selection of newspaper and magazine headlines in Box 1.1 illustrates some of these threats.

Box 1.1: A selection of headlines from newspapers, magazines, and reports of threats to water resources across the world

Thirsty Israel wants clean cars and green grass (NRC Handelsblad, Aug. 18, 2001, Aug 2002)
Israel is drying up. Water shortage has long been neglected but the alarm bell has been sounded. The water level of the country's most important fresh water resource, Lake Tiberias, is dropping dangerously and excessive withdrawals of groundwater are leading to penetration of sea water and pollution. Will Israel import Turkish water to quench the thirst of citizens and agriculture? Or build large and expensive desalination plants? Or reconsider its water use demand altogether? A year after this observation, Israel signs a multi-year agreement with Turkey for the importation of billions of cubic liters of fresh water.

Ambitious water plan divides Spain (NRC Handelsblad, June 21, 2001)
The Spanish senate has agreed on a controversial plan that aims to end droughts in large parts of the country. Water, which is abundant in the north, is to be diverted to the more arid areas of the south to irrigate agricultural lands. The plan has been approved thanks to the current ruling political party's majority and the powerful lobby of construction and water management companies, banks and the directorate of Waterworks. The vehement protests of water management experts, environmentalists, and inhabitants of the northern areas have been pushed aside. These groups view the plan as a social, ecological and economic disaster. According to the plan, the Ebro will have to surrender one sixth of its river water, threatening the delta's diversity of water dependent plant and wildlife.

Saving the last drop- the Aral Sea (The Economist, July 1, 2000)
The Aral Sea was once the world's fourth largest inland sea, but since the 1960s it has lost three quarters of its volume. Water loss is mainly due to diversion of the main rivers that feed the Aral Sea in order to irrigate vast, arid areas for cotton production. Nowadays the winds blow salt across an increasingly barren landscape and the health of local people suffers. People are mobilizing to build a dam to protect the remaining water in the Aral Sea.

China- too much water, too little water (The Economist, August 18, 2001; NRC Handelsblad, June 23, 2001)
Most of the drinking water for Beijing comes from a drinking water reservoir. Due to a number of droughts and growing consumption, this is a third of what it used to be. Moreover, farmers and industry are pumping up so much groundwater so quickly that the aquifer will be drained in fifteen years. On the other hand, part of China has been flooded.

Voices from different water management sectors and society in general united during the World Water Conference in March 2000 to issue warnings about the current state of the world's water resources and possible irreversible effects of human interventions (World Water Forum 2000). Two scenarios in Box 1.2 predict where current crossroads in water resource management may lead in 2025. The scenarios present two opposing views: water management as a source of conflict and stagnation; and water management as a source of cooperation and development. The scenarios are based on various studies and conferences, among them the World Water Vision, whose aim was to formulate a global vision for sustainable water management.

The doom scenario predicts that by 2025 one third of the world's human population will face water shortage. A great number of rivers, lakes, and wetlands will have disappeared and, with them, the biodiversity that is dependent on fresh water. Lack of water will have triggered trade wars and violent conflicts. Inequitable access to water will have become a breeding ground for further conflict. The World Water Vision scenario predicts that in 2025 safe and adequate water and sanitation will be available to almost every person. Damaged water-dependent natural environments and water systems will have recovered and will flourish all over the world. Water management will furthermore have been able to incorporate broader human development goals.

Box 1.2: Scenarios for water resource management in 2025

Doom scenario: Water resource management dilemmas as a source of conflict and stagnation

People and water
In 2025, 2.8 billion people, living in some of the world's most densely populated countries, contend with water scarcity problems. This is 35% of the world's 8 billion population, or one in three people. Access to clean, fresh water reflects social and economic disparity in society.

The natural environment
Scarcity of water has had disastrous consequences for the natural environment dependent on water-related ecological goods and services. The Aral Sea, which in 2000 was a fraction of its original size, has now completely disappeared. A number of other lakes have followed as well as wetlands and marshes such as Lake Chad and the Everglades. For an increasing number of days per year, large rivers such as the Yellow River, Ganges, Rio Grande and Nile no longer run into the sea. Salination of

World Water Vision scenario: Water resource management dilemmas as a source of cooperation and development

People and water
In 2025, the World Water Vision presented in March 2000 has indeed lived up to its promises. Almost every person in the world enjoys safe and adequate water and sanitation and is aware of the importance of hygiene.

The natural environment
As human water services are based on sustainability, water dependent natural environments and water systems themselves have flourished all over the globe. The Aral Sea has returned to its natural boundaries. Wetlands and marshes have been restored. Rivers that were on the brink of disappearing are now once again the flourishing home of water dependent plants and animals. Agriculture, industry, and (mega) cities have become co-stewards of the water environment, taking the natural dynamics of the hydrological cycle as the point of

fresh water resources has rendered a large percentage of agricultural lands unfit for production. Fresh water biodiversity has continued to decrease, exceeding the 50% rate for the 25-year period assessed in 1995.

Triggers for conflicts

Lack of fresh water has triggered a number of trade wars and violent conflicts. Much like oil in the 20th century, clean, fresh water has become a heavy weight commodity generating large power and economic differences between the haves and the have-nots. Some countries and multi-national companies have gained great influence through ownership of water provision, management organizations and sewer systems, and sewage treatment plants in different countries.

Conflicts in multi-national river basins and aquifers have turned violent, with detrimental consequences for both natural and human activities.

Regionally, competition for water resources among urban, industrial and agricultural users has led to untenable situations where citizens have adequate water supply for sanitation and recreation, but food production has been hampered because of water shortage, or vice versa. In a number of areas, water prices have soared out of reach of most household incomes. These inequitable situations are breeding grounds for further conflict.

departure in their own dynamics and expansion.

Triggers for cooperation

Internationally sustainable water management has proven to be the driving force behind a number of successful partnerships to cope with global and local effects of ecological, economic and social-political developments. International conventions and laws such as the Dublin Principles have been implemented into sustainable management practices, including monitoring and exchange of information.

Women, youth and other often under-represented groups in decision making are more involved in water management and are equally represented in management level positions. People contribute to water services according to their ability and the level of service provided.

Watershed-based management has built bridges between up and downstream stakeholders, rural and urban interests, environmental and economic interests.

Overall, water management practices have been able to incorporate broader human development goals.

Sources: Gleick 1993, 1998; Ohlsson 1995; Hinrichsen et al 1998; De Villiers 1999; Worldwatch Institute 1999; World Water Council 1998; World Water Commission for Water in the 21st Century 2000

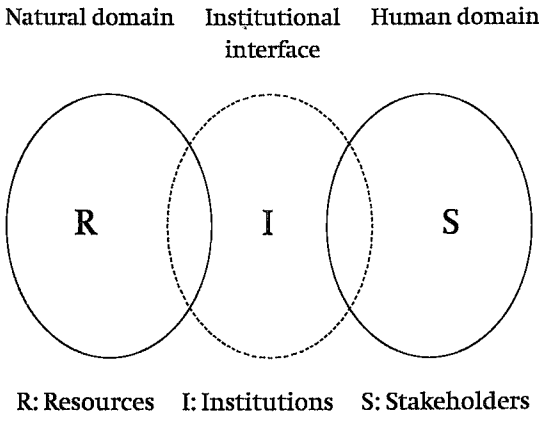
It is likely that most people would prefer the World Water Vision scenario to prevail over the doom scenario. Practice, however, indicates that realizing this scenario is proving no easy matter. The conclusion at the World Water Conference in March 2003 that too little progress had been made in this regard since the conference in 2000 confirms the difficulties of overcoming barriers toward more sustainable water resource management (http://www.world.waterforum3.com, http://www.cispi.it/contrattoacqua/forum-acqua/en).

The World Water Vision exemplifies a call for more sustainable management of water resources in a growing number of international, national and regional conferences, meetings and workshops. Over the past decades, the concept of sustainable development has been the subject of much political and scientific debate. However, this has not had a clear-cut outcome with regard to its definition and realization (Loucks 2000). Depending on the worldview, disciplinary perspective, and livelihood goals of the definer, the concept is defined in terms of variations of 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' (WECD 1987; see http://www.sustainableliving.org; http://www.eeeee.net for overviews of other definitions). Sustainable water resource systems have been defined as 'those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental, and hydrological integrity' (ASCE 1998; UNESCO 1999; UN 2000).

It is not the aim of this research to repeat the conceptual and political discussion on sustainability. Whatever definition is taken, realizing the World Water Vision scenario will require changes in people's decisions and actions as well as changes in the institutions that frame those decisions and actions. The example of water resource management shows that making such changes to restore, maintain, and enhance the resilience of water resources and the human systems dependent on them is no easy matter. In the following section, the characteristics of water resource management, and NRM in general, which have proven barriers to making such changes are further discussed. This research will then investigate how a social-environmental learning perspective may contribute to coping with barriers generated by these characteristics and bring about changes for sustainable NRM. In the process, the research will draw on insights from different scientific disciplines and experiences in water resource management.

1.2 NRM: A complex, dynamic, never-ending story

Figure 1.1: Interacting domains in NRM dynamics



Water resource management, and NRM in general, may be seen as involving the interaction of two domains: the natural and the human. In particular in common property theory, these domains and their interactions have been further specified (Bromley 1992; Ostrom 1990;

Ostrom et al 1994; Hanna & Munasinghe 1995; Edwards & Steins 1998; Steins 1999).
The characteristics of these domains and their interactions contribute to the difficulties of realizing sustainable NRM. Three key features define and shape the interaction of these domains, namely, the natural resources being transformed; the stakeholders transforming resources; and the institutions structuring the transformation when the natural and human domains interact (see Figure 1.1). Each feature may in itself be viewed as a complex, dynamic system. In addition, the interaction of these features may generate complex dynamics. A better understanding of the static and dynamic qualities of these domains and their interactions may help to take more effective actions to bring about necessary adaptations for realizing sustainable NRM.

Natural resources
Natural resources may be viewed as systems that have a static and dynamic component (Ostrom 1990). For example, water can be referred to as a resource stock in which resource elements combine in a conserved and recognizable pattern, such as a groundwater basin, a stream, a lake or a sea. Water is also a dynamic flow in the sense that it is composed of a flow of discernable and regenerative elements. The hydrological cycle visualizes how water in a river may flow to the sea, evaporate into clouds, turn into rain, fall onto the ground, and percolate into river water once again. Different interdependent natural resources are connected through the flow of their constituent elements. For example, trees take up (rain)water molecules through their roots and evaporate such molecules through their leaves. Similarly, other plants, animals, and nutrients may interact in various forms with water resources. Such interacting complexes of different natural resources in a given area are called ecosystems. The dynamic of a resource may be characterized by its renewal rate. This is a resource's ability to maintain stock when its constituent elements are somehow subtracted, for example, through natural evaporation or condensation processes, or for human use. Resilience is the term used to indicate whether a resource system is able to adapt to such influences.

Stakeholders
Stakeholders is a term used to characterize people, as individuals or as collectives, in terms of their interests and capital configurations. Interests are constituted by values and desires and consequent preferences for goods and services that are congruent with those values and desires. With regard to capital configurations, different types of capital may be distinguished, such as natural resources, as well as physical, financial, human and social capital (Bourdieu 1992; Pretty 1994, 1997; Coleman 1998). For example, two farmers may share values and interests in terms of organic farming but have different capital configurations. One may be a fourth generation farmer on 100 acres of land mortgaged to the bank, a chairwoman of the regional farming group, and a member of three farmer study groups to keep up with the latest innovations. The other might be a hobby farmer who has invested his financial capital earned in the IT business in a 45 acre estate, and who aims to escape the city rat race and start a management training center on the side. The first of his former colleagues has already signed up.

As intentional beings, people, individually or collectively, interact with the natural domain to transform resources in order to maintain and improve their livelihoods in line with their interests. The transformation of resources into desired goods and services requires that stakeholders invest or withdraw different types of capital. Depending on their values, preferences and capital resources, people will be differently involved in resource transformation. In line

with their interests and capital configurations, the two farmers may make different use of their land and water resources. Interests and capital configurations are also dynamic. For example, in transforming groundwater into drinking water, drinking water companies rely on human ingenuity (human capital) to develop the necessary water works (physical capital). This may involve long-term loans and subsidies (financial capital) generated by a community of investors (social capital). At the same time, transformation of resources generates capital. For example, water supply companies generate income and new knowledge and skills in the development of waterworks. In this way, stakeholders' capital configurations may change over time. Moreover, the preferences and values that underlie people's choices and behavior may change as well. Accordingly, stakeholders may also be characterized as bundles of changing interests and changing capital configurations.

When stakeholders are transforming a resource into desired goods and services, their decisions and actions affect not only the resource, but also each other. Stakeholders are interconnected through their interests and capital configurations. As such, they may have complementary or competing claims on a resource, leading to situations that may be beneficial or detrimental to the stakeholders and resource involved. For example, the drinking water companies may cooperate in developing technology for groundwater abstraction or compete in drawing water from the same resource as other users. As will be further highlighted in this thesis, such interdependence plays a central role in the interaction of people and their environment and the realization of sustainable NRM.

Institutions

People's interactions with each other and with the natural environment may be viewed as mediated by institutions. Institutions are validated collective assumptions and convictions concerning the strategy to be followed in maintaining and improving livelihoods. North's definition of institutions in his Nobel Laureate lecture (1994: 360) is taken as the point of departure in this research, namely:

> *'the humanly devised constraints that structure human interaction*[1]*. They are made up of formal constraints (e.g., rules, laws, regulations), informal constraints (e.g., norms of behavior, conventions, self-imposed codes of conduct), and their enforcement characteristics.'*

This definition differentiates institutions from organizations. The term organization is used to distinguish a formally organized group of individuals bound together by a common goal to achieve certain objectives. Decisions and actions of organizational members are shaped by both the organization's own institutions and the societal institutions in which the organization is embedded. In this light, institutions are comparable to the rules of the game while aggregates of individuals, i.e., organizations, are the players (North 1994).

With regard to NRM, the focus is on the rules of the game that shape the dynamics of the natural domain, the human domain and their interaction. The organizational and regulative dynamics of the natural domain may be captured in terms of laws of natural science. The regulative dynamics of the human domain and its interaction with the natural one may be captured by legal rules, norms, and informal patterns of behavior.

1 Constraints that both limit and create opportunities for interaction with each other and the physical world.

Although institutions may be captured in such static forms, they are also dynamic in nature in that they may change over time as resources and stakeholders interact. The rules of the game are constructed in line with people's insights into the static and dynamic qualities of NRM domains, and vice versa. For example, the discovery that the earth is round rather than flat influenced the development of sea routes, trade, map making, science, and international relations, among others. Thus, this insight and subsequent developments changed the rules of the game that determined the interaction between stakeholders and the natural domain. And as institutions changed, new insights were gained, and so on.

As such, it is possible to speak of fit between the dynamics of the natural and human domains and mediating institutions (Berkes et al 1998; Folke et al 1998; Constanza et al 2001). Such fit may occur when the rules of the game manage to match dynamics in the natural and human domains. For example, Lansing (1991) showed how religious customs used to play a role in sustainable water management in Bali. This fit is not a matter-of-course or lasting. On the contrary, because we are dealing with different domains and their interactions that each have their own static and dynamic qualities, disturbances within and between domains are frequent. The Bali water management case indicates how claims on the water resources have increased and diversified and the role of religion has changed. Such disturbances may lead to changing insights into the static and dynamic qualities of the different features involved in NRM. Interacting static and dynamic qualities of the natural and human domains appear to be more often out of balance than in equilibrium.

In this light, NRM's complex and dynamic nature calls for an approach to sustainability that takes into account its evolving character rather than an approach that strives to reach an everlasting, optimal equilibrium between the natural and the human domain. Human use changes resource systems, resources themselves entail change processes, and human needs and interests regarding resource systems change. From the interplay of these changes, new, often unforeseen, interdependencies of stakeholders and resources may emerge. Accordingly, no single institutional design to manage natural resources exists or will last (Holling 1995; Lee 1993). In this regard, sustainable NRM development, whether in water resource management or other NRM fields, may be viewed as a never-ending story. Thus, sustainable NRM calls for:

> *'policies and actions that not only satisfy environmental, economic, and social objectives but also achieve continually modified understanding and provide flexibility for adapting to surprises' (Gunderson et al 1995: 491).*

In other words, sustainable NRM emerges from the ability to adapt - not from any particular adaptation. As such, a process approach may be pivotal to sustainable NRM. In such an approach, it is not so much a question of the right blueprint design, but the ability to develop, use, and renew principles that enable people to continuously adapt themselves and their environment. Accordingly, this research will focus on a process approach to sustainable NRM rather than viewing sustainable NRM as a particular, stable, equilibrium end state.

1.3 Facilitating social-environmental learning for sustainable NRM

In light of the above, realization of a more sustainable water management scenario may benefit from a more adaptive, process management approach. Such a change-oriented approach

not only means improving water use and management within existing institutional frames, but may also entail changing the institutions that determine the relations between water resources and stakeholders. In water resource management, people have become very capable of the former in terms of developing technologies to realize more sustainable management practices in the sense of more efficient use. However, resolving some of the dilemmas faced in water resource management involves not so much doing things better in the sense of more efficiently, but doing things differently altogether. Such change entails changes in people's behavior and governing institutions. Bringing about behavioral and institutional change is still a challenge on the water management agenda today (Van der Vlist 1998; Loucks 2000; World Water Commission for Water in the 21st Century 2000; FAO 2000; http://world.waterforum3.com). Such challenges are also faced in other NRM fields.

Various experiences indicate that it is a challenge that people are able to meet. During the past decades, both empirical research and NRM practices have generated evidence of the manner in which people may adapt complex NRM dynamics into sustainable resource management (Ostrom 1990; Uphoff 1992; Lee 1993; Gunderson et al 1995; Ridley 1996, among others). NRM practice shows great diversity in the ways in which individual choices and actions are coordinated to balance the needs and interests of people in line with the capacity and dynamics of the resource system. Institutional arrangements to coordinate decisions and actions may vary from quite simple rules of thumb, for example, refraining from sprinkling crops in daytime when the evaporation rate is highest, to complex social-economic arrangements, such as the Balinese water management system based on water temples (Lansing 1991). The question remains, however, as to how such practices and institutions emerge, and how they may be adapted when interactions among resources, stakeholders and existing institutions call for new arrangements to cope with stakeholder claims that affect the resilience of resources and the people dependent on them.

Researchers and practitioners from different disciplinary, professional and cultural backgrounds have, over the years, shared experiences and insights at the Department of Communication and Innovation Studies, Wageningen University, The Netherlands, in order to gain an understanding of how such innovation and adaptation processes in NRM may lead to a sustainable fit between the natural and the human domain and mediating institutions (see Röling & Wagemakers 1998; Leeuwis & Pyburn 2002, among others). These experiences and insights have contributed to the emergence of a praxeology, i.e., a theory informing practice, for sustainable development: a social-environmental learning perspective for facilitating sustainable natural resource management (FASOLEARN 1996; Röling & Maarleveld 1999; Maarleveld & Dangbegnon 1999; Gibbon et al 2003). This perspective focuses on the learning capacity of aggregates of individuals to create a sustainable fit between the natural and the human domain and mediating institutions. The notion of learning captures the link between understanding and action, i.e., the need to continuously develop both knowledge and the ability to use it. Moreover, because this perspective focuses on learning in dilemmas that arise from the interplay of aggregates of individuals and their natural environment, and because the resolution of these dilemmas requires collective action, it is characterized as *social-environmental learning*.

The potential of learning as a key notion to bring about process-oriented change for sustainable development has been recognized in a number of NRM and NRM-related fields. For example, in development practice a learning approach has been found conducive to developing sus-

tainable community and farmer practices (Korten 1980, 1984; Van den Hoek 1992; Van Schoubroeck 1999). Organizational and management practice and theory have turned to learning as a means to effectively cope with a more interconnected world and, consequently, a more complex and dynamic business environment. To cope with such complexity, collective learning and organizational learning are proposed (Senge 1990; De Geus 1988; 1997; Argyris & Schön 1996). In the field of policy analysis, learning has been used as a factor to explain and improve policy development (Hall 1996; Sabatier & Jenkins-Smith 1993; Glasbergen 1996; Eberg et al 1996). Spatial planning theory and practice have also found a learning approach valuable to facilitate the cooperation necessary to develop and realize plans. (Friedmann 1989; Malki 1999; Van der Vlist 1998). Even in economics, often put in the spotlight as an equilibrium end state oriented discipline, the notions of learning and evolutionary dynamics are gaining ground (Anderson et al 1988; Hodgson 1999; Wit 2003). For researchers and practitioners in NRM who have come to view sustainable NRM more as a process than as an end result, learning provides a means to realize a more adaptive management approach that entails both improvements within existing institutional frames as well as adapting those frames (Dale 1989; Lee 1993; Gunderson et al 1995; Finger & Verlaan 1995; Woodhill 1999).

Since a social-environmental learning perspective is change-oriented, it entails normative views about what type of change is desirable. As indicated, a social-environmental learning perspective specifically focusses on learning with the aim of drawing on and developing the learning capacity of resource users and managers to develop sustainable NRM practices. In this light, facilitation of social-environmental learning has focused on: 1) making visbible properties of the context in terms of qualities of resources, stakeholders and institutions involved; 2) process transformation with the aim of facilitating multiple, interdependent stakeholders towards shared meaning and coordinated action; and 3) creating institutional conditions that enable stakeholders to continuously develop both knowledge and the ability to use it (Groot 2002; Gibbon et al 2003). Three principles may be found to play a role in facilitating social-environmental learning in this regard, namely, systems thinking, experimentation, and communicative action (Maarleveld & Dangbegnon 1999 and this thesis). As the viability of a social-environmental learning perspective for developing sustainable NRM is investigated in this research, the value of these facilitation principles will be further highlighted, discussed, and assessed.

1.4 Assessing the value of a social-environmental learning perspective: Research questions and objectives

In spite of the growing attention, and maybe because of it, social-environmental learning is still a rather elusive perspective (Alexander 1984; Lee 1993; Parson & Clark 1995; Verbeeten 1999).

By integrating and assessing existing and new evidence in research and practice, this dissertation aims to underpin the potential strengths and reduce the elusiveness of social-environmental learning and its facilitation for sustainable NRM. In this light, the following research questions are addressed:

> *Why is social-environmental learning a viable perspective for developing sustainable NRM?*
> *And how may social-environmental learning be facilitated to generate sustainable NRM?*

These research questions have been translated into the following objectives (O):

O1: Explore foundations for social-environmental learning as a viable perspective for sustainable NRM

O2: Identify and assess linkages between social-environmental learning and NRM dynamics in real-time, complex NRM

O3: Propose directions to further facilitate social-environmental learning for sustainable NRM

1.5 Overview of thesis

Figure 1.2 provides an overview of the structure of the dissertation and the chapters in which the research objectives are addressed. Chapter 2 gives an account of the steps taken in the inquiry process.

Figure 1.2: Overview of thesis

<table>
<tr><th colspan="2">PART I: Goals and scope of the thesis</th></tr>
<tr><td colspan="2">Chapter 1
Social-environmental learning for sustainable natural resource management?

Chapter 2
An exploratory research path: Steps taken and considerations</td></tr>
<tr><th>PART II: Foundations for a social-environmental learning perspective</th><th>PART III: Assessing social-environmental learning in complex NRM case</th></tr>
<tr><td>Chapter 3
Managing NRM dynamics: Learning our way out? (O1)

Chapter 4
Learning about social-environmental learning: People's potential capacity for learning (O1)

Chapter 5
Learning to adapt to and adapt the institutional interface in NRM dynamics: Linking institutional and learning dynamics (O1)</td><td>Chapter 6
An analytical framework and methodology to identify and assess social-environmental learning in NRM (O2)

Chapter 7
Cycles of change, cycles of learning: The emergence of groundwater management in Gelderland, The Netherlands (O2)

Chapter 8
Changing practices, changing stakeholders: Learning to adapt to the emergence of groundwater management in Gelderland, The Netherlands (O2)</td></tr>
<tr><th colspan="2">PART IV: Learning lessons</th></tr>
<tr><td colspan="2">Chapter 9: Facilitating social-environmental learning for sustainable NRM (O3)</td></tr>
</table>

In Part II, the foundations for social-environmental learning as a viable perspective for sustainable NRM are explored (O1). In Chapter 3, state of the art developments in four research and practice fields are found to converge towards social-environmental learning as a viable perspective for sustainable NRM. In Chapter 4, a closer look is taken at the notion of learning. The nature of learning dynamics is discussed and a conceptual overview is given of learning repertoires that may be viewed as constituting people's potential for a social-environmental learning. In Chapter 5, theoretical concepts and insights with regard to learning, institutions and cognition are further linked to gain a better understanding of their interplay in NRM.

In Part III, links between social-environmental learning and NRM dynamics are further analyzed in a case study of realtime, complex NRM (O2). In light of the insights gained, an analytical framework is introduced in Chapter 6 to focus further analysis and to anchor tools and learning history methodology. In Chapters 7 and 8 the learning history of the case study, namely, the emergence of groundwater management in Gelderland, The Netherlands, is recounted and discussed. Chapter 7 focuses on the macro-level analysis. Long-term structural shifts and underlying change and learning processes are discussed. In Chapter 8, the focus is on meso-level analysis. Changes and learning processes in the last shift distinguished in the learning history, and the interplay between management practices and changes therein, learning, and the organizational development of a key stakeholder, are further analyzed.

In Part IV, lessons learned from and for a social-environmental learning perspective for sustainable NRM are integrated. In order to propose directions for facilitating social-environmental learning to generate institutional change for sustainable NRM (O3), the research questions and objectives are revisited in Chapter 9. Implications for facilitation principles to further develop social-environmental learning for sustainable NRM are discussed. Strengths and weaknesses of the social-environmental learning perspective, as well as the research approach taken, provide the basis for future learning.

2 An exploratory research path: Steps taken and considerations

Two roads diverged in a yellow wood,
And sorry I could not travel both
And be one traveler, long I stood
And looked down one as far as I could
To where it bent in the undergrowth;

Then took the other just as fair,
And having perhaps the better claim,
Because it was grassy and wanted wear;
Though as for that the passing there
Had worn them really about the same,

And both in that morning equally lay
In leaves that no steps had trodden black.
Oh, I kept the first for another day!
Yet knowing how way leads on to way,
I doubted if I should ever come back.

Excerpt from Robert Frost (1971), 'The road not taken'

Abstract
This chapter accounts for the steps taken in the inquiry process that has generated the outcomes presented in this dissertation. In order to do justice to its exploratory, evolving nature, the how and why of the different steps taken in the inquiry process are made transparent. The steps takenare discussed in terms of considerations, research methodology, and outcomes. The quality of the research is discussed in terms of a number of qualitative research standards and triangulation methods.

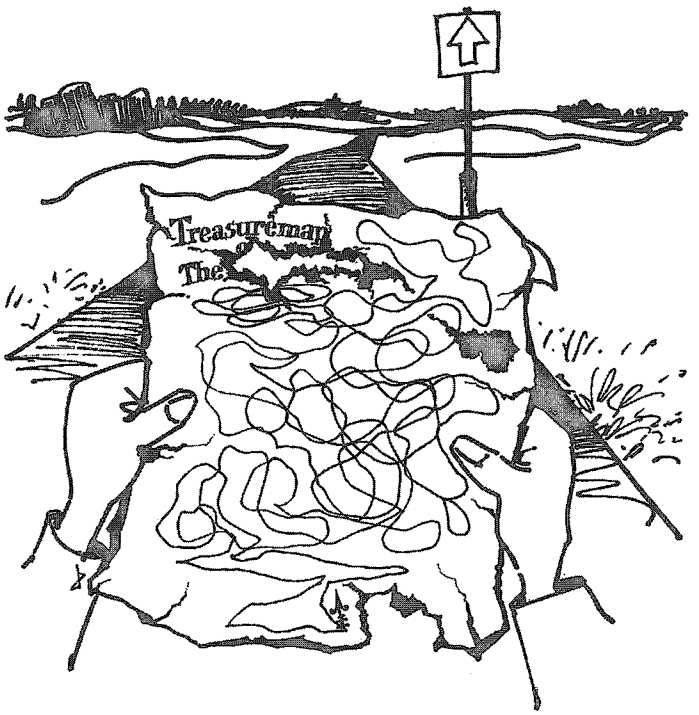
2.1 The inquiry process: An exploratory research path

Many textbooks and courses on social science research methods present scientific inquiry as a cyclical process going from hypothesis formulation, to operationalization of variables, designing the research format, and testing hypotheses (Meerling 1984; Babbie 1983). During an inquiry process, the path can be reiterated when research outcomes trigger the formulation of new research questions. Research practice, however, usually proves to be less straightforward. Depending on the aims of the research, existing and emerging insights, and practical factors

such as budget, time, technical limitations, available (wo)manpower, and political circumstances among other things, the process of inquiry involves different points of departure and becomes mixed in incomplete cycles, dead-ends and U-turns. Nonetheless, many research accounts are often presented as if they are the result of a well-defined itinerary. This may entail omitting wanderings that proved not to lead to the expected outcomes, or including unexpected wanderings as if they were part of the grand design after all.

In order to do justice to the exploratory, evolving nature of the inquiry process that underlies this study, the why and how of the different steps taken are made transparent. Two points were known at the outset of the research: 1) a starting point, constituted by a researcher trained in experimental social psychology and an itinerary, i.e., the funded research proposal; and 2) a destination, a doctoral dissertation contributing insights with regard to the proposed research problem. At first, the path between these points seemed a smoothly paved one-way street (see Figure 2.1). However, in the interplay of the research questions, assumptions, and subsequent emerging opportunities, different paths became visible and others were hidden from sight. En route, all kinds of insights and research tools were encountered. Some were immediately instrumental in gaining insight into the subject of inquiry. Others never proved their merit, or even obscured the view. And some, one hopes, will prove to be worthwhile baggage later on.

Figure 2.1: The inquiry process (Jook Boll)



The evolving character of the inquiry process does not mean that systematic analysis and criteria that guarantee quality scientific research have been disregarded. On the contrary, at each step, choices and insights have been systematically crosschecked. Quality standards such as credibility, transferability, dependability, and confirmability were ensured by means of different types of triangulation. That is, the same finding has been crosschecked using different research methods that are well established in exploratory, grounded theory, case study analysis and qualitative research methodologies (Meerling 1984; Pretty 1994; Yin 1994; Roth & Kleiner 1995; Guba & Lincoln 1985; Denzin & Lincoln 1998; Koelen et al 2001; http://www.learninghistories.com). These standards are discussed in Box 2.1.

Box 2.1: Qualitative research criteria

Credibility is concerned with checking whether the interpretations of the researcher match the meanings of those involved in the subject of inquiry. Methods to check for credibility are prolonged engagement, peer debriefing, and member checks.

Transferability is concerned with the external validity of the research. To ensure transferability, the time, place, and context in which findings were found to be salient must be made transparent. In addition, information collected should be provided in a database in order to facilitate analysis by others who may wish to apply the data for their own research.

Dependability is concerned with the stability of data over time. As an investigation proceeds, insights are gained and may change. These shifts in insights need to be both tracked and trackable for others. This means that the inquiry process and methods need to be documented.

Confirmability assures that the integrity of findings is not so much the result of the method used, but is rooted in the information used. Accordingly, it needs to be made clear where information was found and how information has been interpreted into a structurally coherent whole in the case narrative. In this way, both raw products and the processes used to distil and write them up may be inspected and confirmed by outside reviewers.

Sources: Guba & Lincoln 1989; Pretty 1994; Yin 1994; Denzin & Lincoln 1998

In the following section, the inquiry process is accounted for in terms of steps taken, underlying considerations, methodology, and outcomes. The quality of the research is indicated in terms of the above-mentioned scientific standards and triangulation methods.

2.2 Accounting for steps taken in the inquiry process

Table 2.1 summarizes the different steps taken in the inquiry process underlying this research. Each step is accounted for in terms of considerations, methodology, triangulation, quality standards, and outcomes. Thereafter, each step is discussed.

Steps taken		*Considerations*
Starting out: Defining the playing field	• Formulation of a Ph.D. research proposal	• Gain insight into decision making processes in which individual and collective interests conflict • Develop theoretical basis for communicative interventions to resolve such social dilemmas through voluntary behavioral change
A planned detour: Exploring the grounds of research problems and methods	• Acquaintance with work environment • Literature review experimental research on social dilemmas	• Gain understanding of research problems and expertise work environment • Embed experiments to be undertaken in earlier findings & research fields department
Detour becomes new direction: From experimental approach to institutional analysis & development	• Review other research approaches to resolving social dilemmas • Working visit Workshop in Political Theory and Analysis for in-depth study of institutional analysis and development	• In search of an overarching theory and practice for resolving social dilemmas • Institutional analysis and development seemed most promising perspective to link different experimental findings and real-life bounded rational decision making
Linking theory and practice: A disposition for NRM	• NRM as field of interest • Linking concepts, theory & NRM practice • Revise research proposal	• Integrating theory and concepts theoretical framework • Linking theory and practice domain • Work out research approach
Preparing for a case study analysis: Formulating criteria and choosing a pilot	• Choosing a case study approach • Defining case study criteria • Choosing a pilot case	• Find a case in which different aspects of NRM dilemmas and their management could be investigated
Back to the classroom: Learning about social learning and Dutch water management	• Development & coordination of M.Sc. course Management of Change • Water Management & Water Authorities Law course • Preliminary case study of developments in national & provincial water management in The Netherlands	• In search of concepts and theories to analyze social learning • Need to learn about complex institutional context Dutch water management • Pilot case study social dilemmas in regional Dutch water management case
Learning from field experiences: Groundwater management in Gelderland, NL	• Internship Groundwater Department, Province Gelderland • Development of conceptual learning overview	• Need to study NRM dynamics and dilemmas in real-life context • Need to develop overview to encompass diversity of learning processes encountered • Continued theoretical exploration
Iterative synthesis: Integration of theory & practice, learning & NRM dynamics	• Comparative analysis of NRM cases using learning overview • Workshop on autopoiesis in social systems • Course on ecological economics • Fine tune learning framework • Further nested case analysis to link learning & NRM dynamics • Workshop on adaptive management • Various articles and projects • Write up dissertation	• Need to integrate different aspects and insights of research • Desire to experiment with interactive research mode • Desire to do something practical with research insights

Methods	*Triangulation*	*Quality criteria*	*Outcomes*
• Document/ literature analysis	• Theory	• Credibility • Transferability • Dependability	• The research proposal
• Interviews researchers • Document/ literature analysis	• Theory • Methodology	• Credibility • Transferability • Dependability	• Literature database experimental social dilemma research • Need to link different, often contradictory experimental research outcomes • First acquaintance with action science • Seminar Kerr • Insight into (dis)advantages experimental methods
• Document/ literature analysis • Workshops/courses • Expert consultation • Presentations and debate	• Theory • Methodology • Investigator	• Credibility • Transferability • Dependability • Confirmability	• Overview strategies to resolve social dilemmas • Further insight into (dis)advantage experimental method and other methods to study social dilemmas • Working paper: Participation • Interest in multiple case studies
• Document/ literature analysis • Workshops/ courses • Presentations and debate	• Theory • Methodology • Investigator	• Credibility • Transferability • Dependability • Confirmability	• ISCO conference article & presentation • Revised research proposal & theoretical framework • Colloquium series Participation & Policy
• Expert consultation	• Theory • Data	• Transferability • Dependability • Confirmability	• Choice for case study analysis • Definition of case study criteria • Pilot case groundwater management in Gelderland, Netherlands
• Document/ literature analysis • Workshops/ courses • Expert consultations • Interview stakeholders • Presentations and debate	• Theory • Methodology • Investigator • Data • Participant	• Credibility • Transferability • Dependability • Confirmability	• Building blocks for learning perspective • Knowledge of Dutch water management institutions • Presentation linkage learning and pilot case study • Work visits to learning experts • Choice for groundwater management in Gelderland as Dutch regional case study
• Document/ literature analysis • Interview stakeholders • Participant observation • Presentations and debate	• Methodology • Investigator • Data • Participant	• Credibility • Transferability • Dependability • Confirmability	• In depth case study • Learning overview
• Document/ literature analysis • Workshops/ courses • Interview stakeholders • Presentations and debate	• Theory • Methodology • Investigator • Data • Participant	• Credibility • Transferability • Dependability • Confirmability	• Comparative analysis, article with Constant Dangbegnon • Database • Article with Annemarie Groot • Article with Noelle Aarts • Article INRA book • Various projects • Dissertation

Table 2.1: Overview of steps taken, considerations, methods, triangulation, quality criteria, and outcomes

Starting out: Defining the playing field

The inquiry process started out in a rather straightforward manner with a predetermined research problem, and a research proposal to guide the way. The point of departure was the question of how individuals can be motivated to voluntarily contribute to solving societal problems that have a social dilemma structure, i.e., situations in which optimizing individual interests conflicts with optimizing collective interests, and how social learning may contribute to resolving such dilemmas (see section 3.2 for more on social dilemmas). Researchers, practitioners, and students linked to the Department of Communication and Innovation Studies, Wageningen University and Research Center, where the research project was initiated, face this question time and again when addressing problems such as the reduction of pesticide use in agriculture, depletion of natural resources, motivating people to eat healthily, or fighting the spread of AIDS, among other things (http://www.sls.wau.nl/vlk/vlk.eng.htm).

On the basis of a literature review that included a crosscheck of findings through theory triangulation, the research proposal identified three characteristics of social dilemmas to be further researched by means of experimental laboratory studies: the choice situation in terms of dilemma structure and time scale; the group involved in terms of its identity and size; and individual characteristics of self-efficacy and visibility of behavior (Koelen & Röling 1994). The results of the experiments would form the basis for action research in the field of agriculture, environment or health to be undertaken in the second half of the four-year research project. The open road lay waiting.

A planned detour: Exploring the grounds for the research aims and methods

In accordance with the work plan of the research proposal, the first phase started out by becoming acquainted with the research epistemologies, methodologies and results of the Department of Communication and Innovation Studies and reviewing results of experimental social dilemma research. The Department proved home to researchers with a variety of social science backgrounds - among others, social psychology, sociology, communication science, anthropology, adult education - and a number of natural scientists and professionals interested in communication and innovation processes. A number of colleagues were involved in some form of action science. In action-oriented science, researchers view people whose behavior is the focus of analysis not so much as 'subjects to be studied' but as fellow inquirers in the process of generating knowledge and alternative action strategies (Argyris et al 1985). Such research entails becoming involved in and learning about the change process together with the other actors involved (Engel 1995; Hamilton 1995; Vaandrager 1995; Paine 1997; Salomon & Engel 1997; Song 1998; Van Schoubroeck 1999; Gonzalez 2000; Hounkonnou 2001; Groot 2002; Van Slobbe 2002). This approach to science is anchored in a constructivist-oriented perspective. In this perspective, it is argued that reality does not exist in a single, objectively observable form, but is constructed in the complex interplay of people and their context (Leeuwis 1993; Röling 1995; Te Molder 1995; Van Woerkum 1997; Aarts 1998; Lamerichs 2003). As no two people share the exact same context and people differ in their cognitive and perceptual abilities, multiple views of reality exist. Moreover, as context and people interact and change each other, 'reality' changes. Taking this epistemological approach means embracing the messiness of people research to the fullest.

This forms a stark contrast to the majority of experimental research on social dilemmas in which human decisions and actions are isolated from interfering contextual variables. In a laboratory setting, aspects of 'real-life' situations are modeled, and the behavior of subjects is observed and analyzed in subsequent controlled environments. This research method certainly has its strengths. It enables a researcher to manipulate behavior directly, precisely, and systematically, assuming that the experimental design is able to isolate variables and control for all others (Yin 1994). However, many experimental set-ups that investigate human behavior in social dilemmas are based on game theory and strictly adhere to its rigid assumptions of methodological individualism (see section 3.2 for more on these assumptions). Consequently, behavior is often explained one-sidedly in terms of rational, utility-maximizing principles.

A review of experimental findings in social psychology and economics raised a number of questions that an experimental approach seemed unable to answer. Analogous to other reviews of social dilemma research (Dawes 1980; Wilke et al 1983; Messick & Brewer 1993; Schulz et al 1994; Ledyard 1995; Schroeder 1995; Lichbach 1996; Liebrand & Messick 1996;), the question remained as to the extent to which the different, often contradictory results contributed towards theory and practice for resolving social dilemmas in complex real-life situations. Another question was whether all the variables that play a role in resolving social dilemmas through voluntary behavioral change could be investigated in an experimental setting (Kerr 1995; and personal comment). Thus, theory and methodology triangulation pointed towards the value of research methods, other than the experimental approach, to investigate the research problem.

Detour becomes new direction: From experimental approach to institutional analysis and development

The choice was made not to return to the experimental research route for the time being, but to further explore the results and possibilities of other research approaches. More action-oriented, empirical, theoretical, and practical accounts of policy development and implementation to cope with social dilemma situations were subsequently analyzed. An extensive literature review, expert consultation, and a number of seminars and workshops generated both comparable and new insights (Maarleveld 1995; see also chapter 3). In addition to these insights, the inquiry process also provided a basis to crosscheck findings in terms of theory, methodology and investigator triangulation.

Parallel to findings in experimental literature, state and market governance strategies emerged as dominant alternatives to cope with social dilemmas. In addition, the manner in which a social dilemma is framed, the possibility of communicating, and the frequency and reciprocity of interaction, among other things, were identified as important factors in resolving social dilemmas. Empirically based studies also showed that analyzing decisions and actions in real-life social dilemmas yields a number of insights that shed light upon the different, often contradictory outcomes of experimental research and revealed the existence of alternative strategies to resolve social dilemmas. In laboratory settings, subjects are asked to adapt to the setting, i.e., the social dilemma, created by the experimentator(s), while in a real-life context the possibility exists to adapt the context itself (see Chapters 3, 4, 5, 6, 7, 8). Adapting the (structural) nature of the context itself appears to provide the means to resolve the social dilemma. Thus, in isolating decision and action situations from their complex,

wider environment, experiments block off routes that may present opportunities to resolve social dilemmas in real-life contexts.

Research and theory in institutional analysis and development seemed to provide the most promising leads towards generating insights into the way in which contexts shape people's decision making and action, as well as their ability to influence these contexts. For this reason, it was decided to participate in a semester-long seminar on institutional analysis and development at the Workshop in Political Theory and Policy Analysis, in Bloomington, Indiana (http://www.indiana.edu/~workshop/). Elinor and Vincent Ostrom, recognized experts and pioneers in the field of institutional theory, facilitated intensive debate on the origins and principles of institutional analysis and development. Among other things, the discussions of theoretical and empirical findings highlighted the potential benefits of case study analysis to gain insight into the emergence of institutions and their adaptations. Moreover, members and other visitors to the workshop provided a critical peer audience to further crosscheck insights gained and the methodological approach taken.

Linking theoretical insights and practice domains: A disposition for NRM dynamics and dilemmas

While searching through different approaches to cope with social dilemmas in the different 'Wageningen' fields of interest, NRM proved an interesting terrain for further analysis. The problematic nature of matching the environment's carrying capacity, people's needs and interests, and institutions frequently proved a barrier to resolving social dilemmas. Traditionally, these features are the objects of separate domains of analysis and action, whereas resolving such NRM dilemmas requires finding ways to bring them together (Gunderson et al 1995; Röling 2000). Growing experiences with participatory approaches (see also section 3.4) and the research in adaptive management (see also section 3.3) pointed toward possible alternative and more sustainable practices. In this light, concepts and insights obtained so far were integrated into a theoretical framework to guide further inquiry into the dynamics and dilemmas of participatory NRM (Maarleveld 1996). Some of the conceptual building blocks of the framework were further discussed with a critical audience of soil and water resource managers and scientists at a conference of the International Soil Conservation Organization (Maarleveld 1998; Hurni et al 1996). A colloquium series was organized to exchange ideas and views with a triad of Dutch environmental and social science researchers who were also addressing these issues (Colloquium Participation & Policy 1997). Accordingly, qualitative research criteria were taken into account through different types of peer crosschecks.

Preparing for a case study analysis: Formulating criteria and choosing a pilot

The seminars, subsequent discussions, and continued comparative search of empirical studies contributed to the decision to undertake case study analysis of NRM systems. As case study analysis has proven to be a particularly useful inquiry method for investigating 'a phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident' (Yin 1994: 13), it provides a means to capture interaction among people and the natural environment in participatory and adaptive NRM.

A number of criteria for the case study were formulated. In order to capture the complex and dynamic nature of NRM dilemmas and their management, multiple levels of analysis in terms of time and space scales had to be possible. In other words, the case study had to entail different levels of analysis (local, regional, national, etc.) across a historic, researchable time period. In addition, there had to have been different degrees of stakeholder participation in the management of the resource in order to capture how such participation could play a role in generating sustainable NRM practices. Moreover, it was considered that more needed to be learnt about The Netherlands before diving into complex NRM systems in other contexts. The important role of water resource management in this country led to the decision to begin with a Dutch regional water management case. Experts consulted pointed out some of the dilemmas faced in groundwater management in the Province of Gelderland and shared a number of policy documents that were being produced to resolve these issues. A quick scan of the issues confirmed that this case would be a good pilot. Groundwater management involves all levels from international to local. As active collective management of groundwater resources did not occur until the late 19th century, it has evolved in a manageable historical time period. In addition, various types of stakeholders have been involved in varying degrees in groundwater management adaptations. Finally, the province of Gelderland has an established track record in the area of integrated water management.

Back to the classroom: Learning about social learning and Dutch water management

As concepts and theories, practice domain and research methods were aligned, the notion of social learning, suggested as a perspective to overcome social dilemmas in the original research proposal, continued to be puzzling. Few conceptual tools had as yet been found to grasp it. The opportunity to develop and teach a course on change management for the M.Sc. program, Management of Agricultural Knowledge Systems (MAKS), provided a means to link the insights and developments in (organizational) management science to problems in resource use and management. The concepts of organizational learning and learning organizations proved instrumental in understanding and bridging the participants' different professional experiences across the globe. As a result of undertaking a course on Water Management and Water Authorities Law at the Law Faculty, Utrecht University, insights were also gained into the institutions of Dutch water management under the guidance of Alfred Van Hall, both a professor of Water Management and Water Board Law and an active chairman of a water board (Van Hall 1997; Van den Berg & Van Hall 1997).

These two courses, together with insights gained regarding developments in national and provincial water management in The Netherlands, provided a springboard to translate learning in organizations to learning among the different stakeholders in a managed resource system. The results were presented at the International Water Resources Association Conference in Montreal, Canada (Maarleveld 1997). This conference was combined with visits to MIT's Organizational Learning Group in Boston, USA, and to Kai Lee, Director of the Center for Environmental Studies, Williams College, Williamstown. The former had attracted attention by virtue of its publications on organizational learning used for the Management of Change course and interesting Internet resources on the learning history method (http://learning.mit.edu, http://www.learninghistories.com, see also Chapter 6). The interest in visiting Kai Lee had been triggered by his work to develop a 'civic science' to overcome the paradoxes of sustainable development (Lee 1993; http://www.williams.edu/CES/). Both he and

his colleagues proved knowledgeable and inspiring advisors. 'Because the behavior in systems cannot be understood, much less be predicted, on the basis of studies at the laboratory scale, it is essential to learn from large-scale interventions into populations and landscapes' (Lee 1993: 58). This line of thought confirmed the choice to undertake a case study analysis. The pilot became an in-depth case study analysis.

Learning from field experiences: Groundwater management in Gelderland

Armed with insights and research tools, it was high time to dive deeper into the dilemmas and dynamics of a recognizable, complex, managed resource system: groundwater management in Gelderland. In order to gain insight into the daily practices of groundwater management, a research internship was undertaken at the Department of Groundwater Management, Gelderland Province. Provincial groundwater management departments are one of the key stakeholders in Dutch groundwater management. The inquiry was guided by the previously developed conceptual framework and relied upon a number of analytical tools. These tools and the steps taken are further discussed in Chapter 6. All in all, information was gathered on the various biophysical, economic, political, behavioral, organizational, and institutional processes and outcomes in the managed resource system over time. Information found was crosschecked using different sources.

When material on so many different aspects is being collected, it is easy to become entangled in an information jungle, especially when the boundaries of the phenomenon are being determined as the inquiry proceeds. In this regard, this phase of the inquiry followed a path similar to qualitative research in the grounded theory approach (Strauss & Corbin 1998, 1990), i.e., letting patterns emerge from close-up, detailed observation of critical events in the case. However, contrary to the grounded theory approach, there was a prior commitment to a number of conceptual building blocks that guided the emergence of an overview of people's potential for social-environmental learning (Yin 1994; Denzin & Lincoln 1998; the overview itself is discussed in Chapter 4). Moreover, insights gained and the approach taken were crosschecked with other researchers and different experts involved in groundwater management in Gelderland and water management in The Netherlands.

Iterative synthesis: Integration of theory and practice, learning and NRM dynamics

Further exploration of literature on learning and opportunities to attend workshops on complexity (Colloquium on Autopoiesis and Social Systems 1998) and on ecological economics (Workshop on Ecological Economics 1998) catalyzed the iterative process of case study information collection and analysis. In order to test the explanatory value of the conceptual overview of people's potential learning capacity beyond the case on which it was based, the overview was used as the basis for a comparative analysis (Maarleveld & Dangbegnon 1999) and presented, among others, to a critical peer audience at the Conference of the International Association of the Study of Common Property in Vancouver, Canada. After suggestions for improvement were incorporated, the learning history of the emergence of groundwater management in Gelderland was analyzed in more depth. The tools of analysis used and the iterations undertaken are further discussed in Chapter 6.

Integration and synthesis of various empirical and theoretical findings into a coherent perspective and story line turned out to be a lengthy process, requiring quite a number of 'learning loops'. The richness of the case study made it possible to approach groundwater management in Gelderland as a nested case study (Yin 1994). This provided a comparative basis within the case study to link learning and NRM dynamics. A workshop on Adaptive Management, in which a number of key figures active in the practice and research fields explored in Chapter 3 were becoming more acquainted with each other's work, confirmed the sense of convergence in these areas and, more specifically, the convergence towards the notion of learning (Workshop on Adaptive Management 1998). As insights emerged, they were incorporated into a number of (collaborative) articles (Aarts & Maarleveld 1999; Groot & Maarleveld 2000; Maarleveld 2000; Maarleveld & Dangbegnon 2002). Moreover, insights were put into practice in a number of projects to improve sustainable and participatory water management practices (NVR 1999). They are currently being used in innovation and knowledge management with regard to planning and governance issues at the Dutch Service for Land and Water Management. And, last but not least, the insights are integrated in this dissertation.

2.3 Concluding remarks

In recounting the inquiry process in terms of the steps taken, underlying considerations, research methodology, and outcomes, this chapter aims to contribute to the scientific quality of this research. Throughout the research, qualitative research standards have been taken into account, as the approach taken and insights gained are made explicit and crosschecked through different types of triangulation. The account of the inquiry process indicates how the research has entailed a merging of paradigms on the part of the researcher both in terms of combining experimental research training with action research principles and a case study analysis approach, and in terms of combining insights from different disciplines and practice fields. The methodology and tools used in the case study analysis are further discussed in Chapter 6. In hindsight, the road taken has proven a long and winding, but enriching, learning process.

PART II

FOUNDATIONS FOR A SOCIAL-ENVIRONMENTAL LEARNING PERSPECTIVE

3 Managing NRM dynamics: Learning our way out?

Research objective addressed
O1: Explore foundations for a social-environmental learning perspective as aviable means to develop sustainable NRM.

Abstract
In this chapter, four different research and practice fields are explored to substantiate further investigation of the manner in which a social-environmental learning perspective may provide a viable means to facilitate sustainable NRM. The research and practice fields discussed are: social dilemma research, natural resource management research and practice, management of knowledge and innovation in rural development, and complexity theory research. State of the art developments in each field are found to converge towards learning as a route to sustainable NRM.

3.1 Managing resource dilemmas: Learning our way out?

In the first chapter, social-environmental learning was introduced as a potential perspective for developing sustainable NRM. In this chapter, four research and practice fields are explored in greater detail to substantiate further investigation of the manner in which a social-environmental learning perspective may provide a means to generate sustainable NRM. In the following sections, state of the art developments in social dilemma research (3.2), sustainable natural resource management (3.3), management of knowledge and innovation in rural development (3.4), and complexity theory research (3.5) are highlighted. In conclusion (3.6), state of the art developments in these research and practice fields that have been found to converge towards learning are summarized. Overall, these four fields provide evidence for the potential of a social-environmental learning perspective as a means to develop sustainable NRM, as well as a basis for further investigating this potential.

Social dilemma research has been reviewed because of its focus on the type of complex decision and action situations that often prove obstinate bottlenecks to realizing the effective col-

lective action necessary for sustainable NRM. NRM research and practice has been searched for lessons learned in different approaches to NRM. Management of knowledge and innovation in rural development has provided insights into how methods for knowledge transformation may contribute to voluntary behavioral change for sustainable NRM. Complexity research, a newly emerging and growing research field, contributes a scientific, conceptual language to understand and analyze the dynamics of complex evolving systems, whether natural, social, or both, enabling integration of insights from these interconnected domains for NRM.

3.2 Social dilemma research: Homo economicus meets homo discens

One of the bottlenecks faced in NRM as stakeholders, resources and institutions interact is the social dilemma situation. Social dilemmas arise when individual and collective interests intertwine in a such way that individual decisions and behavior, although individually advantageous, are sub-optimal for the collective. This type of situation dominates the doom scenario depicted in Box 1.2.

Social dilemma interdependence has been extensively conceptualized and analyzed in game theory (Dawes 1980; Wilke & Liebrand 1983; Koelen & Röling 1994). Aiming to develop guidelines to optimize decision making under uncertainty, mathematician Von Neumann and economist Morgenstern (1972) developed game theory. Game theory models show how the choice of one individual can affect the set of action possibilities and outcomes of others. Two popular versions of such decision-making situations are the prisoners' dilemma and the chicken dilemma. These different types of social dilemma interdependence are discussed in Box 3.1.

Box 3.1: Game theory models of social dilemma interdependence

Prisoners' dilemma
In the prisoners' dilemma, two prisoners are presented with the choice of serving a short sentence for a minor crime or turning the other in for a more serious crime and serving a reduced sentence themselves. If they both betray each other, they both end up serving a much longer sentence than if they had both kept quiet.

Social dilemma interdependence
1) Each individual receives a higher pay-off for a socially defecting choice than a socially cooperative choice, no matter what the other individuals in society do.
2) But all individuals are better off if all cooperate than if all defect.

Chicken dilemma
In a chicken dilemma, two drivers simultaneously drive at each other. The driver who swerves first is 'chicken'. The dilemma occurs at the last moment of the game. The worst that can happen is that neither driver swerves. The best thing that can happen is that you do not swerve, and the other, chicken driver, does. Being a chicken is the next worst outcome, but it is better than dying...

Social dilemma interdependence
1) An individual receives a higher pay-off for a socially defecting choice than for a socially

cooperative choice only if more than a certain number of individuals choose to pursue the collective interest.
2) If fewer than the required number make a socially cooperative choice, a socially defecting choice yields a lower pay-off.

Table 3.1 provides examples of such interdependence structures that may be found in NRM as well as other walks of life.

Table 3.1: Examples of social dilemma interdependency in different walks of life

Interdependence situation	*Collective interest*	*Individually rational choice*	*Collective sub-optimal outcome*	*Type of social dilemma*
Common use of a grazing ground	Resource resilience	Graze as many animals as possible to increase individual benefits	Resource depletion (tragedy of the commons)	Prisoners' dilemma
International relations	Peace	Keep up military strength in case of conflict	Arms race	Chicken dilemma
Labor dispute	Labor union to improve working conditions	Profit without paying membership dues	Lack of necessary financial support for organization	Prisoners' dilemma

In theory, the collective optimal choice seems obvious. However, in practice people may decide to forego a collective optimal pay-off and put their own interest first for a number of reasons. Uncertainty about other people's choices may lead people to choose to defect themselves (Sandler 1993; Pellikaan 1994; Aarts et al 1995). At least then they are sure not to get the 'suckers payoff', i.e., make a cooperative choice while all others defect, and thus get the worst individual pay-off. Efficacy of behavior also plays a role in the choices made. Many social dilemma situations may be characterized as situations in which individuals appear to have little control over the outcome; and research reveals that people are less inclined to make choices for the optimal collective outcome when they do not sense that their choice really makes a difference (Kerr 1992; Kerr 1995; Kerr & Kaufman-Gilliland 1994). Moreover, lack of understanding of the outcomes and effects of choices made may also affect people's decisions (Kahneman & Tversky 1982, 2000; Dörner 1996). Having such insight could lead to a different, cooperative choice.

In game theory, choices in social dilemmas are predicted on the basis of methodological individualism (Sandler 1993; Pellikan 1999). This means that, with regard to human motivations and behavior, individuals are assumed 1) to be selfish; 2) to maximize utility; 3) to choose rationally. Choosing rationally means making the choice that yields the greatest expected utility. Thus, game theory explains how a rational individual will tend to choose the alternative

that yields the greatest expected individual utility in the short run, even when that choice leads to a sub-optimal outcome for all involved in the long term and, eventually, the individual's own personal utility (Olson 1965). This view of humankind may be characterized as a homo economicus archetype.

Hardin's tragedy of the commons (the first example in Box 3.1) has become a classic example of social dilemma interdependence in NRM (Hardin 1968). In this example, social dilemma interdependence is illustrated by a group of herders whose actions are bound to lead to the overexploitation of a common grazing ground. Each herder may graze as many animals as (s)he likes on the common. However, the grazing ground can only carry a limited number of animals if it is to remain resilient over time. If the homo economicus view is taken, the prediction is that all herders will choose to maximize the number of their animals on the common even though this will lead to overexploitation, making it useless for all. Short-term individual benefits will prevail over long term collective ones.

In NRM, such type of dilemma has been labeled as a 'commons' dilemmas or appropriators' dilemmas. Overcoming such dilemmas requires rules of the game that restrict individual taking so that sustainability is ensured for all, including the natural system generating ecological goods and services (Ostrom 1990). Traditionally, privatization or centralization is proposed as a means to resolve such social dilemmas. Advocates of privatization argue that free, competitive markets are the means to resolve social dilemmas. The invisible hand of the market is viewed as harmonizing the pursuit of individual interests towards optimal collective outcomes (Smith 1985; Sandler 1993; Picciotto 1995). Advocates of centralization reason that a central body of authority needs to coerce rational actors to jointly pursue collective interests (Hardin 1982; Hobbes 1991; Picciotto 1995). Although capable of transforming social dilemmas into situations of mutually beneficial interdependence, these strategies have not lived up to expectations.

Rather than solving social dilemmas, these strategies most often entail new social dilemma situations. For example, privatization requires institutional arrangements such as contracts, norms, and rules regarding boundaries of property. Centralization relies upon organized collectives that develop and monitor regulations. Both the establishment and the maintenance of institutions required for privatization and centralization may in themselves involve social dilemma type interdependent relationships. Such institutions require collective action that may not be in the direct interest of individuals. Depending on the pay-off structure involved, people may find themselves in social dilemma interdependence situations as described in Box 3.1. Accordingly, a new social dilemma may be nested in the resolution of another.

For some, these evolving conditions in terms of nested social dilemmas confirm that people will inevitably be trapped in a social dilemma because of their inherently selfish nature. However, others have argued that, although the homo economicus archetype captures significant aspects of human behavior, it leaves out important others. People's decisions and actions in both naturally-occurring environments and controlled laboratory experiments indicate that cooperative behavior to obtain optimal collective outcomes, or to reduce negative collective effects in social dilemmas, is more common than game theory models allow us to predict (Ostrom 1990; Ostrom et al 1994; Uphoff 1992; Satz & Ferejohn 1994; Pellikaan 1994; Aarts et al 1995; Ridley 1996; Sen 1997). Moreover, people might make a socially defecting choice because of cognitive limitations to figuring out the optimal collective choice (Simon 1997; Kahneman

& Tversky 1982; Dörner 1996; Gigerenzer & Todd 1999). For example, lack of information about the situation or about the effects of their decisions and actions may lead people to make choices they would otherwise not have made.

Across disciplines, researchers and practitioners have identified conditions and factors that enable effective collective action to evolve. Game theory models of social dilemma interdependence are simplified models of real-life interconnections that omit characteristics that might precisely contribute to breaching social dilemma interdependence (Ostrom & Walker 1997). In particular, people's ability to adapt the rules of the game that create social dilemma interdependencies appears to be a fruitful route to pursue toward overcoming social dilemma interdependence. In other words, change is brought about in the institutional arrangements that structure interdependence among people and the goods or services transformed (Sandler 1993; Picciotto 1995; Ostrom 1995). Coordination systems such as shared norms, monitoring, and sanctioning may create a basis for conditional cooperation (Gambetta 1988; Cook & Levi 1990; North 1994). Communication has proven to play a vital role both in gaining insight into interconnections and in developing and maintaining coordination systems (Dawes 1980; Brewer & Messick 1983; Frey 1993; Ostrom et al 1994; Liebrand & Messick 1996). These conditions and factors are further addressed in following chapters.

These findings do not imply that clear-cut solutions to social dilemmas exist. What they do show is that people can learn to transform social dilemmas into more collectively beneficial interdependence situations. Putting a different archetype in the spotlight, namely, homo discens, i.e., learning (wo)man, highlights the ability of people to adapt social dilemma situations into mutually beneficial situations. Taking the characteristics of this archetype as point of departure for investigating people's decisions and actions in NRM can increase our understanding of possibilities for effective collective action in the face of nested social dilemmas.

3.3 Sustainable development and natural resource management: From myopic to adaptive management

Through publications such as Limits to Growth (Meadows et al ('Club of Rome') 1974) and Our Common Future (WECD ('Brundlandt Commission') 1987), environmental social dilemmas have gained ground on the international agenda. The ensuing global perspective has helped to clarify the collective consequences of decisions and actions on the local, regional, and national level: as a result of human activity across the globe, natural resources formerly considered inexhaustible and/or renewable can become finite. Negative effects of economic growth, the green revolution and technology development are made visible. In order to keep the earth's cornucopia of resources flowing endlessly, a change in the relationship between people and the natural environment was called for.

The Brundlandt Commission introduced the principle of sustainable development in order to bring economic development into line with environmental carrying capacity. Industrial development needed to be stabilized in order to prevent catastrophic environmental scenarios. Meeting the needs of the present was no longer to compromise the ability of future generations to meet their own needs. However, this has proven to be easier said than done.

At first, the solution was thought to lie in target resource management (Holling 1995; Holling & Meffe 1996). Its aim is to control a target variable (i.e., flooding, pests, fish catches) in order to achieve socio-economic objectives such as maintaining or expanding employment or economic activity. This type of NRM is characterized by an instrumental problem-solving approach. As such, it relies on a weak sustainable growth model, i.e., it is guided by a strong belief in future or technological progress and substitutability of human-made and natural capital (Faucheux & O'Connor 1997).

Across different examples of target resource management a common pattern has been found to emerge (Holling 1995):
1 Ecosystems become less resilient;
2 Management becomes more efficient but more myopic;
3 Industries become more dependent and static;
4 Public loses trust.

This pattern has been found to come about as follows. After having successfully controlled the target variable, management institutions shift from their original social and ecological objectives to preservation of the institutions themselves. At the same time however, management of the target resource can have caused slow changes in elements of the enveloping ecosystem, reducing its heterogeneity. Both the narrow problem focus and preservation tendencies can make it difficult to perceive such changes. As a result, disturbances that could previously have been absorbed are now more likely to flip the more spatially homogenized ecosystems into a persistent degraded state (Holling 1995). Consequently, actors involved not only find themselves out of touch with changing ecosystemic conditions, but also discover that their ability to undertake effective collective action has been undermined. As such, target resource management fails to make the relationships between the natural and the human system more sustainable. Instead it may be characterized as myopic management that is unable to switch focus points when changes occur. Some examples of this type of resource management are encountered and discussed in the case study analysis chapters in Part III.

As mentioned in the introductory chapter, sustainable NRM requires a resource management approach that is capable of adapting to evolving conditions, in the sense not only of being able to react to changing circumstances, but also of being able to change circumstances themselves. Adapting to conditions as well as adapting conditions calls for NRM practices that combine understanding and action. In order to resolve dilemmas evolving from interdependent relationships within and between the human and the natural system, we must better understand the physical natural resource system on which we jointly rely, patterns of use, norms of behavior, encouraging/discouraging incentives, costs and benefits of changing rules, and cumulative effects over time (Ostrom 1990). However, insight alone is not enough. This knowledge must also be incorporated in everyday resource use and management. As such, NRM involves a great deal of complexity and many uncertainties, making its path and outcomes highly unpredictable.

Lee (1993) has distinguished two principles essential to guide us to sustainable NRM. A compass is provided by adaptive management (Holling 1978), an experimental approach to natural resource policy that links the scientific method of experimentation with human purpose. The conflict of divergent interests, bounded by open political competition, i.e., democratic institutions, functions as a gyroscope. Together, adaptive management and democratic institutions

can aid in overcoming barriers and building bridges in the search for a sustainable relationship between the natural and the human system. Learning is a key notion to realize this.

3.4 Management of knowledge and innovation in rural development: From teaching to learning

Agriculture is one of oldest managed human/nature interfaces. As such, rural development may provide a number of insights into how to develop and transfer knowledge and innovations in NRM. In particular after WWII, agriculture was effectively rationalized by active knowledge and innovation management. At the time, transfer of technology (TOT) dominated knowledge transformation. TOT presents knowledge and innovation management as a linear model that allots singular goals and abilities to the different parties involved in agricultural development. Researchers are in charge of developing innovative technologies. Extension agents are responsible for transferring the innovations and technology developed by agricultural research institutes to farmers, the end-users. In other words, the role of the agricultural extension agent is to bring about voluntary behavioral change by teaching farmers how to apply new technologies. Depending on the effectiveness of the information transmission, farmers adopt the new practices, closing the TOT chain.

However, this rather controlled, closed-circuit view of knowledge and innovation management and its methods became much contested (Chambers & Jiggins 1987). Neither real-life knowledge transformation nor the communication processes involved satisfied the proposed linear track. For example, linear transmission of information failed to explain the interactions among the different parties. Practice also showed that farmers themselves were a source of innovations (Chambers 1979; Chambers et al 1989). Furthermore, other parties in addition to researchers, extension agents and farmers could play a role in the knowledge transformation process. In addition, negative effects of production-oriented agriculture started to become visible (Van der Ploeg & Van Dijk 1995; Eshuis et al 2001). Goals and practices in the agricultural sector needed to be (re)aligned in accordance with changing ecological conditions as well as changing individual and societal interests. As many of the problems encountered in agriculture were linked to environmental issues, health issues, and governance, among others, their solution extended beyond the agricultural domain.

In order to accommodate these developments and ensure a purposive and viable extension practice, new perspectives were sought. Among others, the Agricultural Knowledge and Information Systems (AKIS) perspective merged ideas about systems thinking and constructivism to accommodate complexities of knowledge and innovation management (Röling 1992). Constructivism helped to show that (scientific) knowledge is never objective, but emerges in the interplay of actors who each actively construct their view of reality (Leeuwis 1993; Engel 1995). Soft systems thinking helped to clarify how innovations emerge from the interactions of the various actors (with their differing perceptions of reality) operating together in the agricultural domain, i.e., the parties already mentioned, but also credit suppliers, government, NGOs, policy makers, agribusiness, and international organizations (Checkland 1981). In addition, soft systems thinking showed how such a knowledge system in its turn is embedded in other systems. Input from disciplines such as communication sciences, social psychology, sociology, applied philosophy, policy sciences, adult education, management studies, and information technology, and integration with other extension domains such as health promotion, environmental education, and public policy further validated a change of

focus. Where formerly the message was central in extension, now interaction is increasingly being emphasized and, with it, joint construction of context-specific knowledge and innovations (Van Woerkum 1997; Van Woerkum 1999). The focus on interaction made the role of negotiation, power, participation, and context more salient and provided new grounds on which to anchor interventions and develop methodologies.

Accordingly, the role of extension agents has diversified. In essence, the purpose of interventions remains the same: bringing about voluntary change through understanding of one's environment, one's actions and the effect of actions on the environment. However, in circumstances characterized by complex interdependence, uncertainty, and evolving conditions, such as NRM, the lay(wo)man is no longer to be taught by the expert what to do to solve the problem. Instead, they must learn together what the problem is and how to deal with it. In these instances, the extension agent has become a facilitator of communication processes that are conducive to developing knowledge and innovations (King 2000; Groot 2002). The methods and tools developed focus on creating understanding of each other's realities and problem definitions, ensuring that all stakeholders have access to arenas in which problems are put on the agenda and solutions are negotiated, and that they have the necessary skills to participate purposefully. This shift in roles and methodologies appears to once again call for a change of focus, namely, from a knowledge system perspective to a learning system one (Roling & Jiggins 1996; Heymann 1997).

Such learning is directed at gaining a better understanding of the structural coupling between actors and their social-physical environment (Röling & Wagemakers 1998; Leeuwis & Pyburn 2002). Platforms, interactive policy making, and participatory methods provide interaction possibilities in which stakeholders may jointly negotiate new meaning or reframe existing ones (Aarts & Van Woerkum 2002). New information and communication technologies may provide tools that overcome existing communication barriers through dynamic visualization of abstract concepts and improve construction of shared meaning (Gonzalez 2000; Lamerichs 2003).

3.5 Complexity theory: Understanding the adaptive dynamics of complex, evolving systems

As already emphasized in the introductory chapters and the previous sections, developing sustainable NRM is no simple matter. In Chapter 1, NRM is discussed in terms of the static and dynamic qualities of the natural and the human system, as well as in terms of their influence on one another. In the natural domain, physics, chemistry, biology, mathematics, and meteorology, among others, have been so successful in building understanding of the world that some claim the end of science is in sight (Horgan 1996). Quite a few phenomena still remain to be understood however, in particular complex phenomena that are labeled chaotic because they cannot be understood by deterministic models that reduce a phenomenon to its components and predict its behavior from an understanding of these parts (Lewin 1993). And, in NRM, the challenge is precisely to understand such complex, dynamic phenomena (Levine 1999; Gunderson & Holling 2002).

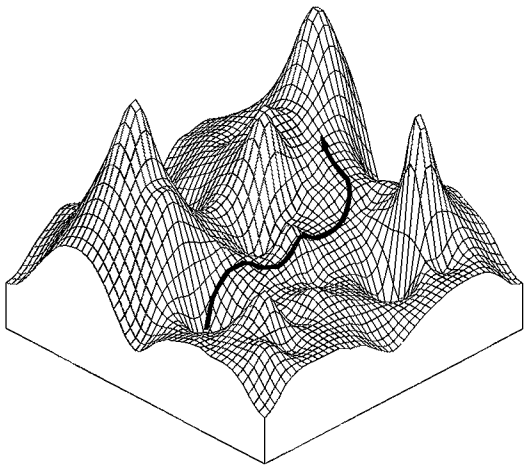
In a newly emerging field of science, namely complexity theory, scientists are connecting across different disciplines in their study of such apparently chaotic phenomena (http://

www.santafe.edu). These scientists have discovered that different chaotic systems have a common dynamic, namely, non-linear dynamics. This entails cause and effect not being proportional (small causes can have great effects, i.e., the butterfly wing movements in Brasil that cause storm in Japan), little repeatability, little predictability, and path-dependency (Geldof 2001, 1994). Interaction in such complex systems can generate characteristics at a higher level than could have been predicted by understanding the separate parts (Casti 1994). The emergent characteristic, a new phenomenon, in its turn influences the behavior of the interacting parts that caused it.

Unlike what is predicted by the second law of thermodynamics, these non-linear systems are not bound to evolve towards a steady state or increased entropy. Because of the strong self-enforcing nature of non-linear processes, complex adaptive systems can take energy from the outside (i.e., they are open systems) and maintain or generate structure from 'inside' (Prigogine & Stengers 1984). Thus order can arise at the edge of chaos. As parts and emergent properties are continuously influencing each other, dynamic, multi-equilibria evolve.

These processes may be visualized in terms of a dynamic landscape of possibilities (see a static version in Figure 3.1). Interacting entities develop emerging properties that become attractors, i.e., mountain tops that attract interaction, or repulsors, valleys that entities want to avoid. As interaction is shaped by the landscape, new attractors and repulsors emerge, changing the landscape, and in turn restructuring interaction. Accordingly, these systems can be characterized as self-organizing, adaptive systems.

Figure 3.1: Landscape of possibilities with mountain peaks as attractors and valleys as repulsors (Geldof 2001)

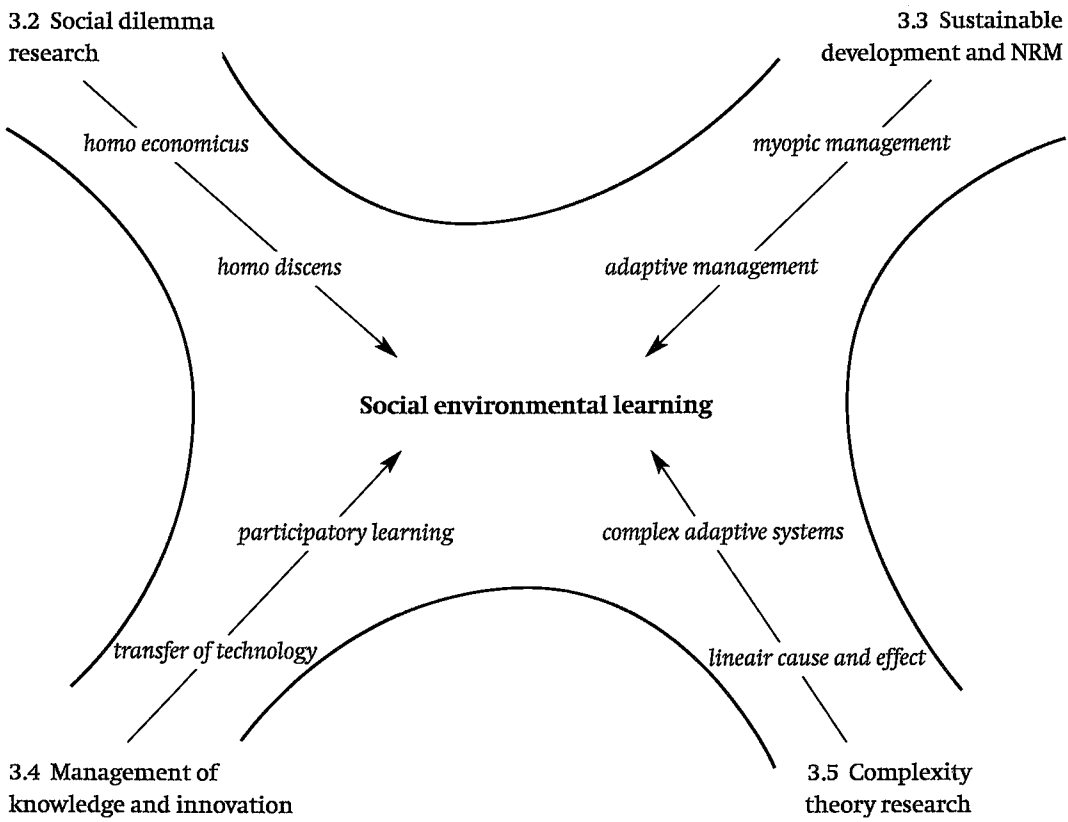


As this type of dynamics is found in both the natural and the human domain, and in their interaction, the possibility landscape provides a way to capture NRM dynamics and gain an understanding of the effects of change on the larger system, and vice versa. The language of complexity is also proving to have its own coordinating strength. Managers who see the world as a complex, adaptive system or dynamic possibility landscape become more adaptive to change, even in situations where previously they felt they could have no effect (Lissack & Roos 1999; Wheatly 1992).

3.6 Convergence: Towards social-environmental learning

Although divergent in origin, the research and practice fields explored in sections 3.2-3.5 all provide foundations for a social-environmental learning perspective as a viable means to develop sustainable NRM. Developments in the four research and practice fields may be viewed as converging toward social-environmental learning. In different ways and in terms of the different labels used in the various disciplines and practices, learning is found to be a key concept to deal with the complex, evolving dynamics that characterize NRM. Figure 3.2 summarizes how highlighted developments in each field converge towards this notion.

Figure 3.2: Divergent explorations, converging outcomes



The developments and the manner in which they provide evidence for a social-learning perspective as a viable approach may be recapitulated as follows:

- Social dilemma research provides a means to conceptualize and analyze complex interdependent relationships among resource, stakeholders, and institutions. Recent approaches in such research that put homo discens in the spotlight highlight possibilities for individuals to undertake effective collective action in traditionally predicted, irresolvable, nested social dilemmas. In light of people's learning capacity, social dilemma interdependence

provides opportunities for cooperation as much as for non-cooperative choices. In particular, people's ability to adapt the rules of the game that create the social dilemma interdependence, and the role of communication therein, deserves further attention.

- Analysis of NRM practices to realize sustainable development reveals that the management practices targeted to resolve NRM dilemmas may actually be the cause of new NRM dilemmas or amplify the ones they set out to resolve. Such effects exemplify myopic management, the inability of certain management approaches to shift focus when their effect has achieved its goal or even proven ineffective. Instead, preservation of the management practice itself and the patterns it generates become points of focus. In order develop and draw on people's ability to cope with evolving conditions, an adaptive management approach and democratic institutions have been found essential to facilitating sustainable development. Both rely on learning as a key notion.

- Developments in knowledge and innovation management in rural development also confirm the significance of a learning perspective. Where first methodologies and tools were mainly used to bring about change by linear transfer of technology, growing insights point towards the importance of creating an enabling environment in which different lay persons and experts can learn from each other and develop and renew practices.

- Complexity theory research provides a means to understand the adaptive dynamics of complex, evolving systems. It has contributed to creating a common conceptual language enabling different disciplines to exchange insights regarding the same complex phenomena, or different ones with similar complex dynamics. As such, it has contributed to clarifying the apparently chaotic dynamics of complex adaptive systems such as NRM.

In addition to converging towards learning, the four research and practice fields explored point out some issues to be taken into account when linking learning and NRM. Recurrent issues are the need to better capture and understand complex, dynamics NRM; institutional dynamics as key to structuring and adapting decisions and actions in NRM, and people's ability to communicate and share meaning to overcome social dilemma interdependence. Moreover, the experiences in the different research and practice fieldd indicate that the facilitation principles systems thinking, experimentation, and communicative action prove valuable in developing knowledge and the ability to use it for realizing sustainable NRM. These principles will be further addressed in Chapter 6.

In order to be able to link learning and NRM dynamics and dilemmas effectively on these issues, the notion of learning itself is first discussed in more depth in the following chapter. In Chapter 5, learning, institutions, and the role of cognition are linked to gain further understanding of the role of the above recurrent issues. In Part III, a real-time, complex NRM case study is analyzed and discussed in terms of these aspects.

4 Learning about social-environmental learning: People's potential capacity for learning

Research objective addressed
O1: Explore foundations for social-environmental learning as a viable perspective for sustainable NRM

Abstract
In order to learn more about social-environmental learning, a closer look is taken at learning. The nature of learning dynamics is discussed and an overview is given of learning repertoires that may be viewed as constituting people's potential for social-environmental learning. Learning is presented as a dynamic process involving cognitive and behavioral processes that enable individuals at different levels of aggregation to adapt to and adapt their environment. Characteristics of a social-environmental learning perspective and insights developed with regard to human learning in general, are linked together in a conceptual overview to capture people's potential learning capacity. The chapter concludes by raising a number of issues that need to be further addressed to gain a better understanding of the links between social-environmental learning and NRM dynamics.

4.1 Introduction

In the introductory chapter, a number of characteristics of a social-environmental learning perspective were discussed. These characteristics are recapitulated in Box 4.1.

Box 4.1: Characteristics of a social-environmental learning perspective

Who: Multiple, interdependent collective stakeholders engaged in resource transformation
What: Facilitation of shared meaning and coordinated action
How: Continuous reflection and action
Why: To develop sustainable NRM

Learning and its facilitation is a key notion in this perspective. In order to learn more about social-environmental learning and its facilitation, the notion of learning is discussed in more depth in this chapter.
The tendency has existed to associate learning with formally designed educational contexts

(Vandenabeele 1999; Ratering & Hafkamp 2000). However, there are probably about as many different ways to learn as there are things to be learned. In addition to formal learning that takes place in a classroom, quite a bit of learning goes on outside those four walls. For example, before children start their formal education, they are already developing knowledge and skills through experience and observing others (Fishbein 1984). Moreover, learning is not something limited to childhood. The dynamics of identity and societal development make it necessary for people to continue to learn when they are already relatively competent adults (Erikson 1963; Maslow 1970; Brookfield 1986; Giddens 1991; Jarvis 1992; Vandenabeele 1999; Ratering & Hafkamp 2000). Pleas for lifelong learning to cope with the complexities of the current information age and of an ever more rapidly evolving society confirm this need (Senge 1990; Ranson 1994; Ranson & Stewart 1994; Nonaka & Takeuchi 1995; Delors 1996; World Bank 1998).

Similarly, in NRM learning may take place outside formal educational contexts and among trained and experienced professionals. The examples in Box 4.2 illustrate some of the different ways in which such learning in water resource management may take place.

Box 4.2: Learning in water resource management

Learning to manage water and soil run-off in Queensland, Australia: The Rainfall Simulator (Hamilton 1995)
A farmer, with a small group of peers, tested a range of water and soil run-off management practices on his farm using the Rainfall Simulator. The Rainfall Simulator is a research tool to study the impact of rainfall on soil/water relations. It is a transportable machine that produces 'rainfall' with a drop size and energy similar to natural rain. The rainfall is applied to small, adjacent, different treatment plots, separated by barriers, allowing different treatments to be visually compared. It has been used as an on-farm demonstration tool to teach farmers how rainfall can be captured rather than running off and causing soil erosion. Due to drought conditions and excessive cultivation, their fallows tended to have a fine tilth with no stubble cover. The group tested a range of options using the simulator, including stubble cover provided by hay, rough tillage and fine tillage. At the end of the simulator demonstration, the targeted farmer said: 'You've convinced me.' He went out that afternoon and bought himself a zero till planter. Another farmer went home and roughened up the surface of his fields.

The contribution of people's participation to sustainable water supply. Evidence from 121 rural water supply projects. (Narayan 1994)
Researchers studied evaluations of 121 rural water supply projects in forty-nine developing countries around the world. Eighteen different agencies supported the projects, which employed a variety of techniques. Systematic qualitative and quantitative analysis consistently indicated that beneficiary participation was more significant than any other factor in achieving functioning water systems and in building local capacity. Two key characteristics determining participation were commitment before construction or demand for the service, and the degree of organization of the beneficiaries. The results for this study have profound implications for the way the World Bank now supports its partners in planning and implementing development programs. Several rural water projects are now based on the principle of local participation, control, and authority, and supported by an approach to project management that emphasizes learning over

blueprint designs. It is too early to draw conclusions about performance, but two facts are already evident. First, although large-scale projects can be designed with a built-in commitment to demand-responsive approaches and active 'experimentation', there is no standard model for doing so. Second, in the absence of a standard model, that is, where learning relies on flexibility, adaptation, and necessarily short planning horizons, monitoring and evaluating are even more important for success than they are in traditional projects.

These illustrations are only a few of the possible examples of learning that takes place in water resource management. Many other manifestations of learning exist in water resource management or NRM in general (http://massey.ac.nz/changelinks/).

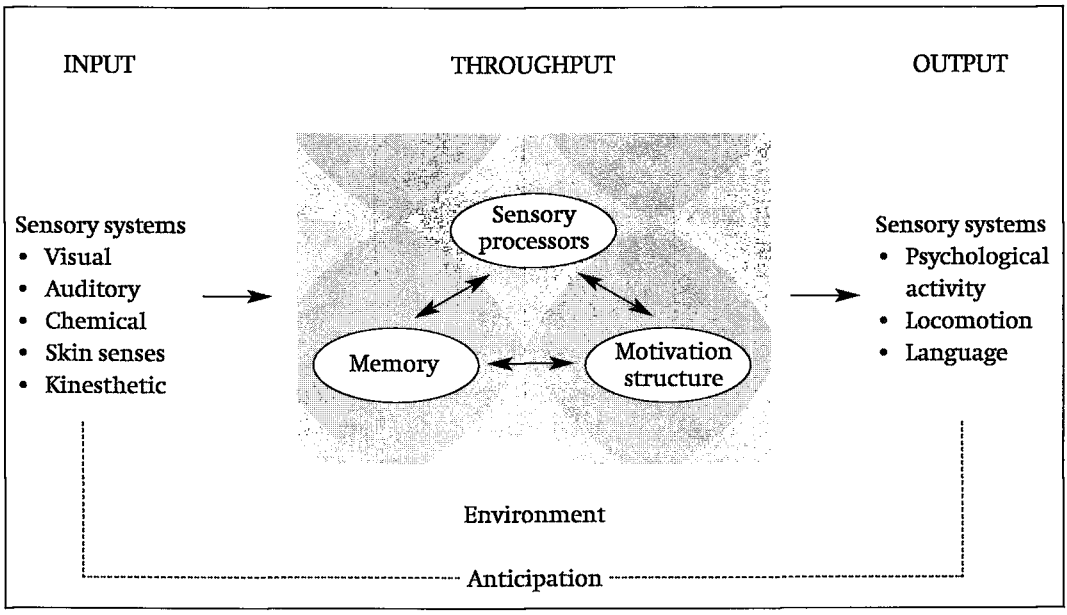
The fact that learning can manifest itself in such different settings, forms, and outcomes does not make it any easier to define it unambiguously. For that matter, the question of what learning is exactly has been the subject of much debate. Some find that learning, and particularly social learning, remains under-theorized (Parsons & Clark 1995; Ison et al 2000). Others claim the concept of learning is over-theorized, with different disciplines advocating their own definitions (Bennett & Howlett 1992). Instead of choosing to let one definition prevail over another, this chapter attempts to draw together various conceptions of learning in an overview. Accordingly, in encompassing different learning definitions the conceptual overview may be seen to capture people's potential learning capacity.

In the following section, the dynamic interaction between people and their environment that generates learning is further discussed. Different models of learning draw attention to the adaptive potential of learning. This adaptive potential is a fundamental notion in a social-environmental learning perspective. After all, it is this capacity that enables entities to continuously modify understanding of NRM dynamics and, accordingly, adapt decisions and actions and the institutions governing those decisions and actions (Holling 1995; Lee 1993; Woodhill 1999; Woodhill 2002). The ability to adapt to, and to adapt, changing circumstances may be referred to as an entity's learning capacity. In section 4.3, characteristics of a social-environmental learning perspective and general learning theory insights are highlighted and drawn together in a conceptual overview that explicates the learning repertoires constituting people's potential learning capacity. The chapter closes by raising a number of issues that need to be further addressed to gain a better understanding of the links between learning and NRM dynamics: the objective addressed in Part III.

4.2 Learning: Adaptations in people-environment interaction

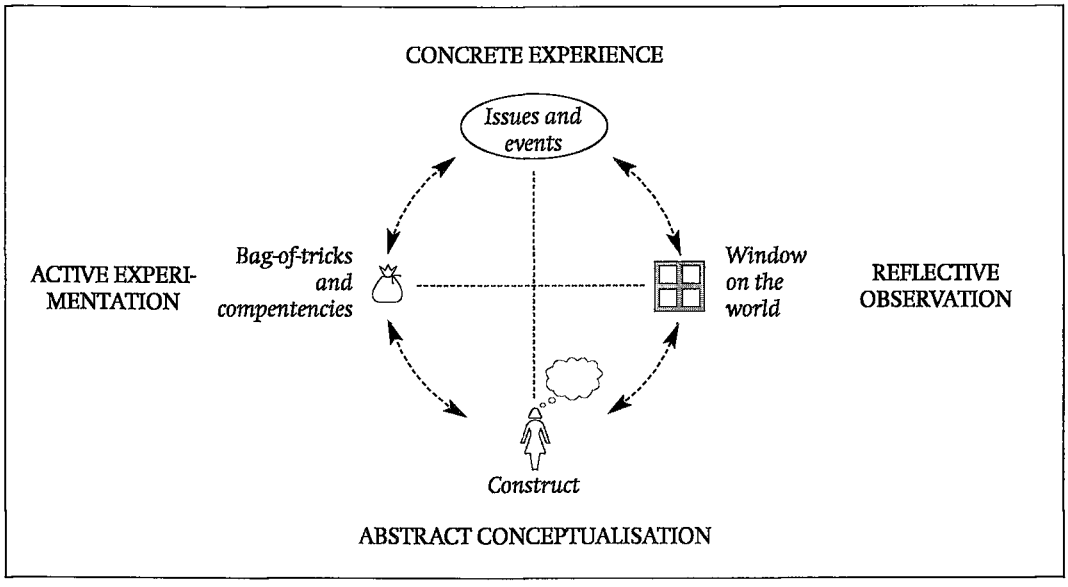
Although learning has been defined in different ways, various conceptualizations tend to share a similar view of the dynamic processes that constitute learning. Whatever its context and outcomes, learning is seen as involving some flux between sensory experiences of the world and cognitive abstractions by the sensing entity. In Figure 4.1 a-d, four models visualize learning dynamics that occur when individuals interact with their environments. These models are rooted in different disciplinary fields and have been developed for different levels of aggregation and types of learning.

Figure 4.1a: (Wo)man as a learning entity



Adapted from Voss 1974

Figure 4.1b: Model of a learning system. The learner coupled with his or her environment



Adapted from Sriskandarajah et al 1989; Kolb 1984

Figure 4.1c: Structural coupling between a living entity and its environment

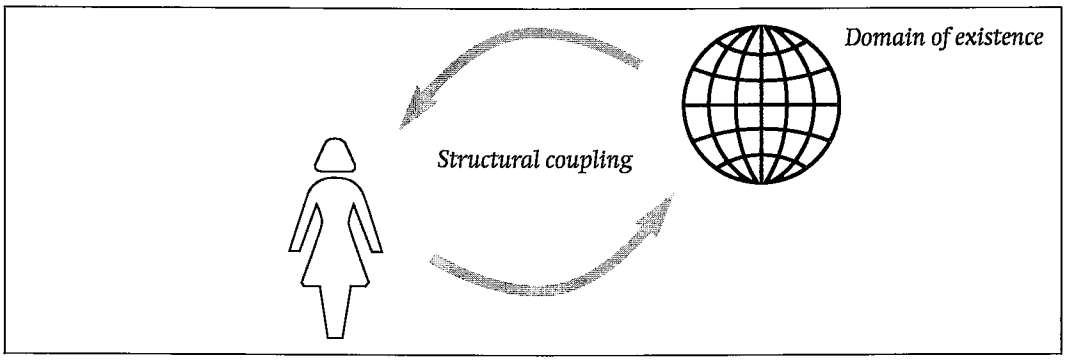
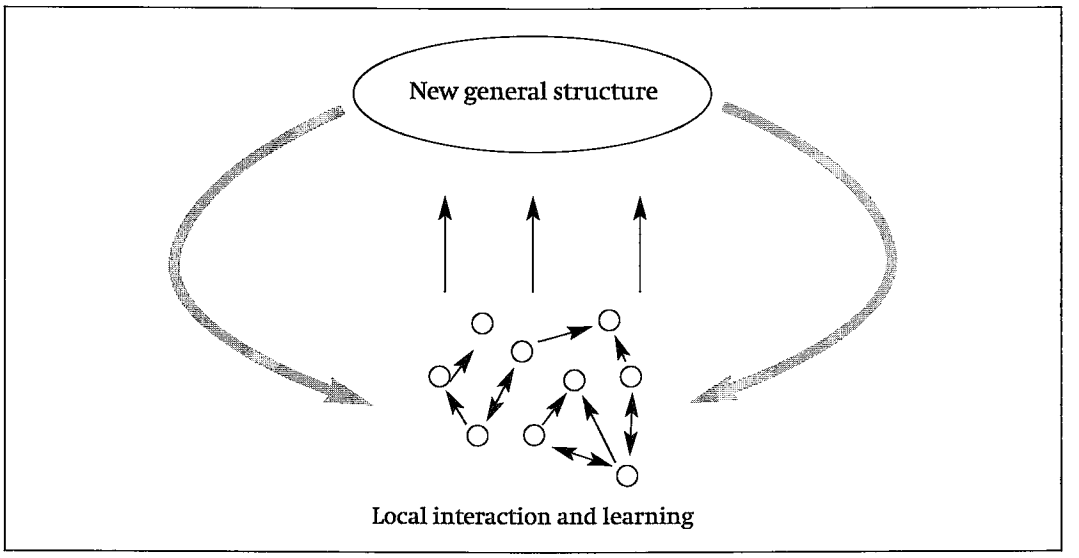


Figure 4.1d: Langton's view of emergence of new properties in complex adaptive systems (Lewin 1993: 26)



The model in Figure 4.1a has its origin in behavioral psychology. It has been developed to gain insight into the 'black box' of psychological processes and their interrelationships when an individual interacts with her/his environment (Voss 1974). In this model, people are viewed as information processors. The model conceptualizes sense-making in people-environment interaction in terms of inputs from the environment that are picked up by people's senses, a 'black box' in which sensory processors, motivational structure, and memory, and outputs, i.e., behavior of the individual, interact. The 'black box' constitutes a feedback loop between output and input and checks whether anticipated environmental effects of behavior have occurred or whether there has been a discrepancy. In the 'black box', one's motivational structure may influence the information being processed by the sensory processors. One's motivational structure is viewed as involving biological motivations such as hunger and thirst, and social motivations such as desire for achievement and approval of peers. Selecting and processing inputs also involves evoking any information pertinent to the issue at hand from one's memory. In other words, input information is processed in relation to what has already been

experienced. In this sense making, which involves an interplay of input, throughput, and output, processed information may change the motivational structure. In this light, it is possible to speak of an adaptive, learning entity.

In Figure 4.1b a view of learning is presented that is in line with the social-constructionist view ascribed to in the latter parts of sections 3.3 and 3.4. The model has its roots in adult education theory (Kolb 1984; Sriskandarajah et al 1989). The experiential learning cycle visualizes how learning is anchored in personal experiences and how making sense of these experiences determines what people do. Four phases are distinguished: concrete experience, reflective observation, abstract conceptualization and active experimentation. Learning is seen as constituted by the apprehension of immediate concrete experience (observation) and the comprehension of symbolic representations of experience (understanding). Transformation of knowledge from apprehension to comprehension takes place through intentional reflection (thinking), or the other way around, via extensional action (experimenting) (Kolb 1984). As such, learning is a continuous dialectic process, whether individually - for example, in terms of observing and understanding effects of one's behavior - or collectively, in terms of observing and understanding the effects of water management policy making and implementation. In this dialectic process an individual or a collective's cognitive frame, or window on the world, and knowledge, and skills are adjusted and re-formulated based on personal experience.

Figure 4.1c visualizes a theory of cognition that aims to further understand how the manner in which living systems experience the world determines which changes in the environment trigger structural changes in the entity (Maturana & Varela 1987; Colloquium on Autopoiesis and Social Systems 1998). The theory has its roots in the biological and neurological sciences. Structural coupling between a living entity, whether human or non-human, and its environment is viewed as a key process underlying cognition. Through recurrent interactions, living entities couple structurally to the environment. In this interaction, entities undergo continual structural change while preserving a recognizable pattern of organization. According to Maturana and Varela (1987), this points toward the autopoietic nature of cognizing, living entities. A living entity is viewed as specifying or directing which environmental perturbations trigger structural changes within the entity. Accordingly, an entity actively 'brings forth a world'. In the process, organisms develop knowledge that is effective in their domain of existence. As different entities change differently, and over time, each organism forms its unique, individual pathway of structural changes in the process of development. These adaptive, cognitive, structural changes constitute the learning ability of living entities. In this light, this developing theory of cognition is felt to be a key to understanding the essence of human learning and even living systems altogether (Capra 1996; Röling et al 1999; Leeuwis & Pyburn 2002).

In Figure 4.1d, a learning model is presented from the field of complexity theory discussed in section 3.5. It provides a means to distinguish learning at different levels of aggregation (Lewin 1993). While the earlier figures tend to depict learning from the point of view of individual learning, this model provides a means to visualize aggregated learning. The model highlights how interacting local learning entities generate emergent properties at an aggregate level (Holland 1995). Such general structures then frame future learning of the local entities. Accordingly, learning dynamics in a complex, dynamic, adaptive system may be visualized. In this interactive process, dynamics similar to those portrayed in the other models may be distinguished. Through internal modeling, agents and aggregates of agents are able to anticipate consequences of behavior based on experience. The complex large-scale patterns of

behavior evolving from the interaction of their individual learning may be captured in terms of emergent properties (Holland 1995). Such a complex of properties may be seen as functioning as a collective cognitive frame for a window on the world. Neither the network of agents nor the interactions are fixed in time (Holland 1995). They are patterns that reflect changing adaptations as time elapses and experience accumulates. This process will be further discussed in terms of NRM in Chapter 5.

Although these four models have different origins and accents, parallels exist. In all four models, learning is conceptualized as involving iterative cycles in which learning entities and their environment are linked through a process that combines a number of different but interrelated cognitive and behavioral processes such as perception, reflection, intentionality, and action. Individuals, as situated, cognizing agents, whether individually or collectively, are able to link their bodily entities and their environment through sense-making and goal-oriented behavior (Voss 1974; Sriskandarajah et al 1989; Kolb 1984; Clark 1997; Varela et al 1997; Holland 1995). This entails a combination of abilities to perceive oneself and one's context, to express intentionality in terms of goals and priorities, and to translate these intentions into action to influence a situation toward a preferred state. In this process, an individual or a collective of individuals organizes and reorganizes the way they experience their environment, generating knowledge and skills. Thus, insight into their context and their position in it may be generated. Accordingly, a cognitive frame (the black box (Figure 4.1a), an individual's window on the world (Figure 4.1b), embodied cognition (Figure 4.1c) or an emergent general structure (Figure 4.1d)) is constructed that subsequently largely influences how individuals experience the world and what future learning occurs.

In this light, learning has both a conserving as well as a renewing character. On the one hand, learning may contribute to developing and maintaining the distinct and coherent identity of a learning entity. In face of short-term perturbations or long-term counter forces, such learning may enable an entity to maintain stable cognitive frames. On the other hand, learning also allows for continuous co-evolution with one's environment. Thus, learning entities may be viewed as continuously evolving disequilibrium systems, rather than as constantly threatened homeostatic ones. The above parallels among the four models and subsequent insights into learning dynamics provide a basis to further investigate the potential of learning as a viable perspective to develop sustainable NRM.

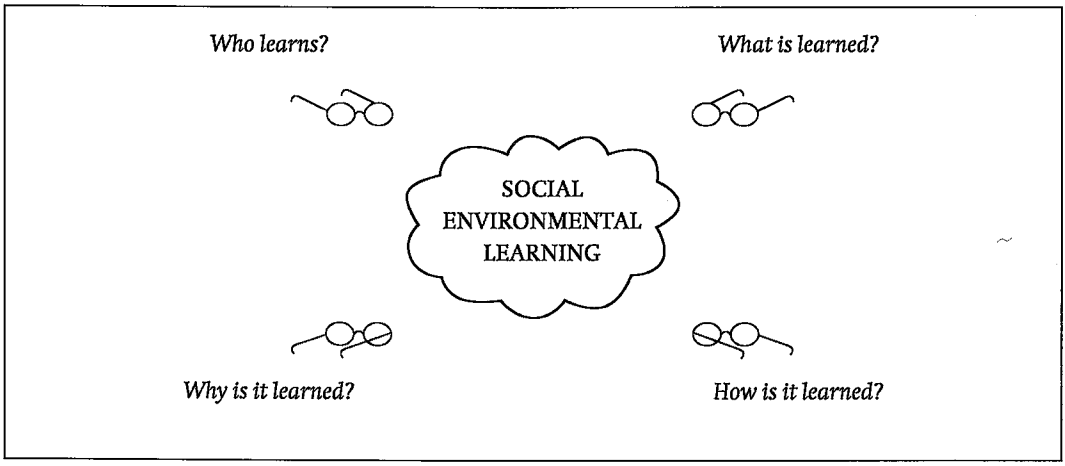
4.3 Capturing people's potential capacity for social-environmental learning

As already mentioned, people's potential learning capacity is fundamental to enabling entities to continuously modify understanding of NRM dynamics and, accordingly, adapt decisions and actions and the institutions governing those decisions and actions. But what does this learning capacity entail? A review of learning theory and NRM practice indicates that there are many different ways in which the learning dynamics discussed in the previous section may generate reflection and action about resources, stakeholders, mediating institutions and their interaction. Taken together, these different manifestations may be viewed as constituting people's potential capacity for social-environmental learning.

In order to capture different learning repertoires that constitute this capacity, four questions are posed, namely, *Who learns?; What is learned?; How does learning occur?; and Why does learning occur?*

In the following subsections, the characteristics of a social-environmental learning perspective and insights developed with regard to human learning in general, are linked in response to each of these questions. Different ways in which people may learn are highlighted. In the concluding subsection, the different learning repertoires are drawn together in an overview that captures people's potential for social-environmental learning. This overview may be used to map people's potential capacity for social-environmental learning.

Figure 4.2: Learning about social-environmental learning



4.3.1 Who learns?

In the previous section, both individuals and collectives are identified as being able to learn. A social-environmental learning perspective particularly focuses on learning by collective entities, that is, learning by interdependent individuals, formally or informally organized (Lee 1993; Parsons and Clark 1995; Woodhill 1999; Röling 1994; Gibbon et al 2003). Collective learning entities have been recognized at ecosystem, organizational, community, regional, national, and global levels. In Box 4.3, a number of these aggregate learning entities are illustrated.

Box 4.3: Collective learning entities in NRM

A sustainable agriculture watershed learning community (Fisk et al 1998)
Ohio's Darby Creeks are home to one of the most important assemblages of fish and mussels in America. As the use of watershed land is 80% agricultural, farmers play a critical role in the protection of this ecosystem. The Darby project provides support for an emergent learning community, an innovative farmer organization called the Operation Future Organization (OFA). In collaboration with the Nature Conservancy and the Ohio State University, the OFA promotes a production system that enhances protection of this

natural resource and net farm income. Desired outcomes of this effort include: a community of farmers connected by the Darby Creeks; increased capacity of individuals to create their destiny and sustain their community; and a clear example that control of agricultural non-point source pollution can be accomplished through a voluntary approach.

Groundwater-LIST: An international learning community on the internet
Through the initiative of Ken Bannister, a groundwater management consultant, an electronic discussion list has been established to discuss groundwater management issues. Professionals and students from all over the world share and develop insights with regard to groundwater modeling, education, and management experiences. Contributions vary from requests for information to more philosophical discussions. Participants vary from one-time questioners to long-term contributors to the discussion. An archive of exchanges can be found at http://www.groundwater.com.

In each of these examples, learning is anchored in a collective of individuals. Individuals are distinguishable as collectives in terms of their interdependent relationships. Interdependence may arise from mutual interests individuals have in NRM. In case of the example provided in Box 4.3, professionals and students from all over the world may share a desire to develop interests with regard to groundwater modeling, education and management. Interdependence can also arise as a result of the consequences for others of pursuing one's own interests, as illustrated in the case of the production practices of Darby Creeks' farmers that affect the wider natural and human community.

As discussed in Chapter 1 and Chapter 3, interests may be mutually intertwined in such a way that social dilemmas occur, creating persistent NRM bottlenecks. In addition, NRM related interdependence does not exist in a vacuum, but is embedded in wider societal dynamics in which people are interconnected through social, cultural, political and economic relations. For example, people living in the Darby Creeks' watershed may have a common interest in the shared ecosystem, but they may also be interconnected through their participation in the same church or soccer team, or by the fact that they own property in the same municipality. Such interconnections may influence the manner in which people experience being a collective entity, and subsequently, the manner in which people go about NRM.

Stakeholder analysis has been adopted from the business sector as a means to identify key actors or stakeholders in an NRM (sub-)system, and assess their respective interests in that system (Grimble & Wellard 1997; Ramirez 2001). Stakeholders may be distinguished in terms of different criteria that are linked to their different interests and capital configurations as discussed in the introductory chapter. Possible criteria are rights to exploit a natural resource, knowledge and skills to manage a resource, gains and losses incurred in the NRM process, historical and cultural relations with a resource, present or potential spillover effects of NRM, and interests varying from economic stakes to normative ones, among others (Borrini-Feyerabend 1996; Van Woerkum et al 1999).

Different boundaries of a collective NRM entity may be highlighted, depending on the criteria used for stakeholder analysis. Consequently, different learning entities and learning repertoires will become visible. Therefore, the effects of the criteria used should to be taken into

account when determining the boundaries of a learning NRM system. For example, the choice of criteria will have consequences for the choice of actors to be involved in social-environmental learning used in a collaborative management approach to facilitate sustainable NRM (Daniels & Walker 1996).

The fact that individuals and collectives have the ability to learn does not mean that they will actually do so. Individual or collective cognitive abilities, as well as physical and social contextual boundaries, co-determine the manner in which individuals draw on and develop their learning repertoires. People differ in their sensory, motivational, and conceptual abilities; and this results in different learning dynamics and outcomes. Phenomena such as groupthink may keep groups from thoroughly considering possible alternatives for action (Janis 1982). In the case of groupthink, high group cohesiveness, time pressure, high commitment to the group's success, and valued membership can bind members to group norms and decisions. Consequently, more eyes and brains will not see more and lead to better outcomes, but rather lock the group into a single solution. In addition, differences in the distribution of natural, physical, human, economic, cultural, and social capital may lead to differences in power structures and influence who learns. Power relations co-determine who has the means to access learning entities and be involved in learning. Often those in power positions will have a greater number of action possibilities and sense that situations can be influenced. By influencing situations, they will gain more insights about the relationships between themselves and their environment, possibly leading to an even greater number of action possibilities and more influence. It is partly such a locus of control that is aimed at when participatory methodologies speak of the need to empower stakeholders in NRM (Chambers & Jiggins 1987; Chambers et al 1989; Engel & Salomon 1997). The ability to translate complex situations into problem situations and possible solutions gives people the sense of control necessary to be able to take action (Garben & Seligman 1980). Knowledge and learning are essential to this process. Power relations may also play a role in negotiations of those deciding the criteria on which collective entities in NRM are identified (Groot & Maarleveld 2000). When maintenance or expansion of power dominates relations, the boundaries of learning entities may become rigid because stakeholders with deviating practices and insights are prohibited or ignored. Such impermeability may result in blinding insights or insensitivity to needs for change, reducing the entity's adaptive capacity.

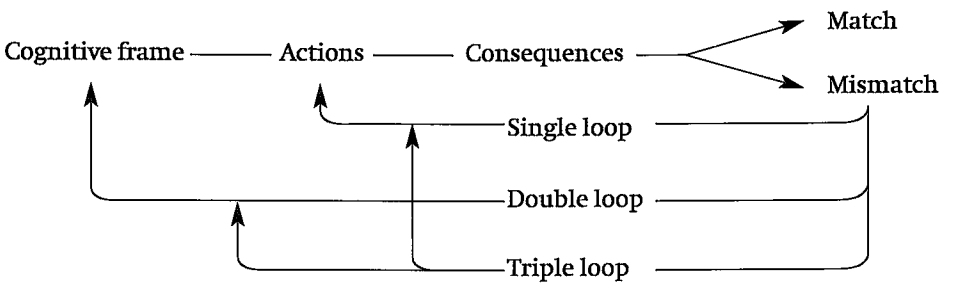
4.3.2 What is learned?

In addition to involving learning by collective entities, a social-environmental learning perspective is particularly concerned with collective problems arising in interactions within and between the natural and the human domain, and the collective action needed to cope with these problems. In identifying three levels of nested learning cycles, Argyris and Schön (1996) have developed a generic means to characterize what is learned in terms of the learning dynamics discussed in section 4.2. In Figure 4.3 the three different learning loops embedded in general learning dynamics are illustrated, namely, single, double, and triple loop learning.

Co-evolving with the environment, learning entities will seek or be sought to create coherence among perceptions, intentionality, and actions (Röling 2002, see also section 4.3.4). This human tendency to reduce discrepancies among perception, intentionality, and action may be illustrated by the behavior of the farmers using the rainfall simulator in the example in Box

4.2. After viewing the results of the Rainfall Simulator, the Australian farmer in the example takes action that is mutually consistent with his interpretation of the results and the outcomes he desires. Having experienced the same experiment, a second farmer chooses a different action, consistent with his interpretations of the results. This tendency has been substantiated by psychology theories such as cognitive dissonance theory (Festinger 1957; Cooper & Fazio 1984) and self-fulfilling prophecy theory (Snyder 1982, 1984; Snyder & Canton 1982). In addition, the general dynamics of complex adaptive systems also recognize this tendency towards coherence (Wheatly 1992; Holland 1995; Lissack & Roos 1999).

Figure 4.3: Single, double, and triple learning loops



The different levels of learning may be illustrated by a technical example of single, double and third order change (Van Nistelrooij 2000). The capacity of a car motor can be changed in different ways: giving gas (i.e., increasing fuel supply to the cylinders) or changing to a different gear. The gear frames the possibilities for speed, climbing, and acceleration. Giving or withholding gas entails first order change, i.e., change that occurs without changing the internal structure of the system. Changing gears changes the internal structure of the system, i.e., change that enables change of a repertoire of behaviors, or second order change. Third order change would be the ability of the system to understand first and second order changes in terms of learning processes involved, and consequently manage change processes in this light.

Adapted from http://www.well.com/user/philips/d-l.html

For both farmers, outcomes of earlier actions were apparently inconsistent with outcomes anticipated. When incoherence among actions, perception, reflection, and intentionality leads to readjusting actions in line with existing goals and intentions, Argyris and Schön (1996) speak of single loop learning (see Figure 4.3). Different practices and disciplines also recognize this type of learning but have labeled it differently, for example, goal-directed learning (Deutsch 1966), lower level learning (Fiol & Lyles 1984), instrumental learning (Eberg et al 1996), adaptive learning (Senge 1990), recurrent learning (Wildemeersch 1991), technical learning (Glasbergen 1996), functional learning (Adolfse & Van Woerkum 1997), problem-oriented learning and solution-oriented learning (Verbeeten 1999) or reproductive learning (Van der Veen 2000).

Single loop learning manifests itself in behavior to solve the problem at hand, for example improving a water model, strengthening policy implementation or decreasing environmental pollution. Such behavior is generated by 'how questions' such as how to improve performance and how to avoid failure. In Box 4.4 a manifestation of such learning in NRM is further illustrated.

Box 4.4: Single loop learning in NRM

Use of economic incentives to control environmental pollution (Anderson 2001. See also http://itdomino2.icfconsulting.com/EE/epa/eerm.nsf)
During the past twenty years, the Environmental Protection Agency, the federal government agency responsible for environmental affairs in the US, has gained experience with economic incentives as a means to protect the environment. Economic incentives have been used to impose liability for natural resource damages caused by oil and hazardous spills to encourage pollution prevention; to control the quantity of emissions and disposal of industrial effluents in water treatment plants by charging emission permit fees; to conserve habitats and control pollution by subsidizing farmers and others. An inventory indicates that economic rewards and punishments help to induce people to change their behavior in ways that reduce pollution and improve the environment. Studies also indicate that such change more often implies learning to optimize one's income than a structural recognition that environmental values themselves necessitate behavioral change.

When inconsistencies among perceptions, intentionality, and actions lead to the questioning of cognitive frames that shape these processes, it is possible to distinguish double loop learning (see Figure 4.3). This type of learning has also been referred to as higher level learning (Fiol & Lyles 1984), generative learning (Senge 1990), epistemic learning (Bawden undated in Woodhill 1999), reframing or frame reflection (Schön & Rein 1994), political learning (Eberg et al 1996), conceptual learning (Glasbergen 1996), substantial learning (Adolfse & Van Woerkum 1997), legitimacy learning (Verbeeten 1999), or communicative and transformative learning (Van der Veen 2000).

As discussed in the previous section, learning involves and is shaped by an entity's cognitive frame. Cognitive frames, individual or collective, make certain features and relations more salient in a world that would otherwise be overwhelmingly complex. In this sense such frames determine what individuals perceive as reality and, consequently, their problems, goals and expectations. A first learning loop may confirm existing cognitive frames or lead to improving performance in line with these frames, but may also lead to further dissonance. Double loop learning constitutes a second learning loop in which these underlying rationales and assumptions driving behavior are the subjects of consideration. As a result, cognitive frames may be reframed, entailing a fundamental shift in a learning entity's being (Rein & Schön 1994; Ayas & Foppen 1996).

Double loop learning is characterized by 'why questions' that probe the underlying assumptions embedded in cognitive frames and behavior. In affecting the cognitive frames that guide behavior, double loop learning may bring about structural changes in a learning entity and its interaction with the environment. Such reframing may occur in terms of changes in individual worldviews, the mission statement and values of an organization, or scientific paradigms. Examples of such double loop learning are provided in Box 4.5.

Box 4.5: Double loop learning in NRM

The changing role of the International Association of Hydrological Sciences (Rodda 2000)
As the oldest of the nonprofit making international non-governmental organizations dealing with hydrology and water resources, the International Association of Hydrological Sciences (IAHS) has contributed to the world of education and learning, and its related areas of economic activity, since it was established in 1922. During these 80 years the world at large has experienced many far-reaching changes, a considerable number impacting on the water environment and society generally. The introduction of principles such as sustainable management and integrated water management has altered IAHS' general mission, organization and activities more in line with these principles. These changes have not only affected the science of hydrology, but have also altered the structure of IAHS and how it functions.

Taking into account the role of religion in Bali water management (Lansing 1991)
On Bali, thousands of farmers are linked together in productive relationships that cover entire watersheds. In the name of the Goddess of the Crater Lake, a network of water temples once managed the flow of irrigation water. Based on a system of power relations so subtle as to be completely overlooked by colonial administrators, the practical role of the temples was unnoticed until the advent of the 'Green Revolution' of the 1970s. At that time, the water temples lost control of water management. Ecological crises occured and the bureaucratic model of irrigation control was too over-simplified to be able to deal with them. Development plans that assume agriculture to be a purely technical phenomenon threaten the ancient system of water temples. Using the techniques of ecological simulation modeling as well as cultural and historical analysis, Lansing argues that the material and the symbolic form a single complex.The temple rituals are not merely a symbolic system, but a key institution in the agricultural production process. Understanding of the role of this institution may help to realize a more sustainable water management.

Double loop learning may be further specified as triple loop learning or meta-learning when such learning specifically concerns the conditions that structure interaction patterns of single and double loop learning, i.e., learning to learn. When people learn how to learn, they begin to understand the process of learning itself and the behaviors and strategies that inhibit and facilitate it. Triple loop learning may be characterized by underlying 'why questions', such as why do we have the assumptions that underpin our behavior and mental models, and how do they influence our behavior? Examples of reframing of cognitive models that involves triple loop learning are provided in Box 4.6.

Box 4.6: Triple loop learning in NRM

Participatory approaches in government bureaucracies: Facilitating the process of institutional change (Thompson 1995)
A growing number of large government organizations are attempting to develop and integrate participatory research and development programs into policy development and implementation. Three large public agencies in Sri Lanka, Kenya, and the

Philippines have made significant progress toward building internal capacity to effectively employ participatory approaches and facilitate the process of institutional change. The training of personnel in participatory principles, concepts, and methods has played an important role in this process. Analysis of this learning process reveals that, to have a lasting impact, training must be viewed as part of a broader process of organizational learning. Ten key elements are proposed to facilitate such learning on an on-going basis.

Knowing and learning for change in agriculture in industrialized countries (Learn Group 2000)
Crises in farming, natural resource use, food systems, and rural livelihoods make particular demands on R&D professionals and policy makers. A much-needed response to these crises is to change practices associated with knowing and learning. To understand and improve learning processes, R&D professionals will have to become involved in the doing. They can no longer conduct their research outside or at the periphery of action, but must learn with practitioners while they take action. An important professional role is to make learning processes explicit and a learning resource for others.

Linked local learning: Learning about learning in decentralization of agricultural services in East Africa (Lightfoot et al 2001)
Many East African governments are in the process of decentralizing and privatizing agricultural services like extension, research, supply of inputs and credit provision. As stakeholders take on new responsibilities, their relationships change. Yet, there are no set guidelines to help people take on their new roles. Roles and partnerships need to be re-invented. In a linked local learning approach, stakeholders of different levels learn about each other's interests, perceptions, opportunities, and constraints with respect to agricultural development. This approach involves intensive interaction, dialogue, and negotiation, in which collective stakeholders' capacities to reinvent and innovate are facilitated. People are encouraged to build their skills to reinvent their own tools and operate them in their own setting. In addition, stakeholders are invited to articulate their own indicators to monitor performance and realization of learning expectations.

Although it might appear that the higher order learning loops are more important than the lower ones, this is certainly not the case (Groot & Maarleveld 2000). All three types of learning play an essential role in social-environmental learning, as different types of adaptations call for different learning loops. A bias for single loop learning may lead to a 'technical fix', treating the symptoms but not the root of the problem. Similarly, a bias for double or triple loop learning may lead to a 'process fix', a lot of thinking and talking about why the problem is occurring, saying that something should be done, without any action being taken to address the problem. For example, reframing water management in terms of integrated water management values, without bringing about institutional, organizational, and technical changes to realize it, may lead to a lot of discussion about the value of integrated water management without actually putting it into practice.

In addition, it needs to be emphasized that even though the different loops may contribute to a learning entity's adaptive capacity, learning might not always have this effect (Fishbein 1984). On the contrary, learning loops may decrease one's ability to adapt one's context. For

example, instead of developing a sense of efficacy, i.e., a sense that one's actions have intended effects (Kerr 1992; Kerr 1995), people may develop a sense of learned helplessness. Learned helplessness entails the feeling that whatever action one takes, one has no influence on the situation. Consequently, people learn to no longer articulate and act on their intentions and goals (Garben & Seligman 1980).

4.3.3 How does learning occur?

A social-environmental learning perspective tends to particularly focus on learning through interaction and dialogue (Lee 1993; Finger & Verlaan 1995; Röling & Wagemakers 1998; Woodhill 1999). In this light, such a perspective greatly relies on participatory approaches and methods that facilitate learning by direct experience to develop sustainable NRM (Korten 1984; Pretty et al 1995; Salomon & Engel 1997). However, interaction and dialogue may also be conductors for other modes of social-environmental learning. Different learning modes may be characterized in terms of the different processes that have been identified as shaping learning in the previous section, i.e., action, perception, and reflection. Three modes are highlighted, namely, direct experience, observation of others' experience, and abstraction. Although in a sense the most basic mode of human learning, experiential learning, has been overshadowed by learning through observation and abstraction. Since the Enlightenment, these modes have gained ground in scientific disciplines as an exclusive source of knowledge.

Focusing on direct personal experience as the central mode of human development, and thus learning, goes back to Dewey (1938), Lewin (1952), Piaget (1969), and has been much expanded by Kolb (1984). This learning mode is conceptualized in the experiential learning cycle illustrated in Figure 4.1b. Examples in Box 4.7 illustrate how direct experience may contribute to gaining an understanding of more complex, abstract phenomena such as water and soil run-off, computerized spatial information, and process management.

Box 4.7: Experiential learning in NRM

Learning to manage water and soil run-off in Queensland, Australia: How Wet (Hamilton 1995: 92)
How Wet is a decision support tool that aims to give farmers a better understanding of soil-water relationships from rainfall records. Computer software converts daily rainfall figures to stored soil moisture, evaporative loss, and run-off and soil loss. However, the 'black box' nature of the data conversion meant that farmers did not trust the outcomes. The process was altered so farmers went through the pen and paper process and learned to understand what happened to individual rainfall events, how much was stored on the surface and was lost to evaporation, and how much ran off. The insights created allowed farmers to access a range of scientific information, otherwise hidden in the black box of the software. After making their own calculations, farmers trusted the computer program and were willing to use it.

Bridging participation and GIS in joint learning for sustainable watershed management with the Ifugaos of the Philippines (Gonzalez 2000)

In spatially visualizing the consequences of human behavior, GIS has proven a valuable tool to improve sustainability of land and water management. However, this realization most often occurs in the domain of the experts developing and using GIS tools, with the result that the insights gained are not embedded in local management practices. A joint-learning approach directly involving local Ifugao stakeholders in developing GIS-based watershed management data has contributed to learning twofold. On the one hand, the process has improved and contributed to integrating quantitative and qualitative spatial information available at local level to international levels. On the other hand, anchoring the development of GIS and its outcomes in the experience of local stakeholders has created a tool for facilitating a dialogue of ideas about the space that the Ifugaos are managing with others. With GIS at their disposal, it has been possible to construct alternative perspectives about their environment (e.g., as map layers), and discuss or negotiate them (e.g., as screen displays, overlays, aggregation) to arrive at shared knowledge, and hopefully the wisdom to act accordingly.

Directing interactive policy making: Learning from a play producer (Ministerie van Verkeer & Waterstaat 1998)
Exploratory research indicated that play production processes exhibit a number of interesting commonalities with management of policy and implementation projects of the Dutch Ministry of Transportation and Water Management. Under the lead of a director of the Amsterdam Playhouse, nine employees of the ministry gained hands-on experience of the tricks of the play-directing trade. After an intensive study week that ended with a performance, participants identified key factors that positively affected the quality of their work process and the end result. These factors were then translated into practices to improve the quality of policy and implementation projects.

Human cognitive capacities also allow learning to take place by observing other people's behavior and the consequences it has for them. In this mode, the element of reflective observation or cognition is more dominant. Bandura (1977) has been a key figure in drawing attention to this human capacity for learning. In this learning mode, people's behavior is guided by anticipated consequences of behavior based on observing other people's experiences in similar situations. Such vicarious learning is a judgmental and constructed process. The individual must perceive the behavior and consequences, recall it, have the skills to translate memories into action, and be motivated to do so. Bandura actually labeled this type of learning as social learning. However, over the years the concept of social learning has broadened, as discussed in this thesis. For this reason, social learning, in Bandura's sense, is referred to as learning by observation. In Box 4.8 an example of learning by observation in NRM is given.

Box 4.8: Learning through observation in NRM

Field visits to learn about alternative irrigation designs and management in Senegal (Scheer 1996, Pradhan & Yoder 1989)
In order to learn about alternative irrigation designs and management, Aere Lao farmers visited their colleague Diomandou farmers. Visiting farmers were enthusiastic about the idea of excursion. Project managers encouraged both visiting and receiving parties to prepare what they wanted to get out of the visit. The visiting farmers grouped

their questions around different themes, varying from contact management between farmers and the irrigation scheme project development members, job possibilities, division of plots after construction, practices to improve farm production, and differences between their village irrigation system and the one the Diomandou used. The receiving farmers made preparations about how visitors were to be received, what route was to be followed when showing the visitors around in the irrigation scheme, and who would tell the visitors about the different levels in the scheme. The atmosphere between visiting and receiving farmers was open. The explanations the Diomandou farmers gave their colleagues proved to be an eye opener to project members present, in particular with regard to information about check structures used and attitudes toward design engineers. The project members felt it was knowledge that they would have never picked up otherwise and therefore would have been unable to pass on to other farmers. After the visit, the visiting farmers informed their villagers about what they had observed and the answers they had received to their questions. Their memory of things was remarkably good and precise.

People also have the capacity to learn through abstraction. Abstract conceptualization, which dominates in this learning mode, has its roots in people's ability to make sense of the world through symbolic representations. Since time immemorial, stories and myths have provided a means to pass on assumptions about relations between people and the environment, and their effects within and between generations. In scientific endeavors, researchers formulate general rules of behavior that go beyond what has been experienced or observed. Such rules may be formulated through extrapolation across different experiences and observations. In addition, imaginary or theoretical conditions can be taken as a point of departure for further abstract conceptualizations. In NRM, brainstorming sessions, scenario studies, vision development and story telling are used to stimulate stakeholders to draw on this mode of learning. Learning through abstraction is illustrated in Box 4.9.

Box 4.9: Learning through abstraction in NRM

Learning about river and floodplain management- Computer-based simulation tool for river management (Schmidt 1998)
This tool simulates floodplain management from the perspective of six fictive stakeholders, each with their specific objectives. The interactive tool allows participants to simulate the interaction of these stakeholders, the types of conflicts tha tmay occur, and the interactions between stakeholders' decisons and the resources system. The computer-based simulation tools calculate the effects of decisions taken on physical and socio-economic characteristics of the floodplain. This information is provided to participants for following rounds of decision making. After the simulation, participants can reflect on their individual and collective performance. Thus, participants may learn about the effects of their actions on the floodplain, as well as the position of different stakeholders in such a decision making process.

The three learning modes distinguished draw attention to the existence of two different flows of reasoning in learning dynamics: induction and deduction. Inductive reasoning goes from concrete to conceptual, as implications of tangible changes are generalized into broader conclusions and concepts. Deductive reasoning goes from conceptual to concrete, as broad changes in

concepts are worked through to tangible occurrences. Learning through direct experience relies mainly on inductive reasoning, while abstraction makes use of deductive reasoning. Observational learning leans on both.
In light of their different qualities, all three modes are necessary to grasp and bring about a variety of changes in NRM. However, it might not always be possible or desirable to facilitate learning through each of the three modes. For example, direct experience has as its starting point the actual concrete situation. One may question the desirability of having an actual global environmental crisis to learn how to prevent or manage it. Learning from small-scale crises, or even imagined ones, by observation or by abstraction could be a more environmentally sound use of human learning capacity. At the same time, learning through observation and abstraction also has its limitations. The cognitive processes people rely on in observation and abstraction are not foolproof. Human observation processes tend to fill in patterns where they do not always exist (Voss 1974; Kahneman et al 1982). For example, people may fill in linear cause and effect relationships, even when they are not present. Moreover, the logic of people's deductive and inductive reasoning is frame-dependent; and one person or group's reasoning may not be so logical when assessed in terms of other frames (Dörner 1996; Kahneman & Tversky 2000).

The different learning modes distinguished are often monopolized by different societal domains. Learning by doing is often ascribed to practice, while learning by observation and by abstraction are the dominant modes for scientific research. Accordingly, the possibility exists that knowledge gained through the latter learning modes is too far removed from every day practice, as the infamous ivory tower of academe testifies (see also section 3.4). Such disconnectedness may entail not only scientific endeavors that are cut loose from actual NRM practice, but also the inability of society to act upon relevant scientific insights.

4.3.4 Why does learning occur?

A social-environmental learning perspective tends to focus on ecological crises, small or large, potential or real, as a trigger for learning (Gunderson et al 1995; Röling & Jiggins 1996; Woodhill 1999). However, creativity may also be a trigger for learning (Heymann 1999). These triggers may have a natural-physical as well as a cognitive origin. Triggers may be further differentiated as occurring inside or outside the learning entity

Crises in the natural domain that affect the human domain are most easily identified as triggers for learning. For example, a flood in a river delta, such as the one in Zeeland in 1953, triggered Dutch water managers and engineers to figure out ways to cope with its consequences and to figure out ways to prevent floods from happening in the future. Besides crises in the natural domain, cognitive crises may trigger learning. For example, when people have opposing perspectives, cognitive crisis may occur. The degree of crisis may vary from individual cognitive dissonance, to a heated debate among parties with opposing views, to a violent conflict. Each may set off various learning repertoires in order to cope with conflicting perceptions and actions generated.

Learning literature points out how a desire to maintain the status quo may also trigger learning (Argyris & Schön 1996). This is in line with people's tendency to maintain coherence among perception, reflection, intentionality, and action. In this light, learning may be set off

by an individual's desire to maintain his/her distinctive identity in face of evolving conditions. Such a trigger for learning may also occur for collective entities such as organizations, regions and nations. Standardization through rules and regulations aiming to control and direct countries toward more environmentally sound practices are an example of the manner in which learning to maintain order might be triggered.

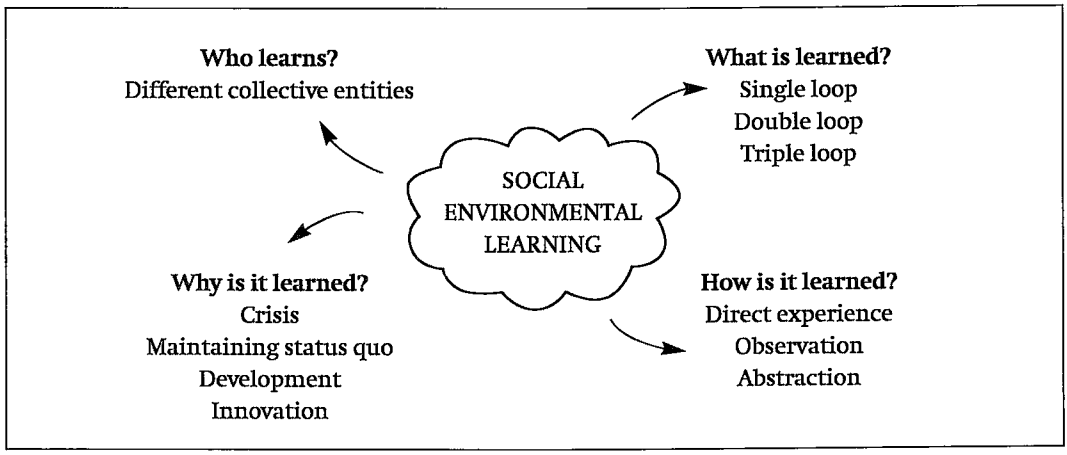
Natural and cognitive development processes, and their interaction, may trigger learning as the needs and abilities of an entity change as it matures over time. For example, in the natural system, stages of succession in ponds or other ecosystems trigger learning (Keeton 1980). People also go through recognizable developmental phases (Piaget 1969; Erikson 1963). Such developmental phases may trigger different types of learning (Ratering & Hafkamp 2000). Similarly, collectives of people, such as organizations, have been found to go through a number of development stages, where each stage is characterized by different physical and cognitive characteristics that may trigger learning processes (Katz & Kahn 1978; Cherrington 1994).

Innovation or renewal may also trigger learning. For example, some people have an explicit desire to look for new combinations and relations among cognitive frames, actions and outcomes. Curiosity and need of cognitions are examples of intrinsic, cognitive triggers of learning. People with a high need for cognition find learning inherently satisfactory and will look for new challenges (Cacioppo et al 1984; Cacioppo et al 1996). Aggregates of individuals may also have a high need for cognition, take for example a research institute. In such organizations, curiosity and the desire to undertake something different may be dominant shared values, leading to innovative insights and products.

4.3.5 People's potential capacity for social-environmental learning

In the previous subsections, characteristics of a social-environmental learning perspective and insights into human learning in general have been highlighted and linked in response to the four questions posed. As a result, generic clusters of learning manifestations have been generated. In Figure 4.4 the different clusters are summarized for each viewpoint focused on.

Figure 4.4: Learning about social-environmental learning: An overview of generic manifestations



Taken together, these different manifestations may be viewed as constituting people's potential capacity for social-environmental learning. Categories of the different clusters may be combined into different learning repertoires. For example, an individual (who) may learn about the dynamics of a natural resource at the single loop level (what) through direct experience triggered (how) by actions of individuals outside the NRM system to maintain the status quo (why). The same individual may also learn about the management of that resource at the double loop level through abstraction triggered by a conflict of his/her values. Moreover, such learning may also manifest itself for other collective NRM entities such as organizations, networks, regions, and ecosystem-bounded stakeholders. These learning repertoires, and the illustrations provided throughout the previous subsections, constitute but a fraction of people's potential for social-environmental learning. All in all, the overview allows an infinite number of combinations to be made and identified through which people are potentially able to adapt to and adapt NRM. As such, the overview provides a framework that may help to explicate people's diverse learning repertoires.

4.4 Towards linking social-environmental learning and NRM dynamics

In this chapter, the notion of learning has been looked at more closely. On the one hand, different conceptualizations of learning in people-environment interactions have been discussed. Various conceptions of learning reveal its cyclical dynamics, involving cognitive and behavioral processes that enable individuals at different levels of aggregation to adapt to and adapt their environment. On the other hand, the different learning repertoires that enable people to adapt to and adapt their environment have been discussed. Based on the characteristics of a social-environmental learning perspective and the insights developed with regard to human learning in general, an overview of people's learning repertoires has been generated. Taken together, these different manifestations may be viewed as constituting people's potential capacity for social-environmental learning.

Insights into learning dynamics, together with people's learning repertoires, provide further grounds on which to pursue social-environmental learning as a viable perspective for developing sustainable NRM (O1). Overall, it may be concluded that people do indeed have the capacity to learn to adapt to, and adapt, their environment individually and collectively. However, the discussions of repertoires involved indicate that, even though people have the capacity to learn, this does not mean they will do so and that their learning will necessarily entail sustainable NRM. People may also learn practices that trap them in social dilemma-like situations rather than help them to adapt (to) such situations.

In order to gain insight into the way in which social-environmental learning may be a viable perspective for developing sustainable NRM, relationships among people, their environment and, in particular, institutions need to be further addressed and understood. As discussed in the introductory chapter, institutions play a role in capturing the learning of collectives. The way in which this occurs, i.e., how such institutions frame the decisions and actions of people, and how such institutions may be adapted as a result of learning, may provide insights to identify and assess links between social-environmental learning and NRM dynamics. Taking into account the nature of learning dynamics and people's potential for social-environmental learning, the interaction among resources, stakeholders and institutions are further addressed in the next chapter. As feedback loops and cognitive frames play a crucial role in the mediating role of institutions, these are particularly investigated.

5 Learning to adapt to and adapt the institutional interface in NRM: Linking institutional and learning dynamics

As what we do in this world is determined by the way we see it; then, if we want to change the way we do things, we need to change the way we go about our seeing. (Bawden & Packham 1991)

Research objective addressed
O1: Explore foundations for social-environmental learning as a viable perspective for sustainable NRM

Abstract
As proposed in Chapter 1, institutions of various forms may be viewed as playing a mediating role in the interactions among people and their natural environment. This view is discussed in more detail in this chapter. More specifically, institutions are presented as being a similar regulatory interface in governing people's behavior as the (collective) cognitive frame highlighted in the learning dynamics discussed in Chapter 4. Accordingly, insight into the institutional interface and its constituent dynamics may provide a means to further identify and reflect on ways in which learning and NRM may be linked for sustainable NRM. The regulative capacity of institutions is discussed in terms of the dual dynamics of direct and indirect emergence. Parallels are drawn between such dynamics and the learning dynamics discussed in Chapter 4. A crucial condition for the emergence of learning as well as institutional interfaces is for feedback loops to occur among people, their environment and institutions. Insights from cognitive theories are drawn on to further understand how such dynamics and resulting institutional and cognitive frames emerge in the interaction among people, their environment, and institutions. In conclusion, insights gained are recapitulated in terms of possibilities to reframe institutional interfaces.

5.1 Introduction

Institutions, as defined in Chapter 1, are humanly devised constraints that structure human interaction. However, institutions are not only instruments of coercion and control, they are also indispensable components of order that provide us with security, certainty, and, above all,

meaning (Zijderveld 2000). If they function well, institutions constitute what the ancient Greeks called a nomos, a meaningful infrastructure that provides people with a sense of place in the world. Accordingly, institutions help to filter the way people see the world around them, their place in it and their action possibilities. In incorporating values, norms and meanings, institutions give content and direction to human actions and interactions (Zijderveld 2000).

As such, institutions may be seen as constituting the 'extelligence' of particular aggregates of individuals, a term coined by Stewart (1998) to parallel the concept of individual intelligence. But where intelligence is used as a measure of individual learning, extelligence comprises

> *'not just the span of an individual's life or of a generation of a society, but the learning embodied in individuals, groups, and societies that is cumulative through time and that is passed on intergenerationally by the culture of a society'* (North 1994: 360).

In this regard and in their mediating role in the interaction among people and their environment, the institutional interface in NRM dynamics may be viewed as entailing tangible collective manifestations of the cognitive frames in the learning dynamics discussed in Chapter 4. Similar to such cognitive frames, institutional interfaces embody beliefs, perception and appreciation. They are not free-floating, but are grounded in the cognitive frames of interacting individuals and collectives that sponsor them, and vice versa (Schön & Rein 1994). Understanding the manner in which such institutional interfaces develop, and the way individual and collective cognitive frames interact in the process, may provide further means to identify and reflect on ways in which learning and NRM dynamics may be linked for sustainable NRM, the second research question posed in this thesis.

During the past few decades, institutions and their role in structuring human behavior have increasingly received attention in both NRM practice and social and economic theory. This chapter discusses different insights that provide a theoretical basis to develop an analytical framework and propose analytical tools for identifying and assessing links between social-environmental learning and complex NRM (O2). In section 5.2, two processes that constitute the regulatory capacity of institutions are highlighted, namely direct and indirect emergence. The former helps to identify how the learning of adaptive entities contributes to the development of institutional frames. The latter helps to conceptualize how such frames in their turn may guide behavior and shape future learning. A crucial condition for the emergence of both learning and such institutional interfaces is for feedback loops to occur in the interaction among people, their environment and institutions. The nature of such feedback loops is further discussed in section 5.3. In section 5.4 insights from cognitive theories are drawn on to further understand how such dynamics and resulting institutional and cognitive frames emerge and interact in the interplay among people, their environment, and institutions. In conclusion, insights gained are recapitulated in terms of possibilities to reframe institutional interfaces for sustainable NRM.

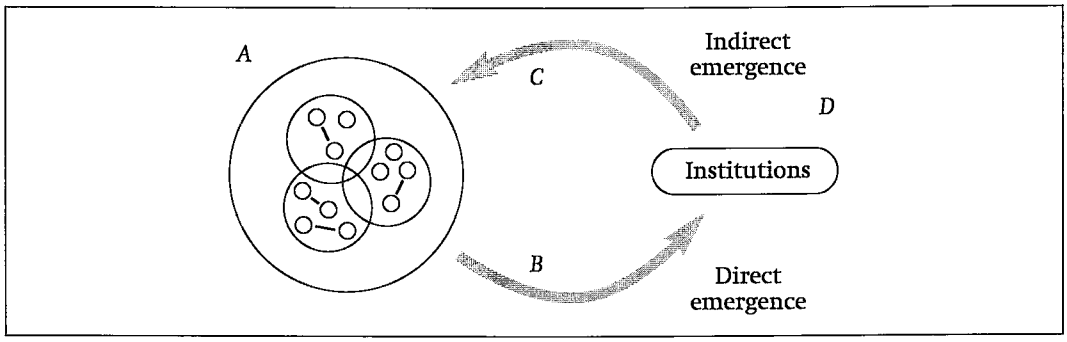
5.2 Institutions and learning in NRM

The reason and manner in which institutions evolve and structure human interactions are still being debated among different schools of political and legal theorists, sociologists, social

psychologists and economists (see among others Dworkin 1979; Giddens 1984; Long & Long 1992; Crawford & Ostrom 1995; Knight & Sened 1995; Zijderveld 2000; Cliteur & Loth 1992). Depending on one's world-view or disciplinary background, views of institutions will differ. Institutions may be viewed as being an effect of people's decisions and actions. This effect may come about spontaneously or deliberately, for example through contracts (Knight & Sened 1995). Institutions may also be viewed as a means to govern people's decisions and actions. In addition, when the existence of an institution becomes a pursuit in itself, institutions may be viewed as overly self-referential systems.

These different views of institutions highlight different aspects of the dual nature of institutional dynamics. Institutional dynamics may be characterized by two apparently opposing processes. On the one hand, institutions are viewed as emerging directly from interactions among people and their environment. On the other hand, institutions are claimed to structure interactions among people and their environment by shaping their decisions and interactions. Although somewhat contradictory in nature, both claims are valid derivatives of the mediating, structuring role that institutions may play in such interactions (Giddens 1984; Douglas 1986, 1992; Ostrom 1990; Ostrom et al 1994; Knight & Sened 1995; Clark 1997; Stacey et al 2000). This duality of institutional dynamics is visualized in Figure 5.1 and further discussed below in terms of the different possible views of institutions in NRM.

Figure 5.1: Dual dynamics in the emergence of self-regulation through institutions



Adapted from Mingers 1997, letters are used for reference in text.

To realize their intentions and goals to maintain and improve their livelihoods people, individually or collectively, interact with each other and the natural domain to transform resources (Figure 5.1, A, see also section 1.2). In this interaction, people tend to develop not only the desired goods and services, but also related values and norms to maintain this beneficial interaction. For when interaction has given rise to beneficial goods and services, there is an incentive to maintain these types of behavior patterns as they increase fitness (Axelrod 1984, 1997; Gambetta 1988; Putnam 1993; Ridley 1996, Ostrom 1998a, 1998b). For example, in their interaction to develop their watershed, the watershed community in Ohio discussed in Box 4.3 developed norms that control agricultural non-point source pollution. The process through which the interactions of individuals realize their goals and generate such patterns and effects may be referred to as agency or direct emergence (in Figure 5.1 B- right arrow, Giddens 1984; Clark 1997).

At the same time, individuals draw on institutional structures, i.e., existing patterns of behavior and related norms and values, to organize their decisions and actions (in Figure 5.1, C- left arrow). In such cases, behavioral patterns and underlying values and interests may constitute norms that stabilize across time and space scales beyond the interactions in which they emerged. In this light, institutions have been recognized as having a number of structural effects on people's decision and actions. For example, as discussed in Box 4.4, a system of economic incentives may influence people's decisions and actions towards control of environmental pollution. This process may be referred to as indirect emergence (Clark 1997).

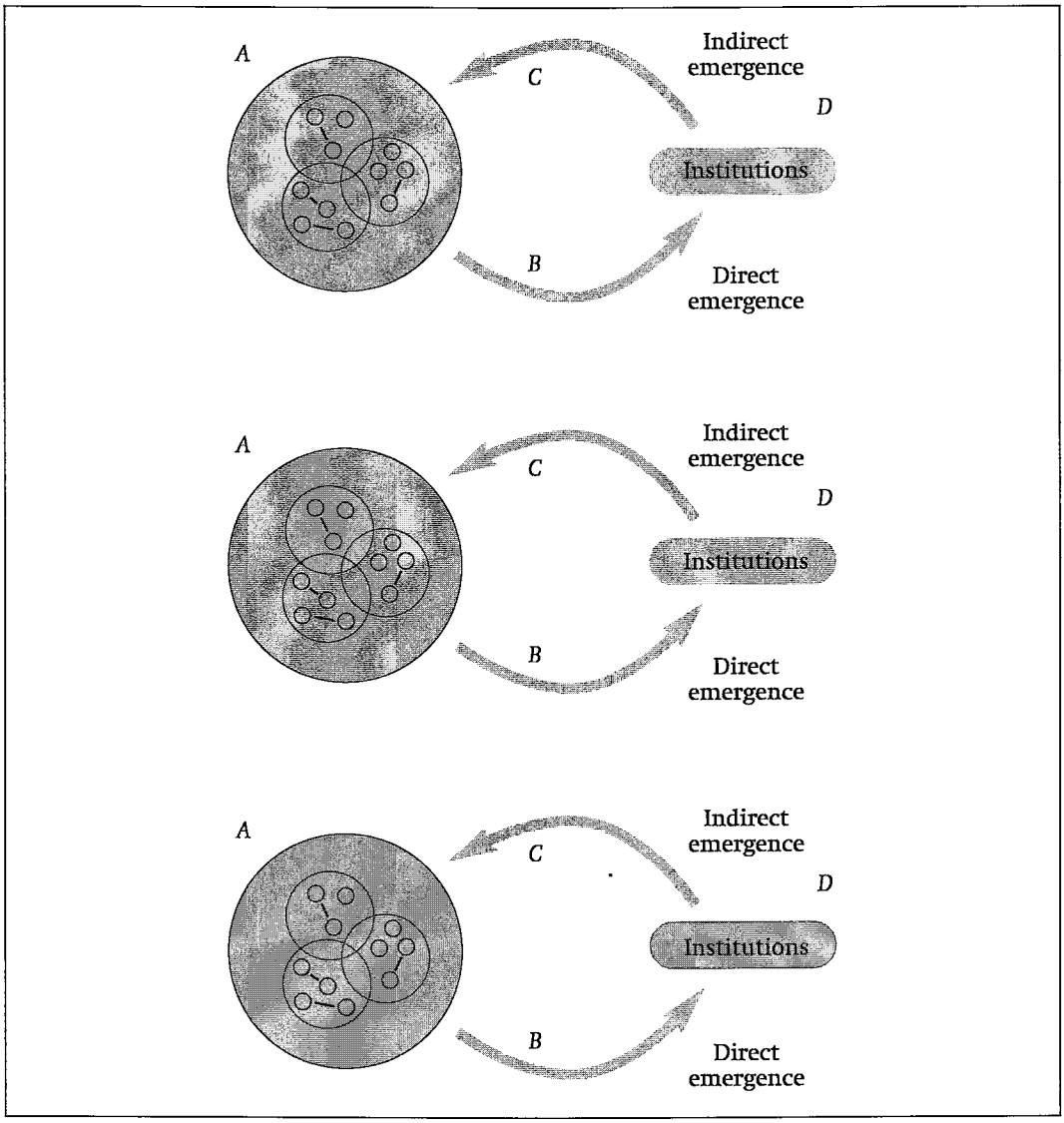
For institutions to be maintained, people must reiterate the behavior that has given rise to them. As such, institutions may be viewed as self-referential equilibria (Sened 1991; Douglas 1986). The notion of management myopia, discussed in section 3.3, indicates how this self-referential tendency of institutions may lead to management practices that no longer fit resources and resource use dynamics. When maintenance of an institution becomes separated from the motives and aims that led to its emergence, the institution becomes a goal in itself (Figure 5.1, D, Zijderveld 2000).

From a social-environmental learning perspective, both the static institutional interface and its constituent dual dynamics of direct and indirect emergence provide parallels to learning as characterized in Chapter 4. Similar to the collective and individual cognitive frames identified in learning dynamics, institutional frames play a pivotal role in a dialectical process. On the one hand, such frames are the result of sense-making and goal-seeking behavior of people as they interact with each other and their environment. In this process, people, individually and collectively, perceive, reflect and act, and share and create meaning, ideas, emotions, and contexts. On the other hand, such frames guide people in drawing on and developing diverse learning repertoires. Thus, individual and collective frames shape the manner in which intentionality is translated into action, and this in its turn contributes to realizing desired changes in one's environment and one's position in it.

The interaction among people, their environment, and institutions may be captured at different levels of interaction as illustrated in Figure 5.2. At a micro level (Figure 5.2 top), the focus is on the interaction between an individual person (dark gray) and his/her context (light gray). At a meso level (Figure 5.2 middle), the focus is on the interaction between a group of individuals (dark gray) and its context (light gray). At a macro level (Figure 5.2 bottom), the focus is on the totality of interaction and consequent properties.

In terms of learning and NRM, such different focus points draw attention to different observations and links between social-environmental learning and complex NRM dynamics, and the role of institutions therein. At the micro level, the learning entity is the individual. Accordingly, learning and institutional dynamics may be discussed in terms of the decisions and actions of the individual and the manner in which individual decisions and actions shape and are shaped by the individual's context, i.e., other stakeholders and the institutional interface. At the meso level, the learning entity is a collective, i.e., a group of individuals. Learning and institutional dynamics may be discussed in terms of how such a collective entity (see Box 4.3 for examples) influences, and is influenced by, other stakeholders and the institutional interface. At the macro level, the totality of interaction is the learning entity. Learning and institutional dynamics may be discussed in terms of the reflexivity of interacting stakeholders and institutions as a whole (Beck et al 1994).

Figure 5.2: Learning and institutions at micro level (top), meso level (middle), and macro level (bottom)



As discussed in Chapters 1 and 4, a social-environmental learning perspective focuses on the learning of collective entities. For this reason, later analysis will focus on the meso and macro levels of interaction (see also 6.2).

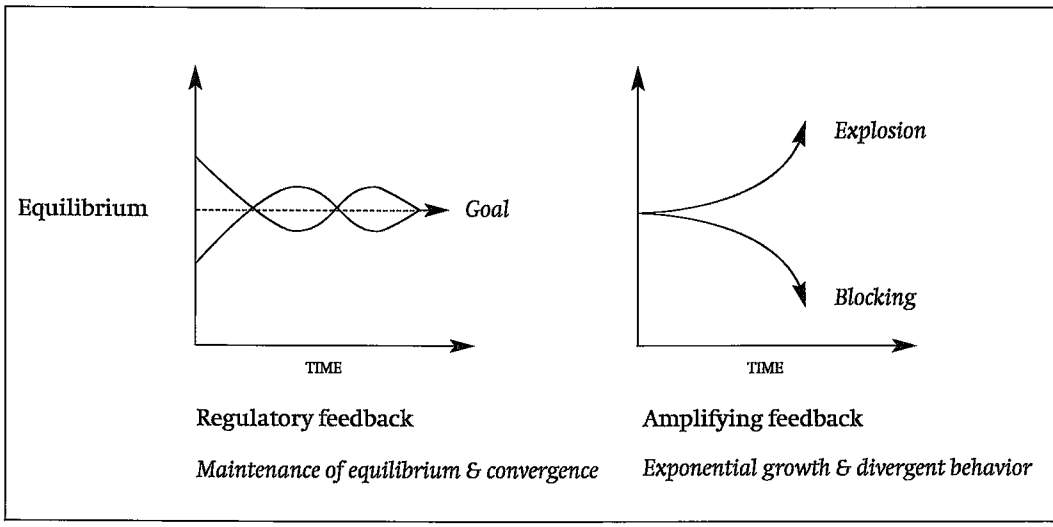
5.3 The role of regulatory and amplifying feedback loops

The interactions among people, resources and institutions constitute feedback loops and co-evolving learning dynamics. As discussed in Chapter 4, learning cycles may provide an entity with information regarding the way in which its behavior affects others in the situation, and

vice versa. Thus, an entity learns about its environment and its position in it. In this way, people gain insights and develop expectations concerning the possible outcomes of their own decisions and actions and the future behavior of others. Knowledge of the effects of one's own actions and the decisions of others is vital in the case of the social dilemma interdependence structures, discussed in section 3.2, which require the willingness of different parties to reciprocate behavior in order to realize optimal collective benefits (Ostrom 1998a, 1998b). Frequent interaction not only allows single loop learning to take place, but may also facilitate double loop learning. This is because repeatedly occurring mismatches between expected actions and outcomes and actual actions and outcomes may lead the stakeholders involved to question the values and norms that frame their decisions and actions.

In general, two types of feedback loop are distinguished: regulatory and amplifying (Gleitman 1986; Dörner 1996; http://pcp.lanl.gov/FEEDBACK.html). These two types of feedback loops are visualized in Figure 5.3.

Figure 5.3: Regulatory and amplifying feedback



Adapted from http://pcp.lanl.gov/FEEDBACK.html- Principia Cybernetica

A regulatory feedback loop reverses the action that produces it to reach or maintain equilibrium. Temperature control by a central heating system is a much-used illustration of this type of feedback. Whenever the temperature rises above a point set by a thermometer, or falls below it, the heating system will shut off or come into action until the temperature returns to the set point. Similarly, institutions can regulate the behavior of individuals around a policy goal. This type of feedback loop tends to perpetuate the status quo or equilibrium state of a system.

An amplifying feedback loop strengthens the action that produces it. In other words, these feedback loops generate a snowball effect. The result may be an ever increasing or decreasing level of activity. Examples are population growth, capital invested at compound interest, inflation, the Matthew effect ('s/he who has, shall be given'). Because of its exponential nature, this type of feedback loop tends to undermine the stability of an entity, through either an explosion or a blocking of all its functions as effects are amplified.

For quite some time, regulatory feedback has been thought to be good, while amplifying feedback has been considered to be a bad. In equilibrium-oriented schools of economics and social sciences, research has mainly focused on the workings and possibilities of regulatory feedback loops. Viewing the world, or parts of it such as a market, an organization or NRM, as a closed system has contributed to this bias toward the regulatory feedback loop. In such a view, stability is key to the survival of systems; and as regulatory feedback loops are instrumental in conserving and repairing the equilibrium of the system, such feedback loops need to be developed and maintained.

If amplifying feedback loops have received any attention, it has been to harness them as quickly as possible, to reduce their threat to destabilize the system. Although for analytical purposes viewing interactions within and between the natural and the human domain as a closed system has allowed us to gain an understanding of their static and dynamic qualities, it is more realistic to view most interacting entities as open. After all, system boundaries are in part imposed by the observer. In interacting natural and human domains everything is ultimately interconnected, and everything ultimately feeds back on itself (Miller 1975). Therefore, in an open system view, amplifying feedback loops may be seen in a different light.

In part thanks to the insights of complexity theory, the role of amplifying feedback loops has been increasingly recognized and used to understand phenomena so far inexplicable or deemed irrational in equilibrium-oriented schools of thought (see section 3.5; Wheatley 1992). In particular, the introduction of time into the study of thermodynamics has diverted interest from system structure to system dynamics and has expanded insight into how disequilibria and amplifying feedback loops contribute to the growth and adaptation of open systems (Prigogine & Stengers 1984; Wheatly 1992; Sherman & Schulz 1992; Holland 1995). Instead of leading to the inevitable deterioration of a system as discussed above, amplifying feedback loops that knock a system out of equilibrium may actually contribute to its ability to adapt in a dynamic environment. In magnifying effects of actions, amplifying feedback brings the system out of equilibrium. If the system has the capacity to respond however, such disequilibrium may actually lead to a reconfiguration of the system so that it can deal with the disturbance rather than be destroyed by it. Important in this role of amplifying feedback is the assumption that a single equilibrium state is neither the goal nor fate of entities (Wheatly 1992). Rather, entities actively exchange with their environment; and such an exchange may entail structural renewal of the entity that constitutes moving from one recognizable stable state to another. Thus, resilience or adaptability, rather than stability, is a distinguishing feature of complex, evolving entities.

In a similar way, an amplifying feedback loop may jumpstart cooperative social interaction, i.e., new structural relations within the system, required to realize a collective outcome necessary to overcome social dilemma situations. Evolutionary studies of early agricultural societies and trade expansion have shown how reciprocity, and individuals' reputations for being trustworthy to reciprocate behavior in social relations, generate patterns of behavior and related values and norms. These latter in turn may create structures such as collective facilities, management of common pool resources, guilds and trade markets that change the structure of social dilemma situations (Axelrod 1984, 1997; Cook & Levi 1990; Cosmides & Tooby 1992; Milgrom & Robert 1992; Greif 1995; Ridley 1996; Ostrom 1998b; Clark 1997). This research indicates that people have a predisposition for reciprocal behavior. Individuals tend

to react positively to the positive actions of others and negatively to negative actions. In other words, in their interactions people have a predisposition for generating amplifying feedback loops. This predisposition may prove vital when people desire individually beneficial outcomes that require collective action. However, a crucial condition for the emergence of institutions is that interactions occur repeatedly (Snidal 1985; Raub & Voss 1986; Sened 1991; Hoffman et al 1995; Ostrom 1998a, 1998b). It is through repeated interaction that patterns of behavior and related values and norms emerge. In other words, stakeholders will need to meet more than once, otherwise no feedback loop, amplifying or regulatory, can be established.

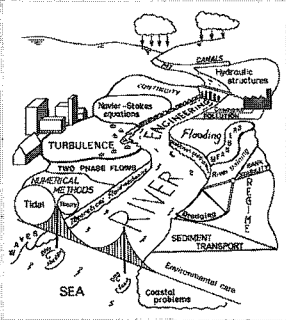
Both regulatory and amplifying feedback loops may also have their drawbacks. Regulatory feedback may lock people around a set point that is no longer feasible, as illustrated in the examples of myopic NRM discussed in section 3.3. Amplifying feedback may lead to polarization and bring a system so far out of equilibrium that resilient restructuration becomes impossible (Tainter 1988). Another thing to keep in mind when looking at institutional dynamics is that the nature of the cause-effect relationship of feedback loops is somewhat different than we are used to in many natural systems (Mingers 1997). Institutional feedback loops can be broken or be performed in right or wrong ways and still structure interaction, while physical-chemical interactions in the natural domain are determined. As such, approximate compliance is sufficient for an institutional feedback loop to be recognized and to function (Cleaver 1998; Cook & Levi 1990). This makes their predictability and change an entirely different ballgame. At the same time, such approximate compliance provides windows of opportunity to adapt institutions.

5.4 The role of cognition and language

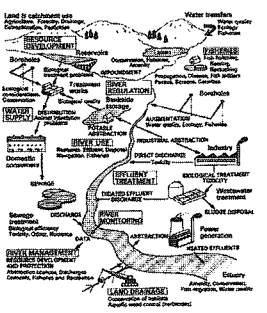
In the previous sections, some light has been shed on the generic, dynamic process that constitutes the mediating role of institutions in NRM. However, the manner in which institutions govern interactions between people and resources is dependent on the way people see the world. The manner in which people interpret and give meaning may be very different. Such differences in cognitive frames may consequently influence the way people perceive the world and action possibilities to tackle problems, as is illustrated in the three views of a river basin depicted in Box 5.1.

These views are the result of values, norms, and insights that constitute collectively shared frames in the different professional and knowledge disciplines involved. Each view highlights different aspects of the natural and human domains and their interaction in a river basin. People viewing a river basin through such a filter will see different problems and take different decisions and actions to tackle them. In this section, the focus is on gaining understanding of the manner in which individual and collective cognitive frames become tangible, meaningful infrastructure and how language plays a role in this process.

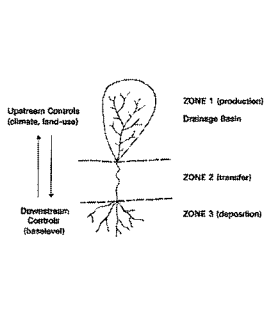
Box 5.1: A river basin from the perspective of an engineer, a hydrologist and a water manager



An engineer's perspective



A hydrologist's perspective



A water manager's perspective

The engineering view depicts the river basin as a set of hydraulic problems. Through careful planning, design and operation of waterworks, these problems may be resolved in line with people's needs such as irrigation, navigation, flood management and recreation. The hydrologist's view emphasizes transformations and controls in the river basin, paying particular attention to the relationships between surface and groundwater and natural processes such as sediment transport and deposition. Human activities tend to be viewed as threatening the natural functioning of the river basin. The water manager's view focuses on land and catchment use of the river basin, emphasizing in particular social and economic activities. These activities can call for multiple and contradictory water availability and quality.

Sources: Newson 1997; Ruijgh-van der Ploeg & Verhallen 1999

People's abilities to generate and share meaning through langauge contributes to their capacity to perform the simple and more complex behaviors involved with seemingly little effort (Clark 1997; Pinker 1997, 1994). Weick (1979, 1995) views such creation of shared meaning as the very act of organizing. Because this does not just concern the use of words in a discourse, but the structuring of our behavior, Maturana (Colloquium on Autopoiesis and Social Systems1998) refers to this working of language as languaging: coordination of coordinating behavior. In this light, language is not so much a tool to describe the world, as a tool to realize changes in one's environment. One way in which this application of language becomes tangible is in institutions. Institutions may be viewed as language constructs (Crawford & Ostrom 1995; Zijderveld 2000). Cooperation and coordination of action are a matter of language. As people develop a language around something, they create a shared community of meaning with privilege of access, common understanding, and mastery of others. As human affairs emerge and organize, language provides a means for developing and settling a system.

So how does it work? How do people's cognitive abilities, language and the way people interact play a role in the process of adapting to and adapting institutional interfaces and the consequent interaction of cognitive frames at individual and collective levels? A number of insights from cognitive sciences are discussed in order to shed light on the still somewhat black box of individual and collective cognitive frames and their interrelationship. First, a paradigmatic shift in cognitive sciences, in which perspectives on mind-body relationships have changed

from viewing the mind as a central information processor to embodied cognition, is further discussed. This shift has contributed to gaining more insight into the manner in which language and cognition emerge and structure people's perceptions and behavior. These insights are further discussed with regard to people's ability to adapt to and adapt institutions by connecting individual and collective cognitive frames.

A paradigmatic shift in cognitive sciences

For quite some time, Descartes' view of the mind as a ghost in the machine dominated developments in cognitive science. In this view, the mind is described in terms of a central problem-solving engine that directs the body in its interaction with the outside environment. Based on this view, communication sciences and artificial intelligence tend to portray the mind as a filing cabinet in which data are stored in different files to be retrieved when necessary. This conception of the mind as an information processor, however, ignores the fact that minds have evolved to make things happen (Clark 1997). In order to emphasize a more active and integral role of the mind in relation to the other parts of the body and its environment, the notion of embodied cognition has emerged.

The notion of embodied cognition represents a paradigmatic shift in cognitive sciences in thinking about the relationship among mind, body, and environment (Maturana & Varela 1987; Clark 1997; Varela et al 1997; Colloquium on Autopoiesis and Social Systems 1998). The connectionist view of cognition puts mind and body back together again. Mind and body are seen as working together to complete or transform patterns perceived in the outside world. The mind is no longer seen as the central center of control of an individual, but part of a network of organs that constitute an individual and enables him/her to make sense of the world and perform desired behavior. Embodied cognition in the connectionist view not only links body and mind, but also includes the dynamics and complex response loops that couple brains, bodies and environments. Accordingly, the adaptive success of an entity is as much constituted by the complex interactions among body, world, and mind as in the inner processes bounded by skin and skull (Clark 1997).

Language plays an important role in an embodied cognition perspective. It is viewed as a means to connect mind, body, and world as it contributes to guiding and shaping behavior. In this light, language is 'a tool for structuring and controlling action, not merely a medium of information transfer between agents' (Clark 1997: 195). People may use language to express individuality, but language also connects people with each other and unveils norms, life forms, soul, life. Thus, language enables people to express the dual dynamics in their existence, as highlighted in section 5.2.

Language label or cognition first?

Cognitive and language scientists, philosophers, and psychologists continue to investigate the manner in which language and cognition emerge and structure people's perceptions and behavior. Questions such as whether the individual abstract conception or the language label used to describe a phenomenon comes first divides parties in this discussion (Whorf 1956; Vygotsky 1978; Heymann 1999; Wittgenstein 1992; Clark 1997; Pinker 1994). On the one hand, people have the ability to develop language to give expression to their perceptions, cognitions, and feelings. People are able to synthesize abstractions into concepts and ascribe words to these concepts. For example, a professional of the engineering discipline exemplified in Box 5.1 may have learned to express a water management problem with the term 'Navier-Stokes

equations'. In communicating with each other, such personal coding of meaning in words is transformed into institutionalized codification. Thus, a label, such as 'Navier-Stokes equations' that at first has meaning for an individual, becomes widely shared by a collective to express and share a phenomenon. At the same time, language structures our perceptions, cognitions, and feelings. Existing words may trigger understanding of a concept in people. For example, a student of engineering will learn to understand concepts and the world as (s)he encounters the labels used to describe them in a course on hydraulic engineering. Thus, the use of existing labels and symbol structures also represents a trade-off between collectively achieved representations and otherwise possibly time-intensive and labor-intensive internal computations, minimizing the energy expended to transmit a shared context.

Both the constituent dual dynamics and the debate on the origin and functioning of language resemble the debate on the origin and functioning of institutions. In both, neither individual decisions and actions nor institutions are accorded priority or primacy, but both are mutually constituted in the recursive interaction among resources, stakeholders and institutions (Stacey 2001). As with institutional dynamics, it is often not so much a question of whether the process of direct or indirect emergence constitutes language and concept development (the proverbial chicken or egg question). It is the combination of these processes that constitutes people's cognizing and acting abilities. Both contribute to enabling people to link individual and collective cognitive frames when learning to adapt to and adapt institutional interfaces. Sharing meaning through language, and language constructs like institutions, allows second-order cognitive dynamics to be generated (Clark 1997). This type of dynamics refers to capacities to self-evaluate and self-criticize. In such cases, people are reflecting about their individual and collective cognitive profiles, or about specific thoughts and consequences of action. As such, language and language constructs play a role in bringing about learning.

A label is more than a thousands words...

When expressing meaning in terms of language, it is not only the meaning of the word used that may be expressed, but also all that is interwoven with that meaning. The different uses from which the meaning of a word emerges need not be consistent. In an information processing perspective, such phenomena are viewed as inconsistencies in the generic and consistent rules on the grammar of language. In line with an embodied cognition view, Nonaka & Yamanouchi (1989), however, see uses for this ambiguity of language in a complex world. Metaphors that are used in language may help to cope with ambiguity and to interpret large amounts of data. Thus, word choice may be viewed as an interpretative scheme to aid in the reduction of uncertainty; and, in carrying multiple meanings, language can help to open up new possibilities for change (Lissack & Roos 1999).

Possibilities and limits of oral and written communication

It is not only what people communicate, but also the way in which they communicate it, that influences the manner in which language plays a role in linking individual and collective cognitive frames and adapting to institutional frames. Van Woerkum (2002) reviews a number of differences between written and spoken communication. Spoken communication tends to make more use of stories, metaphors, or vivid examples. Oral communication mostly is much more redundant. Written communication allows for more differentiation between aspects of a subject and for more detailed information. It can convey complex data, in particular when visual aids are used such as maps, photographs and drawings. In spoken communication, people are exposed to direct feedback. Accordingly, people may react directly and can adapt

their messages. In written communication, such a possibility to monitor effects is less direct. Readers can scrutinize the text more carefully and can perceive contradictions more easily. However, if the writer is incomprehensible and thus excludes people from understanding his/her ideas, (s)he may never find out. Readers look more at the details, at words and syntax, whereas listeners are more occupied with the intentions of the sender and the gist of the story. Thus, spoken communication can be used to play with different perspectives, in which the intentions of the speaker and his general ideas count, not the details. The 'fuzziness' of speech and the opportunity to redress certain formulations directly are a big advantage for creative problem solving. This may be a valuable aspect when addressing complex issues in NRM.

Overall, language is a tool that may help us to make tangible the ideas and feelings that emerge and play a role in the goal-directed and sense-making behavior that constitutes the learning dynamics discussed in Chapter 4. Accordingly, individual cognitive frames, but also collectively shared ones, become manifest in the words and metaphors people use to convey meaning and direct action. In the words people speak and write, individual values, norms, and rules become explicit, as well as the collective ones that make up institutional interfaces. As people's concepts, ideas, and feelings change, either because of changes in the interaction between people and their environment or because of new labels learned, the labels people use may change accordingly.

5.5 Linking institutional and learning dynamics: Reframing of institutional interfaces

This chapter has discussed a number of theoretical concepts and insights that clarify the way people may adapt to and adapt institutions in NRM. First, the dual dynamics of institutions has been pointed out. On the one hand, institutions are the effect of people's actions and, on the other hand, institutions are collective frames governing people's decisions and actions. This dialectical nature enables people to create and share meaning, ideas, emotions, and contexts. The dynamics parallel the learning dynamics discussed in Chapter 4. Institutions may be viewed as the result of people's sense-making and goal-seeking behavior as they interact with each other and their environment. As people learn about the effects of their actions, they may adjust their actions and/or the way institutions are developed. Accordingly, an institutional interface may be reframed.

The role of two aspects that play an important part in institutional and learning dynamics has been further addressed, namely, the role of feedback loops and the role of language and cognition. Feedback loops may be distinguished in terms of being either regulatory or amplifying. Where earlier research findings tended to highlight the strength of regulatory feedback and the danger of amplifying feedback, this research points out the strengths and weaknesses of both. In order to learn to adapt to and adapt institutional interfaces, both types of feedback loops are necessary.

People's ability for language and cognition enables them to generate and share meaning through institutions. Where earlier research findings focused on people as information processors and, consequently, more linear processes in language and cognition, this research attempts to take into account an embodied view of cognition. This entails the acknowledge-

ment of dialectical processes in the development of language and cognition and their fuzzy nature. Doing so enables one to have a better understanding of more non-linear aspects in the development of institutions.

Interaction among people, their environment and institutions may be distinguished as occurring at three levels: between the individual and his/her context (micro level), a collective of individuals and its context (meso level) and the totality of interaction (macro level). In line with a social-environmental learning perspective's focus on the learning of collectives, the analytical framework developed in the following chapter will focus on the meso and macro levels. Insights have been gained with regard to the dual dynamics of institutions, the role of amplifying and regulatory feedback loops, and the role of language and cognition. These insights provide direction to further focus on the links between social-environmental learning and complex NRM dynamics in real-time, complex NRM (02) and to propose/select supporting analytical tools, and methodology.

PART III

ASSESSING SOCIAL-ENVIRONMENTAL LEARNING IN A COMPLEX NRM CASE

6 An analytical framework and methodology to identify and assess social-environmental learning in NRM

Research objective addressed
02: Identify and assess links between social-environmental learning and NRM dynamics in real-time, complex NRM

Abstract
A social-environmental learning perspective aims to draw on and further develop the learning capacity of people to develop sustainable NRM practices. This entails identifying and assessing multiple stakeholders across multiple scales and their ability for joint reflection and action as they interact and transform natural resources. Based on theoretical insights and concepts discussed in Chapter 5, an analytical framework and tools of analysis to identify and assess links between social-environmental learning and complex NRM dynamics are brought together. In order to assess the quality of learning repertoires drawn on and developed in NRM, earlier mentioned facilitation principles are operationalized into evaluative criteria. A learning history approach, developed in action learning science, is proposed as an approach for case study analysis. The manner in which the analytical framework, evaluative criteria, and methodology have been combined for the case study undertaken in Chapters 7 and 8 is discussed.

6.1 Introduction

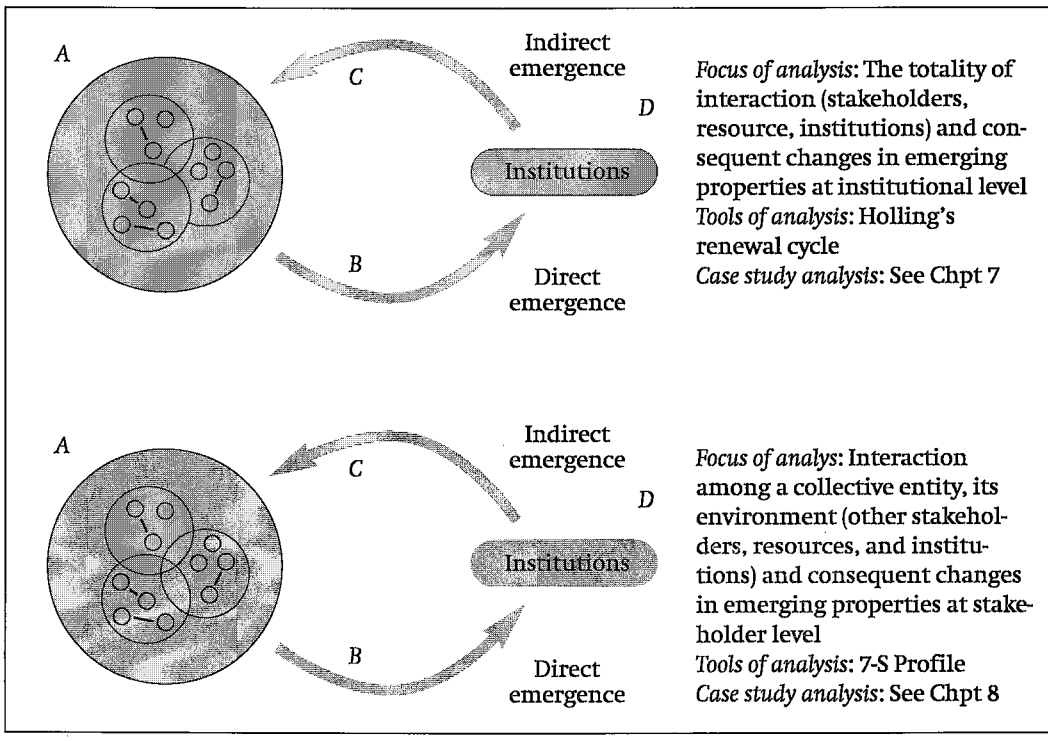
In order to identify and assess how learning and NRM dynamics are and may be linked to facilitate social-environmental learning for sustainable NRM in complex NRM contexts (O2), an analytical framework, a triad of evaluative social-environmental learning criteria, and a methodology are discussed in this chapter. In section 6.2, an analytical framework and supporting tools to identify and assess links between social-environmental learning and complex NRM dynamics are discussed, based on the theoretical insights and concepts discussed in Chapter 5. In order to assess the quality of learning repertoires drawn on and developed in NRM adaptations, earlier mentioned facilitation principles are operationalized into evaluative criteria. These principles, namely, systems thinking, experimentation, and communicative action, are discussed in section 6.3. A learning history approach is proposed in section 6.4

as a methodology for case study analysis. In conclusion, the manner in which the analytical framework, evaluative criteria, and methodology have been combined to gain further understanding of the linkages between NRM and learning dynamics in the case study undertaken in Chapter 7 and 8 is discussed.

6.2 An analytical framework to capture social-environmental learning in NRM

In Chapter 5, a number of theoretical concepts and insights linking institutional and learning dynamics were discussed. These insights and concepts provide a basis for bringing together an analytical framework and supporting tools to identify and assess links between social-environmental learning and complex NRM dynamics. This framework provides structure for the case study analysis of learning in a complex NRM case in terms of levels, focus, and tools of analysis. Figure 5.2 illustrates how the interaction among people, their environment, and institutions may be captured at different levels of analysis. As discussed in Chapter 4, a social-environmental perspective mainly focuses on the learning of collective entities. In line with this focus, the analytical framework used in the case study analysis will focus on the macro and meso levels. Each level of analysis has its specific focus and tools. These are illustrated in Figure 6.1.

Figure 6.1: Analytical framework for identifying and assessing links between social-environmental learning and NRM at macro level (top) and meso level (bottom)

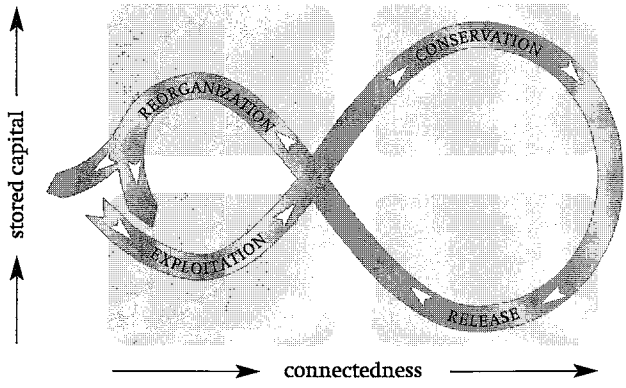


Macro level of analysis

At the macro level of analysis (Figure 6.1, top), the totality of interaction and consequent properties are the focus of analysis. Learning and institutional dynamics may be analyzed and discussed in terms of reflexivity of interacting stakeholders and institutions as a whole (Beck et al 1994). This entails analysis of interaction patterns among resource, stakeholders, and mediating institutions. Holling's ecosystem renewal cycle, with its roots in ecology, is proposed as a tool to capture structural shifts among interacting stakeholders, resources and institutions in NRM over time. The renewal cycle is first discussed in terms of its use in ecology. Subsequently, three features are discussed that make it an effective tool for capturing change and learning in NRM dynamics at this level of analysis.

In origin, Holling's ecosystem renewal cycle (see Figure 6.2) was developed to elucidate how ecosystems such as forests evolve through a succession of different stable states (Holling 1995). Four phases are distinguished, namely, exploitation, conservation, release and reorganization. In these phases, stored natural capital (Y-axis) and connectedness of this capital (X-axis) increase and/or decrease.

Figure 6.2: Holling's ecosystem renewal cycle (Holling 1995)



In the exploitation phase (Figure 6.2, lower left box) newly discovered niches are rapidly colonized. Natural capital and energy are readily available and easily transformed, with loose connections forming among entities. In terms of a forest ecosystem, open spaces offer different species easy access to energy and resources. In these gaps, microclimates are created in which early inhabitants rapidly reproduce and are loosely interdependent.

In the conservation phase (Figure 6.2, upper right box) nutrients and energy slowly accumulate in more tightly bound systems. Over time, the system becomes dominated by a number of larger entities and differentiated into a hierarchy of highly interdependent entities. Competition grows and efficiency becomes increasingly important. This tendency towards growing homogeneity and specialized adaptation, however, makes the system as a whole particularly brittle. In the forest ecosystem, colonizers of the open space will have become more interdependent as they have specialized. Under the shield of established, large trees, a smaller number of specialist organisms thrive. Together, niche specialists start to constitute a more stable and predicable ecosystem.

When flows of material and energy become increasingly intertwined, the system becomes susceptible to triggers that suddenly release the tightly bound biomass and nutrients (Figure 6.2, lower right box). For example, more specialized forests are more susceptible to insect attacks and diseases. Accordingly, earlier strengths of the system tend to become the breeding ground of release processes. Moreover, the build up of burnable materials in mature forests makes them more prone to fires. When highly developed structures disintegrate as a result of such release forces, smaller scale entities that have been able to develop under their umbrella become fully exposed to the variability of the environment. Capital and energy are no longer concentrated in dominating structures and specific entities, but become more scattered.

During the reorganization phase (Figure 6.2, upper left box) capital losses are minimized and reorganized for the next exploitation phase. Depending on the impact or strength of the release phase, an ecosystem is able to renew itself in a sustainable manner and develop a recognizable, coherent identity. With regard to the forest ecosystem, a new forest is waiting to bud in the aftermath of crisis, depending on its intensity. In ecology, this ability 'to absorb pertubations; the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables and processes that control behavior' (Holling 1995:29) is referred to as resilience.

A number of key features make this model an effective tool to capture NRM dynamics and provide a basis to identify and assess linkages between NRM and learning dynamics (Holling 1995; Hurst 1995). Three such features are discussed below, namely, the system and cyclical principles underlying the model; the possibilities for capturing the different types of capital flows that constitute NRM dynamics; and consideration of both regulatory and amplifying feedback loops. Together these features can provide linkages to identify and assess the different learning repertoires underlying NRM adaptations.

Holling's renewal cycle draws on system and cyclical principles to capture complex, natural system dynamics. These principles fit a social-environmental learning perspective. With regard to systems thinking principles, the model aims to develop a holistic view of ecosystems in which different levels and relationships may be distinguished as natural capital connects and breaks down into recognizable component entities. Moreover, the model provides a cyclical, continuous view of change. Traditional models of ecosystem dynamics usually only entail exploitation and conservation phases. This is similar to conventional life cycle models in business management that represent product life cycles. In adding the release and reorganization phases, the renewal cycle draws attention to the ability of a system to adapt in the aftermath of a crisis (Hurst 1995; Van Slobbe 2002). Thus, the renewal cycle provides possibilities for capturing both direct and indirect emergence processes and consequent adaptations of the collective cognitive frames that shape the system.

In origin, the renewal cycle focuses on natural capital build-up and connectedness. NRM dynamics, as discussed in the previous chapters, also involves other capital stock and flows. Financial, physical, human, and social capital also build up and break down when the natural and the human domain interact (see also section 1.2). Examples of these different capitals are formal laws and regulations (social capital), drinking water purification plants (physical capital), and management skills (human capital). Similar build-up and breakdown dynamics have been observed for these other types of capitals as they interconnect. For example, societal, eco-

nomic, and political systems show dynamics similar to the renewal cycle (Tainter 1988; Olson 1982; Arrow et al 1988). Accordingly, the renewal cycle may be used as a tool to capture these different capitals integrally as they intertwine in NRM, taking into account the role of different feedback loops and the use of language and cognition.

The renewal cycle also considers the role and effects of both regulatory and amplifying feedback loops in NRM. During the exploitation phase, new niches are developed as capitalizations of different resources receive a positive response, i.e., amplifying feedback loops. According as it becomes desirable to conserve obtained positions and behavior, regulatory feedback loops start to predominate, i.e., institutions standardize and control. Then at a number of points, regulatory feedback loops become overly self-referential and lock around equilibria that are no longer feasible. As such feedback loops break down, different amplifying feedback loops may gain weight in the possibility space created, and the process may start again as the system reorganizes and re-enters an exploitation phase.

Together, these features of the renewal cycle allow a variety of learning repertoires to be captured. For example, with regard to who learns, different system levels of entities may be identified as capital configurations change over time. With regard to what is learned, the natural and the human domain as well as their interaction can be taken into account. In addition, single, double, and triple loop learning may be captured as the model not only takes into account first order change (from the exploitation to the conservation phase), but also captures potential second and third order change (in the transition from the conservation to the release and reorganization phases). Dynamics of the former parallel dynamics of single loop learning (see section 4.3.2), improving till the system breaks down. Dynamics of the latter parallel dynamics of double and triple loop learning (see section 4.3.2), the ability to reconsider the variables and processes that drive behavior and constitute the system. With regard to triggers for learning, the different phases distinguished in the model are congruent with the triggers for learning distinguished in the learning framework.

The manner in which Holling's ecosystem renewal cycle may be used as a tool to analyze and assess learning in complex NRM is further discussed in section 6.5. A macro-level analysis of this type will be discussed in Chapter 7.

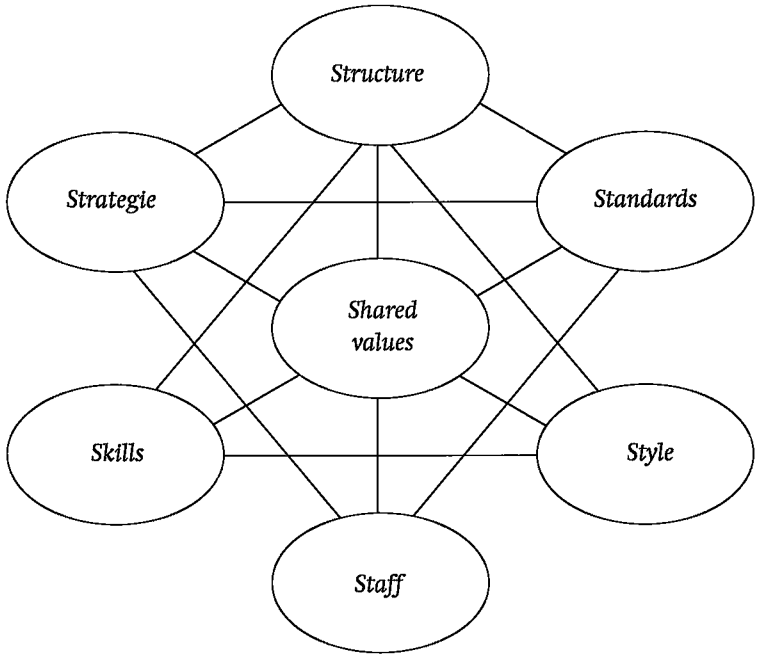
Meso level of analysis

At the meso level of analysis (Figure 6.1, bottom), the relationship between a collective entity (dark gray) and its context (light gray) is the focus of analysis. Learning and institutional dynamics may be analyzed and discussed in terms of how a collective entity (see for examples Box 4.3) influences and is influenced by other stakeholders and the institutional interface. This entails analyzing changes in collective stakeholders. The 7-S profile, developed in organizational management science and practice, is introduced as a tool to capture properties that interplay to constitute change in stakeholder collectives as they adapt to and adapt their environment.

In origin, the 7-S model, illustrated in Figure 6.3, was developed to identify a multiplicity of related factors that influence an organization's ability to change (Waterman et al 1980). At the time of its development, organizational management theory tended to focus mainly on structure and strategy as the crucial properties of an organization for bringing about organizational change. However, research and practice indicated that the majority of strategies and

changes in organizational structure did not bring about the desired effects. It transpired that other variables, which tended to be considered soft, informal, or not of interest to researchers and managers, also played a critical role in an organization's ability to change. The 7-S profile identifies and links seven properties. They include strategy and structure, but also staff, skills, standards, style, and shared values (the alliteration is meant to serve as a memory aid). These different properties may become manifest in the way people use language and communicate with each other.

Figure 6.3: Capturing institutional changes in terms of the 7-S profile



Adapted from Waterman et al 1980

- *Staff* refers to the people joined together in a collective, for example, a stakeholder in NRM. The concept of stakeholder has been explained in Chapter 1.

- *Skills* refers to the collective's dominating attributes or capabilities. These can be captured by asking what an organization does best. For example, a stakeholder may be characterized by certain crucial qualities such as the ability to exploit natural resources for human use, facilitate co-management of a resource, or the ability to model resource stock and flows.

- The constituent parts of a collective, and their interrelationships, may be captured in terms of *structure*. For an organization, its constituent parts are often visualized in an organogram. Similarly, the relations among the different stakeholders in NRM may be mapped. Examples of structures are hierarchies and networks.
- As already mentioned, *strategy* is traditionally focused on as a main driving force for change in organizational development. A strategy consists of planned actions in response to, or in anticipation of, changes in the external environment. Strategies may also be developed to

realize shared values. For example, a drinking water company may develop a business plan to improve the quality and services provided. Similarly, different stakeholders in a watershed might plan the direction of its development.

- *Standards* refers to the formal and informal procedures that regulate an organization's day-to-day operations. These formal and informal norms and regulations, or rules of the game, structure the actions of people within the organizations and with stakeholders outside it.

- *Style* may be captured by looking at the way people communicate and act. In other words, it entails looking not so much at what is said and done, but how. Accordingly, it may become evident, for example, that similar standards may have completely different effects depending on whether they are implemented top-down or more interactively.

- *Shared values* refers to the fundamental, guiding concepts and aspirations around which a collective entity evolves. In terms of complexity theory as discussed in 3.5, this parallels the attractors around which behavior revolves in complex adaptive systems. Such shared values may also guide decisions and actions of stakeholders in NRM. For example, since the Club of Rome report introduced the notion of sustainable development, different organizations around the world have adopted it as a shared value to guide the decisions and actions of its members.

The shape of the 7-S profile has been chosen to convey the idea that there is no starting point or hierarchy intended among its components. Each of the seven properties, individually or in combination, may be a driving force for change at a particular point in time. A change in strategy and structure may appear to happen quickly, while changes in major systems or shared values may take years. The profile also allows one to think about interactions and fit. The different properties may be viewed as compasses. Second or third order change has been found to occur when all the components in the profile are aligned. As such, the 7-S profile provides not only a means to further specify changes in a collective entity, but also a diagnostic tool that may help to identify which changes are still needed to achieve necessary or desired change. It may prove helpful to take this into account when facilitating social-environmental learning for sustainable NRM.

Linking a 7-S profile analysis with changes in stakeholder-environment interaction in terms of Holling's ecosystem renewal cycle provides a means to identify and analyze changes in a stakeholder over time. The manner in which the 7-S profile may be used as a tool to analyze and assess learning in complex NRM is further discussed in section 6.5. A meso-level analysis of this type will be discussed in Chapter 8.

In light of the above, the analytical framework may help to identify manifestations of social-environmental learning and the learning repertoires that contributed to their emergence. However, identification of social-environmental learning does not necessarily say anything about its quality and contribution to sustainable development of NRM. For this reason, the analytical framework is expanded with a triad of evaluative criteria that say something about the quality of the learning repertoires identified.

6.3 Assessing social-environmental learning: Facilitation principles as evaluative criteria

The NRM examples from across the globe provided in Chapter 4, and the many others that could be given, indicate that social-environmental learning in itself is nothing new. Whether one is looking at NRM from a social-learning perspective or not, some sort of learning is taking place. However, a social-environmental learning perspective specifically focuses on learning with the aim of drawing on and developing the learning capacity of resource users and managers to facilitate development of sustainable NRM practices. As such, the perspective aspires to generate actionable knowledge about how people develop knowledge about how people may collectively learn about the environment. In this light, a social-environmental learning perspective has a normative character. This normative side of a social-environmental learning perspective provides a basis to assess the relationship between institutional change in NRM and the quality of learning repertoires drawn on and developed. In Part II, triad of principles has been identified to facilitate social-environmental learning for sustainable NRM. In order to assess the quality of learning repertoires drawn on and developed, these facilitation principles are operationalized into evaluative criteria.

The principles that have been identified are systems thinking, experimentation, and communicative action. Each principle is further discussed and operationalized in terms of a number of indicators to assess the quality of social-environmental learning. An overview of indicators for each principle and the research and practice in which they have been developed is provided in Box 6.1. To illustrate assessment of learning repertoires, some of the learning examples provided in the boxes in Chapter 4 are evaluated.

Box 6.1: Indicators of social-environmental learning principles of systems thinking, experimentation, and communicative action

systems thinking indicators (March & Olson 1975; Senge 1990; Garvin 1993; Kim 1993; Weisbord 1998)
- Consideration of biophysical and human systems and their interaction
- Consideration of sub/supra-system on time/space scale in which learning entity is anchored
- Consideration of multiple perspectives/interdisciplinary approach

Experimentation indicators (Senge 1990; Garvin 1993; Ayas 1995)
- Completeness of learning cycles
- Diversity of learning repertoiresx
- Order of change

Communicative action indicators (Renn et al 1995; Habermas 1984; White 1994; Groot & Maarleveld 2000)
- Communicative action rationality
- Fairness
- Communicative competence

Systems thinking

Systems thinking provides a way in which to draw attention to the importance of understanding the system as whole; the different parts that make up the system; and how different levels interact and influence each other. Many participatory approaches to facilitating learning towards sustainable development of NRM focus on the local or grass root stakeholders, for example the linked local learning approach referred to in Box 6.2. However, interventions to facilitate learning at local level for sustainable NRM often have problems scaling up learning to other system levels (Van Schoubroeck 1999). Often this is because stakeholders on these other system levels are not included within the learning entity's boundaries. As systemic change occurs mostly when all parts of the system learn to understand how the system works, social-environmental learning for sustainable NRM will need to involve the whole range of stakeholders with their multiple perspectives (Weisbord 1998). System thinking provides a means to assess the boundaries of the learning entity. According to this notion, boundaries of an entity are not clearly and objectively definable but constructed on the basis of agreed upon goals, feedback loops, and goal seeking processes (Von Bertalanffy in Katz & Kahn 1978; Holling 1978; Checkland 1981; Maturana & Varela 1991; Röling 1992).

Different indicators may be used to identify and assess whether some form of systems thinking has been taken into account. These are consideration of biophysical and human systems and their interaction; consideration of sub and supra-system on time and space scale in which learning entity is anchored; and consideration of multiple perspectives/interdisciplinary approaches. With regard to consideration of biophysical and human systems and their interaction, a social-learning perspective proposes that a collective learning entity's boundaries encompass the natural and human systems, as well as their interaction, when facilitating development of sustainable NRM (Holling 1995; Lightfoot et al 2001). Because many NRM problems emerge at system levels other than the one where they originate, the quality of learning may also be assessed in terms of the degree to which learning repertoires take into account the sub and supra-systems in which a learning entity is nested. Such nestedness can occur in terms of time as well as in terms of spatial scales (Gunderson & Holling 2002). The involvement of multiple disciplines or an interdisciplinary approach may also be an indicator of systems thinking. When different disciplines are involved, the tendency exists for different parts and/or levels of a system to be taken into account.

Box 6.2: Assessing systems thinking in social-environmental learning: Consideration of sub and supra-system

When the linked local learning experience highlighted in Box 4.3 is assessed, it becomes clear that sub and supra-systems have been included in developing stakeholders' learning ability to decentralize agricultural services (Lightfoot et al 2001). The experience has involved at least three levels of learners, namely, stakeholders at local, district, and national level. The local level encompasses collectives from the myriad of farmer self-help groups, producer organizations like cooperatives and other community-based organizations. The district level includes district organizations, education centers, local non-governmental organizations and the private sector. At the national level representatives from a number of ministries, education (universities and colleges), national and international non-governmental organizations, private sector, and donor organization have been involved in the learning process. All in all, it has been attempted to develop a

learning coalition across different geographical and institutional system levels. As a result, the linked local learning approach has helped farmers, NGOs, government ministries and departments, and donors to deal with far-reaching changes imposed at district and village level by the decentralization policy. In addition, individuals have used skills and knowledge developed in other policy areas such as health and education.

Experimentation

In recognition of the uncertainties that play a role in understanding relationships in natural and human subsystems and their interplay, a social-environmental perspective calls for an experimental approach (Holling 1978, 1995; Lee 1993; Garvin 1993; Gunderson 1999). Treating types of resource use, policies, and management as experiments creates room for systemic learning, as insights evolve from experience and change. An experimental approach to NRM is explicit about expectations when designing management strategies and evaluation methods. Accordingly, information is collected to check assumptions with practice. Learning becomes manifest through correcting errors, improving understanding, and changing plans and actions. Moreover, in the experimental approach, diversity is a key notion. Uncertainty and complex dynamics make the achievement of a single preferred state problematic, making sensitivity to different types of developments and the ability to cope with them crucial (Aarts & Van Woerkum 2002).

Three indicators are distinguished in light of this principle, namely, completeness of learning cycle; diversity of learning repertoires; and order of change. Taking an experimental approach means undertaking a full learning cycle. In this way, the existing situation is reflected on, acted on and subsequent effects are taken into account. Thus, making the full learning cycle may be an indicator for quality of learning. The notion of experimentation also draws attention to how different problems call for different types of learning. Although capable of learning in potentially diverse ways, people tend to have or develop a disposition for certain ways of learning (Kolb 1984; Argyris & Schön 1996). This is not necessarily problematic. Evolutionary theory indicates how survival of a species is dependent on its ability to develop a functional role and behavior in its environment (Keeton 1980). However, limited learning repertoires might result in the development of rather destructive learning asymmetries. Blind spots for certain types of change, failure to grasp opportunities to bring about change and to generate different alternatives for action, may develop, thereby decreasing adaptiveness. Evolutionary theory has also shown how this endangers survival. After all, the greater the learning diversity of a species, the greater the flexibility of its adaptation (Fishbein 1984). Thus, diversity of learning repertoires may be used as a measure for quality of learning. Diversity of learning repertoires can be assessed using the overview presented in Figure 4.4. Asymmetries in terms of who learns, what is learned, how it is learned, and why it is learned can be identified when learning tends to predominantly rely on one of the categories highlighted. Using the full range of their learning potential also contributes to the adaptiveness of entities. Adaptiveness may be assessed in terms of the degree to which learning repertoires are drawn on and result in changes in the cognitive frames that govern people's actions. Learning may entail first order change, i.e., improving within existing frames, or second order change, i.e., doing things differently by changing these frames. In some cases, this may mean the difference between learning that addresses the symptoms of the NRM problem and learning that addresses its roots, which are often embedded in the cognitive frame that governs perceptions and actions that cause the problem.

Some examples of how these indicators elucidate diversity of learning repertoires or lack there-

of may indicate how experimentation stagnates and learning does not lead to sustainable NRM. In the discussion on 'how it is learned' in the previous section, consequences of limiting learning to stakeholders of established power structures, or monopolization of learning by observation and abstraction to the ivory tower of academe, were discussed. Similarly one-sided, single or double loop learning may have negative consequences such as a technical or process fix (see Chapter 4). On the other hand, some of the participatory approaches mentioned in section 3.4 specifically address creating space for contributions from people with different learning repertoires. Experiences such as the Ohio Darby Creek farmers (Box 4.3) and involving local people in GIS analysis (Box 4.7) show how this may lead to new understanding and action possibilities earlier not deemed possible.

Communicative action

A third principle often drawn on to create an enabling learning environment for sustainable NRM is communicative action (Renn et al 1995; Woodhill 1999; Groot & Maarleveld 2000). This principle, drawn from the philosophy of Habermas (1984; Brand 1990), highlights how people have the ability to identify problems and questions and to explore alternatives through dialogue and deliberation. Based on subsequent shared understanding, decisions and actions can be adjusted if necessary. A communicative action principle further implies that everyone who is affected by the issue addressed may participate in the dialogue and deliberation, and is competent to do so. All stakeholders must be able to make claims, challenge claims made by others, and influence choices regarding the manner in which claims are made, challenged and further pursued. Communicative action is not the only way to come to understanding and action, but it is a principle that often guides the facilitation of social-environmental learning for sustainable NRM.

Three indicators may identify whether this principle plays a role in social-environmental learning, namely, communicative action rationality; fairness; and communicative competence. People's action rationalities have been found to contribute to the nature of interaction between them. When interaction is based on communicative rationality, people interact with the intention of reaching mutual understanding and agreement through dialogue. The fairness indicator may be used to verify whether everyone who considers him/herself to be potentially affected by the results of learning has had equal opportunity to participate. Key to active and effective participation is communicative competence. This indicator may be used to assess whether every person participating is able to express him/herself coherently to others, is open to alternative definitions of reality, and is able to listen to other people's arguments with an open mind.

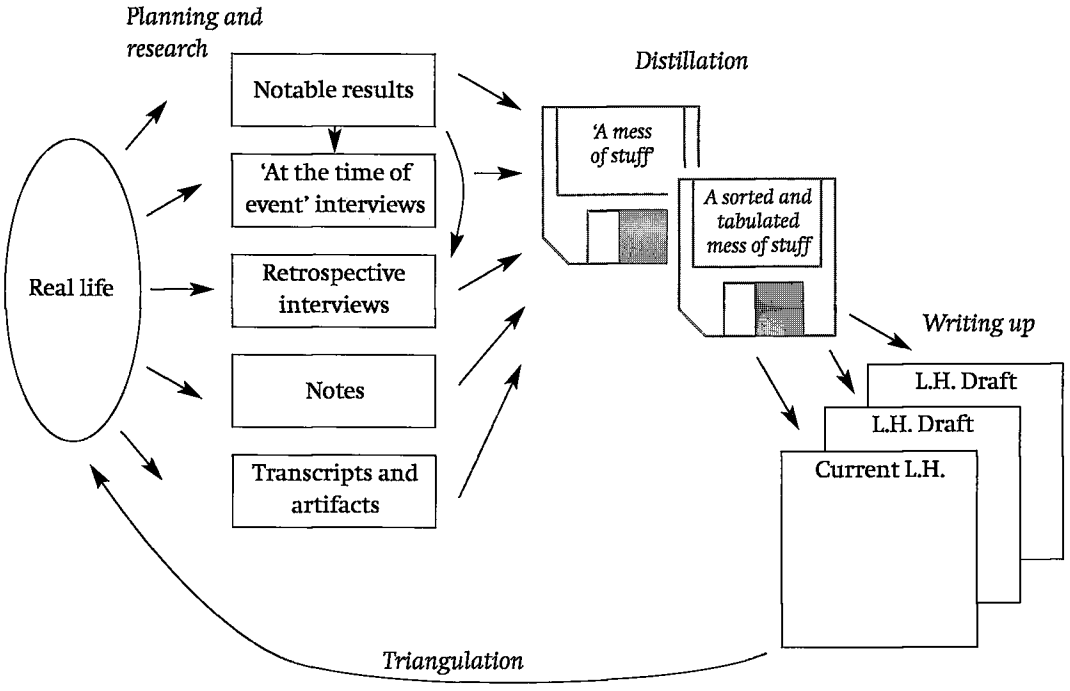
These indicators are not always easy to measure. In principle they require individual reflective interviews with those involved in the learning process. As this is not always feasible, institutions that directly or indirectly constitute learning environments may also be assessed in this regard.

6.4 Method of case study analysis and presentation: Learning history

A case study approach has been used to ground reflection with regard to linking social-environmental learning and NRM dynamics in a complex real-time context (see also Chapter 2). The case study analysis and presentation have drawn on a learning history method (Roth &

Kleiner 1995; http://www.learninghistories.com). As its name implies, a learning history particularly focuses on assessment of learning over time with the aim of elucidating and developing actionable knowledge, i.e., 'both the *know-how* and the *know-why* that guide people's actions so that they realize the results they set out to achieve' (http://learning.mit.edu/res/wp/18004.html: 4). The method is visualized in Figure 6.4.

Figure 6.4: The learning history process



Adapted from Roth & Kleiner 1995

Planning and research
In this phase, noticeable results that indicate changes in, for example, NRM dynamics are identified. To analyze linkages among these noticeable results and the change processes underlying these results, document analysis, reflective interviews, and participant observation need to be planned and undertaken with stakeholders. Techniques of ethnography and action research are used for this. This entails bringing to light not only what people do, but also the reasons why.

Distillation
In order to develop a coherent account for analysis, information gathered through participant observation, reflective interviews, site visits, and documents must be systematically distilled. In this case study, Holling's renewal cycle and the 7-S profile have been used as frames to distill patterns at the NRM and stakeholder level. This is further discussed in section 6.5.

Writing up the analysis: Multiple column format
A learning history approach makes use of a multiple column format. Such a format con-

tributes to conveying the complexity of the case and making transparent the reasoning underlying the analysis. For the presentation of the case study examined in this research, the emergence of groundwater management in Gelderland (GL), The Netherlands, a three-column format has been chosen. In the left-hand column, developments in groundwater management in GL are highlighted. The middle column shows developments in the context that has influenced the emergence of groundwater management in GL. In the right-hand column, the commentary indicates choices by identifying shifts in Holling's renewal cycle in terms of the groundwater resource transformed, stakeholders involved, mediating institutions and their interaction, as well as links to the analysis of underlying social-environmental learning. The three-column format used is illustrated in Table 6.1, which is an extract from the full learning history in Appendix 1.

Table 6.1: Illustration of a three-column format learning history

Groundwater management in GL, NL	*Context*	*Comments*
Subcycle Ia: Exploitation of the first drinking water companies (mid 19th century-1910s)		*NRM dynamics* *Exploitation-exploitation*
In Gelderland the first drinking water supply company was established in Nijmegen in 1879. Other municipalities in Gelderland soon followed suit. The high quality and easily available groundwater in the province was the main source of drinking water. By the early 1900s, about 22 municipal drinking water companies had been established in Gelderland	Engineers proved eager to develop drinking water companies and apply knowledge and experiences gained in Great Britain, France and Germany where drinking water companies had already been established (W7). The legislative frames provided by existing civil law (Burgerlijk Recht), Expropriation Act (Onteigeningswet), and Nuisance Act (Hinderwet) were used as a basis to establish	*Stakeholders involved in learning* • *Engineers* • *Municipalities* • *National government* • *Municipal drinking water companies* *Single loop learning-improving within existing frames*

The multiple column format requires a different kind of reader involvement. The reader will have to make choices about whether to follow a column to its end or wander to another. On the one hand, this may be experienced as somewhat irritating, as most readers are used to reading a page from top to bottom, from left to right. On the other hand, this type of involvement parallels the dynamics in the emergence of groundwater management in GL. Its development is characterized by events that occur concurrently at different levels of analysis. Sources of the learning history may be found in Appendix 2.

Triangulation

In order to validate choices in the distillation of information in terms of Holling's renewal cycle and the 7-S profile, theory, methodology, investigator, data and participant triangulation were undertaken. These triangulation methods have also been used for the research as a whole and have already been discussed in Chapter 2.

6.5 Combining method and frames of analysis for complex NRM case study analysis

In order to gain further understanding of the ways NRM and social-learning dynamics may be linked to the analytical framework, the evaluative social-environmental criteria and learning history methodology have been combined in a case study analysis. Three iterations of the learning history cycle have been undertaken. The specific research methods used for each iteration are summarized in Table 6.2. The overview of sources used for the learning history is attached in Appendix 2.

Table 6.2: Learning history cycle iterations and research methods used

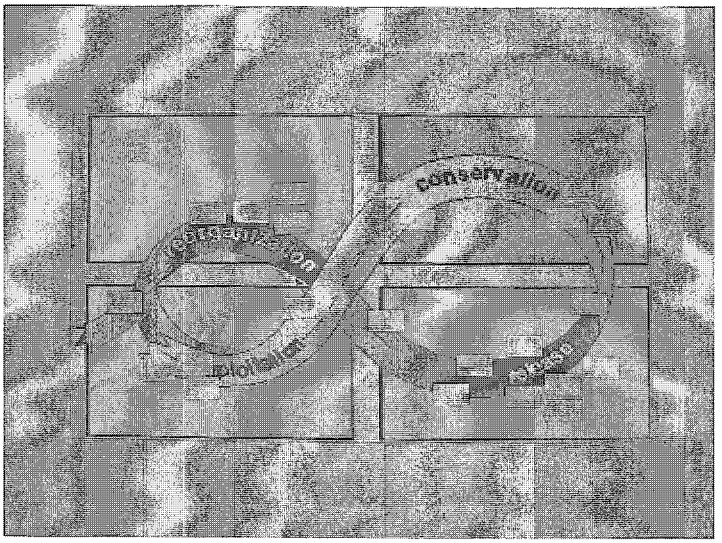
Learning history cycle iteration	*Research methods used*
First iteration: macro-level analysis	• Document analysis • Interviews • Water management and water board law training
Second iteration: macro-level analysis	• Document analysis • Interviews • Five month internship at Water Management Department, Province Gelderland
Third iteration: meso-level analysis	• Document analysis • Interviews • Five month internship at Water Management Department, Province Gelderland • Participatory observation at meetings

The learning history approach has structured the case study analysis. In different iterations, the learning history of the case study, development of groundwater management in Gelderland, The Netherlands, has been recounted and analyzed. During the distillation and write-up phase, the analytical framework, with Holling's ecosystem cycle and the 7-S profile as tools, has been used in structuring the information generated by the planning and research phases. The evaluative social-environmental criteria have been used to assess identified social-environmental learning in shifts in NRM. Throughout, insights gained have been validated by different types of triangulation.

First iteration of the learning history cycle - macro-level analysis
A pilot study of critical events and stakeholder analyses pointed toward the existence of a number of development phases in the emergence of groundwater management in Gelderland. Holling's ecosystem renewal cycle provided a frame in which to capture the noticeable results and underlying change processes in the interaction among resource, stakeholders and institutions in groundwater management dynamics. Information regarding who was involved in what, when, how and why has been entered into a database to allow systematic analysis. A metaplan or storyboard approach has been used to analyze database information. Holling's ecosystem cycle has provided the basic structure of the storyboard. Each item in the database,

varying from stakeholders to research studies undertaken, among others, has been assessed in terms of its nature and role in the emergence of groundwater dynamics. Accordingly, clusters became visible in terms of the different renewal cycles phases.

Example of metaplan analysis of the emergence of groundwater management in GL using Holling's renewal cycle.



To validate the shifts in groundwater management in Gelderland, identified in terms of Holling's renewal cycle and commentary analysis, different types of triangulation were undertaken. Results were crosschecked with different stakeholders and other histories of water management and societal developments in Gelderland and The Netherlands. During this assessment process, discrepancies in the story line of the learning history were encountered. For example, items that historically appeared to fit in the exploitation phase seemed to indicate release in terms of their role in breaking down capital and existing connections in the NRM system. In light of these discrepancies, the learning history cycle was repeated.

Second iteration of the learning history cycle - macro-level analysis
To fine-tune the learning history, and to identify and assess the social-environmental learning that underlies historical shifts, more detailed stakeholder, critical incident and institutional analyses were undertaken. Further iterations of the planning, research, distillation, write-up and validation phases indicated how previously recognized shifts were made up of renewal sub-cycles. This Droste-like effect fits the notion that NRM dynamics are constituted by interacting entities, each in its turn composed of subsystems and going through its own change processes. Thus, depending on time, space, or aggregate scale taken, different renewal cycles may become visible. Although more layers of cycles could be analyzed, the current analysis focuses on two such layers. The results of the macro-level analysis are discussed in Chapter 7 and the more detailed learning history is provided in Appendix 1.

Third iteration of the learning history cycle - meso-level analysis
The iterations discussed have provided input for the 7-S profile analysis of a key stakeholder,

the provincial water department. A third iteration of the learning history cycle specifically focused on this stakeholder and the manner in which it has influenced, and has been influenced by, its environment. Because the level of detail is increased, the time scale has been decreased in order to keep the research manageable. The focus on time scale is further justified in Chapter 8 in which the meso-level analysis is further discussed.

The iterations of the learning history cycle have generated the detailed overall learning history of the case study provided in Appendix 1. The learning history follows the three-column format as discussed in section 6.4. In addition, the learning history is divided into time phases that follow the phases distinguished in Holling's ecosystem renewal cycle discussed in section 6.2. In the column for comments, the choice of a certain phase is justified. In addition, learning is characterized in terms of the characteristics distinguished in the overview of learning repertoires discussed in Chapter 4 and the evaluative principles discussed in section 6.3. Thus, insights into the ways in which NRM and social-environmental learning dynamics may be linked are made clear for a specific case study. In order to make the case study chapters in which the macro and meso-level analyses are further discussed more readable, summary accounts of the learning history are provided in those chapters. In Chapter 7, these summary accounts provide a bird's eye view of macro-level developments in the case study. In Chapter 8, the summary account is elaborated with a meso-level analysis of changes for a specific stakeholder in terms of the 7-S profile properties discussed in section 6.2.

7 Cycles of change, cycles of learning: The emergence of groundwater management in Gelderland, The Netherlands

Research objective addressed
02: Identify and assess linkages between social-environmental learning and NRM dynamics in real-time, complex NRM

Abstract
To identify and reflect on ways social-environmental learning and NRM dynamics are and may be linked to facilitate such learning for sustainable NRM development, a case study analysis of a complex, evolving NRM system was undertaken. The case analyzed is the emergence of groundwater management in Gelderland, The Netherlands. The analytical framework, tools, and methodology discussed in Chapter 6 were used to capture and analyze structural changes and learning in the interaction among resource, stakeholders and institutions. In this chapter, focus is on the macro level of analysis. General, long-term structural changes in interactions among stakeholders, resource and institutions are discussed in terms of the phases distinguished in Holling's renewal cycle. To gain understanding of these structural changes and how learning plays a role in their occurrence, a social-environmental learning analysis and assessment of the more detailed learning history were undertaken. This analysis clarifies how nested renewal sub-cycle and learning repertoires underlie the structural changes found as groundwater management has emerged. The quality of these learning repertoires is assessed in terms of the evaluative social-environmental learning criteria discussed in the previous chapter. In conclusion, lessons learned with regard to facilitating social-environmental learning for sustainable NRM are discussed.

7.1 Introduction

In order to identify and reflect on ways social-environmental learning and NRM dynamics are and may be linked to facilitate such learning for sustainable NRM development, a case study

analysis of a complex, evolving NRM system was undertaken. The case study analyzed is the emergence of groundwater management in Gelderland (GL), The Netherlands. The motivations for this choice are discussed in Chapter 2. The learning history of the case study recounts the changing roles groundwater has played in natural and human activities in Gelderland from its inception in the mid 19th century until the late 1990s, when the case study analysis was undertaken. In its long history, the role of groundwater management in The Netherlands and in Gelderland was invisible until the middle of the 19th century. During this time, the management of groundwater in GL started to evolve from its first exploitation for collective drinking water provision into a complex system of different stakeholders with diverse interests involved in various activities today.

In this chapter, the findings of the macro-level analysis of the learning history are discussed. The analytical framework, tools and methodology discussed in Chapter 6, and a number of iterative cycles of analysis, have helped to reveal cyclical patterns in the NRM dynamics in this case. The analyses indicate how NRM and learning dynamics may be characterized by nested cycles of change and learning in which different capital resources, on different system levels and time scales, may build up and break down, interconnect and disconnect. The emergent patterns and changes have been found to be both the result and the trigger of learning as multiple stakeholders, directly or indirectly involved in the transformation of groundwater across multiple scales, draw on and develop their learning capacity. For that matter, the title of this chapter, cycles of change, cycles of learning, has not been chosen without reason.

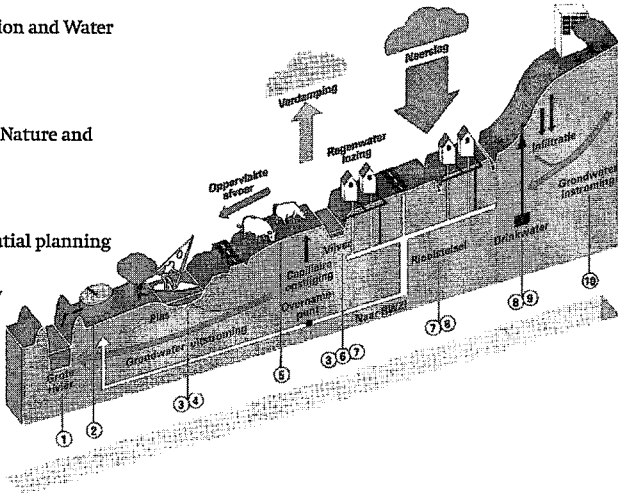
Before these macro-level changes are further discussed, some background information is provided regarding Dutch water resource dynamics and the province of Gelderland in section 7.2. In section 7.3, general, long-term, structural changes that have occurred in the emergence of groundwater management in GL as stakeholders, institutions and the groundwater resource interact are discussed in terms of Holling's renewal cycle. To gain understanding of these structural shifts and of how learning plays a role in their occurrence, a social-environmental learning analysis and assessment of the more detailed learning history is discussed in section 7.4. This analysis reveals how nested renewal sub-cycles and learning repertoires underlie the structural changes found as groundwater management emerged. The quality of the learning repertoires drawn on and their contribution to effecting changes in groundwater management are assessed in terms of the evaluative principles proposed in Chapter 6. In conclusion, implications for learning more about facilitating social-environmental learning for sustainable NRM are discussed.

7.2 Brief introduction of water management resources in The Netherlands and case study area

As a delta area, The Netherlands has a long tradition in water resource management (Van der Ven 1994). Some general background information concerning water resource dynamics in the Netherlands and the stakeholders involved in its management is provided in Box 7.1.

Box 7.1: Water resource dynamics in The Netherlands

1 Ministry of Transportation and Water
2 Waterboard
3 Waterboard
4 Recreationboard
5 Ministry of Agriculture, Nature and Fisheries
6 Fishing club
7 Municipality
8 Ministry of Housing, Spatial planning and Environment
9 Drinkingwater company
10 Province



The Netherlands lies on the deltas and floodplains of the Rhine, Meuse, Scheldt and part of the Eems. The groundwater regime in this area depends on groundwater recharge, seepage and abstraction. Recharge is primarily determined by climate, but also by aspects such as infiltration from large rivers, surface or shallow underground drainage and soil permeability. Only a small percentage of recharge comes from the large rivers, as their beds have poor permeability. The most important factor is precipitation excess, i.e., the difference between precipitation and evaporation. Much of the water that infiltrates into the ground directly or indirectly returns in surface water, via upward seepage, drainage and as a result of regional water management interventions to maintain agreed levels in watercourses and polders. In addition, abstraction of groundwater for drinking, industrial and agricultural purposes leads to water leaving the groundwater system and reappearing in the surface water.

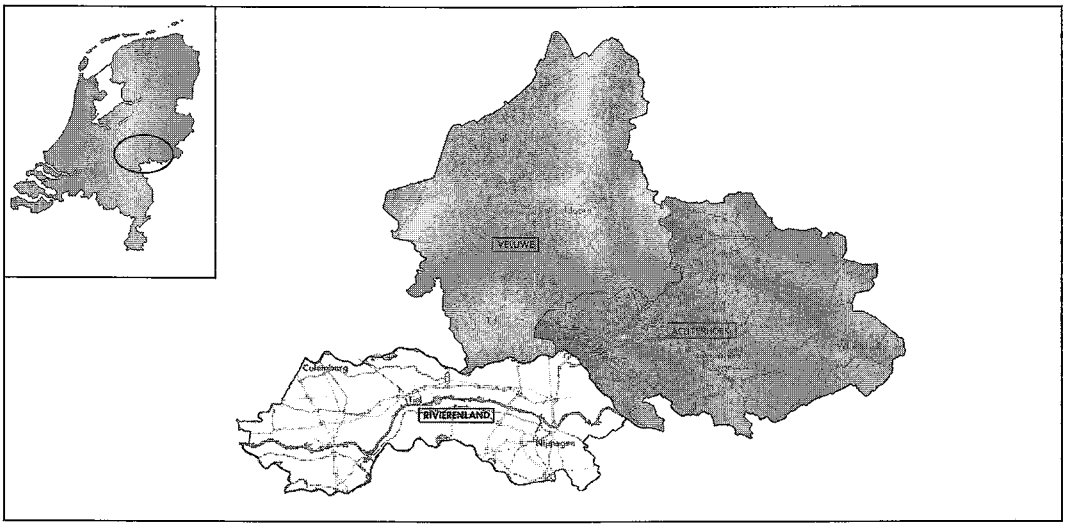
In The Netherlands, different stakeholders are currently involved in water management. The Ministry of Transport, Public Works and Water Management is responsible for making and enforcing legislation and policy relating to water control structures, groundwater and bodies of surface water. With regard to the latter, the ministry is also responsible for the operational management of bodies of water of national importance, such as the large rivers, the estuaries, coastal waters and the IJsselmeer. The Ministry of Housing, Spatial Planning and Environment has more recently been given responsibilities in water management, namely with regard to the quality of the aquatic environment (including groundwater quality) and for the supply of drinking water. The Ministry of Agriculture, Nature Management and Fisheries is concerned with water management aspects that are related to nature management and agriculture, such as the protection of soil, surface and groundwater, in particular pollution, e.g., from fertilizers and consequences of groundwater abstraction occurring in the agricultural sector. The provinces are responsible for strategic water management at regional level and operational groundwater management. Water supply companies are responsible for the

provision of quality drinking water for household and industrial use. Water boards implement operational management of surface water. Municipalities are responsible for the sewage system in their respective communities. Numerous interests groups, varying from the local angling club to national environmental organizations, are also involved in water management, depending on where their interests coincide with the hydrological cycle.

Source: Van Rooij 1997;Elshof 1997; Dufour 1999

The province of Gelderland is located in the eastern part of the Netherlands, bordering Germany (see Figure 7.1). Covering 5,143 km2, of which 4,988 km2 land and 149 km2 water surface, it is the largest province of the country. In 1999 the population was counted at 1.9 million with a density of 380 per square km (Gelders Jaarboek 2000).

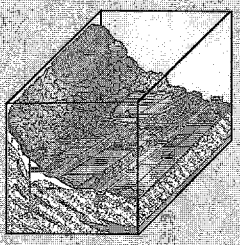
Figure 7.1: Map of Netherlands and province of Gelderland in which the groundwater management study took place.



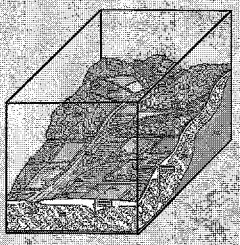
Sources: Province Gelderland 1991

In Gelderland, three areas are currently distinguished in terms of interrelated surface and groundwater resource systems: Veluwe, Achterhoek, and Rivierengebied (Province Gelderland 1991). These are further discussed and visualized in Box 7.2.

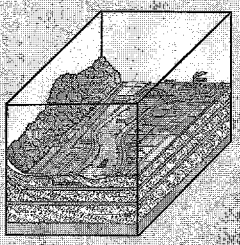
Box 7.2: Groundwater/surface water systems currently distinguished in Gelderland, NL



The Veluwe is characterized by a sandy plateau dominated by a large nucleus of dry land vegetation at higher elevation with wetland and aquatic vegetation at the lower edges. The high parts of the Veluwe form a large infiltration area with deep groundwater, which remains in the region for a relatively long time. At the edges, this groundwater percolates into brooks and springs.



The Achterhoek is characterized by surface water systems that mostly flow east/south-east to west/north-west and begin in Germany. The deeper groundwater also flows in this direction, but predominantly originates in the region itself. The shallow clay layer of the East-Netherlands plateau in the east of Achterhoek only accommodates shallow groundwater that is subject to rapid drainage. In this region, watercourses naturally run dry in summer. In the rest of the region, sand deposits produce local percolation and infiltration systems. Infiltrated rainwater percolates both at the edges of these systems and in areas further away. At the western side of the Achterhoek, groundwater from the Veluwe surfaces.



As the name suggest (probably even for those who do not know Dutch), Rivierengebied is characterized by a number of large rivers and their forelands. Both flooding and droughts occur easily. Via sandstrokes in the subsoil, percolation water from the large rivers surfaces in the area, and, in some locations, groundwater from the Veluwe. A part of this region's watershed lies in Germany.

Sources: Province Gelderland 1992

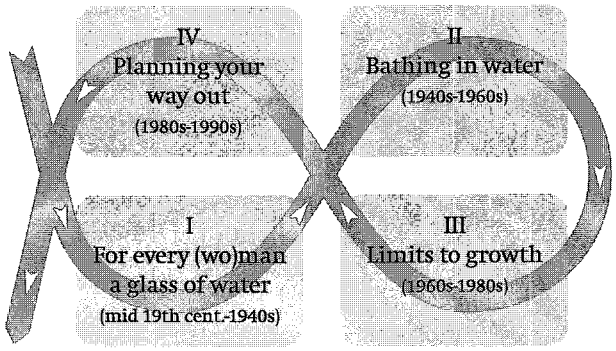
7.3 Macro-level structural changes in the emergence of groundwater management in GL

The learning history of the emergence of groundwater management in GL provided in Appendix 1 describes how different stakeholders, when realizing their goals and interests, adapt to and adapt institutions in their interaction with each other and the groundwater resource. In this section, macro-level structural changes that have taken place in groundwater management from its inception in the mid 19th century until the late 1990s, when the case study analysis was undertaken, are discussed in terms of Holling's renewal cycle dynamics.

The structural changes manifested themselves in the first iteration of the learning history methodology (see also section 6.5). Stakeholder, critical events and institutional analyses have generated clusters of change in the totality of interaction of resource, stakeholders, and the mediating institutions. Each cluster may be characterized by a predominant NRM dilemma

around which emerge insights and actions that have triggered changes in the groundwater resource, stakeholders and institutions. Together, they form the context from which new interaction patterns and mediating institutions emerge. This on-going dynamic matches the dual dynamics of direct and indirect emergence illustrated in Figure 5.1. The clusters have been found to fit the phases in Holling's ecosystem renewal cycle. The phases that have been distinguished are: I Exploitation phase: For every (wo)man a glass of drinking water (mid 19th century - 1940s), II Conservation phase: Bathing in water (1940s - 1960s), III Release phase: Limits to growth (1960s - 1980s), IV Reorganization phase: Planning a way out (1980s - 1990s), V Treading water or three strokes forward, two backward? (1990s - future). The different phases are visualized in terms of Holling's ecosystem renewal cycle in Figure 7.2.

Figure 7.2: The emergence of groundwater management in Gelderland, NL in terms of a long-term Holling renewal cycle



V Treading water or Three strokes forward, two backward? (1990s-future)

The discovery of the possibility of exploiting groundwater to provide clean drinking water characterizes the initial phase (Figure 7.2, lower left - I). Amplifying feedback loops predominate the interactions among stakeholders, the resource, and institutions that mediate the exploitation of groundwater, as drinking water companies mushroomed. In order to consolidate groundwater exploitation and the positions of stakeholders involved, stakeholders' decisions and actions started to generate regulatory feedback loops (Figure 7.2, upper right - II). Thus, this cluster of interactions may be characterized as the conservation phase. Then crisis after crisis occured. At a number of points, the institutions that contribute to maintaining existing regulatory feedback loops started to become overly self-referential and lock stakeholders around equilibria that are no longer feasible. This stage is characterized in terms of Holling's release phase (Figure 7.2, lower right - III). Then, institutions and behavior that generate these feedback loops start to break down and other institutions and stakeholder-resource interactions start to gain weight. This stage is characterized as moving towards the reorganization phase (Figure 7.2, upper left - IV). The future will tell whether such reorganization will have entailed improvement of the institutional interface or structural renewal (Figure 7.2, - V).

The different phases are each further analyzed in terms of changes in NRM dynamics and the groundwater resource transformed, stakeholders involved, mediating institutions and their interactions. These different aspects are summarized for each phase in Table 7.1. Each analysis includes a summary account of that phase of the detailed learning history (see Appendix I) on which these analyses are based.

Table 7.1: Summary table of shifts in NRM dynamics dilemmas, learning, groundwater resource, stakeholders, institutions and interaction patterns in the emergence of groundwater management of Gelderland, NL

	For every (wo)men a glass of drinking water (mid 19th century - 1940s)	*Bathing in water (1940s - 1960s)*	*Limits to growth (1960s - 1980s)*	*Planning our way out (1980s - 1990s)*
NRM dynamics phase	Exploitation	Conservation	Release	Reorganization
NRM dilemmas	Exploiting the resource	Maintaining & expanding position	Coping with pollution& scarcity	Integrating quantity and quality, surface & groundwater
Social-environmental learning	Learning to be effective	Learning to expand	Learning to be efficient	Learning to integrate
Resource	Pristine hidden resource	Abundant useful resource	Scarce, polluted resource	More resilient resource
Stakeholders	National government; Provincial government; Municipalities Engineers Drinking water companies National research committees	Sector ministries Drinking water network Sectors (agr., infra, indust) Waterboards	Provincial research committees Environmental groups Quality waterboards	Interdepartmental working groups Environment All-in waterboards
Institutions				
Shared values	Public hygiene	Reconstruction/economic development	Environmental hygiene Integrated water management	Sustainable development
Regulations	Existing civil law New health law Provincial permit system	Land consolidation Nat & prov water supply regulation Nat & prov spatial planning regulation	Soil protection Litigation Forced reorganizations	Integrated planning Interactive policy-making
Policy strategy	Adhoc	Expand Concentrate, rationalize and consolidate	Decentralization Policy analysis Pollution control	Co-management Area-oriented Action-oriented
Interaction patterns	Amplifying feedback	Regulatory feedback	Amplifying feedback	Regulatory feedback
	Hierarchical ← →			Network
	Sectoral ← →			Problem-oriented
	National/provincial centered ← →			Regional/European
	Formal ← →			Informal
	Control ← →			Facilitative
		Consultation Corporatist	Confrontational More democratic	Experimental Interactive

I Exploitation phase: For every (wo)man a glass of drinking water (mid 1800s - 1940s)

Exploiting the groundwater resource for human use is the main issue in the exploitation phase. Not previously used for human purposes on a large scale, the groundwater resource lies pristine, waiting to be discovered. The main stakeholders involved are the national, provincial, and municipal governments. The former creates the institutional context, in part based on existing legislation and in part on sparse new legislation. Moreover, national research committees investigate exploitation possibilities. Engineers and municipalities are involved in the actual development of drinking water companies. The latter, once developed, become stakeholders in their own right. The institutional interface is characterized by a newly emerging shared value - public hygiene. This value is integrated into new national legislation. Interaction in the development of drinking water companies is further regulated by existing civil law and a provincial permit system for establishing drinking water companies. Otherwise, there is no shared policy strategy. Where opportunities exist, drinking water companies emerge quickly.

Learning history summary
In the mid 19th century, epidemiological studies began to reveal that cholera epidemics result from using contaminated water for drinking, cooking, and cleaning. New national legislation delegated responsibility to municipalities to provide clean drinking water. Existing national legislation provided standards in terms of the procedures involved in establishing drinking water companies. Municipalities started to invest in the establishment of drinking water companies to provide clean drinking water for their citizens and guarantee public hygiene. In Gelderland, the first municipal drinking water company was established in 1879. The easy availability of groundwater made it the natural choice for drinking water provision in this province. Drinking water companies quickly mushroomed all over the province in order to provide every (wo)man a glass of clean, fresh drinking water. Drinking water companies therefore became the first stakeholders in Gelderland to exploit groundwater for large-scale production purposes. To counter uncontrolled growth of drinking water companies, a provincial regulation represented the first steps towards standardizing their establishment and expansion. Although the establishment of drinking water companies was a groundbreaking development, such companies were established in line with the structure and style of interactions of the time, traditional hierarchical and formal relations. National research began to highlight the lack of strategic planning with regard use of groundwater resources. A crisis outside the emerging groundwater system, WWII, interrupted plans to further develop groundwater management practices.

II Conservation phase: Bathing in water (1940s - 1960s)

Maintaining and expanding positions gained, both within the drinking water sector and in other sectors, are the main issues in the conservation phase. The post-war reconstruction spirit reinforces the desire to further consolidate and rationalize developments with regard to groundwater management initiated before the war. After the war, the role of national government in terms of sector ministries increases, each looking after its sectoral interests. Moreover, drinking water stakeholders also organize themselves in professional networks in order to bundle their capital. These developments are paralleled by a surge of legislation, both nationally and provincially, that aims to safeguard vested interests. Thus, different, collective-

ly shared institutional interfaces emerge. Decisions and actions that contribute to guaranteeing food production and economic development dominate. Thus, land consolidation influences water supply and spatial planning regulations. Within sectors, established stakeholders are consulted in the development of legislation.

Learning history summary
Recovery from the war strongly impacted the direction of change in this period. In the spirit of the reconstruction, activities that had been sidetracked, as well as new ones, were taken on with renewed energy. The financial capital impetus of the Marshall Plan helped on both accounts. Public hygiene as a shared value was complemented by reconstruction, economic development and self-sufficiency. Nationally, the drinking water sector established a network to professionalize, represent the sector's interests, undertake research and exchange relevant information. Strategic plans were developed to further expand, concentrate, rationalize and consolidate drinking water interests. The growth spurt of the 1950s entailed extensive land consolidation, growing industrialization, and urbanization that increasingly affected groundwater appropriation for drinking water and industrial purposes. Large-scale drainage interventions for agriculture and infrastructure projects were undertaken to keep groundwater from negatively affecting these activities. Consequently, these sectors were becoming stakeholders in the emergence of groundwater management in GL. In particular, the interests of the agricultural sector began to dominate land use development. In terms of water management, this meant that interventions were taken to improve production possibilities. To safeguard drinking water interests in groundwater resources, two national acts and provincial legislation were developed, while spatial legislation indirectly addressed the protection of groundwater quality. Regulations included a national subsidy and national legislation that regulated groundwater abstractions through a permit system and established sanitary criteria for the quality of drinking water supplied. National and provincial spatial planning measures were developed to protect groundwater extraction areas from pollution. Although stakeholders were increasingly connected in their use of, and effects on, groundwater resources, physical, human, financial and social capital tended to build up per sector. Within the different sectors, interdependence increased among public and private stakeholders, research and practice, with each sector developing its own system of norms and regulations. Across sectors, a similar focus and style of interactions prevailed, namely, improving groundwater resource exploitation in a manner much as before the wartime period.

III Release phase: Limits to growth (1970s - 1980s)

Groundwater pollution and scarcity become the dominating issue in the release phase, as providing households and industry with clean, fresh water, land consolidation, and infrastructure projects have an increasingly negatively effect on the groundwater resource. After efforts to contain conflicts of interests in the previous phase, provincial research committees, and the new voice of environmental groups, call for a new approach to management of water resources. The latter also bring in a more confrontational style. In response to crises previously acknowledged, but now widely visible, new notions about water management appear. Environmental hygiene and integrated management emerge as shared values. Although the necessity for such change is felt by various different stakeholders, actual change does not come about immediately. Changing both the resource practices and the institutional framework proves a lengthy process in which stakeholders do not easily agree to realign their inter-

ests and capital. In addition, different motives for bringing about changes interweave as both the state of resources and global economic crises trigger changes in policy strategies.

Learning history summary

Numerous crises, in which capital that had built up in the previous phases was broken down or started to lose ground, characterized this phase. Human activities started to increasingly threaten ecological goods and services generated by groundwater resources. Pollution, as well as scarcity and management deadlocks that had begun to surface in the first phase, re-emerged. This time, dilemmas interlocked and it became clear that limits to growth were coming into view. A wave of democratization ran across the country leading to changes in style and structures. In this turbulence, a new stakeholder, namely, environmental groups, gained ground, upsetting the balance of power in existing structures. Their presence and manner of communication started to stir up interaction patterns. In addition to being more confrontational, these groups introduced a less formal working style. Environmental groups, together with the outcomes of a number of research committees, started to give the environment a voice of its own. National and provincial legislation was also found to no longer meet the demands of the time. Existing legislation negatively affected drinking water and groundwater interests instead of safeguarding them; and although zoning measures had been taken to fight pollution, old inheritances of point pollution and on-going diffuse pollution continued to threaten groundwater resources. Revising legislation proved no easy matter. Sector ministries and networks struggled to align their competencies. In Gelderland, the amalgamation and standardization of drinking water companies proved a hard nut to crack. A number of extremely dry summers in the mid nineteen seventies further depleted groundwater resources, with implications for those dependent on them. This led to some paradoxical decision making. For example, after the groundwater tables for agricultural land were lowered so that heavy production machinery could be used, increased sprinkling measures had to be taken to ensure irrigation of that very same ground. As the oil crisis hit the globe in the seventies, capital started to break down across sectors. This put pressure on public budgets. Decentralization was adopted as a strategy to accommodate public deficits. As a second global oil crisis occurred in the nineteen eighties, the newly emerging, environmental shared values gained ground. In preparation for a second national water management strategy, policy analysis was undertaken as a means to cope with changing insights and values and the increased complexity of society. In Gelderland, provincial civil servants were feeling the need for a strategic frame to guide the issuing of permits for groundwater extractions. In the wake of the cumulative wave of crises, the notion of integrated water management was developed to balance the different and growing demands on (ground)water resources and their spillover effects. With this concept, researchers and policy makers aimed to clarify again the connections between surface and groundwater management, both quantitative and qualitative. Accordingly, a more integrated approach to water management was called for. Translating the concept into policy and action, however, proved a bridge too far.

IV Reorganization phase: Planning our way out (1980s - 1990s)

Although it had proven difficult in the release phase, integrating different aspects of water management that have become separated over the years is the main issue of the reorganization phase. Existing stakeholders organize into different types of collectives in order to bridge existing gaps and barriers between different, sectorally shared institutional frames and

actions. The complexity of the problems faced increasingly becomes the basis for involving stakeholders. Legislation and the policy-making process change. Instead of having control-oriented institutional interfaces and dynamics, the emphasis is now more on condition creation. Covenants, water agreements, general rules and interactive policy making are some examples of more flexible regulations and policy-making work forms. Overall, the language used to communicate becomes more informal and visual, as can be observed at meetings and in policy document titles and contents. For example, catchy, metaphoric titles have replaced the more descriptive titles of policy documents in earlier phases.

Learning history summary
In this phase, earlier changes in shared values about integrated water management and sustainable development were complemented by changes in institutions, the transformation of groundwater and the stakeholders involved. The environmentally oriented shared values and the notion of integrated water management were supported by recognition at international level of the need for sustainable development. Although political competency struggles and existing, historically grown structures had so far prevented the realization of integrated water management legislation, the concept of integrated water management was taken up in various pieces of sectoral, national, and provincial legislation, and management plans. Planning was the main coordination system adopted to translate these values into new water management practices. Such planning proved a learning process in itself, not only with regard to the content of the plans, but also with regard to the manner in which these plans were developed. Initial experiences with planning that took integrated water management into account made it clear that such planning requires an integrated process-oriented approach rather a technical, content-oriented one. Accordingly, new regulations, new policy strategies and a new style of interaction were developed. Previously developed detailed rules and regulations were complemented with more flexible, experimental approaches such as interactive policy making, non-legally binding covenants and collective monitoring. Area and action-oriented strategies were introduced to involve stakeholders in co-management of water resources. Realizing such a strategy was found to require process management skills. Existing stakeholders found themselves reorganizing to fit these developments. Moreover, new stakeholders evolved in the form of multi-actor platforms. Such platforms contributed to changing the relationships among stakeholders. In addition, undertaking pilot projects and monitoring the planning and implementation process constituted attempts to interweave action and reflection in the policy process. In line with these developments, more flexible, adaptive legislative and working procedures were further developed.

V Improvement or renewal: Treading water or three strokes forward, two backward ? (1990s - future)

The future will have to tell whether such reorganization will have entailed improvement of the institutional interface or structural renewal. Because too little time has yet passed for long-term structural changes to become visible, the analysis of this phase is limited to the learning history summary account. The account gives an indication of the structural changes that may emerge.

Learning history summary
Future developments will have to make clear whether planning and the changes it aims to

realize have indeed been able to bring about resilient structural renewal, or whether it has proved to be more of the same. A number of changes point toward such change in groundwater management in Gelderland and its wider context. More stakeholders participate in groundwater management, in new coalitions that cut across geographical, sectoral and ideological boundaries. Attempts are made to take into account management of the complete resource transformation cycle, from appropriation to sanctioning. Covenants have been agreed upon with groundwater appropriators to decrease the amount of groundwater extracted. In addition, businesses using groundwater have been approached with a tailored sanctioning approach. Instead of all businesses being approached with the 'thou shall' treatment, they are given the option of being approached as a good will company, as a company that needs to be strictly approached, or as a mixture of both. This has made monitoring and sanctioning more effective. Decentralization and subsidiarity promote interactions and responsibilities to develop at the most appropriate level. And groundwater has been acknowledged as a shared value in itself. Nonetheless, mismatches in the natural and human domains continue to exist. Groundwater continues to be overused and polluted. Conflicts continue over who is allowed to withdraw what amount of groundwater; and evaluations of strategic, national and provincial integrated water management plans indicate that, although some environmental objectives have been achieved, overall economic goals still tend to dominate. In addition, new NRM dilemmas continue to emerge. For example, the call for more market dynamics in the drinking water sector has led to a drift toward expansion on the part of some of the regional companies. These actions go against existing policy for the collective drinking water sector. Moreover, the increase in the number of foreign investors and owners may lead to management decisions that have currently unforeseeable consequences. New planning systems in response to EU and national policy measures stack plan upon plan, leading to a multitude of planning layers. In addition to the fact that this jungle of plans reduces the transparency of measures to be taken, actual implementation stagnates. However, the EU Water Framework Directive, together with the river floods in the later 1990s, have led to multiple and larger scales being taken into account. In addition, steps are being taken not only towards integral water management, but also towards integrating water, environmental and spatial planning policies.

The phases in the learning history have been validated through different types of triangulation. They fit phases that have been distinguished by other researchers of water management (Van der Ven 1994; Van Rooy 1997; Van Slobbe 2002). Moreover, the phases have been checked with groundwater management practitioners in Gelderland (see also section 6.5).

In terms of fit among resource, stakeholder and institutional dynamics, the following may be concluded. The first phase may be regarded as the pioneering phase. New collective stakeholders emerge to develop the niche for drinking water provision. This development occurs in part within the frame of existing institutions, but in part also leads to the development of new institutions. During the conservation phase, the collective stakeholders build up their capital and start to interconnect more frequently. Thus, thicker networks develop. On the one hand, this strengthens the drinking water sector as whole, and other sectors that develop in this way. On the other hand, it decreases their adaptability as these networks become more and more like a closed system. Increased self-referentiality eventually leads to such networks and mediating institutions locking around individual and collective goals that no improvement of actions will achieve. Instead, existing crises are reinforced. In order to overcome such crises, new collective frames and interaction patterns need to be developed. At such a point, these

alternatives may take hold and emerge as the new structures that shape the interactions of stakeholders, resource and institutions. Thus, stakeholders and mediating institutions may reorganize, and the system as a whole may reframe or renew itself.
In line with the above characterization of the phases, the overall learning dynamics in the exploitation phase may be characterized as learning to be effective in using the groundwater resource for a new need. The conservation phase may be characterized as learning to expand positions achieved. When confronted with crises, the reaction is to learn how to use resources more efficiently. When it becomes clear that there is a limit to efficient use, learning to integrate dominates as a means to bring about new, more sustainable resource management practices.

Although it has been possible to distinguish different long-term structural phases in the emergence of groundwater management in GL, the clustering of stakeholders, critical events, and institutions is less homogeneous. Discrepancies have been found, such as crises that occur in phases other than the release phase, or attempts at integration in phases other than the reorganization phase. Take, for example, the notion of integrated water management. Different stakeholders have claimed to have 'discovered' this notion in the early nineteen eighties. When introduced at that point, it indeed provided, after some bumps, a means to create synergy and coordinate the decision and actions of stakeholders. The notion has now resonated through the system (Van Ginneken 2000). However, the historical analysis makes it clear that the notion of integrated water management has made earlier appearances, but with less effect. At such moments, change appears to be absorbed without a trace, or the exact opposite occurs. The question remains as to why and how such change has been amplified in the 1980s and 1990s (and with current insights, continues to do so in the new millennium) and failed to trigger structural changes earlier. Similarly, other changes and signals that may contribute to sustainable groundwater resource management have emerged, but failed to bring about structural changes. These discrepancies are the basis for a second iteration of the learning history methodology in which the dynamics that fit Holling's renewal cycle, as well as those that do not, are more closely analyzed from a social-environmental learning perspective.

In the following section, a social-environmental learning analysis and assessment will further investigate how learning repertoires drawn on and developed have contributed to these macro-level changes in the interactions of groundwater resource, stakeholders, and institutions.

7.4 A social-environmental learning analysis and assessment of structural changes in the emergence of groundwater management in GL

A social-environmental learning perspective focuses on people's ability to draw on and develop their learning capacity in order to adapt to and adapt NRM dynamics in a sustainable way, as discussed in previous chapters. On the one hand, this entails an analysis of the learning repertoires drawn on and developed by stakeholders in the light of people's potential learning capacity. On the other hand, it entails an assessment of the quality of learning repertoires distinguished in terms of the evaluative criteria discussed in Chapter 6. Accordingly, the clusters and discrepancies that constitute the phases in the emergence of groundwater management in GL are analyzed and assessed.

In terms of learning, in the one hundred and fifty years covered by the case study analysis, insights into the qualities of the groundwater resource, into the stakeholders involved in its transformation, and into the institutions mediating that transformation appear to have increased. There appears to be more insight into groundwater flows today than at the time when they were first exploited to provide collective drinking water. The groundwater resource itself is better mapped and monitored than ever before. Nonetheless, its quality and quantity needs to be carefully managed. Knowledge concerning stakeholders' decisions and actions and the effects of institutions seems to have grown. Throughout, some changes have entailed structural shifts while others have disappeared without leaving a mark. In line with these changes, stakeholders have come and gone, and with them learning repertoires and insights gained. Other stakeholders have remained but have undergone changes in goals, values and capital configurations. At times, institutions have managed to capture and carry insights and practices across generations. At other times, these very institutions have proven barriers for new practices to develop.

However, learning in the emergence of groundwater management in GL has not necessarily been cumulative. As mentioned in the concluding remarks of the previous section, it is not yet clear whether some of the structural shifts that have taken place will actually lead to fundamental renewal. On the one hand, there have been structural changes in the collective cognitive frame in terms of institutional changes in shared values, regulations and policy strategies. Moreover, stakeholders who opposed each other in earlier phases are now cooperating to achieve groundwater use and management that is more in line with the renewal capacity of the resource. On the other hand, research by Van Slobbe (2002) regarding renewal processes in regional water management argues that fundamental crisis and renewal still need to occur. Current debates about the restructuring of water boards, and water regulations and policy could just as well have taken place in any of the phases distinguished. Many of the issues remain the same.

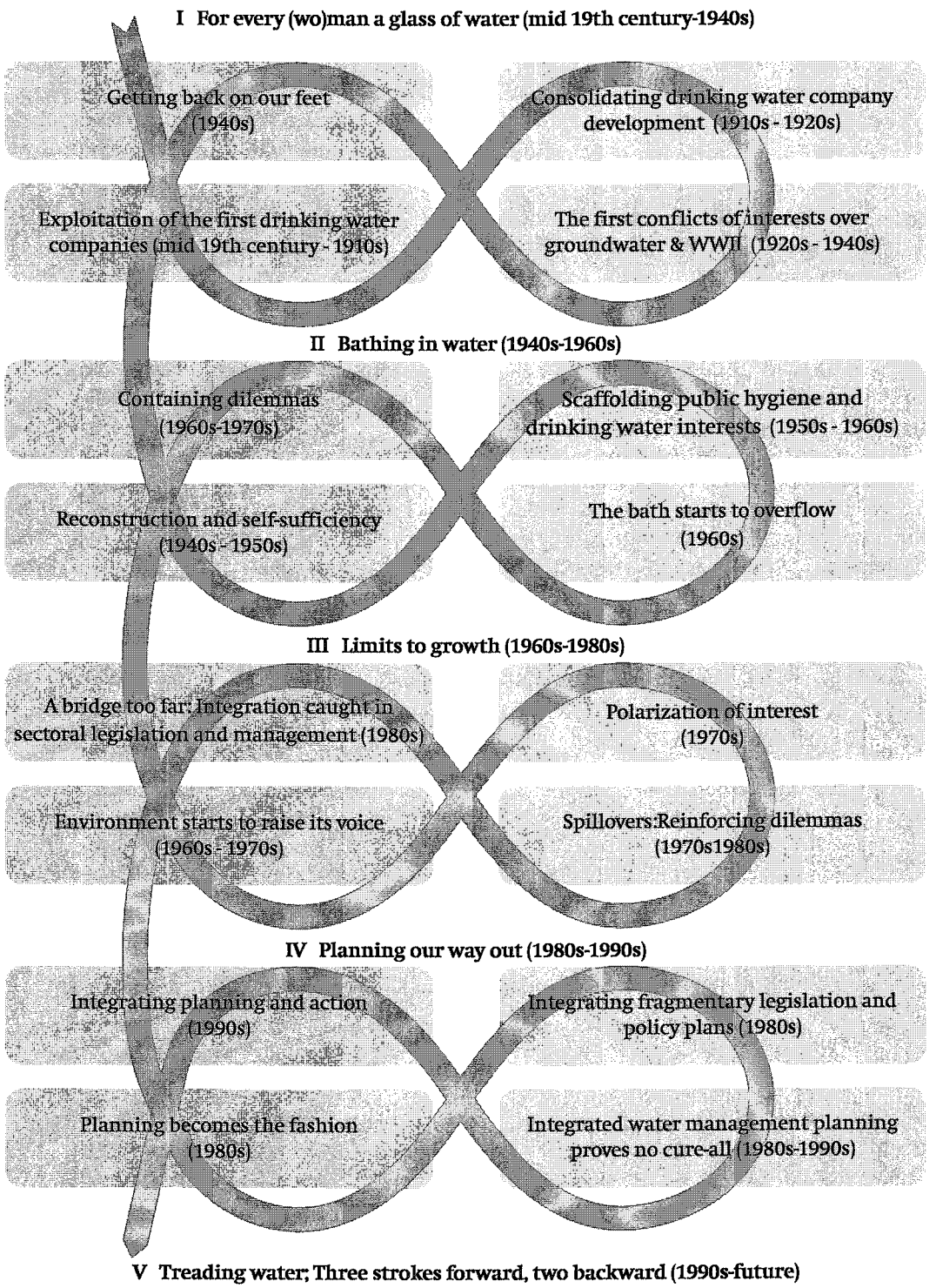
A closer analysis of the clusters and discrepancies that constitute the long-term structural shifts discussed in the previous section has elucidated how nested renewal sub-cycle and accessed learning repertoires underlie the structural changes found as groundwater management emerged. These sub-cycles are illustrated in Figure 7.3.

In the following subsections, summary accounts of the nested renewal sub-cycles provide the basis for the discussion of the social-environmental learning analysis and assessment. Again, the more detailed learning histories on which these summary accounts and assessments are based can be referred to in Appendix I. The quality of the learning repertoires drawn on during these nested renewal cycles is assessed in terms of the evaluative social-environmental learning criteria discussed in the previous chapter.

For every (wo)man a glass of drinking water (mid 1800s - 1940s): Learning to be effective

Changes and learning in the nested renewal cycle of the exploitation phase may be characterized as rapid exploitation of learning repertoires already available to transform groundwater resources in order to effectively fulfill the newly emerging demands for clean drinking water.

Figure 7.3: Sub-cycles in the emergence of groundwater management in GL



- *Exploitation of the first drinking water companies (mid 19th century - 1910s)*
  Before the mid 19th century, the possibilities and role of groundwater were hardly recognized in Gelderland, or in The Netherlands in general for that matter. Groundwater use was limited to a small number of private groundwater wells. In response to deadly cholera epidemics, a national research committee was appointed to investigate how the use of contaminated water for cooking, washing and drinking caused cholera epidemics. Confirming the relationship, the report of this research committee contributed toward putting public hygiene on the agenda as a new, shared value. By national law, municipalities became responsible for public hygiene and the provision of drinking water for its inhabitants. Engineers were eager to copy experiences from abroad to establish the first drinking water companies in The Netherlands. In provinces that had abundant groundwater resources, such as Gelderland, this resource was the natural choice for drinking water provision. Where population density made it feasible, municipalities were quick to invest in the exploitation of groundwater to provide every (wo)man with a glass of clean drinking water.

- *Consolidating drinking water company development (1910s - 1920s)*
  In less densely populated areas, investment costs were too high for individual municipalities to establish drinking water companies. Based on experiences in other rural areas and input from national advisory committees, cooperation among rural municipalities was stimulated and start-up problems were overcome. Exploitation dynamics came into full swing. Different forms of capital began to build up around drinking water companies. In addition to natural, financial and human capital, social capital started to build up in the form of institutional arrangements and sectoral organizations. A provincial permit system was developed to control proliferation of local drinking water companies.

- *The first conflicts of groundwater interests and WWII (1920s - 1940s)*
  As demand for drinking water increased, drinking water companies started to look beyond the boundaries of their original supply area to withdraw groundwater and expand provision possibilities. Thus, the city of Amsterdam looked toward the groundwater resources of the Veluwe region in Gelderland to meet the drinking water needs of its growing population. Anticipating that such large-scale withdrawals would have damaging consequences for cultivated lands and existing water wells in the area, Veluwe inhabitants protested against this proposal. The Ministry of Interior, at the time responsible for dealing with such matters, established a research committee to investigate the potential effects of groundwater withdrawals in the area. This, and other research undertaken in relation to the Western part of The Netherlands, indicated how conflicts over groundwater interests were emerging and would grow if the course of exploitation were not changed. Nonetheless, groundwater management remained in the shadow of the more dominant surface water management. A crisis of a different nature, WWII, intervened in developments that were proving to be a source of groundwater management dilemmas.

- *Getting back on our feet (1940s)*
  Neither the first signs of interconnectedness of a social-dilemma nature nor an external crisis in the form of WWII could divert the growing tendency towards further specialization and standardization in the drinking water sector. On the contrary, after the war the goal to provide every (wo)man with a glass of drinking water was taken up with renewed energy. Central coordination of these and other reconstruction tasks was organized in sectoral ministries. This consolidation of capital resources foreshadows dynamics in the next phase.

Overall, the learning in the renewal cycle nested in the initial phase of the emergence of groundwater management in GL may be characterized as learning to exploit the groundwater resource effectively. After public hygiene is adopted as a newly shared value in the institutional frame, different capital resources are bundled to provide as many people as possible with clean drinking water as quickly as possible. As stakeholders are learning to do this effectively, locations where drinking water provision is most easily realized are exploited first. Based on these experiences, other, more difficult locations are exploited. Thus, the amplifying behavior of a small group of active, goal-directed individuals is able to overcome uncertainties and leads to a shift in the system.

The main trigger for this learning is the public health crisis caused by growing, deadly cholera epidemics. This crisis spurs the national government to instigate an investigation to gain a better understanding of the relationship between the state of water resources and consequences for human health. Once insights gained point toward the unhealthy effects of the use of contaminated water in cities, action is undertaken to provide people with clean drinking water. Accordingly, people's interests, goals desired, and possibilities to transform resources are aligned. Actions involve changes in the institutional frame and stakeholder-resource interactions.

With regard to the former, changes in the institutions that frame the establishment of the drinking water supply may be characterized as improvements to existing frames. As drinking water companies start to mushroom, these institutions aim to curb and control actions even more strongly. With regard to the changes in stakeholder-resource interactions, engineers are given space and means by some municipalities to put into practice experiences observed elsewhere and/or come up with new ones to establish drinking water companies. In Gelderland, this entails applying drinking water supply technology developed elsewhere in The Netherlands and abroad and improving such technology for the Gelderland context. Overall this may be viewed as single loop learning, i.e., how to be more effective given the institutional frame of the time.

In terms of the evaluative criteria of the social-environmental learning framework, learning dynamics may be assessed as follows. Although the research recommendations acknowledge the importance of the natural and human systems and their interaction as well as the sub and supra-systems in which water exploitation occurs, these insights are not translated into changes in the institutional frame and interactions among stakeholders and the groundwater resource. Basic knowledge about the quality of the groundwater resource, and the stakeholders and institutions involved, is still lacking. Moreover, at the time, a number of disciplines with the potential to introduce multiple perspectives are still being developed. With regard to experimentation, a great deal of it is going on at the operational level, but the manner in which it is taking place indicates a lot of change in institutions and interaction patterns and, accordingly, a large diversity of learning repertoires. Moreover, double and triple loop learning with the potential to contribute to completeness of learning cycles, diversity of learning repertoires, and adaptiveness is hampered by the onset of WWII. In terms of communicative action, those involved are quite competent. The motivations to be involved vary from the desire to improve the livelihoods of fellow citizens, test and improve skills, and build up capital. However, it is mostly educated professionals in medicine, engineering, and law that are involved in developing the niche for drinking water provision, while others are involved in a laboring capacity and/or as beneficiaries or end-users. In terms of systems thinking and fair-

ness indicators, involvement is thus rather limited to a certain segment of society in traditional roles - a result of the structure and style of the time.

Bathing in water (1940s- 1960s): Learning to expand

As WWII ends, reconstruction and economic development come into full swing. In the conservation phase, the self-referential nature of institutions and underlying learning dynamics starts to become visible as different sectors expand and consolidate their competing interests in the groundwater resource. Stakeholders seek to maintain and expand their established positions; and institutions are designed to help them to do so, regardless of the consequences for the resource beyond their own interests. Overall, there is an increase in the institutional framing of decisions and actions of stakeholders involved in groundwater exploitation, and an increase in knowledge about the resource.

- *Reconstruction and self-sufficiency (1940s - 1950s)*
  The spirit and financial impetus of reconstruction after WWII stimulated further build up of capital in the drinking water and other sectors. The importance of drinking water provision was further confirmed and strongly anchored in a network of national organizations that aimed to develop and safeguard drinking water interests. In Gelderland, a ten-year plan was developed to connect the last remaining areas to the public water supply network, supported by a national subsidy. At the same time, measures were taken to stimulate further rationalization and amalgamation of drinking water companies. As a result of these measures, the two Gelderland intermunicipal drinking water companies were able to incorporate a number of smaller municipal ones. Increased production and efficiency also gained ground in other sectors. Agriculture and industry were expanding and specializing as well. Subsequent land consolidation, stimulated by national legislative measures, and industrial activities increasingly influenced groundwater resources.

- *Scaffolding public hygiene and drinking water interests (1950s - 1960s)*
  In order to safeguard public health and drinking water provision from the competing interests of agriculture, industry and infrastructure development, two national acts were developed. This legislation required drinking water companies to obtain permits for groundwater withdrawals and affected parties to tolerate these abstractions subject to compensation for damages suffered due to the abstractions. In addition, sanitary norms for drinking water supply were developed. At provincial level, spatial planning measures were launched to protect groundwater extraction areas from bacterial pollution that posed threats to public hygiene.

- *The bath starts to overflow (1960s)*
  Despite these conservation measures, local level dilemmas already recognized before WWII started to re-emerge. The side effects of groundwater withdrawals on land and of land use on groundwater resources started to make the system more susceptible to conflicts of interest. Preventive measures such as spatial planning fell short, particularly because land use planning itself became more and more problematic as land became an increasingly scarce resource.

- *Containing dilemmas (1960s - 1970s)*
  Research by a number of provincial and national committees, similar to that of the committees of the 1930s, revealed that the limits of groundwater use were in sight. It appeared that the time to change was approaching, or else. In the country at large, the potential force of release dynamics was already becoming visible as a wave of democratization started to sweep through all layers and domains of society. Institutional arrangements were once again drawn on to maintain order. Based on recommendations of the provincial research committee, a provincial ordinance was developed that required registration of groundwater withdrawals for purposes other than drinking. In addition, a platform of provincial drinking water companies was established for consultation regarding policy and regulations affecting the sector. At national level, a first strategic water management plan that took into consideration the interconnectedness of water management sectors was developed. However, the main investments recommended were for the improvement of water infrastructure.

Analysis and assessment of the learning dynamics in this nested renewal cycle may be characterized as learning to expand the exploitation of the groundwater resource started in the previous phase. The reconstruction spirit and subsequent financial impetus stimulate further development of groundwater interests by stakeholders in the drinking water sector as well as stakeholders in agriculture, infrastructure and industry. This expansion entails further learning not only about groundwater resource exploitation, but also about its management institutions. Both types of learning are mainly directed at improving existing practices, i.e., single loop learning. Re-emergence of some of the dilemmas that started to become visible before WWII does not alter the course of resource exploitation.

In order to improve its position and the drinking water supply, the drinking water sector reorganizes and strengthens its expertise base and network. The sector learns to use these qualities to contribute to the development of structures, standards and strategies directed at consolidating interests. A first reaction to the realization of interconnectness among stakeholders in terms of groundwater use is to throw up institutional barriers to safeguard drinking water interests. Here, the self-referential dynamics of institutions become visible. As mentioned, institutions will often involve regulatory feedback loops that control behavior around a certain value or interest. As such, institutions tend to perpetuate the status quo or equilibrium state. This entails certain transformation patterns of various resources, varying from natural to social. In order to realize these resource transformations, certain relationships among stakeholders and the natural domain need to be maintained. In such circumstances, maintaining an institution means maintaining coercive and power relations that contributed to creating the institution in the first place. Although these relationships may produce desirable goods and services, these outputs, and the relationships that produce them, may not necessarily be mutually satisfying to all stakeholders involved and/or affected.

Attempts are undertaken to include monitoring in legislation and management, but these do little to improve effectiveness and efficiency of water use. Learning about the groundwater resource is given an impetus by assigned researchers who start an extensive mapping of groundwater resources and flows.

An examination of learning dynamics in terms of systems thinking, experimentation, and communicative action indicators generates the following assessment of the learning reper-

toires drawn on and developed. Some stakeholders show awareness that human activities may negatively affect groundwater resources. However, as such insights are translated into the sectoral legislation and actions discussed above, they diminish the integrative potential of systems thinking rather than contribute to it. In the implementation of land consolidation, an attempt is made to integrate different disciplines. Both technical and social-economic aspects are taken into account. The contributions of multiple perspectives become streamlined because of the uniformity of target groups involved and goals to be realized. Thus, diversity of learning repertoires is limited. This contributes to incomplete learning cycles, as learning that occurs is not translated into changes in the institutional frame. Nonetheless, there is a growing tendency to consult stakeholders in the policy-making and management process. This consultation is mainly of a strategic nature, i.e., will stakeholders accept the policy and its implementation? Those who participate are competent to do so, but there are still many not participating. Growing social turmoil across Dutch society as a whole addresses marginal participation on the part of its citizens. There are more voices that want to be heard in the decision-making processes. This questioning of relations foreshadows double loop learning that looks at the 'why' questions behind the way people interact.

Limits to growth (1960s - 1980s): Learning to be efficient

As learning dynamics continue to contribute toward conserving and expanding existing capital configurations, stakeholders fail to capture and adapt to existing and emerging dilemmas. However, these dilemmas begin to reinforce each other in a manner that highlights the limits of the groundwater resource and its management. Through learning to be more efficient, the system appears to be weathering the storm. Nonetheless, capital configurations start to break down and established learning cycles are affected. Increased interconnections appear to provide bridges for latent alternative stakeholders, values and systems to emerge in which learning to integrate appears to gain ground.

- *Environment starts to raise its voice (1960s - 1970s)*
  While democratization waves reverberated through Dutch society, environmental hygiene started to gain a place on the political agenda. Indirectly affecting groundwater resources, national legislation was approved to make polluters of surface water pay for the damaging effects of their actions. In addition, strategic management of environmental hygiene was anchored in a national ministry. The global impact of an oil crisis together with the publication of the report Limits to Growth (Club of Rome 1972, see Meadows et al 1974) further signaled that use of natural resources and economic growth were finite. In response, environmental groups became active and concentrated their lobby power. In Gelderland, a research committee was installed to undertake scientific investigation of optimal management of surface and groundwater resources.

- *Polarization of interests (1970s)*
  Legislation developed to safeguard drinking water interests had started to weaken the position of the drinking water sector. Moreover, in part due to sectoral management, short-term interests seemed to win over longer-term interests time and again. Review of national legislation was caught up in competency struggles between water management and environmental sectors. In Gelderland, amalgamations in the drinking water sector proved a breeding ground for conflict. While there had been a number of takeovers, the remaining compa-

nies were set on keeping their autonomy and a mixed provision of utilities, counter to national and provincial policy. Implementation and enforcement of spatial planning regulations to protect groundwater resources proved extremely difficult due to the diversity of measures.

- *Spillovers: Reinforcing dilemmas (1970s - 1980s)*
  Extremely dry summers in the mid-seventies and growing pollution of groundwater resources further intensified groundwater management dilemmas. A second global oil crisis greatly decreased financial capital across sectors, resulting in drastic cuts in public budgets. Changing insights and demands in water management, together with the increasing complexity of society, triggered an in-depth policy analysis in preparation for a second national water management strategy. Decentralization was viewed as a means to ease pressure on government budgets as well as to improve implementation of policy. At the same time, the workload of government increased, as it was deemed government responsibility to resolve groundwater and NRM dilemmas in general. In Gelderland, growing requests for groundwater withdrawals not only increased the workload, but also made it clear that a long-term strategic frame was required to weigh the pros and cons of permit requests.

- *A bridge too far: Integration caught in sectoral legislation and management (1980s)*
  The previously mentioned provincial research committee coined the notion of integrated water management to increase sustainability of water management. This notion was also adopted in national level water management policy. In addition, it was attempted to integrate sectoral water-related legislation into a single, integral water management act. This proved a bridge too far. The principle of integrated management was caught up in sectoral legislation and management. Government responsibility for a sustainable environment was, however, anchored in the Dutch constitution.

As crisis upon crisis occurs in this phase, the learning of stakeholders in groundwater management is mainly directed toward becoming more efficient. This includes economizing capital resources in both the natural and the human domain. In other words, it is not only the groundwater resource itself that is under scrutiny, but also the institutions involved in its management. New stakeholders, who give a voice to the environment, start to participate in groundwater management and also introduce a different style of interaction. The communicative competence of parties leaves much to be desired. Stakeholders representing different interests tend to dig themselves further into their trenches, instead of gaining understanding of each other's value frames and interests - let alone, develop shared ones. Efforts to consider groundwater management in a wider context break down in competency struggles between water and environmental sectors. Such amplification of negative actions is an example of the manner in which amplifying feedback loops may completely frustrate the collective action necessary to realize interests and goals, as discussed in Chapter 5. Therefore, groundwater, in terms of both quantity and quality management, actually loses out in the management deadlocks. Although insights are gained about the values and motivations that guide action and their effect on the resource, transition from single loop learning to double loop learning proves difficult, and stakeholders are unable to shift to a more cooperative amplifying feedback relationship. Accordingly, learning repertoires encompass incomplete learning cycles, failing to make the translation from insights to action.

Learning about the groundwater resource and its management remains the business of experts. In response to scarcity and pollution and changing societal demands, expert policy analysis is to lay the foundation for structural changes in strategic water management planning and its implementation at national level. Such analysis brings in new techniques and takes systems thinking into consideration, but experimentation and communicative action are limited. The diversity of learning repertoires drawn on is limited and mostly directed at gaining insight rather than experimenting and involving different stakeholders. Solutions developed mainly entail efficiency measures to counter the effects of dry summers, and oil and financial crises. Spillover effects indicate that strategies and systems developed fall short of translating the potential of systems thinking into actual changes in behavior. However, institutional frames are changed as the responsibility of national government for environmental values is grounded in the Dutch constitution. Although still with a sectoral focus, this is taken into account in the development of legislation that affects groundwater and its management.

As similar insights accumulate across different domains and levels of groundwater management, the basis for an integrated approach broadens. These insights are triggered not only by the crises, but also by both the intrinsic passion of some stakeholders to understand the dynamics of the water system and the wish to give environmental and ecological values a place in water management. The manner of communication still leaves a lot to be desired. Technical analyses and multi-criteria modeling are found not to communicate very well with anyone other than those who developed them.

Planning our way out (1980s - 1990s): Learning to integrate

Repeated confrontation, with mismatches among intentionality, actions and perceptions, appears to trigger the double loop learning necessary to integrate earlier learning outcomes into changes in institutions, such as newly shared values, regulations and policy strategies, that constitute structural shifts in the emergence of groundwater management.

- *Planning becomes the fashion (1980s)*
  At both national and provincial level, planning was adopted as a means to translate the concept of integrated water management into policy and action. The notion of integrated water management gave an impetus to changes in groundwater management, and water management in general. Translation of this principle was supported by the international introduction of the notion of sustainable development. As plans were required under different sectoral laws, this happened first in separate plans. In a national water management plan, a strategic shift was made from infrastructure to water management. Taking this principle into account, provincial plans were made for groundwater quantity and quality management.

- *Integrating fragmentary legislation and policy plans (1980s)*
  While the notion of integrated water management was translated into policy measures, its sectoral approach called for further integration to fulfill its potential. A national memorandum aimed to give an impetus to, and make further understandable, the notion of integrated water management. Preparation for the third national water management plan entailed different preparatory studies involving different disciplinary groups; and a newly recognized groundwater management dilemma, desiccation, was taken in hand by an interdepart-

mental working group. Approval of the national Water Management Act signified the institutionalization of an integrated planning system. It also included instruments for quantity surface water management. Other instruments for water management were accommodated in still other acts.

- *Integrated water management planning proves no cure-all (1980s - 1990s)*
  Overall, the first generation of plans failed to fully operationalize integrated water management. In addition to the fact that competition in groundwater use remained problematic, competition concerning competencies in groundwater management surfaced. Such conflicts often involved core qualities of organizations and people. In touching the core values of identities, such conflicts are highly sensitive. Evaluations of planning processes, contents of plans and implementation of plans revealed that linkage of policy-action-evaluation was limited. Development of plans, both at national and provincial level, was in the first instance a highly technical and internal affair leading to descriptive plans with strategy as a closing entry. As such, making integrated water management plans proved a learning process in itself.

- *Integrating planning and action (1990s)*
  In this regard, the principle of area-oriented policy provided a way of thinking that could link physical and human systems. By taking the regional area as the point of departure, it is hoped to break through other institutional boundaries. This has been complemented by government actors learning to take a facilitative rather than a control-oriented approach, and giving space to the initiatives of other stakeholders. Changes in institutional arrangements that supported a more open and flexible way of working were undertaken, such as interactive policy making, covenants, and possibilities to make general rules. Changes were paralleled in GL's water management department to match and bring about new dynamics in groundwater management. The future will have to tell whether these changes and their constituent learning processes entail recasting the collective frame in which the groundwater management system has renewed itself in a sustainable manner and maintained a recognizable, coherent identity; or whether it is simply another way of doing the same thing.

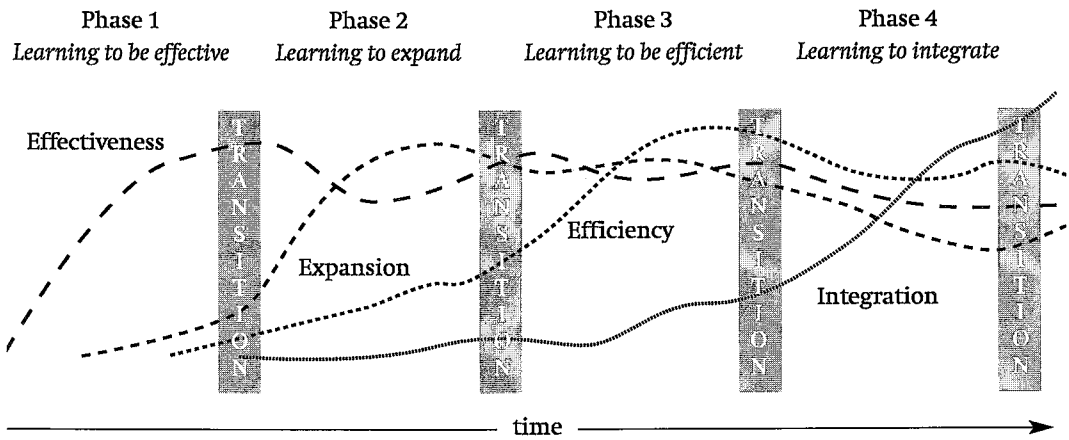
Overall, NRM and learning dynamics in this phase may be characterized as learning to integrate. In different ways, the notion of integrated water management, coined in the previous phase, is given further meaning. As institutional changes coherently constitute conditions for integration, decisions and actions may be facilitated. This does not occur without some struggle. In the process, a number of stakeholders start to realize that paying lip service to the notion of integrated water management is not enough: internal, structural changes in groundwater management also mean structural change in themselves. In such change processes, some interests gain ground, but others lose out. Even when win-win situations are aimed for, achieving them proves a process of learning and negotiating with no single, right outcome.

Moreover, integration within one's sector is found not to be enough. Integration must occur across sectors. In line with the findings discussed in Chapters 3 and 5, bringing stakeholders repeatedly together does not automatically lead to learning and adaptations to their institutional interface. Interesting adaptations do occur when sudden exchanges take place between networks that were previously isolated from each other. Moreover, learning in this phase of

the emergence of groundwater management in GL supports the value of horizontal ties and of many change oriented participatory methods to create environments that enable participants to draw on the different learning repertoires discussed in Chapters 4 and 5.
In terms of the evaluative social-environmental criteria, the following may be observed. The principle of systems thinking is taken into account in different ways in the notion of integrated management: first of all, in recognizing the interconnectedness of the physical water system and issues of quantity and quality management; and second, in recognizing the need to involve different stakeholders in the water management system and its wider context as well as the different disciplines this calls for. How this can be managed remains something to be learned however. Such learning to integrate may be further characterized as learning to manage the management of groundwater and its related physical and human resources. Principles of experimentation and communicative action provide means to learn how the notion of integrated water management and sustainable development may be implemented. Although the motivation to involve stakeholders is still often of a strategic nature, involvement is more often directed at gaining an understanding of each other's value frames and goals. As stakeholders learn to develop shared value frames, these are found not always to match existing systems, structures and strategy. More flexible institutional arrangements are developed that allow more space for experimentation. Accordingly, the learning cycle may be completed in a shorter period of time. Involving stakeholders throughout the learning process helps the making of adjustments more feasible as insights are gained. Experimentation with different work and discussion forms facilitates introducing and developing a greater variety of learning repertoires. In the process, adaptiveness is improved. Nonetheless, structural change proves a complex and lengthy change and learning process.

The social-environmental learning analysis and assessment of the structural shifts in the emergence of groundwater management indicates how qualitative differences in learning dynamics that underlie structural shifts may influence the manner in which stakeholders adapt to and adapt institutions in their interaction with each other and the groundwater resource. Qualitative differences in learning dynamics found in the phases of emergence of groundwater management in GL are graphically visualized and characterized in Figure 7.4.

Figure 7.4: Graphic presentation of learning dynamics in the emergence of groundwater management in Gelderland, The Netherlands



Note: This graphic aims to visualize a qualitative assessment of learning. It should not be taken as a quantitative assessment.

Although learning dynamics in a particular phase may be analytically characterized as learning to be effective, to expand, to be efficient and to integrate, all have been found to be more or less latently present in the nested renewal cycles that underlie changes in the emergence of groundwater management in Gelderland, NL. More specifically, it appears that these different types of learning may be linked to the different phases in Holling's ecosystem renewal cycle. In the nested sub-cycles, similar patterns of learning to be effective in the exploitation phase, learning to expand in the conservation phase, learning to be efficient in the release phase and learning to integrate in the reorganization phase become visible. Depending on the actual interaction patterns of resource, stakeholders and institutions, the combination of different types of learning leads to single or double loop learning. Learning to improve within existing frames mainly occurs in the exploitation and conservation phases, while learning to change existing frames mainly occurs in the release and reorganization phases.

Whatever type of learning takes place, it appears as if some sort of crisis phase is necessary. In addition to alerting stakeholders that change is necessary, crisis may help to create space for innovations and insights that have been developing in the shade of existing institutions. Moreover, it should be acknowledged that, although learning generally has a positive connotation, the change involved in learning may involve resistance (Argyris & Schön 1996).

The learning history of the emergence of groundwater management in GL confirms the fact that, although people are intentional, goal-oriented beings, this does not guarantee that they are able to reach their goals. Desired outcomes are often not realized, or only approximately. One of the problems is that the environment is not immediately responsive to the action taken, but responds with a delay (Dörner 1996). Each decision or action is a transmittal of information that takes time, and these 'dead times' may have important consequences. Depending on the tightness of the feedback loop between an entity and the environment, a new action might be undertaken before an action has had its full effect on the environment. Moreover, because of the complexity of interacting dynamic domains, we might never have correctly estimated the effect of an action in the first place. This tendency to 'over steer' is characteristic of human action in dynamic systems. People tend to let themselves be guided by the situation at hand rather than the development within the system, that is, by time differentials between sequential stages (Dörner 1996). In other words, people regulate the situation, not the process. As a result, the inherent behavior of the system and attempts at steering it may combine to carry it beyond the desired mark, or beyond what the system can handle.

Oversteering may result in system dynamics that overswing and in which people are no longer able to recognize any patterns at all. In the worst case, people may lose their sense of efficacy. Such loss of the sense that one's actions have an effect on one's environment contributes to a loss of meaning and, consequently, alienation or learned helplessness (Garben & Seligman 1980; Van Haaften 2002).

The learning history also indicates that institutional memory is limited. Although knowledge of the resource may be said to have increased, stakeholders appear to rediscover again and again how their decisions, actions and interactions affect the world around them. On the one hand, this reinvention of the wheel may be viewed as a sign of learning leaks. On the other hand, it is exactly this reinvention that allows for adaptations to take place. In this regard, it is important to understand that knowledge in NRM is not necessarily cumulative but needs to be recreated.

In the light of people's potential learning capacity, a review of the learning repertoires used indicates that a rather limited repertoire is drawn on and developed. In the phases distinguished, stakeholders have drawn on and developed various learning repertoires to both adapt institutions and adapt to them.

7.5 Implications for learning about social-environmental learning for sustainable NRM

In this chapter, macro-level structural changes in the emergence of groundwater management have been discussed. From its inception in the mid 19th century, groundwater management in Gelderland has evolved from exploitation for collective drinking water provision into a complex system of different stakeholders with diverse interests involved in various activities today. In this time period, the groundwater resource has evolved from being hidden and pristine into being heavily used and often polluted. Some stakeholders have come and gone, while others have remained, but have undergone changes in goals, values and capital configurations. Mediating institutions have managed to capture and carry insights and practices across generations. At other times, these very institutions have proven barriers for new practices to develop.

The first analysis in section 7.3 pointed out how, in line with Holling's ecosystem renewal cycle, different phases may be distinguished in the emergence of groundwater management in GL. These phases may be characterized as clusters of interactions among resource, stakeholders, and mediating institutions. In Table 7.1, the main characteristics of these clusters are summarized. Each cluster may be further characterized by a predominant NRM and learning dynamic, namely, learning to be effective, learning to expand, learning to be efficient and learning to integrate. A closer look at the clusters indicates that learning and NRM dynamics do not always fit homogeneously. Both fit and discrepancies have been the starting point for further social-environmental learning analysis and assessment.

The social-environmental learning analysis and assessment in section 7.4 revealed that nested renewal cycles and learning repertoires may be distinguished to underly these structural changes and discrepancies. Analysis and assessment of these cycles and repertoires show how different types of learning dynamics may be linked to the different NRM dynamics distinguished in Holling's ecosystem renewal cycle. In the nested sub-cycles, similar patterns of learning to be effective in the exploitation phase, learning to expand in the conservation phase, learning to be efficient in the release phase, and learning to integrate in the reorganization phase become visible as in the long-term Holling renewal cycle discussed in section 7.3.

Whatever type of NRM dynamics dominates, it appears as if some type of crisis is always necessary for learning to occur. The natural tendency is for stakeholders to follow through with existing interaction patterns until their limits are reached, i.e., until regulatory feedback loops flip into amplifying ones that polarize stakeholders instead of helping them to adapt and find new positions that match natural and human domain dynamics. Only then does signaling occur that existing interactions are not sustainable; and although the case study indicates that people are able to bring about change, such change may take a long time to occur, even when alternatives are available. However, even though the learning history confirms that people are indeed able to adapt to and adapt changing NRM dynamics, the case study also

indicates that such adaptation does not necessarily lead to more sustainable NRM. This is certainly the case when people have goals and values that are opposing and/or negatively affect the resource, but may also be so when goals and values are collectively shared and take into account the renewability of the resource. Purposefully managing interaction among resources, stakeholders, and institutions proves extremely difficult because of the combination of equilibrium and non-equilibrium dynamics involved.

In this light, it would appear that NRM could benefit from exposure to social-environmental learning that takes into account the role of crisis, people's potential learning capacity, and the need to reinvent the wheel. These lessons are complemented by findings from other research and practice experiences. It needs to be kept in mind that crisis plays an essential role in signaling the effects of interaction patterns among resource, stakeholders and institutions. The current tendency in NRM is to reduce possibilities for crisis both in the natural and in the human domain and their interaction. For example, with regard to water management, flooding possibilities are decreased to almost zero, and conflicts among stakeholders are avoided or quickly mediated. However, it is such crises that generate feedback signals that help people to gain understanding of the effects of their decisions and actions, and mediating institutions. Accordingly, actions and decisions may be evaluated in terms of whether they contribute to realizing the desired effects or whether the effects are to be desired after all. Of course this conclusion is not meant as an unconditional plea for crisis; but allowing crisis to occur, rather than attempting to harness it until it becomes uncontrollable, may provide more rapid feedback and allow people to draw on and develop their potential learning capacity to cope with the disturbances created. Accordingly, disturbance management practices aim at allowing small crises to occur in order to develop the resilience of the system (Berkes & Folke 2002). Examples of such practices are allowing river spring flooding to occur, or forcing stakeholders to learn to deal with stalemates instead of making government officials responsible for them. In such cases, people may put into practice repertoires to deal with crisis or be encouraged to develop new ones.
Of course, one may wonder whether actual crises need occur. The overview of people's potential learning capacity indicates that actual crisis is just one of the triggers for learning. Creativity, in combination with people's ability to learn through direct experience, observation and abstraction, allows people to learn how to deal with different types of NRM dynamics and outcomes. Methods used include computer modeling, role play, scenario studies and learning from the experiences of others. The learning history presented here and other case studies indicate that drawing on and developing such learning repertoires is still limited in NRM (refs). The evaluative criteria used to assess learning may provide a means to facilitate diversity of learning repertoires drawn on and developed.

But whatever the trigger is for learning, what is learned, how and by whom, the learning history of groundwater management indicates that lessons will need to be learned again and again. Other experiences in NRM in different resource fields across the globe support these findings. People's cognitive abilities, both individual and collective, are limited; institutional memory does not function as a huge database from which people may draw information at will. In other words, many learning leaks occur. Although this may seem a rather despondent lesson to learn, it is not necessarily so. Reinventing the wheel also provides the possibility for change, in the sense of both improvement and renewal.

8 Changing practices, changing stakeholders: Learning to adapt to the emergence of groundwater management in Gelderland, NL[1]

Research objective addressed
02: Identify and assess linkages between social-environmental learning and NRM dynamics in real-time, complex NRM.

Abstract

In the previous chapter, long-term structural changes in the emergence of groundwater management in Gelderland, NL, were discussed. This chapter focuses on a meso-level analysis. In other words, the focus is on how such macro-level structural changes shape, and are shaped by, aggregate stakeholders involved. As this entails a more detailed level of analysis, the time scale focused on is reduced to one of the phases distinguished in terms of the long-term Holling's ecosystem renewal cycle in Chapter 7, namely, the reorganization phase. The collective stakeholder focused on is the provincial water management department, one of the main stakeholders in groundwater management in GL. Adaptations by this stakeholder are discussed in terms of changes in the different properties of the 7-S profile. In this light, the chapter analyzes the linkage between social-environmental learning and the manner in which organizational development may influence individuals and the institutional interface that frames learning.

8.1 Introduction

In order to gain further insight into linking learning and NRM dynamics for sustainable NRM, a meso-level analysis of the emergence of groundwater management in GL has been undertaken. As discussed in Chapter 6, such an analysis focuses on the relationship between a collective entity and its context. Learning and institutional dynamics are analyzed and discussed in terms of how such a collective entity shapes, and is shaped by, the interaction with other stakeholders and the institutional interface. As this entails a more detailed level of analysis, the time scale focused on is reduced to one of the phases distinguished in terms of the long-

1 This chapter is based on M. Maarleveld (2000).

term Holling's ecosystem renewal cycle in the previous chapter, namely, the reorganization phase 'Planning our way out'. This phase is an interesting one on which to focus because in terms of learning about social-environmental learning it is the phase in which structural systemic change may occur. In addition, in terms of research, it has been possible to undertake both desk research and participatory observation during this phase.

The stakeholder focused on is the provincial government's water management department. The department is a key aggregate stakeholder in groundwater management in GL. In The Netherlands, the province is responsible by law for strategic and operational groundwater management within its boundaries. Each province has a water management department responsible for these tasks. As dilemmas and demands in water resource management have changed, these departments have co-evolved both reactively and proactively. The third iteration of the learning history methodology discussed in Chapter 6 focused on the adaptive behavior of the provincial water management department of Gelderland, and in particular the sections that have played a role in groundwater management. Analysis of archives, interviews, and participant observation have generated insights into the changes that have occurred in the organization and its groundwater management practices in their interaction with other stakeholders and the institutional interface.

In section 8.2, the meso-level changes that have occurred in the provincial water management department and its management practices during the 'Planning a way out' phase are discussed. In section 8.3, these meso-level changes are captured in terms of a 7-S profile analysis of the department and learning repertoires drawn on and developed. In conclusion, lessons learned with regard to facilitating social-environmental learning for sustainable NRM are discussed.

8.2 Meso-level changes in the emergence of groundwater management: Adaptations of the provincial water management department in GL

The learning history of the emergence of groundwater management in GL (see Appendix I) describes how different stakeholders adapt to and adapt institutions in their interaction with each other and the groundwater resource. In the previous chapter, macro-level changes in the history have been distinguished in terms of Holling's ecosystem renewal cycle. These structural macro-level changes emerge from and influence the interaction of stakeholder and their context. In this section, the adaptations of changes that have occurred in the provincial water management department and its management practices are singled out. The time scale focused on is the reorganization phase 'Planning a way out'.

Planning becomes the fashion (1980s)

In the early nineteen seventies, the provincial government of Gelderland mandated a research committee to generate scientifically based recommendations for optimal use and management of the province's water resources. New staff were brought in to set up and carry out the research. On the basis of multi-disciplinary technical analyses and computer modeling, the research group developed a system-thinking-based integrated water management approach.

Through the nineteen seventies and early eighties, the work and findings of this steadily growing research group played a dominant role in the provincial water management department. Previously, the department had provided technical input and operationalization of surface and groundwater management, whereas the province's general secretariat/registrar's office was in charge of translating the water department's technical work into policy, and vice versa. Although responsibilities changed, relations between and within the provincial department and other stakeholders remained highly formal, bureaucratic and top-down. As a result of interplay among the research findings, societal developments, and subsequent expansion of both personnel and tasks, the water management department was reorganized in order to better meet research and policy-making demands (see Figure 8.1a & b for changes in organizational structure). The research committee was institutionalized as a sub-department, while tasks groups, such as the roads and ferries services, were transferred to other departments.

In addition, the provincial government revised its groundwater ordinance to include a regulation requiring actors to obtain a permit for groundwater withdrawals. The water department was responsible for handling the work around issuing these permits. In order to be able to make a more balanced assessment of interests affected by permit applications, staff members desired a more systematic approach for the approval of permits. They felt that planning could provide a means to develop a coherent strategic framework to guide decision making and action regarding multiple requests for permits within a region (Provincie Gelderland 1981a; 1981b; 1983).

On the national and provincial level, planning had previously proven capable of producing guiding frames in this sense, taking into account different interests involved in the spatial planning of protected groundwater withdrawal and recharge areas. Moreover, the drinking water sector regularly developed national strategic plans for long-term planning of investments to guarantee a continuous, high quality, drinking water supply. Subsequently, the planning instrument acquired a central place in the design of the national Water Management Act, initiated in the late nineteen seventies. What is more, the principle of integrated water management, developed in the department's research, was a guiding principle for the development of this act.

Integrating fragmentary legislation and policy plans (1980s)

The department faced, and undertook, a number of reorganizations in order to carry out its principles of integrated management and to accommodate the growing weight of policy-making tasks and legal affairs (see Figure 8.1c for changed organizational chart). The increase in policy making and legal tasks was mostly due to further regulation of water management as well as general government decentralization and budget reductions, macro-level changes discussed in the previous chapter. More operational tasks, such as measurement services, were moved to a different department; and first steps were taken to merge existing sub-departments in line with the integrated water management approach.

As the national Water Management Act was being developed, the provincial water management department approached planning for water resource management in line with this pending statutory obligation. The act would oblige provincial governments to develop integrated water management plans every four years for the area under their jurisdiction. These

plans were to take into account the general policy prescribed in the national level policy plans as well as the statutory obligations for stakeholder consultation and appeals. In addition, the plans were to integrate and replace existing plans for quantity and quality management of surface and groundwater resources. Otherwise, the content of these integrated water management plans was left up to the respective provinces.

The water department's own research regarding integrated water management also paved the way for an integrated planning approach. Having gained insight into the ins and outs of the provincial water system in its research, the department had to translate these insights into water management practices. At first, provincial surface and groundwater management planning was approached in much the same way as the research on which it was based. Experts in the department developed plans on the basis of the department's own technical research and multi-criteria models. In the process, water boards were consulted about the contents of the plan. The first provincial water management plan (WHP I) (Provincie Gelderland 1991) provided insight into the water system, the water management system (policy aspects, responsibilities) and policy guidelines based on thorough research and technical analysis. Most of the time was spent on the analysis and description of the social and physical characteristics of the water system. Although other experts and stakeholders were consulted as prescribed, planning remained a highly internal affair. Moreover, in the process, existing formal and hierarchical relations were generally observed, limiting space for experimentation and change.

Integrated water management planning proves no cure-all (1980s - 1990s)

Implementation and evaluation of first and some second-generation national and provincial plans made it clear that planning proved no panacea for resolving water resource management dilemmas. Because of disappointment and problems with the implementation of the first provincial integral water management plan, the responsible civil servants chose a different approach to achieve integrated water management in the second plan.

After an internal and external evaluation of the first plan, it was decided to bring in more expertise on planning and process management itself for the realization of the second plan. Existing planning practices needed to be improved in terms of integration of surface and water management perspectives, stakeholder participation, development of measurable objectives, and policy-action-evaluation linkages (Ministerie van Verkeer & Waterstaat 1994; Provincie Gelderland 1994). Integration of different types of water management policy entailed more than bringing different sector policy measures together in one plan. Moreover, in the plans many water resource management dilemmas were well analyzed, but still unresolved, as implementation proved problematic. Technical expertise, however sound, had fallen short of creating the support and ownership necessary to realize policy measures. Policy objectives needed to be capable of measurement in order to ensure more effective use of available work time and financial resources, and to monitor the achievement of policy measures.

Changes in operational procedures and style, both within the province and with regard to other stakeholders, created working environments that were more conducive to sharing problem perceptions and action strategies. Internally, formal department lines started to become less rigid and tasks were organized into clusters (see Figure 8.1d for changes in organizational structure). Overall, the department increasingly focused on its policy-making tasks.

Hydrology research, once the heart of the department's identity, was no longer perceived as a core activity.

Integrating planning and action (1990s)

In order to further improve the sustainable management of water resources, more attention was paid to the process design of integrated water management planning, both at the national and provincial level (Ministerie van Verkeer & Waterstaat 1994; Provinice Gelderland 1996, Provincie Gelderland 1996b). So when the Water Management Act required the first provincial water management plan to be revised, a different approach was taken. In addition to the impetus provided by statutory obligation, the second provincial water management plan (WHP II) (Provincie Gelderland 1996) was motivated by the experiences with the previous plan and an internal and external stakeholder evaluation. The evaluation made it clear that the focus needed to be on the implementation of existing policy. Again, civil servants from the provincial water management department were leading the planning process. This time however, other stakeholders were involved in the agenda setting, formulation of policy goals and guidelines, and the implementation of policy. Stakeholders included both other public parties and private parties. After a broad participation of stakeholders in the problem formulation and agenda setting, a smaller group prepared the planning document. The results were discussed with stakeholders, both informally and formally. In addition to policy measures, the planning process generated insight into the dynamics of interactive policy making, understanding of the interests of the stakeholders involved, and new coalitions. The provincial government approved the plan simultaneously with the provincial environmental and spatial planning plans.

In order to develop measurable policy objectives, an attempt was made to improve accountability for the time and financial resources used in respect of tangible products. Multi-stakeholder monitoring groups were used to explore possibilities for collaborative monitoring and exchange of information. Policy, action and evaluation have been linked by taking a more experimental approach to policy development (Provincie Gelderland 1996a). In this approach, existing policy frameworks are continuously questioned, and policy and management practices are adapted to changing circumstances. Thus, new insights are obtained in the planning and implementation process.

In addition, other institutional developments have contributed to improving linkages in policy-action-evaluation. For example, the possibility of policy co-ordination by non-binding legal agreements such as covenants makes it possible to enter provisional working agreements when the grounds for collaboration are still being explored. This approach has been adopted, for example, in the anti-desiccation action plan developed in response to the national policy to combat desiccation, the goals set in the second provincial water management plan and the existing desiccation problems in Gelderland (see also the learning history). Although the provincial water management civil servants were leading the planning process in the first instance, other stakeholders became very much involved in the development of the plan and its implementation. They were involved in the problem formulation, mapping of perceptions, developing a vision and strategy development. The plan provided insight into groundwater use and water system dynamics, shared understanding of problems and actions to be taken. The action plan was ceremonially approved by representatives of the stakeholders. After the

approval, implementation bottlenecks were further addressed collectively. The action plan process aimed to interweave policy making and implementation.

More direct linkage of policy, action and evaluation has facilitated co-management in which different stakeholders experiment with different responsibilities. In this interaction, a more open system vision that takes account of other stakeholders' perspectives has taken root to guide decisions and actions of the water department. These changes in style have co-evolved with changes in the type of personnel and skills brought into the organization and rewarded. Flexibility, and the ability to network, negotiate and generate collaborative commitments among stakeholders are now equally important as in-depth knowledge of hydrology, if not more so. Many of the more operational tasks that require such knowledge are being integrated into other departments or delegated to other stakeholder organizations.

Figure 8.1a: Organogram provincial water management department until 1980/81

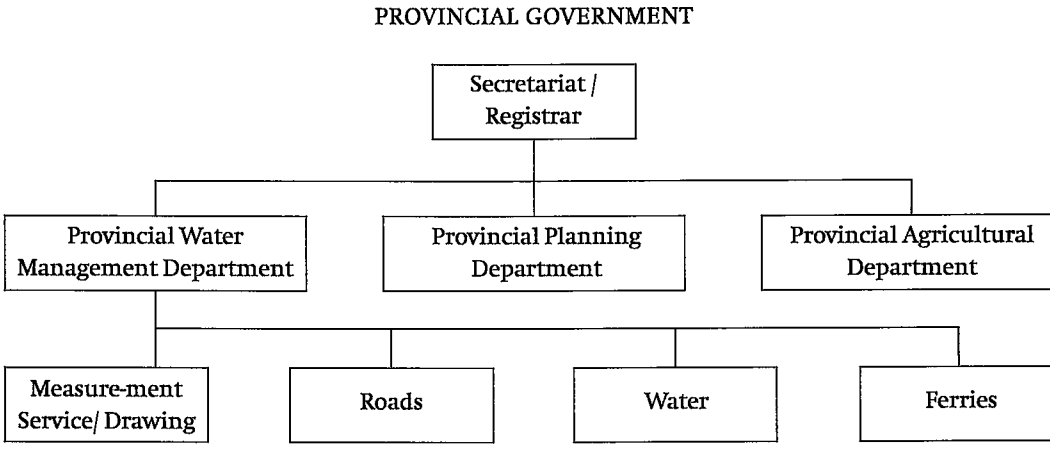


Figure 8.1b: Organogram provincial water management department 1980/81- 1985

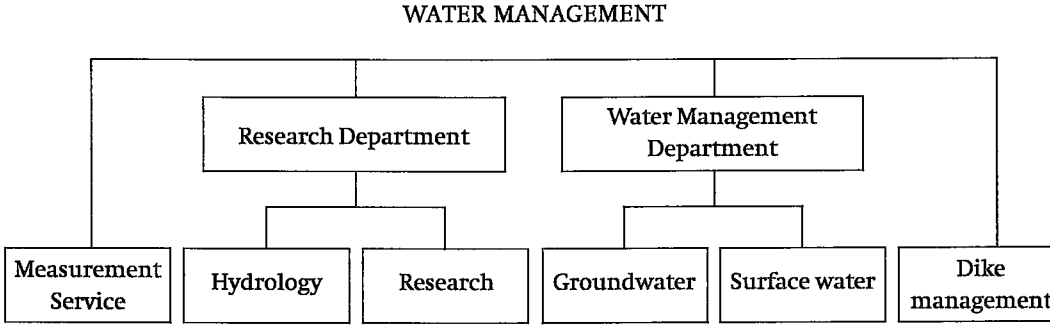


Figure 8.1c: Organogram provincial water management department 1987-1992

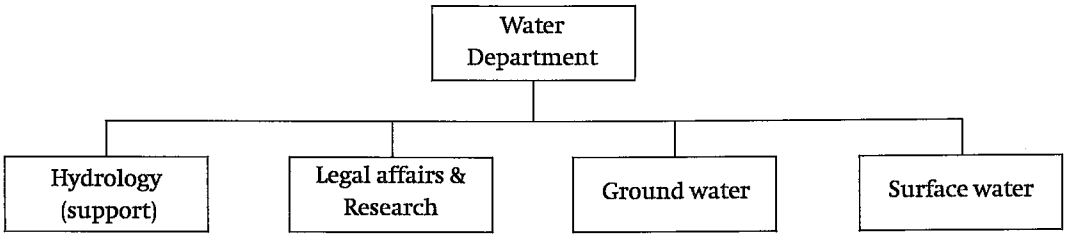
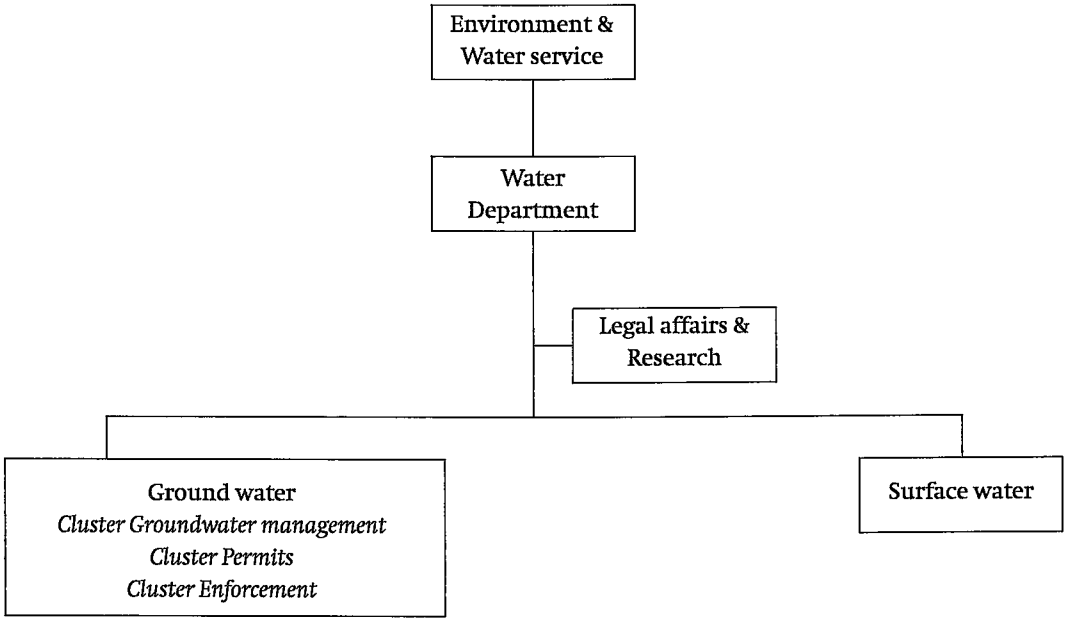


Figure 8.1d: Organogram provincial water management department 1993-1996



8.3 A 7-S profile analysis of meso-level changes in the provincial water management department

In Chapter 6, the 7-S profile was introduced as a tool to capture properties that interplay and constitute change in a stakeholder collective as it adapts to and adapts its environment. The 7-S profile changes in the provincial water management department that occurred during the 'Planning a way out' phase are summarized in Table 8.1. Changes in structure are visualized in four organograms provided in Figure 8.1a-d. As the analysis will indicate, the realization of integrated management has entailed changes in all 7-S factors, not just structure or strategy, but also in terms of people working in the organization and the values they share.

Table 8.1: Adapting (to) groundwater management dynamics by the provincial water department, Gelderland, The Netherlands (1979-1996)

Planning	*(Re)discovery of the planning instrument*	*Planning is the fashion*	*Planning proves no cure-all*[a]	*Integrating planning and action*
Staff	Technical personnel →			
	Legal staff →			
			Planners →	
Skills	Hydrology research →	I		
		Strategic planning & policy making →		
				Facilitation of co-management →
	Registration of groundwater withdrawal & infiltration →			
		Grant permits for groundwater withdrawal & infiltration →		
Strategy	Integrated water management →			
Structure	Figure 8.1a to Figure 8.1b	Figure 8.1b to Figure 8.1c	Figure 8.1c to Figure 8.1d	
Systems	Technical analysis/research ←	Planning →		Project, product & process thinking
Style	Top-down, bureaucratic ↔			Interactive
	Formal ↔			Informal
	Expertise-oriented ↔	Multi-disciplinary ↔		Collaborative approach
	Control ↔			Facilitative
Shared goals	Ad-hoc/closed system vision ↔			Open system vision
	Government as regulator ↔			Government as facilitator

During the phase 'Planning our way out', staff and their skills in the provincial water management department changed from mainly technical and research personnel to people skilled and experienced in legal affairs and planning. Not only the content of skills changed, but also their nature. New job descriptions indicate that staff should be able to use skills in a participatory way, be more sensitive to the environment, cooperative, customer-oriented and take on a more facilitating government attitude: in other words, pick up signals and translate those into policy rather than propagate policy measures.

Changes in staff and skills came about by bringing in new people as well as by training and personnel development. Bringing in new people brings in new perspectives and new energy to take on roads already trodden or untrodden.

> *I was new and still looking a bit for what could become my main responsibility. The sprinkling planner as a tool to manage groundwater use by farmers sounded logical to me, while others, who had seen it all before, were more skeptical. That happens often. They had seen similar initiatives run aground. I did not know, so I took on the issue, and the ball started rolling.*

As the nature of the organization changed, some staff members moved to the foreground. Others felt the department was no longer the right place for them and looked elsewhere to apply and develop their individual skills. The nature of managers also changed. They are increasingly more personnel managers, facilitating staff members to do their jobs as well as possible and to feel responsible for the products delivered. Of course, in theory and legally, the manager remains ultimately responsible, but staff members are selected and trained to be more responsible for their own work.

In the nineteen seventies and early eighties, the department had developed a reputation as a center for quality hydrology research. During the planning phase, the organization's skills changed toward policy making and facilitation of co-management arrangements. These changes were in line with the department's developing strategy. Although earlier it appeared as if the department was mainly reacting to (pending) statutory obligations, the principles of integrated water management have contributed to the development of a strategy that guides the actions planned by the department in response to, or in anticipation of, changes in its external environment.

Developments in terms of strategy have co-evolved with changes in the department's structure. These are captured by organograms of the formal organizational design (see Figure 8.1a-d). As boundaries of the department and its sub-departments were realigned or even broken down, integrated water management has been institutionalized, creating new opportunities to further develop this approach. Where previously staff had certain functions, they now have roles in clusters, or even across cluster boundaries. The idea is that such terminology will increase flexibility.

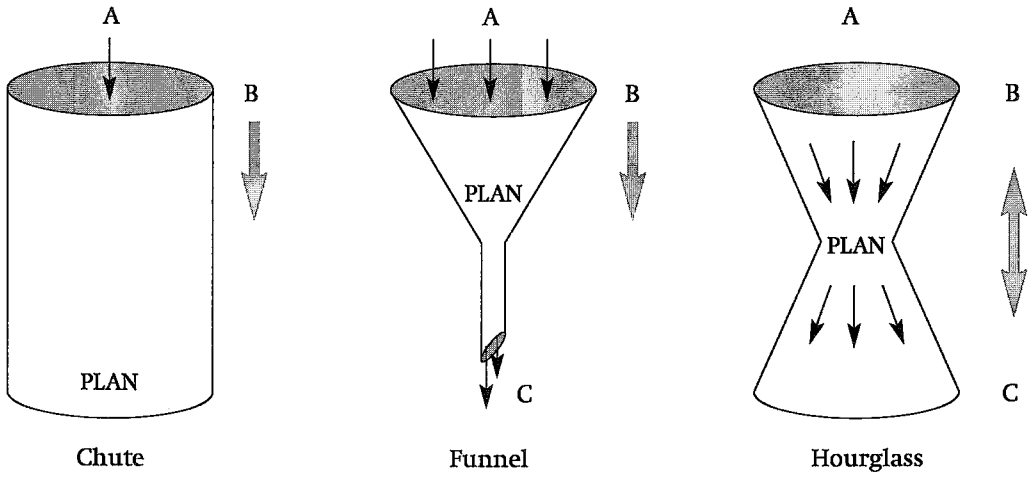
> However, as one staff member indicates:
> *The most important change is the change in working procedures. More area-oriented policy, more integral ways of approaching problems versus you do agriculture, you sewage, etc. That has definitely changed. There is more cooperation with other departments. Now you talk with others. In the past, things went through the hierarchical paper circuit of advisory forms and signatures. And the head manager had the last word. Now, different people get together and*

discuss the provincial line to be taken. And the relationship with the provincial council member is also different. Previously, only the department head discussed matters with the provincial council member, now different people do. This means you are more responsible for your own product and can't hide behind your boss's back.

The organization's standards, i.e., its formal and informal procedures for day-to-day operations, have evolved from being detailed and technical oriented to being process and product oriented, giving individual staff members room to act as they see fit.

This change also becomes visible in some of the planning practices discussed in the previous section. These planning practices are illustrated in Figure 8.2. Where development of the first provincial water management plan was like a chute, the development of the second provincial water management plan was more like a funnel. The first water management plan was triggered by a single, formal trigger (point A), entailed little widening and narrowing of goals and participating stakeholders (boundaries of chute), moved from policy development to implementation (point B), and the plan landed pretty much at the bottom of the chute, to stay there. The second water management plan was triggered by the legal obligation, lessons learned from the previous planning process, and interests of other stakeholders (point A). The process diverged and converged with regard to goals and stakeholders involved (boundaries of funnel); and in moving from policy development to implementation (point B), implementation measures were developed to be taken on by different stakeholders (point C). The anti-desiccation plan adopted a similar approach, but has incorporated implementation in the policy development process, making the process more like an hourglass. As implementation proceeds, it is attempted to have immediately feedback into the policy making process (point C).

Figure 8.2: Chutes, funnels and hourglasses: Planning practices



Adapted from Bert Meijers

Changes within and across the different planning processes were made possible by developments described in the other 7-S properties.

Because of the nature of some of the tasks, for example the legal procedures to be followed for issuing groundwater permits, some very precise procedures do remain in place. However, as formal, restrictive, specific rules changed into more general, condition creating ones and monitoring has been improved through computer and GIS technology, it is increasingly possible to take a more tailored approach to rules and monitoring.

The style in which these procedures are carried out, captured by looking at the way an organization's members communicate and act, has changed during the period analyzed. Overall top-down, bureaucratic, formal communication has become more interactive and informal, as already touched upon in the analysis of staff, skills, structure and standards. For the water management department staff, this entailed letting go of the expert attitude and taking on a more service oriented one. Both a study of minutes of meetings and participatory observation during meetings indicate the effect of more or less formal language use. Accordingly, there is more space for collaborative and facilitative action. Where interaction is more open, a first name basis and the informal form of address appear to be the rule. During some meetings, the researcher noted that people reverted to the formal form of address when they had conflicting views.

Many of these changes can be traced back to changes in shared values. In this regard, while the principles of integrated water management have played an important role, societal changes in ideas about the role and position of government as discussed in the previous chapter have also influenced the way in which the water management department has developed. Where previously government's role had been viewed as that of a regulator, during the phase 'Planning our way out' government's role has more and more become that of a facilitator. Staff members have worked to translate this view into a more open system vision of the department and its role in groundwater management.

8.4 Implications for learning about social-environmental learning for sustainable NRM

Different types of lessons may be drawn from the meso-level analysis of the emergence of groundwater management in GL. First, the meso-level changes in the provincial water management department confirm that, for change to occur, complementary changes need to occur in terms of the different 7-S properties. Changes in structures are not enough to bring about change. These need to be complemented by changes in staff, style, standards, and so on. No single property carries enough weight of itself to bring about change.

The meso-level learning history and the 7-S property analysis also indicate that changes in a collective stakeholder need to be supported by change at macro level. One stakeholder cannot change a system as whole. Systemic change requires changes both in the institutional interface and in its constituent stakeholders. This may seem obvious, but stakeholders often lose faith when another stakeholder does not immediately respond to new intentions and/or behavior. However, insights into the way feedback loops work indicate that, for new interactions to generate new behavioral patterns and institutions, they need to occur more than once or twice; and stakeholders will need to take into account the possible time lag between action taken and effects on other stakeholders and the institutional interface. Similarly, the design of new regulations or policy measures will not automatically take effect. The planning proce-

dures undertaken (depicted in terms of chutes, funnels, and hourglasses in Figure 8.2) indicate that the goal-directed behavior of stakeholders (direct emergence), a supporting institutional frame (indirect emergence) and continuous smaller, short-term cycles of policy development and evaluation (learning dynamics of reflection and action) are all needed to ensure that changes will actually occur.

The meso-level learning history and 7-S property analysis also indicate that changes in a collective stakeholder entail changes at micro level. Meso and macro-level changes entail individual learning and personnel development. The staff members interviewed indicated that the change processes of which they have been part have entailed changes with regard to their own personal development. Such changes may vary from getting a better understanding of one's abilities to actually changing, for example, the way one communicates with others. It is also interesting to note how sometimes someone's lack of experience may actually jumpstart an amplifying feedback loop for a change trajectory that others have learned to doubt or learned to regulate.

With regard to learning, the meso-level analysis also teaches us to beware of agreement in talk and policy documents. The fuzziness of language that allows people to bridge different ideas and perceptions in talk and in policy documents may turn out to be less of a bridge when it comes to action. This provides another reason for reflection and action to be more closely linked when it comes to sustainable NRM. The interviews for the meso-level analysis also indicate that learning for sustainable NRM lies not only in large structural changes, but also in the small talk after meetings when people exchange views and reflect on the way things have gone. This is confirmed in knowledge management techniques such as the after-action review.

The nature of the changes that have occurred confirm that the three evaluative criteria of systems thinking, experimentation, and communicative action are principles that may guide facilitation of social-environmental learning and sustainable NRM. As the members of the provincial water management department learn to integrate different aspects of groundwater management, a system perspective, working with pilots, and taking a more participatory approach becomes more mainstream. However, experiences also indicate that their implementation entails learning process in itself.

PART IV

LESSONS LEARNED

9 Facilitating social-environmental learning for sustainable NRM

The roots of social order are in our heads, where we possess the instinctive capacities for creating not a perfectly harmonious and virtuous society, but a better one than we have at present. We must build our institutions in such a way that they draw out those instincts. (Ridley 1996)

Research objective addressed
O3: Propose directions to further facilitate social-environmental learning to generate institutional changes for sustainable NRM

Abstract
In this chapter the research questions and objectives are revisited. Lessons learned in the preceding chapters are reviewed in terms of the research questions and objectives. On the basis of these findings, directions for facilitating social-environmental learning for sustainable NRM are proposed. In conclusion, suggestions for future learning about the viability of a social-environmental learning perspective are discussed.

9.1 Revisiting the research questions and objectives

In Chapter 1, two scenarios for water resource management in 2025 were discussed. The doom scenario predicts that by 2025 people and nature will face the consequences of increasing fresh water shortages. The World Water Vision scenario predicts that in 2025 people will have learned to manage water in a sustainable way so that both people and the environment will have ample access to the water they need. The World Water Forum meeting in March 2003 has confirmed that the latter is still the path most people would prefer to follow (http://world.water-forum3.com). The reports from this forum have also confirmed, however, that realizing such a scenario will prove no easy matter. It appears that technological knowledge is not so much the problem. People have created a great number of technological innovations that could contribute to more efficient and effective management of water resources. The bottleneck will arise in relation to agreeing on the strategy to take and subsequently realizing it. Such a process involves challenges with regard to changing the institutions that determine the relationships between stakeholders and the environment; and these challenges often appear to have a social-dilemma character (see section 3.2) that may constitute an insurmountable barrier to developing sustainable NRM.

The research undertaken for this thesis has aimed to integrate and assess existing and new evidence in research and practice to further understand the potential of a social-environmental learning perspective to contribute to realizing sustainable water management, and NRM in general. A social-environmental learning perspective focuses on the learning capacity of collectives to cope with complex NRM issues that require some form of collective, coordinated action. Accordingly, a social-environmental perspective focuses on how people learn to adapt to and adapt their environment and the institutions that frame their actions and decisions. Moreover, as a social-environmental perspective views sustainable NRM as an on-going process, it aims to gain an understanding of, and facilitate how, people may continuously develop both knowledge and the ability to use it.

The characteristics of the social-environmental learning perspective appear to render it viable to deal with dilemmas faced in water management and in other fields of NRM today. In this section, lessons learned in the preceding chapters are reviewed in terms of the research questions and objectives posed at the outset regarding the viability of this perspective for developing sustainable NRM. On the basis of these findings, directions for facilitating social-environmental learning are proposed in section 9.2. In conclusion, suggestions for future learning about the viability of a social-environmental learning perspective for sustainable water management and NRM in general are discussed.

In Chapter 1, research questions and a number of objectives were formulated to structure the inquiry into whether social-environmental learning was a viable perspective for facilitating sustainable NRM. The questions and objectives are recapitulated in Box 9.1.

Box 9.1: Research questions and objectives

Research Questions
Why is social-environmental learning a viable perspective for developing sustainable NRM? And how may social-environmental learning be facilitated to generate sustainable NRM?

Research objectives
O1: Explore foundations for social-environmental learning as a viable perspective for sustainable NRM
O2: Identify and assess linkages between social-environmental learning and NRM dynamics in real-time, complex NRM
O3: Propose directions to further facilitate social-environmental learning to generate institutional changes for sustainable NRM

These research objectives have been addressed in Chapters 3 to 8 in a combination of theoretical and case study research to investigate whether and how a social-environmental perspective may fulfill its promise. All in all, it may be concluded that: *In highlighting people's potential capacity for learning and how this capacity may contribute to realizing a sustainable fit among resources, stakeholders, and the institutions mediating their interactions, a social-environmental learning perspective can contribute to developing sustainable NRM.* This conclusion is further elaborated in terms of the research objectives.

In Part I, foundations for a social-environmental learning perspective as an approach to realizing sustainable NRM were explored (O1). The exploration in Chapter 3 of state of the art developments in the four research and practice fields reveals how learning may be a key concept to deal with complex, evolving dynamics and consequent dilemmas that characterize NRM.

- Social dilemma research provides a means to conceptualize and analyze complex interdependent relationships. Recent developments show that, when the learning ability of people is taken into consideration, it becomes clear that cooperation might be as natural a part of the human repertoire as unchecked, self-interest maximizing behavior. Putting homo discens in the spotlight highlights possibilities for individuals to undertake effective collective action in traditionally predicted, irresolvable, nested social dilemmas. In light of people's learning capacity, social dilemma interdependence provides opportunities for cooperation as much as for defective choices. In particular, people's ability to adapt the rules of the game that create the social dilemma interdependence, and the role of communication therein, deserves further attention.

- Sustainable development and NRM practice provide a means to reveal to the collective the consequences of management practices at different levels of analysis. Analysis of NRM practices to realize sustainable development shows that the management practices targeted to resolve NRM dilemmas may turn out to actually be the cause of new NRM dilemmas or amplify the ones they set out to resolve. Such effects exemplify myopic management, the inability of certain management approaches to shift focus when their effect has been achieved, or even proven ineffective. Instead, preservation of the management practice itself and the patterns it generates become points of focus. In order to develop and draw on people's ability to cope with evolving conditions, an adaptive management approach and democratic institutions have been found essential to facilitate sustainable development. Both entail dynamics that provide conditions for a learning environment.

- Developments in knowledge and innovation management in rural development also confirm the significance of a learning perspective. Where first methodologies and tools were mainly used to bring about change by linear transfer of technology, growing insights point towards the importance of creating an enabling environment in which different laypersons and experts can learn from each other and develop and renew practices.

- Complexity theory research provides a means to understand the adaptive dynamics of complex evolving systems. It has contributed to creating a common conceptual language enabling different disciplines to exchange insights regarding the same complex phenomena or different ones with similar complex dynamics. As such, it has contributed to the elucidation of the apparently chaotic dynamics of complex adaptive systems such as NRM.

In addition to converging towards learning as a key notion, the four research and practice fields explored reveal the importance of institutions in structuring and adapting decisions and actions in NRM and of people's ability to communicate and share meaning when linking learning and NRM. Principles such as systems thinking, experimentation, and communicative action have been found to provide direction in the facilitation of such processes towards more sustainable NRM.

In Chapter 4, the notion of learning itself was addressed in more depth. Different models of learning emphasize its adaptive potential. This adaptive potential is a fundamental notion in a social-environmental learning perspective. After all, it is this capacity that enables entities to continuously modify understanding of NRM and, accordingly, adapt decisions and actions, and the institutions mediating those interactions. A review of different models of learning indicates that learning may be viewed as a dynamic, iterative process involving cognitive and behavioral processes that enable people at different levels of aggregation to adapt to and adapt their environment. This entails a combination of abilities to perceive oneself and one's context, to express intentionality in terms of goals and priorities, and to translate these intentions into action to influence a situation toward a preferred state. In this process, an individual or a collective of individuals organizes and reorganizes the way they experience their environment, generating knowledge and skills. Thus, insight into one's context and one's position in it may be generated. Accordingly, a cognitive frame is constructed that subsequently largely influences how individuals experience the world and what future learning occurs.

The manner in which such learning may manifest itself in terms of interactions among resources, stakeholders, and institutions is very diverse. Based on the characteristics of a social-learning perspective and insights with regard to human learning in general, different manifestations have been drawn together in an overview that clarifies people's potential for social-environmental learning (see Figure 4.4). The overview indicates how people may draw on an infinite number of learning repertoires to develop sustainable NRM.

The question is how to capitalize on this potential for social-environmental learning. For this reason, a closer analysis of the role of institutions in NRM was undertaken in Chapter 5. Further theoretical analysis of the relationships among stakeholders, resources and institutions indicates how institutions may be viewed as a collective cognitive frame in the interaction between people and their environment. The ways in which institutions give shape to, and are shaped by, people's decisions and actions have been found to parallel learning dynamics. Both involve a dual dynamic (direct and indirect emergence) of iterative feedback loops in which the creation and sharing of meaning plays an important role. Insight into the role of amplifying and regulatory feedback shows that both types of feedback may play a role in learning to adapt to and adapt the institutional interface in NRM. Thus, it is not only the regulatory nature of institutional dynamics that must be taken into account, but also amplifying feedback loops, that may indicate when institutions become overly self-referential or have the potential for new equilibria. Insights into the collective creation and sharing of meaning in terms of the notion of embodied cognition have indicated how a number of characteristics of language may contribute to learning and changes in the institutional interface in NRM dynamics.

Overall, the findings in Part II indicated that there is a sound basis in both theory and practice for social-environmental learning as a perspective for developing sustainable NRM. However, the insights gained also indicate that, although people have the potential for social-environmental learning for sustainable NRM, this does not mean they always achieve it. Practice and theory have also indicated that people have the ability to learn both non-sustainable and sustainable NRM practices. Further investigation of both in a real-time, complex NRM case could help to better understand people's potential for social-environmental learning, and generate knowledge that might be used to develop sustainable practices.

In Part III, linkages between social-environmental learning and NRM dynamics in a real-time, complex NRM case were further identified and assessed (O2). Based on the insights gained in Part II, an analytical framework, supporting tools and a methodology for analysis were proposed in Chapter 6. The analytical framework focuses the analysis on the macro and meso level. The tools of analysis (Holling's ecosystem cycle and the 7-S profile) and the learning history methodology were chosen as they have proven capable of taking into account both static and dynamic qualities of resources, stakeholders and institutions discussed in the introductory chapter and Part II. In this research, they are for the first time combined for macro and meso-level analysis and assessment of structural linkages in social-environmental learning and NRM dynamics in a complex NRM case.

In Chapter 7, macro-level analysis of the emergence of groundwater management in GL has shown how social-environmental learning and NRM dynamics may interact to generate institutional changes in a complex, real-time case. Such learning may be viewed as occurring in terms of interacting and nested Holling renewal cycles in which learning to be effective, learning to expand, learning to be efficient and learning to integrate occur in different degrees. As indicated in Chapter 4, learning may have both a conserving and a renewing character. The case study makes clear how learning has contributed to the on-going understanding of groundwater resource dynamics, decisions and actions of stakeholders involved, and changes in mediating institutions. Groundwater management in GL has evolved from single issue, sectoral management to a multiple, integrated management approach. The overview in Table 7.1 indicates what such learning has entailed in terms of changes and fit among the characteristics of the groundwater resource, stakeholders involved, and mediating institutions. The emergence of groundwater management in GL has also shown that it can take quite some time for changes to occur. For example, the insights that currently play a role in integrated (ground) water management already existed during the first steps of its exploitation.

A social-environmental learning analysis and assessment has indicated how people tend to draw on only part of their potential capacity for social-environmental learning. Institutional and cognitive-related factors may underlie possibilities and pitfalls with regard to people's ability to draw on and develop their learning potential and, accordingly, adapt to and adapt institutions for sustainable NRM. Static and dynamic qualities of institutions may inhibit or provide possibilities for different learning, thus either hiding new developments in the undergrowth of mainstream institutions or providing a fertile underground for them to develop. The analysis and assessment has indicated how some institutions are more restrictive in nature and create learning asymmetries, while others are more condition creating and stimulate stakeholders to develop more flexible collectives and to experiment. In addition, the dual dynamics of institutions are not foolproof. Examples of over-steering, crowding out effects, and self-referentiality have indicated the limits of the regulative power of institutions. Time lags in the feedback loops and cognitive fallacies have been found to underlie such limitations. The tendency to harness amplifying feedback loops as quickly as possible also reduces people's ability to recognize when they are beginning to become overly self-referential or have the potential of new equilibria. Moreover, institutional memory often proves to be a sieve, as the wheel is reinvented in the different renewal cycles.

In Chapter 8, the meso-level changes in the provincial water management department have confirmed that, for change to occur, complementary changes need to occur in terms of the different 7-S properties within the stakeholders involved. Changes in structures are not

enough to bring about change. These need to be complemented by changes in staff, style, standards, and so on. No single property carries enough weight of itself to bring about change.

The meso-level learning history and 7-S property analysis also indicated that changes in a collective stakeholder need to be supported by change at macro level. One stakeholder cannot change a system as whole. Systemic change requires changes in both the institutional interface and its constituent stakeholders. This may seem obvious, but stakeholders often lose faith when another stakeholder does not immediately respond to new intentions and/or behavior. However, insights into the way feedback loops work indicate that, for new interactions to generate new behavioral patterns and institutions, they will need to occur more than once or twice; and stakeholders will need to take into account the possible time lag between action taken and effects on other stakeholders and the institutional interface. Similarly, the design of new regulations or policy measures will not automatically take effect. The planning procedures undertaken (depicted in terms of chutes, funnels, and hourglasses in Figure 8.2) indicate that goal-directed behavior of stakeholders (direct emergence), a supporting institutional frame (indirect emergence) and continuous smaller, short-term cycles of policy development and evaluation (learning dynamics of reflection and action) are all needed to ensure that changes will actually occur.

The meso-level learning history and 7-S property analysis also indicated that changes in a collective stakeholder entail changes at micro level. Meso and macro-level changes entail individual learning and personnel development. The staff members interviewed indicated that the change processes of which they have been part have entailed changes with regard to their own personal development. Such changes may vary from getting a better understanding of one's abilities to actually changing, for example, the way one communicates with others. It is also interesting to note how sometimes someone's lack of experience may actually jumpstart an amplifying feedback loop for a change trajectory that others have learned to doubt or learned to regulate.

Overall, the findings in Part III have revealed a number of linkages between social-environmental learning and NRM dynamics that may play a role in a real-time, complex NRM case. The primary linkages are the resources, stakeholders, and mediating institutions themselves. These are all interconnected at macro, meso and micro levels; and their interaction within and between levels is the result of and frames the learning of stakeholders involved. Changes in one may thus lead to changes in another. The type and direction of change and learning repertoires drawn on and developed will differ, however, depending on the NRM dilemmas and dynamics faced. This highlights other possible linkages between learning and NRM.

Directions to further facilitate social-environmental learning to generate institutional changes for sustainable NRM (O3) in light of these lessons are discussed in the following section.

9.2 Facilitating social-environmental learning for sustainable NRM: Taking a closer look at facilitation principles

The lessons learned in terms of the first two research objectives both confirm the use of principles such as systems thinking, experimentation, and communicative action for the facilita-

tion of social-environmental learning for sustainable NRM and draw attention to a number of other principles that should be taken into account. With regard to the three facilitation principles that have been taken into account, some implications for future facilitation of social-environmental learning are discussed. Diversity, redundancy, and resonance are proposed as additional principles to take into account when facilitating social-environmental learning for sustainable NRM.

Both the foundations for social-environmental learning and the real-time, complex NRM case have indicated that mastering systems thinking, experimentation, and communicative action entails a learning process in itself. Thus, facilitation of social-environmental learning in this regard should take into account the fact that stakeholders will need to go through a process of single, double, and triple loop learning in which the possibilities and limits of these principles for developing sustainable NRM are learned. With regard to systems thinking, the research has confirmed that the boundaries of the system perspective taken, whether in terms of biophysical and human systems and their interaction, sub and supra-systems in terms of time and space scales, or multiple perspectives involved, are greatly influenced by the eye of the beholder. Such boundaries influence learning repertoires drawn on and developed in terms of who is learning, what is learned, how learning takes place, and why learning takes place. Moreover, the notions of complexity science have helped to clarify that system boundaries in NRM are continuously changing as the equilibria around which they emerge change. Thus, facilitation of social-environmental learning will need to build in safeguards that trigger awareness of possible biases and possibilities of switching the system perspective taken.

With regard to experimentation, monitoring has been found to play an important role in triggering individual and collective reflection. However, monitoring is often not a priority activity and, if it takes place, it is often at the end of a concrete project cycle and in terms of quantity and product indicators (vs. qualitative and process ones), reducing the possibility of actually using the outcomes of the reflection to adjust future action. In order to facilitate future social-environmental learning, it is proposed to better match monitoring with learning cycles embedded in the different renewal cycles that may be distinguished in an NRM case (See for example Guijt in preparation). The research has indicated that stakeholders, both at the individual and collective level, are often not aware of the goals and intentions they may have. Thus, future facilitation of social-environmental learning in terms of communicative action needs to take into account the articulation of goals and intentions. Such awareness raising may involve personal development trajectories at the micro level.

Based on the research findings, three additional principles are proposed for facilitation of social-environmental learning for sustainable resource management, namely, diversity, redundancy, and resonance. Diversity is proposed as a facilitation principle in order to highlight the importance of diversity in its different forms. The findings in Part II and Part III have shown that diversity in stakeholders, institutions, and learning repertoires may help to increase adaptiveness in NRM. Such diversity may be facilitated in terms of the overview of people's potential capacity for social-environmental learning. Current learning repertoires drawn on may be matched against people's potential for learning. Where learning asymmetries occur in terms of a biased reliance on certain repertoires, diversity may thus be increased.

The principle of redundancy is suggested because the research has identified the tendency to want to design the perfect institutions, plan, organization structure, and so on. However, the research has also shown that most interactions among resource, stakeholders, and mediating institutions occur by approximation. Thus, some overlap in learning and institutions may contribute to ensuring dilemmas at different time and space scales can be coped with. Redundancy may create the necessary space to turn around crisis in a system into a new equilibrium situation (Hirschman 1970) or a breeding ground for new synergy among stakeholders, resources and, institutions (Evans 1996a, 1996b). Moreover, such redundancy may contribute to increasing diversity of NRM practices developed.

The principle of resonance is proposed in order to better capture the role of amplifying feedback loops. Recognizing and using resonance in relation to overly self-referential institutions and stakeholders, and potential new equilibrium points, may contribute to using the potential of crisis that is currently more often approached in terms of conflict and disaster management. The research findings indicate that crisis has an important role in learning that should be taken into account. Research in communication indicates how such resonance may lead to radical, quick changes in people and institutions (Van Ginneken 1999).

In line with the social-learning perspective, the value of these principles for providing direction to further facilitate social-environmental learning will need to be assessed as resources, stakeholders, and mediating institutions co-evolve towards new dilemmas and dynamics.

9.3 Future learning

As mentioned in the introduction, a social-environmental learning perspective is inherently an evolving perspective. In light of the approach taken in this research and the insights gained, the following directions are proposed for further learning about a social-environmental learning perspective for sustainable NRM. Three areas for future investigation are recommended: linking of learning at micro, meso and macro levels of interaction and analysis; comparative study of learning environments and learning outcomes; and taking an action science approach.

- *Linking learning at micro, meso and macro levels*
  In Chapter 5, three levels of interaction among people, their environment and institutions are distinguished. As a social-environmental learning perspective focuses on learning by collectives, this research has focused on the meso and macro levels of analysis. Both the macro and meso-level analysis indicate that individual learning plays a role in learning at these levels. Future research needs to link the learning history method that has been undertaken at macro and meso levels in this research with biographical studies of individuals involved in NRM (see for example Vandenabeele 1999) in order to gain further understanding of how individual learning and collective learning are and may be linked.

- *Gain more understanding of learning environments and learning outcomes*
  This research has contributed to gaining insight into which types of institutional and organizational environments are conducive to facilitating social-environmental learning for sustainable NRM. However, this insight is still rather limited and based on the context that has been studied. Other types of institutional and organizational environments exist.

Insight into the relationship between these contexts and learning, and - where possible - comparisons, may indicate patterns in learning environments, learning repertoires drawn on, and learning outcomes generated. These insights could then be used as a basis for further facilitation of social-environmental learning.

- *Undertake action science research*
  This research has used methods and principles from action science. However, the main focus of the research has been to integrate and assess existing and new evidence in research and practice, making it more a reflective, theoretical study. In light of the research questions and approach, this has been fitting. In light of the lessons learned, however, a more action-oriented approach is recommended to learn more about social-environmental learning in NRM. The interviews and participatory observation undertaken for the case study have revealed the richness of practitioners' experiences and knowledge, whether they intentionally reflect on their practices or not. Moreover, learning about social-environmental learning is a social-environmental learning process in itself. Thus, it is important to involve NRM stakeholders in research and reflection with regard to their own learning processes. This entails linking research dynamics with everyday working practice dynamics (see for example Gibbon et al 2003).

Pursuing these areas for further investigation will contribute to further underpin the potential strengths and reduce the elusiveness of social environmental learning and its facilitation for sustainable NRM. This research has shown that social environmental learning is a viable perspective. However a social environmental learning perspective is in itself a complex evolving approach that requires continuous modified understanding and innovation.

References

Aarts, Noelle 1998. *Een kwestie van natuur. Een studie naar de aard en het verloop van communicatie over natuur en natuurbeleid.* Wageningen: Wageningen University Published Dissertation.

Aarts, Noelle & Marleen Maarleveld 1999. Interactieve beleidsvorming. In Cees van Woerkum & Puk van Meegeren (eds.), *Basisboek communicatie en verandering.* Amsterdam: Boom.

Aarts, Noelle & Cees van Woerkum 2002. Dealing with uncertainty in solving complex problems. In: Leeuwis, C. en R. Pyburn (eds). *Wheelbarrows full of frogs; social learning in rural resource management.* Assen: Koninklijke van Gorcum.

Aarts, Kees, Huib Pellikaan & Robert-Jan Van der Veen 1995. *Sociale dilemma's in het milieubeleid.* Amsterdam: Spinhuis.

Adolfse, Luc & Cees Van Woerkum 1997. *Naar een methodiek voor interactieve beleidsvorming. Experiment Landinrichting Bosaanleg op landbouwgronden.* Wageningen: Vakgroep Voorlichtingskunde

Alexander, E.R. 1984. After rationality what? A review of responses to paradigm breakdown. *American Planning Association Journal, 50,* 62-69.

Anderson, Philip A., Kenneth J. Arrow & David Pines 1988. *The economy as an evolving complex system.* Volume V, Santa Fe Institute Studies in the Sciences of Complexity, Addison-Wesley Publishing Company.

Anderson, Robert C. 2001. *Environmental economics report inventory. The United States Experience with economic incentives for protecting the environment.* Washington, D.C.: Environmental Protection Agency. See also http://itdomino2.icfconsulting.com/EE/epa/eerm.nsf

Argyris, C. & D. Schön 1996. *Organizational Learning II: Theory, method, and practice.* Reading: Addison-Wesley Publishing.

Argyris, C., R. Putnam & D. Maclain Smith 1985. *Action Science.* San Fransisco: Jossey-Bass Publishers.

Arrow, Kenneth J. 1988. Workshop on the economy as an evolving, complex system: Summary. In Anderson, Philip A., Kenneth J. Arrow & David Pines 1988. *The economy as an evolving complex system.* Volume V, Santa Fe Institute Studies in the Sciences of Complexity, Addison-Wesley Publishing Company, 275-281.

ASCE 1998 to be added

Ayas, Karen 1995. *Design for learning for innovation. Project management for new project development.* Delft: Eburon.

Ayas, Karen & J. Wil Foppen (eds.) 1996. *The learning organization and organizational learning.* Rotterdam: Rotterdam School of Management.

Axelrod 1984. *The evolution of cooperation. New York:* Basic Books.

Axelrod, Robert 1997. *The complexity of cooperation. Agent-based models of competition and cooperation.* Princeton: Princeton University Press.

Babbie, Earl 1983. *The practice of social research.* Belmont: Wadsworth.

Bandura, A. 1977. *Social learning theory.* Englewood Cliffs: Prentice Hall.

Bandura, A. 1986. *Social foundations of thought and actions.* Englewood Cliffs: Prentice Hall.

Bawden, Richard 1991. Systems thinking and practice in agriculture. *Journal of Dairy Science, 74,* 2362-2373.

Bawden, R. undated in J. Woodhill 1999, *Sustaining Rural Australia: A political economic critique o natural resource management.* Canberra, Australian National University.

Bawden, R. & R.Packham 1991. Action researching systems: Extension reconstructed. Paper

presented for Workshop in Agricultural Knowledge systems and the Role of Extension. University of Hohenheim, Stuttgart, Germany, May 21-25.
Beck, Ulrich 1992. *Risk Society: Towards a new modernity*. London: Sage Publications.
Beck, Ulrich, Anthony Giddens & Scott Lash 1994. *Reflexive modernization. Politics, tradition and aesthetics in the modern social order*. Standford: Stanford University Press.
Bennett, C.J. & M. Howlett 1992. The lessons of learning: reconciling theories of policy learning and policy change. *Policy Sciences, 25*, 275-294.
Berkes, Fikret & Carl Folke (eds.) 1998. *Linking social and ecological systems. Management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press.
Berkes, Fikret & Carl Folke 2002. Back to the future: Ecosystem dynamics and local knowledge. In Lance Gunderson & C.S. Holling (eds.), *Panarchy. Understanding transformations in human and natural systems*. Washington D.C.: Island Press.
Borrini-Feyerabend, G. 1996. *Collaborative management of protected areas: Tailoring the approach to the context*. Geneva: IUCN Social Policy Division.
Bourdieu, Pierre 1992. Opstellen over smaak, habitus en het veldbegrip. Amsterdam: Van Gennep.
Brand, A. 1990. *The Force of Reason: An introduction to Habermas' theory of communicative action*. Sydney: Allen & Unwin Pty Ltd.
Bromley, Daniel W. (ed) 1992. *Making the commons work: Theory, practice and policy*. San Francisco: ISC Press.
Brookfield, S. 1986. *Understanding and facilitating adult learning*. Milton Keynes: Open University Press.
Cacioppo, J. T., R. E. Petty, and C. F. Kao 1984. The efficient assessment of need for cognition, , *Journal of Personality Assessment, 48*, 306-307
Cacioppo, J. T., Petty, R. E., Feinstein, J., & Jarvis, B. 1996. Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119*, 197-253
Campbell, A. 1994. *Landcare - Communities Shaping the Land and the Future*. Sydney, Allen and Unwin.Capra, F. 1996. *The Web of Life: A new synthesis of mind and matter*. London, Flamingo.
Casti, John L. 1994. *Complexification. Explaining a paradoxical world through the science of surprise*. New York: Harper.
Chambers, R. 1979. *Whose Reality Counts, Putting the First Last*. London, Intermediate Technology Publishers.
Chambers, Robbert & Janice Jiggins 1987. *Agricultural research for resource poor farmers: A parsimonious paradigm*. Brighton: University of Sussex.
Chambers, R., A. Pacey & T. Thrupp, Eds. 1989. *Farmer First: Farmer innovation and agricultural research*. London: Intermediate Technology Publications.
Checkland, P. 1981. *Systems thinking, systems practice*. Chichester: John Wiley & Sons.
Checkland, P. and J. Scholes 1990. *Soft Systems Methodology in Action*. Chisester: John Wiley & Sons.
Cherrington, David 1994. *Organizational behavior: The management of idividual and organizational performance*. Boston: Allyn Bacon
Clark, Andy 1997. *Being there. Putting brain, body, and world together againg*. Cambridge: MIT Press.
Cleaver, Frances 1998. Moral-ecological rationality: Institutions and the management of communal water supplies, Nkayi District, Zimbabwe. Paper presented at the 7th Conference of the International Association for the Study of Common Property, Vancouver, June 10-14.

Cliteur, P.B. & M.A. Loth 1992. *Rechtsfilosofen van de 20ste eeuw.* Arnhem: Goude Quint
Coleman, J. 1990. *Foundations of social theory.* Cambridge: Harvard University Press.
Coleman, J. 1998. Social capital in the creation of human capital. *American Journal of Sociology, 94,* S95-S120.
Colloquium on Autopoiesis and Social Systems1998. London School of Economics and Political Science, UK, May 11-12.
Colloquium Participation & Policy 1997. Pieter Glasbergen, Parnertship als sturingsmodel in het milieubeleid; Matthijs Hisschemöller, The democracy of policy problems: The relationship between the structuring of policy problems and methods of political decision making; Jac Geurts, Methods for participatory policy analysis. Wageningen: Department of Communication & Innovation Studies, Wageningen University.
Constanza, Robert & Carl Folke 1996. The structure and function of ecological systems. In Susan Hanna, Carl Folke, Karl-Goran Maler (eds.), *Rights to nature: Ecological, economic, cultural and political principles of institutions for the environment.* Washington D.C.: Island Press.
Constanza, Robert, Bobbi Low, Elinor Ostrom & James Wilson 2001. *Institutions, ecosystems, and sustainability.* Lewis Publishers.
Cook, Karen & Margaret Levi 1990. *Limits of rationality.* Chicago: Chicago University Press.
Cooper, J. & R.H. Fazio 1984. A new look at dissonance theory. In L. Berkowitz (ed.), *Advances in experimental social psychology, 17.* New York: Academic Press.
Cornes, R. & T. Sandler 1986. *The theory of externalities. Public goods and club goods.* New York: Cambridge University Press.
Cosmides, Leda & John Tooby 1992. Cognitive adaptations for social exchange. In Jerome H. Barkow, Leda Cosmides & John Tooby (eds.), *The adapted mind. Evolutionary psychology and the generation of culture.* Oxford: Oxford University Press.
Crawford, Sue E.S. & Elinor Ostrom 1995. A grammar of institutions. *American Political Science Review 89, 3,* 582-600.
Dale, Norman 1989. Getting to co-management: Social learning in the redesign of fisheries management. In Evelyn Pinkerton (ed.), *Cooperative management of local fisheries: New directions for improved management and community development.* Vancouver: University of British Columbia Press.
Dangbegnon, Constant 1998. *Platforms for resource management. Case studies of succes or failure in Benin and Burkina Faso.* Wageningen: Wageningen University Published Dissertation.
Daniels, S. & G. Walker 1996. Collaborative Learning: Improving Public Deliberation in Ecosystem-based Management. *Environmental Impact Assessment Review* 16: 71-102.
Dawes, Robyn M. 1980. Social dilemmas. *Annual Review of Psychology, 31,* 169-193.
De Boo, H.L. & K.F. Wiersum 2002. *Adaptive management of forest resources: Principles and process.* Discussion Paper 2002-04, Forest and Nature Conservation Group. Wageningen: Wagening University.
De Geus, A. 1988. Planning as Learning. *Harvard Business Review,* March-April, 70-74.
De Geus, Arie 1997. *The Living Company. Growth, learning, and longevity in business.* London: Brealy.
Delors, J. (UNESCO, International commission on education for the 21st century) 1996. *Learning: The treasure within.* Paris: UNESCO
Denzin, N. and Y. Lincoln, Eds. 1998. *Strategies of Qualitative Inquiry.* Thousand Oaks: Sage.
De Villiers, M. 1999. *Water wars.*
Deutsch, K.W. 1966. *The nerves of government. Models of political communication and control.* New York: The Free Press.
Dewey, J. 1938. *Logic: The Theory of inquiry.* New York: Rinehart & Winston.

Dörner, D. 1996. *The Logic of Failure: Recognizing and avoiding error in complex situations.* Reading: Addison-Wesley
Douglas, Mary 1986. *How institutions think.* Syracuse: Syracuse University Press.
Douglas, Mary 1992. *Risk and blame: Essays in Cultural theory.* London: Routledge.
Dufour, F.C. 1999. *Groundwater in the Netherlands. Facts and figures.* TNO. See also http://www.nitg.tno.nl/ned/appl/g_resources/groundwater/522.shtml
Dworkin, R. 1979. *Taking rights seriously.* London: Duckworth.
Eberg, J., R. van Est & H. van der Graaf 1996. *Leren met beleid. Beleidsverandering en beleidsgericht leren bij Nimby-, milieu- en technologiebeleid,* Amsterdam: Spinhuis
Economist, The 2000. The Aral Sea. Saving the last drop. July 1st,, 64.
Economist, The 2001. Water in China. In deep. August 18th, 45.
Edwards, Victoria & Nathalie Steins 1998. Developing an analytical framework for multiple-use commons. *Journal of Theoretical Politics, 10,* 347-383.
Elshof 1997. Interactieve planvorming voor Waterbeheer. Het Waterschap, 82, 732-734.
Engel, 1995. *Facilitating innovation: an action-oriented approach and participatory methodology to improve innovative social practice in agriculture.* Wageningen: published doctoral dissertation
Eshuis, J. and M. Stuiver (2001). Learning in context through conflict and alignment: farmers and scientists in search of sustainable agriculture. *Agriculture and Human Values*
Engel, Paul and Monique Salomon 1997. *Facilitating Innovation for Development: A RAAKS resource box.* Amsterdam, KIT Press.
Erikson, Erik 1963. *Childhood and society.* New York: Norton.
Evans, Peter 1998a. Development strategies across the public-provaate divide. *World Development, 24,* 1033-1037.
Evans, Peter 1998b. Government in action, social capital and development: Reviewing the evidence on synergy. *World Development, 24,* 1119-1132.
FASOLEARN, 1996. *Social learning for collective natural resource management: Facilitation, institutions and policies.* EU Technical Proposal. Department of Communication & Innovation Studies, Wageningen UR, Wageningen.
FAO (Food and Agriculture Organization) 2000. *New dimensions in water security. Water, society and ecosystem services in the 21st century.* Rome: FAO.
Faucheux, Sylvie & Martin O'Connor 1997. *Valuation for sustainable development : Methods and policy indicators.* Cheltenham: Edward Elgar.
Festinger, L. 1957. *A theory of cognitive dissonance.* Stanford: Stanford University Press.
Finger, M. and P. Verlaan 1995. 'Learning our Way out': A conceptual framework for social-environmental learning. *World Development, 23,* 503-513.
Fishbein, Harold D. 1984. *The psychology of infancy and childhood: Evolutionary and cross-cultural perspectives.* Hillsdale: Laurens Erlbaum.
Fisk et al 1998. In Röling, Niels & Annemarie Wagemakers, 1998. *Facilitating sustainable agriculture: Participatory learning and adaptive management in times of environmental uncertainty.* Cambridge: Cambridge University Press.
Folke, Carl, Lowell Prichard Jr., Fikret Berkes, Johan Colding & Uno Svedin 1998. *The problem of fit between ecosystems and institutions.* IHDP Working Paper no. 2. Bonn: IHDP. Http://www.uni-bonn.de/IHDP/WP02main.htm
Friedmann, J. 1989. *Planning in the public domain. From knowledge to action.* Jersey: Princeton.
Frost, Robert 1971. *Robert Frost's poems.* New York: Washington Square Press.
Gambetta, Diego 1988. *Trust. Making and breaking cooperative relations.* London: Basil Blackwell
Garben, J. & M. Seligman 1980. *Learned helplessness. Theory and applications.* New York: Academic

Press.
Garvin, David A. 1993. Building a learning organization. *Harvard Business Review*, July-August, 78-91.
Gelders Jaarboek 2000. Arnhem: Van der Wiel
Geldof, Govert 2001. *Omgaan met complexiteit bij integraal waterbeheer*. Deventer: Tauw.
Geldof, Govert 1994. *Adaptief water beheer*. Deventer: Tauw.
Gibbon, David, Janice Jiggins, Niels Röling, Pier Paolo Ruggero, Muriel Tichit & Drennan Watson 2003. *Learning process analysis with an emphasis on methods and tools for social learning*. Slim Working Paper Series
Giddens, Anthony 1984. *The constitution of society: Outline of the theory of structuration*. Oxford: Policy Press.
Giddens, Anthony 1991. *Modernity and self-identity. Self and Society in Late Modern Age*. Stanford: Standord University Press.
Gigerenzer, G. & P.M. Todd 1999. *Simple heuristics that make us smart*. Oxford: Oxford University Press.
Glasbergen, P. 1996. Learning to Manage the Environment. In W. Lafferty and J. Meadowcroft, Eds. *Democracy and the Environment: Problems and prospects*. Chelterham, Edward Elgar: 175-193.
Gleick, Peter 1993. *Water in crisis: A guide to the world's fresh water resources*. New York: Oxford University Press.
Gleick, Peter 1998. *The world's water. Biennial report on fresh water resources*. Washington, D.C.: Island Press.
Gleitman, Henri 1986. *Psychology*. New York: Norton.
Gonzalez, Rhodora 2000. *Platforms and terraces. Bridging participation and GIS in joint-learning for watershed management with the Ifugaos of the Philippines*. Enschede: ITC & Wageningen University. Wageningen University Published doctoral dissertation.
Gordon, Line & Carl Folke 2000. Ecohydrological landscape management for human well being. IWRA, *Water International*, *25*, 178-184.
Greif, Avner 1995. *Institutional structure and economic development: Economic history and the new institutionalism*. Stanford: Stanford University, Department of Economics.
Grimble, R. and K. Wellard 1997. Stakeholder Methodologies in Natural Resource Management: A review of principles, context, experiences, and opportunities. *Agricultural Systems* 65: 173-193.
Groot, Annemarie 2002. *Demystifying facilitation of multi-actor learning processes*. Wageningen: Wageningen University Published Dissertation
Groot, A. and M. Maarleveld 2000. *Demystifying Facilitation in Participatory Development. Gatekeeper Series, 89*, 1-19.
Guba E.G. & Y.S. Lincoln 1989. *Fourth generation evaluation*. Newbury Park: Sage.
Guijt, Irene In preparation. *Seeking Surprise: The role of monitoring to trigger learning in rural resource management*. Wageningen: Dissertation.
Gunderson, Lance H. & C.S. Holling (eds.) 2002. *Panarchy. Understanding transformations in human and natural systems*. Washington: Island Press
Gunderson, Lance, C.S. Holling & Stephen S.Light, 1995. Barriers broken and bridges built: A synthesis. In Gunderson, Lance H., C.S. Holling & Stephen S. Light (eds.). *Barriers and Bridges to the renewal of ecosystems and institutions*. Columbia University Press, New York.
Habermas, J. 1984. *The Theory of Communicative Action, Volume 1, Reasons and the Rationalism of Society*. Boston, Beacon Press.
Hall, R.H. 1996. *Organizations: structures, processes, and outcomes*. Englewood Cliffs: Prentice-Hall

Hamilton, G. 1995. *Learning to Learn with Farmers: A case study of an adult learning extension project conducted in Queensland, Australia 1990-1995.* Department of Communication and Innovation studies. Wageningen, Wageningen University Published Dissertation.

Hanna, Susan & Mohan Munasinghe 1995. *Property rights and the environment. Social and ecological issues.* Washington: Beijer International Institute of Ecological Economics and World Bank.

Hardin, G., 1968. Tragedy of the commons. *Science 162,* 1243-1248.

Hardin, R. 1982. Collective action. Baltimore: Johns Hopkins University Press.

Heymann, Fanny 1999. *Denken en doen in dialoog.* Wageningen University: Published doctoral thesis.

Heymann, Fanny 1997. From extension science to communication and innovation science. New theoretical trends from Wageningen. *European Journal of Agricultural Education and Extension,* 4, 245-252.

Hinrichsen D. et al 1998. *Water crisis looms as world population grows.* UN Population Reports. See also http://www.jhuccp.org/popreport/14m14edsum.stm

Hirschman, Albert O. 1970. *Exit, voice, and loyalty. Responses to decline in firms, organizations, and states.* Cambridge: Harvard University press.

Hisschemoller, Matthijs & Rob Hoppe 1996. Coping with intractable controversies: The case for problem structuring in policy design and anlysis. *Knowledge & Policy: The International Journal of Knowledge Transfer and Utilization,* 8, 40-60.

Hobbes, T., 1991. *Leviathan.* Cambridge: Cambridge University Press.

Hodgson, Geoffrey M. 1999. *Evolution and institutions: On evolutionary economics and the evolution of economics.* Cheltenham: Edgar Elgar.

Hoffman, Elisabeth, Kevin McCabe & Vernon Smith 1995. Behavioral foundations of reciprocity: Experimental economics and evolutionary psychology. Paper presented at Game theory in the behavioral sciences, Tuscon, Arizona, October 11-12.

Holland, John 1995. *Hidden order. How adaptation builds complexity.* Reading: Addison Wesley.

Holling, C.S. (ed). 1978. *Adaptive environmental assessment and management.* Chichester: John Wiley & Sons.

Holling, C.S. 1995. What barriers? What bridges? In Gunderson, Lance H., C.S. Holling & Stephen S. Light (eds.), *Barriers and Bridges to the renewal of ecosystems and institutions.* New York: Columbia University Press.

Holling, C.S. & Gary K. Meffe 1996. Command and control and the pathology of natural resource management. *Conservaiton Biology, 10,* 328-337.

Homan, T. 2001. *Teamleren: Theorie en facilitatie.* Schoonhoven: Academic Service.

Horgan, John 1996. *The end of science : Facing the limits of knowledge in the twilight of the scientific age.* Helix Books.

Hounkonnou, Dominique 2001. *Listen to the cradle. Building from local dynamics for African renaissance. Case studies from rural areas in Benin, Burkina Faso and Ghana.* Wageningen: Wageningen University Published Disseration.

http://learning.mit.edu/res/wp/18004.html:4

http://massey.ac.nz/changelinks/

http://pcp.lanl.gov/FEEDBACK.html

http://www.cispi.it/contrattoacqua/forum-acqua/en (People's world water forum, March 2003)

http://www.eeeee.net

http://www.groundwater.com

http://www.indiana.edu/~workshop

http://www.learninghistories.com

http:/www.santafe.edu
http://www.sls.wau.nl/cis
http://www.sustainableliving.org,
http://www.well.com/user/philips/d-l.html
http://www.williams.edu./CES/
http://world.water-forum3.com
Hurni, H., with the assitance of an international group of contributors 1996. *Precious Earth: From water and soil conservation to sustainable land management.* Berne: International Soil Conservation Organization (ISCO) & Center for Development and Environment (CDE).
Hurst, David K. 1995. *Crisis & renewal. Meeting the challenge of organizational change.* Boston: Harvard Business School Press
Ison, Ray, C. High, C.P. Blackmore & M. Cerf 2000. Theoretical frameworks for learning-based approaches. 2000 in Learn Group, *Cow up a Tree: Knowing and Learning for Change in Agriculture. Case Studies from Industrialised Countries.* Paris: INRA.
Janis, I.L. 1982. *Groupthink.* Boston: Houghton-Mifflin.
Jarvis, P. 1992. *Paradoxes of learning. On becoming an individual in society.* San Francisco: Jossey Bass.
Jiggins, J. and N. Röling, 1999. Adaptive management: Potential and limitations for ecological governance. *International Journal of Agricultural Resources, Governance and Ecology.* Accepted for publication.
Katz, D. & R. Kahn 1978. *The social psychology of organizations.* New York: John Wiley & Sons.
Kahneman, Daniel, Paul Slovic & Amos Tversky (eds.) 1982. *Judgement under uncertainty: Heuristics and biases.* Cambridge: Cambridge University Press.
Kahneman, Daniel & Amos Tversky (eds.) 2000. *Choices, values and frames.* Cambridge: Cambridge University Press.
Keeton, W.T. 1980. *Biological science.* New York: Norton.
Kerr, Norbert, L. 1992. Efficacy as a causal and moderating variable in social dilemmas. In W. Liebrand, D. Messick & H. Wilke (eds.), *Social dilemmas: Theoretical issues and research findings.* New York: Pergamon Press.
Kerr, Norbert L. 1995. *Does my contribution matter?: efficacy in social Dilemmas.* Colloqium. Wageningen: Department of Communication & Innovation Studies.
Kerr, Norbert L. & C.M Kaufman-Gilliland 1994. Communication, commitment, and cooperation in social dilemmas. *Journal of Personality and Social Pychology, 66,* 513-529.
King, C. 2000. *Systemic Processes for Facilitation Social learning: Challenging the legacy.* Department of Rural Development Studies. Uppsala, Swedish University of Agricultural Sciences.
Knight, Jack & Itai Sened (eds.) 1995. *Explaining social institutions.* Ann Arbor: University of Michigan.
Koelen & Röling 1994. *Project proposal Social learning processes in relation to social dilemma like societal problems.* Wageningen: Department of Communication & Innovation Studies.
Koelen, M., L. Vaandrager and C. Colomer 2001. Health Promotion Research: Dilemmas and challenges. *Journal of Epidemiology Community Health, 55,* 257-262.
Kolb, David 1984. *Experiential learning. Experience as a source of learning and development.* Prentice-Hall: Englewood Cliffs.
Korten, David 1980. Community Organisation and Rural Development: a learning process. *Public Administration Review, 40,* 480-511.
Korten, David 1984. *People-centered development: Contributions toward theory and planning frameworks.* West Hartford: Kumarian.
Lamerichs, Joyce 2003. *Discourse of support: Exploring online discussions on depression.* Wageningen:

Wageningen University Published Dissertation.
Lansing, J.S. 1991. *Priests and programmers. Technologoes of power in the engineered landscape of Bali.* New Jersey: University Press.
Ledyard, John O.1995. Public goods: A survey of experimental research. In John H. Kagel & Alvin H. Roth, *The handbook of experimental economics.* Princeton: University Press.
Learn Group 2000. Fostering Emergence: New research and development traditions for knowing and learning. In M. Cerf, D. Gibbon, B. Hubert, R. Ison, J. Jiggins, M. Paine, J. Proost and N. Röling, Eds. *Cow up a Tree: Knowing and learning for change in agriculture. Case studies from industrialised countries.* Paris, INRA Editions.
Lee, Kai N. 1993. *Compass and Gyroscope: Integrating science and politics for the environment.* Washington, D.C.: Island Press.
Leeuwis, C. 2000. Reconceptualizing Participation for Sustainable Rural Development: Towards a negotiation approach. *Development and Change 31*: 931-959.
Leeuwis, C. 1993. *Of computers, myths, and modelling. The social construction of diversity, knowledge information, and communication technologies in Dutch horticulture and agriculture extension.* Wageningen: Wageningen University Published Dissertation.
Leeuwis, Cees & Rhiannon Pyburn (eds.) 2002. *Wheelbarrows full of frogs. Social learning in rural resource management.* Assen: Koninklijke Van Gorcum.
Levine, Simon A. 1999. *Fragile dominion. Complexity and the commons.* Reading: Helix Books.
Lewin, Roger 1993. *Complexity. Het grensgebied van de chaos.* Amsterdam: Uitgeverij Contact.
Lewin, K. 1952. *Field Theory in Social Science: Selected papers on group dynamics.* London: Tavistock Publications.
Lichbach, Mark I. 1996. *The cooperator's dilemma.* Ann Arbor: University of Michigan Press.
Liebrand, W.B.G. & David M. Messick 1996. *Frontiers in social dilemma research.* Berlin: Verlag
Lightfoot, C., R. Ramirez, A. Groot, R. Noble, F. Shao, D. Kisauzi and I. Bekalo 2001. *Learning Our Way Ahead: A Linked Local learning Approach to decentralization. Gatekeeper Series 98*: 1-20.
Lissack, Michael & Johan Roos 1999. *The next common sense. Mastering corporate complexity through coherence.* London: Nicolas Brealey Publishing.
Long, N. and A. Long 1992. *Battlefields of Knowledge: The interlocking of theory and practice in social research and development.* London: Routledge Publications.
Loucks, Daniel P. 2000. Sustainable water resources management. *Water International, 25*, 3-10.
Lubchenco, J. 1998. Entering the century of the environment: A new social contract for science. *Science, 279*, 491-496.
Maarleveld, Marleen 1995. *Between a rock and a hard place: Strategies for solving social dilemmas in natural resource management.* Wageningen: Working Paper.
Maarleveld, Marleen 1997. Inducing sustainabble practices through stakeholder participation: Possibilities for water resource management. Paper presented at IXth World Water Congress: Water resources outlook for the 21st century: Conflicts and opportunities, Montreal, Sept. 1-7.
Maarleveld, Marleen. 1998. Improving Participation and Cooperation at the Local Level: Lessons from economics and psychology. In: H. Blume, Ed. *Towards Sustainable Land Use: Further cooperation between people and institutions.* Vol. II. Reiskirchen, Catena Verlag.
Maarleveld, Marleen. 2000. Linking natural resource management dynamics and organizational development: Adapting to emerging groundwater management in Gelderland, The Netherlands, in Learn Group (Eds.), *Cow up a tree, Knowing and learning for change in agriculture. Case studies from industrialized countries.* Paris: INRA.
Maarleveld, Marleen & Constant Dangbegnon, 1999. Managing natural resources: A social

learning perspective. *Agriculture and Human Values,* 16, 267-280.
Maarleveld, Marleen & Constant Dangbegon 2002. Social learning: Major concepts and issues. Lessons from natural resource management in 'terroirs' and 'landelijke gebieden'. In Cees Leeuwis & Rhiannon Pyburn (eds.), *Wheelbarrows full of frogs. Social learning in rural resource management.* Assen: Koninklijke Van Gorcum.
Malki, M 1999. *Re-humanzing the development process: on participation, local organizations, and social learning as building blocks of an alternative development view in Algeria.* Wageningen: Wageningen University Published Dissertation.
Mansbridge, J.J. 1990. *Beyond self-interest.* Chicago: Chigago University Press.
March J. & J. Olson 1989. *Rediscovering instititutions.* Chicago: Chicago University Press.
Margolis, H. 1982. *Selfishness, altruism and rationality: A theory of social choice.* Chicago: Chicago University Press.
Margolis, A. 1988. *Patterns, thinking and cognition. A theory of judgement.* Chicago: Chicago University Press.
Maslow, Abraham 1970. *Motivation and personality.* New York: Harper & Row.
Maturana, H. and F. Varela 1987. *The Tree of Knowledge, the Biological Roots of Human Understanding.* Boston: Shambala Publications.
Meadows, D.H., D.L. Meadows, J. Randers, & W.W. Behrens 1972. *Limits to growth.* New York: New American Library.
Meerling 1984. *Methoden en technieken van psychologisch onderzoek. Deel 1 & 2.* Meppel: Boom.
Messick, D.M. & M.B. Brewer 1993. Solving social dilemmas. In L.Wheeler & P. Shaver (eds.), *Review of Personality and Social Psychology.* Beverly Hills: Sage.
Milgrom Paul & John Robert 1992. *Economics, organization, and management.* Englewood Cliffs: Prentice Hall.
Miller, G. Tyler 1975. *Living in the environment.* Belmont: Wadsworth.
Mingers, John 1996. A comparison of Maturana's autopoietic social theory and Giddens' theory of structuration. *Systems Research,* 13, 496-482.
Mingers, John 1997. Systems typologies in the light of autopoiesis: A reconceptualization of Boulding's Hierarchy, and typology of self-referential systems. *Syst. Res. Behav. Sci.,* 14, 303-313.
Ministerie van Verkeer & Waterstaat 1994. *Evaluatienota Water.* Den Haag.
Ministerie van Verkeer & Waterstaat 1998. *Regie & regisseurs: de kunst van het afkijken.* Den Haag: Directoraat Rijkswaterstaat.
Moran, Emilio F. 1982. *Human Adaptability. An introduction to ecological anthropology.* Boulder: Westview Press.
Narayan, D. 1994. *The contribution of people's participation: evidence of 121 rural water supply projects.* UNDP-World Bank Water Supply and Sanitation Program. Washington D.C.: World Bank.
Newson, Malcolm 1997. *Land, water, and development. River basin systems and their sustainable management.* London: Routledge.
Nonaka Ikijiro & Hirotaka Takeuchi 1995. *The knowledge creating company.* New York : Oxford University Press.
Nonaka, I. and Yamanouchi, T. 1989. Managing Innovation as a Self-Renewing Process. *Journal of Business Venturing,* 4, 299-315.
North, Douglas 1994. Economic performance through time. *American Economic Review,* 84, pp. 359-368.
NRC Handelsblad 2001. Ambitieus waterplan verdeelt Spanje (Ambitious water plan divides Spain). June 21.

NRC Handelsblad 2001. Wassende Woestijn. (Washing Desert). June 23.
NRC Handelsblad 2001. Dorstig Israel wil schone auto's en geen dor grasveld (Thirsty Israel wants clean cars and green grass), August 18.
NRC Handelsblad 2002 August.
NVR (Nederlandse Vrouwen Raad) 1999. *Van woorden naar daden. Duurzaamheid en vrouwenparticipatie in het waterbeheer in de 21ste eeuw.* (From talking to action. Sutainability and women participation in water management in the 21st century) Den Haag: NVR.
Ohlsson, Leif (ed). 1995. *Hydropolitics. Conflicts over water as development constraint.* London: Zed books.
ODA 1995. *Guidance Note on how to do Stakeholder Analysis of Aid Projects and Programmes.* London, ODA.
Olson, Mancur. 1965. *The logic of collective action.* Cambridge: Harvard University Press.
Olson, Mancur 1982. *The rise and decline of nations: Economic growth, stagflation, and social rigidities.* New Haven: Yale University Press.
Ostrom, Elinor 1990. *Governing the Commons. The evolution of institutions for collective action.* Cambridge: Cambridge University Press.
Ostrom, Elinor 1998a. A behavioral approach to the rational choice theory of collective action. Presidential address, American Political Science Association, 1997. *American Political Science Review, 92,* 1-22.
Ostrom, Elinor 1998b. Coping with the strategy of the commons. Paper prepared for the Annual Meeting of the Association for Politics and the Life Sciences, Boston, September 3-6.
Ostrom, Elinor, Roy Gardner & J. Walker 1994. *Rules, games, and common pool resources.* Ann Arbor: University of Michigan Press.
Ostrom, Elinor, Roy Gardner, & James Walker 1996. Theory, field and the laboratory: The continuing dialogue. *Understanding strategic interaction- Essays in honor of Reinhard Selten.* Berlin: Springer-Verlag
Ostrom, Elinor, Larry Schroeder, & S. Wynne 1993. *Institutional incentives and sustainable development: Infrastructure policies in perspectives.* Boulder: Westview Press.
Ostrom, Elinor & James Walker 1997. Neither markets nor states: Linking transformation processes in collective choice arenas. In D.C. Mueller (ed.), *Perspectives on public choice: A handbook.* Cambridge: Cambridge University Press.
Paine, Mark 1997. *Doing it together: Technology as practice in the New-Zealand dairy sector.* Wageningen: Wageningen University Published Dissertation.
Parson, E. and W. Clark 1995. Sustainable Development as Social Learning: Theoretical Perspectives and Practical Challenges for the Design of a Research Programme. In L. Gunderson, C. Holling and S. Stephen (eds.), *Barriers and Bridges to the Renewal of Ecosystems and Institutions.* New York: Columbia University Press.
Pellikaan, Huib 1994. *Anarchie, staat en het prisoner's dilemma.* Delft: Eburon.
Piaget, Jean 1969. *The moral judgement of the child.* New York: Free Press.
Picciotto, Robert 1995. *Putting institutional economics to work: From participation to governance.* Washington, D.C.: World Bank Discussion Paper.
Pinker, S. 1994. *The language instinct.* New York: W Morrow.
Pinker, S. 1997. *How the mind works.*
Pinkerton, Evelyn 1989. *Co-operative management of local fisheries. New directions for improved management and community development.* Vancouver: University of British Columbia Press.
Pradhan, N. L. & R. Yoder 1989. *Improving irrigation systems through farmer to farmer training: examples from Nepal.* Colombo: IIMI.

Pretty, Jules 1994. Alternative systems of inquiry for a sustainable agriculture. *IDS Bulletin, 25*, pp. 37-48. Sussex: IDS

Pretty, J. 1997. *Regenerating Agriculture: Policies and practice for sustainability and self-reliance.* London: Earthscan Publications Ltd.

Pretty, J., I. Guijt, J. Thompson and I. Scoones 1995. *A Trainer's Guide for Participatory Learning and Action.* London: IIED.

Prigogine, Ilya & Isabelle Stengers 1984. *Order out of chaos. Man's new dialogue with nature.* New York: Bantam Books.

Provincie Gelderland 1981a. *Groundwaterwithdrawal in Nijmegen and surroundings. Memorandum on for permit requests in Nijmegen for groundwater withdrawal.* Arnhem: Provincie Gelderland

Provincie Gelderland 1981b. *Influence of groundwater withdrawal on groundwater tables and stream drainage in south Veluwe.* Arnhem: Provincie Gelderland

Provincie Gelderland 1983. *Short term policy for groundwater withdrawal in Renkum and Wageningen.* Arnhem: Provincie Gelderland

Provincie Gelderland 1991. *Provincial watermanagement plan.* Arnhem: Provincie Gelderland

Provincie Gelderland 1992. *Desiccation attacks.* Arnhem: Provincie Gelderland

Provincie Gelderland 1994. *Towards tommorrow.* Arnhem: Provincie Gelderland

Provincie Gelderland 1996. *Provincial water management plan 1996-2000.* Arnhem: Provincie Gelderland.

Provincie Gelderland 1996a. *Action plan Combating desiccation.* Arnhem: Provincie Gelderland

Putnam, Robert 1993. *Making democracy work.*

Ramirez, Ricardo 2001. Understanding the Approaches for Accommodating Multiple Stakeholders' Interests. *International Journal of Agricultural Resources, Governance and Ecology,1* , 264-285.

Ranson, S. 1994. *Towards the learning society.* London: Cassell.

Ranson, S. & J. Stewart 1994. *Management for the public domain : Enabling the learning society.* Basinstoke: MacMillan.

Ratering, Dick & Koos Hafkamp 2000. *Zelfsturend leren. Begeleiden van ervaringsgericht leren in organisaties.*

Raub, W. & T. Voss 1986. Conditions for cooperation in problematic social situations. In A. Diekman & P. Mitter (eds.), *Paradoxical effects of social behavior: Essays in honor of Anatol Rapoport.* Heidelberg: Physical Verlag.

Renn, O., T. Webler and P. Wiedemann, Eds. 1995. *Fairness and Competence in Citizen Participation: Evaluating Models for Environmental Discourse.* Dordrecht, Boston, London, Kluwer Academic Publisher.

Ridley, Matt 1996. *The origins of virtue. Human instincts and the evolution of cooperation.* London: Penguin.

Rodda 2000. *Water Policy* 2001, Supplement, 2nd World Water Forum, Session Reports, Vol. 3, S1-S213

Röling, Niels 1992. The emergence of knowledge systems thinking: a changing perception of relationships among innovation, knowledge processes and configuration. *Knowledge and Policy: The international journal of knowledge transfer and utilization, 5*, 42-64.

Röling, Niels 1994. Platforms for decison-making about ecosystems. In L, J. Fresco, Stroosnijder, J. Bouma & H. Van Keulen (eds) *The future of the land: Mobilizing and integrating knowledge for land use options,* Chichester: John Wiley & Sons

Röling, Niels 2000. *Gateway to the Global Garden: Beta/Gamma science for dealing with ecological rationality.* Eight Annual Hopper lecture, October 24, 2000. Guelph, University of Guelph,

Canada.
Röling, Niels 2002. Beyond the aggregation of individual preferences. Moving from multiple to distributed cognition in resource dilemmas. In Cees Leeuwis & Rhiannon Pyburn (eds.), *Wheelbarrows full of frogs. Social learning in rural resource management.* Assen: Koninklijke Van Gorcum.
Röling, Niels & J. Jiggins 1996. The Ecological Knowledge System. In the proceedings of the Second European Symposium on Rural and Farming Systems Research: Technical and social systems approaches to sustainable rural development, 27-29 March 1996. Granada, Spain.
Röling, N., J. Jiggins & C. Coehoorn, 1999. The Santiago Triangle. The cognitive system as heuristic device for saving our souls. Paper presented at the 14th ESEE Conference, September, Krakow, Poland.
Röling, Niels & Annemarie Wagemakers, 1998. *Facilitating sustainable agriculture: Participatory learning and adaptive management in times of environmental uncertainty.* Cambridge: Cambridge University Press.
Roth, George & Art Kleiner 19 *The car launch: The human side of managing change.* New York: Oxford University Press.
Ruijgh-Van der Ploeg, M. & A.J.M. Verhallen 1999. Gaols and methods for teaching integrated water management to engineering students. A. Van der Beken, M. Mihailescu, P. Hubert, & J. Bogardi (eds.), *Proceedings of the international symposium The learning society and the water-environment, La société cognitive et les problemes de l'eau,* Paris, June 2-4, Brussels: EU Directorate-General Research.
Sabatier, P.A. & H.C. Jenkins-Smith (eds.) 1993. *Policy change and learning. An advocacy coalition approach.* Boulder: Westview.
Salomon, M. and P. Engel 1997. Networking for Innovation: Windows and tools. In P. Engel and M. Salomon. *Facilitating Innovation for Development: A RAAKS resource box.* Amsterdam: KIT Press.
Sandler, T. 1993. *Collective action.* Ann Arbor: University of Michigan Press.
Satz, D. & J. Ferejohn 1994. Rational choice and social theory. *Journal of Philosophy, 91,* 71-87.
Scheer, Stephan 1996. *Communication between Irrigation Engineers and Farmers: The case of project design in North Senegal.* Wageningen, Wageningen University Published Dissertation.
Sen, Amartya K. 1997. Rational fools: A critique of the behavioral foundations of economic theory. *Philosophy & Public Affairs, 6,* 317-344.
Schön, D. and M. Rein 1994. *Frame Reflection: Towards the resolution of intractable policy controversies.* New York, Basic Books.
Schroeder, David A. (ed.) 1995. *Social dilemmas. Perspectives on individuals and groups.* Westport: Praeger.
Schulz, Ulrich, Wulf Abers, Ulrich Mueller 1994. *Social dilemmas and cooperation.* Berlin: Springer Verlag
Senge, Peter M. 1990. *The fifth discipline: The art and practice of the learning organization.* London: Century Business Press.
Sherman, Howard & Ron Schultz 1998. *Open boundaries. Creating business innovation through complexity.* Santa Fe Center for Emergent Strategies. Reading: Perseus Books.
Simon, Herbert 1997. *Models of bounded rationality. Empirically grounded economic reason.* Cambridge: MIT Press.
Schmidt, A.L. 1998. *Role play on river and floodplain management- STORM-RR.* Delft: IHE.
Snidal, Duncan 1985. Cooridniation vs. Prisoner's dilemma: Implications for international cooperation and regimes. *American Political Science review, 79,* 923-942.

Snyder M. 1982. When believing means doing: Creating links between attitudes and behavior. In M. P. Zanna, E.T. Higgins & C.P. Herman (eds.), *Consistency in social behavior*. Hillsdale: Erlbaum.

Snyder M. 1984. When belief creates reality. In L. Berkowitz (ed.), *Advances in experimental social psychology, 18*. New York: Academic Press.

Snyder M. & N. Cantor 1979. testing hypotheses about other people: The use of historical knowledge. *Journal of Experimental Social Psychology, 15*, 330-342.

Song, Yiching 1998. *'New' seed in 'old' China. Impact of CIMMYT collaborative programme on Maize breeding in south-western China.* Wageningen: Wageningen University Published dissertation.

Sriskandarajah, N., R. Bawden and R. Packham 1989. *Systems Agriculture: A Paradigm for Sustainability.* Paper presented at the ninth annual Farming Systems Research/Extension Symposium, University of Arkanas, Fayetteville, Arkansas, USA.

Stacey, Ralph D. 2001. *Complex response processes in organizations. Learning and knowledge creation.* London: Routledge.

Stacey, Ralph D., Douglas Griffin & Patricia Shaw 2000. *Complexity and management. Fad or radical challenge to systems thinking?* London: Routledge

Steins, N. 1999. *All Hands on Deck: An interactive perspective on complex common-pool resource management based on case studies in the coastal waters of the Isle of Wight (UK), Connemara (Ireland) and the Dutch Wadden Sea.* Wageningen: Wageningen University Published Dissertation.

Stewart, Ian 1998. *Complexification and simplex.* Lecture, De Balie, Amsterdam.

Strauss, A. and J. Corbin 1998. Grounded Theory Methodology: An overview. In N. Denzin and Y. Lincoln, Eds. *Strategies of Qualitative Inquiry*. Thousand Oaks, London, New Dehli, Sage.

Strauss, A. and J. Corbin 1990. *Basics of Qualitative Research: Grounded theory procedures and techniques*. Newbury Park (etc.): Sage.

Tainter, Joseph A. 1988. *The collapse of complex societies*. Cambridge: Cambridge University Press.

Te Molder, Hedwig 1995. *Discourse of dillemas. An analysis of government communicators' talk.* Wageningen: Wageningen University Published Dissertation.

Thompson, J. 1995. Participatory Approaches in Government Bureaucracies: Facilitating the process of institutional change. *World Development, 15*, 1521-1554.

Uphoff, N. 1992. *Learning from Gal Oya: Possibilities for participatory development and Post-Newtonian social science*. Ithaca (etc.), Cornell University Press.

Upreti, B. 2001. Conflict Management in Natural Resources: A study of land, water and forest conflicts in Nepal. Wageningen, Wageningen University Published Dissertation.

Vaandrager, Lenneke 1995. *Constructing a healthy balance. Action research ingredients to facilitate the process of health promotion.* Wageningen: Wageningen University Published Dissertation.

Vandenabeele, Joke 1999. *Sociale verantwoording en het debat over landbouw, milieu, en natuur. Een kritisch empirrisch onderzoek naar het leren van volwassenen in het perspectief van duurzaamheid.* Leuven: Proefschrift Katholieke Universiteit Leuven

Van den Berg, J.T. & A. Van Hall 1997. *Waterstaats- en waterschapsrecht.* Deventer: Tjeenk Willink.

Van den Hoek, Annet 1992. *Planning as a learning process. A strategy for planning land use programmes at local level with special reference to the uplands of Java.* Wageningen: Dissertation.

Van der Ploeg, Jan Douwe & Gerrit van Dijk (eds.)1995. *Beyond modernization. The impact of endogenous rural development.* Assen: Van Gorcum.

Van der Veen, R. (2000). Learning Natural Resource Management. In Guijt, I., J. Berdegué and M. Loevinsohn, Eds. *Deepening the Basis of Rural Resource Management.* The Hague,

Netherlands, ISNAR and RIMISP.
Van der Ven, G.P. (ed.) 1994. *Man-made lowlands: History of water management and land reclamation in the Netherlands.* Utrecht: Uitgeverij Matrijs.
Van der Vlist, Maarten 1998. *Duurzaamheid als planningsopgave. Gebiedsgerichte afstemming tussen ruimtelijke ordening, het milieubeleid en het waterhuishoudkundig beleid voor het landelijk gebied.* (Sustainaibility as a task of planning. Coordination and integration at the regional level among spatial planning, environmental planning and water management planning in the rural areas of the Netherlands.) Wageningen: Dissertation.
Van Ginneken, Jaap 1999. *Brein-bevingen. Snelle omslagen in opinie en communicatie.* Amsterdam: Boom.
Van Haaften, E.H. 2002. *Linking ecology and culture. Towards a psychology of environmental degradation.* Tilburg: KUB Published doctoral dissertation.
Van Hall, Alfred 1997. *Reader Waterstaats- en waterschapsrecht.* Utrecht: Faculty of Law.
Van Nistelrooij, Antonie 2000. *Werken met conferenties: het collectief organiseren van team based organisaties.* Utrecht: Lemma.
Van Rooy, Peter 1997. *Interactieve planvorming voor waterbeheer.* Utrecht: Stowa.
Van Schoubroeck, Frank 1999. *Learning to fight a fly: developing citrus IPM in Bhutan.* Wageningen: Published doctoral thesis.
Van Slobbe, Erik 2002. *Waterbeheer tussen crisis en vernieuwing. Een studie naar vernieuwingsprocessen in de sturing van regionaal waterbeheer.* Wageningen: Wageningen University Pulished doctoral dissertation.
Van Woerkum, Cees, 1997. *Interactieve beleidsvorming.* (Interactive policy making). Houten/Diegem: Bohm Stafleu Van Loghum.
Van Woerkum, Cees, Dik Kuiper & Elroy Bos 1999. *Communicatie en innovatie: Een inleiding.*
Van Woerkum, Cees 2002. Orality in environmental planning. *European Environment, 12,* 160-172
Van Woerkum, Cees and Noelle Aarts 1998. Communication between Farmers and Government about Nature: A new approach to policy development. In: N. Röling and M. Wagemakers, Eds. *Facilitating Sustainable Agriculture: Participatory learning and adaptive management in times of environmental uncertainty.* Cambridge, Cambridge University Press.
Van Woerkum, Cees and Noelle Aarts 2002. *Wat maakt 't verschil? Over de waarde van pluriformiteit in interactieve beleidsprocessen.* Den Haag: Innovatienetwerk Groene Ruimte en Agrocluster.
Van Woerkum, Cees & Luc Adolfse 1998. Interactieve kennisontwikkeling en -benutting. *Sociale Interventie, 7,* 1, 10-19.
Varela, Francisco J., Evan Thompson & Eleanor Rosch 1997. *The embodied mind. Cognitive science and human experience.* Cambridge: MIT Press.
Verbeeten, T. 1999. *Wijs met de Waddenzee? Een onderzoek naar leerprocessen.* Utrecht. Universiteit Utrecht Published Dissertation.
Von Bertalanffy, L. in Daniel Katz & Robert L. Kahn (eds.) 1978. *The social psychology of organizations.* 2nd ed. New York: John Wiley & Sons.
Von Neumann, J. & O. Morgenstern 1972. *Theory of games and economic behavior.* Princeton: Princeton University Press
Voss, James F. 1974. *Psychology as a behavioral science.* Pacific Palisades: Goodyear Publishing Company.
Vygotsky, L.S. 1978. *Mind in society.* Harvard: Harvard University Press.
Waterman, R., T. Peters & J. Phillips 1980. Structure is not organization. *Business Horizons,* June.
WECD (World Commission on Environment & Development) 1987. *Our common future.*

Weick, Karl 1979. *The social psychology of organizing*. Reading: Addison Wesley.
Weick, Karl 1995. *Sensemaking in organizations*. Thousand Oaks: Sage Publications.
Weisbord, M. 1998. *Discovering common ground*. San Francisco: Berret-Koehler Publishers.
Wheatley, M. 1992. *Leadership and the New Science: Learning about organisations from an orderly universe*. San Francisco, Berret-Koehler.
Whitaker, Randall D. 2003. *Tutorial Autopoiesis & Enaction*. http://www.informatik.umu.se/~rwhit/
Whorf, B.L. 1956. *Language, thought, and reality*. Cambridge: MIT Press.
Wilke, W. Liebrand, & D.M. Messick 1983. Sociale dilemma's, een overzicht. *Nederlands Tijdschrift voor de Psychologie, 38*, 463-480.
Wildemeersch, D. 1991. Learning from regularity, irregularity, and responsibility. *International Journal of Lifelong Learning, 10*, 151-158.
Wit, Ulrich 2003. *The evolving economy: Essays on the evolutionary approach to economics*. Cheltenham: Edward Elgar.
Wittgenstein, Ludwig 1992. *Filosofische onderzoekingen (Philosophical Investigations)*. Meppel: Boom.
Woodhill, Jim 1999. *Sustaining Rural Australia: A political economic critique of natural resource management*. Canberra, Australian National University.
Woodhill, Jim 2002. Sustainability, social learning and the democratic imperative. In Cees Leeuwis, & Rhiannon Pyburn (eds.). *Wheelbarrows full of frogs. Social learning in rural resource management*. Assen: Koninklijke Van Gorcum
Workshop on Adaptive Management 1998. Beijer Institute, Stockholm, Sweden.
Workshop on Ecological Economics 1998. Department of Rural Development Studies & Department of Economics, Swedish University of Agricultural Sciences, Upsala, Sweden, June 2-14.
World Bank 1998. *Knowledge for development*. World Development Report Series. New York: Oxford University Press.
Worldwatch Institute 1999. *State of the World Report*. Washington, D.C.: Worldwatch Institute.
World Water Council1998. *Water in the 21st century*. Paris: WWC.
World Water Commission for Water in the 21st Century 2000. *World water vision. Commision report. A water secure world. Vision for water, life, and the environment*. Paris: WWC.
World Water Forum 2000. *Second World Water Forum. From Vision to Action. Final Program*. The Hague, March 17-22.
Yin, R.K. 1994. *Case study research: design and methods*. Thousands Oaks: Sage Publications.
Zijderveld, Anton C. 2000. *The institutional imperative. The interface of institutions and networks*. Amsterdam: Amsterdam University Press.

Summary

This dissertation aims to investigate the value of a social-environmental learning perspective for realizing sustainable natural resource management (NRM).

Part I Scope and goals of the study

In Chapter 1, current dilemmas in water management are discussed to illustrate the need for more sustainable NRM. The complex and dynamic nature of NRM, such as water resource management, makes it a never-ending story. Interacting resources, stakeholders and mediating institutions create complex, evolving dynamics and dilemmas. Thus, understanding needs to be continuously developed and acted upon. A social-environmental learning perspective focuses on developing the learning capacity of resource users and managers. Developments in NRM research and practice indicate that facilitating learning may help to facilitate sustainable NRM. The following research questions and objectives structure the research in order to learn more about why and how this may be the case.

Research questions
Why is social-environmental learning a viable perspective for developing sustainable NRM? And how may social-environmental learning be facilitated to generate sustainable NRM?

Research objectives
O1 Explore foundations for social-environmental learning as a viable perspective for sustainable NRM
O2 Identify and assess linkages between social-environmental learning and NRM dynamics in a real-time, complex NRM case
O3 Propose directions to further facilitate social-environmental learning to generate institutional changes for sustainable NRM

These research questions and objectives are addressed in the different parts of the thesis.

In Chapter 2, the steps taken in the inquiry process that has generated the outcomes presented in this dissertation are explained. In order to do justice to the exploratory, evolving nature of the research, the hows and whys of the different steps taken are made transparent. The quality of the research is discussed in terms of several qualitative research standards and triangulation methods.

Part II Foundations for a social-environmental learning perspective (O1)

Learning our way out?
Four different research and practice fields are explored in Chapter 3 to substantiate further investigation of how a social-environmental learning perspective may support facilitation of sustainable NRM. The research and practice fields discussed are: social dilemma research, natural resource management research and practice, management of knowledge and innovation in rural development, and complexity theory research. State of the art developments in each field are found to converge towards learning as a route to sustainable NRM. Social dilemma

research contributes to highlighting the different interdependence structures that stakeholders may face in NRM. Focussing on *homo discens* highlights actions that people may undertake to cope with such dilemma situations. Experiences in natural resource management research and practice indicate pitfalls of myopic target management. A more process-oriented, adaptive approach may help to draw on and develop people's learning capacity for more sustainable NRM. Management of knowledge and innovation in rural development highlights the way in which such learning may be facilitated. Tools and methodologies have been and are being developed that enable stakeholders to learn together how to cope with social dilemma interdependence. Complexity research contributes insights and a language to understand the adaptive dynamics of complex, evolving systems such as NRM. In addition, these research and practice fields confirm the value of guiding principles for facilitating learning.

Learning about learning

In Chapter 4, the notion of learning itself is addressed in more depth. Four different models of learning are reviewed. The review indicates that learning may be viewed as a dynamic, iterative process involving cognitive and behavioral processes. This process enables people at different levels of aggregation to adapt to and adapt their environment. Adaptation entails a combination of abilities to perceive oneself and one's context, to express intentionality in terms of goals and priorities, and to translate these intentions into action to influence a situation toward a preferred state. In this process, organizing and reorganizing the way one experience s ones environment generates insight into one's context and one's position in it. A cognitive frame is constructed that subsequently largely influences how individuals experience the world and what future learning occurs. This adaptive potential is a fundamental notion in a social-environmental learning perspective. After all, it is this capacity that enables entities to continuously modify understanding of NRM and, accordingly, to adapt decisions and actions, . Such learning may manifest itself in diverse ways in terms of interactions among resources, stakeholders, and institutions. Based on the characteristics of a social-learning perspective and insights with regard to human learning in general, different manifestations of learning have been drawn together in an overview that makes visible people's potential for social-environmental learning (see Figure 4.4). The overview indicates how people may draw on an infinite number of learning repertoires to develop sustainable NRM. Facilitation principles such as systems thinking, experimentation, and communicative action may contribute to drawing on and developing this learning potential.

Learning and institutions

The mediating role of institutions in the interactions among people and their natural environment is discussed in more detail in Chapter 5. Institutions are presented as being a similar regulatory interface in governing people's behavior as the (collective) cognitive frame highlighted in the learning dynamics discussed in Chapter 4. Accordingly, insight into the institutional interface and its constituent dynamics may provide a means to further reflect on ways in which learning and NRM may be linked for sustainable NRM. The regulatory capacity of institutions is discussed in terms of the dual dynamics of direct and indirect emergence. On the one hand, the interaction among people generates institutions. On the other hand, this interaction is framed by institutions. Parallels are drawn between such dynamics and the learning dynamics discussed in Chapter 4. Both involve a dual dynamic of iterative feedback loops in which the creation and sharing of meaning plays an important role. Insight into the role of amplifying and regulatory feedback shows that both types of feedback may play a role in learning to adapt to and adapt the institutional interface in NRM. Thus, it is not only the

regulatory nature of institutional dynamics that must be taken into account, but also amplifying feedback loops. Amplifying feedback loops may indicate when institutions have the potential to become new equilibriums or are beginning to become overly self-referential. Insights into the collective creation and sharing of meaning in terms of the notion of embodied cognition have indicated how a number of characteristics of language may contribute to learning and changes in the institutional interface in NRM. A numbr of characteristics are further discussed such as the dual dynamics of language development, the fuzziness of language, and the use of language.

Part III Assessing social-environmental learning and NRM dynamics in a real-time, complex NRM case (O2)

Case study approach

Based on the insights gained in Part II, an analytical framework, supporting tools and a methodology are proposed in Chapter 6 for assessing social-environmental learning in a real-time, complex NRM case. The analytical frame focuses on the macro and meso level of analysis as a social-environmental learning perspective deals with the learning of collective entities. The analysis tools (Holling's ecosystem cycle and the 7-S profile) and the learning history methodology, developed in action learning science, are introduced as they have proven capable of taking into account both static and dynamic qualities of resources, stakeholders and institutions. In this research, they are combined for the first time for macro and meso-level analysis and assessment of structural linkages in social-environmental learning and NRM dynamics in a complex NRM case.

Macro-analysis of the emergence of groundwater management in Gelderland

In Chapter 7, the case study is introduced, namely, the emergence of groundwater management in Gelderland, The Netherlands. This chapter discusses the macro level of analysis. This level of analysis of the emergence of groundwater management in Gelderland has shown how social-environmental learning and NRM dynamics may interact to generate long-term institutional changes in a complex, real-time case. Such change may be viewed as occurring in terms of interacting and nested Holling renewal cycles in which learning to be effective, learning to expand, learning to be efficient and learning to integrate occur to different degrees. The case study indicates how learning has contributed to the on-going understanding of groundwater resource dynamics, decisions and actions of stakeholders involved, and changes in mediating institutions. Groundwater management in Gelderland has evolved from single issue, sectoral management to a multiple, integrated management approach. The overview in Table 7.1 indicates what such learning has entailed in terms of changes and fit among the characteristics of the groundwater resource, stakeholders involved, and mediating institutions. The emergence of groundwater management in Gelderland has also shown that it can take quite some time for changes to occur. For example, the insights that currently play a role in integrated (ground) water management already existed during the first steps of its exploitation. However, for such insights to bring about systemic change, they need to come out of the undergrowth of mainstream institutions. As indicated in Chapter 4, learning may have both a conserving and a renewing character. Thus, social-environmental learning will involve struggles among those aiming to maintain mainstream institutions and those aiming to change them.

Social-environmental learning at the macro level

A social-environmental learning analysis and assessment has indicated how stakeholders tend to draw on only part of their potential capacity for social-environmental learning. Institutional and cognitive-related factors may underlie people's ability to draw on and develop their learning potential and, accordingly, adapt to and adapt institutions for sustainable NRM. Institutions may inhibit or provide possibilities for different learning. The analysis and assessment has indicated how some institutions are more restrictive in nature and create biases for certain types of learning, while others create conditions and stimulate stakeholders to develop more flexible collectives and to experiment. In addition, the dual dynamics of institutions are not foolproof. Examples of over-steering, crowding out effects, and self-referentiality have indicated the limits of the regulative power of institutions. Time lags in the feedback loops and cognitive fallacies are the basis for such limitations. The tendency to harness amplifying feedback loops as quickly as possible also reduces people's ability to recognize when they are beginning to become overly self-referential or have the potential of new equilibriums. Moreover, institutional memory often proves to be a sieve, as the wheel is reinvented in the different renewal cycles.

Meso-analysis of the emergence of groundwater management in Gelderland

In Chapter 8, a meso-level analysis provides insight into how macro level structural changes shape, and are shaped by, aggregate stakeholders involved. As this entails a more detailed level of analysis, the time period which is analyzed is restricted to only one of the phases distinguished in the long-term Holling's ecosystem renewal cycle (see Chapter 7), namely, the reorganization phase. The collective stakeholder is the provincial water management department, one of the main stakeholders in groundwater management in Gelderland. Adaptations by this stakeholder are discussed in terms of changes in the different properties of the 7-S profile. The chapter analyzes the linkage between social-environmental learning and the manner in which organizational development and its effect on individuals may influence the institutional interface that frames learning, and vice versa. The meso-level changes in the provincial water management department have confirmed that, for systemic change to occur, complementary changes are needed in terms of the different 7-S properties within the stakeholder. Changes in structures are insufficient to bring about such change. Changes are also needed in staff, style, standards, and so on. No single property is influential enough on its own to bring about systemic change, i.e., change at double and triple loop learning levels.

Change and learning at meso and macro-level

The meso-level learning history and 7-S property analysis also indicated that changes in a collective stakeholder need to be supported by change at the macro level. One stakeholder cannot change an entire system. Systemic change requires changes in both the institutional interface and its constituent stakeholders. This may seem obvious, but stakeholders often lose faith when another stakeholder does not immediately respond to new intentions and/or behavior. However, insights into how feedback loops work indicate that, for new interactions to generate new behavioral patterns and institutions, they will need to occur more than once or twice. Furthermore, stakeholders will need to take into account the possible time lag between action taken and effects on other stakeholders and the institutional interface. Similarly, the design of new regulations or policy measures will not automatically take effect. The planning procedures undertaken (depicted in terms of chutes, funnels, and hourglasses in Figure 8.2) indicate that goal-directed behavior of stakeholders (direct emergence), a supporting institutional frame (indirect emergence), and shorter cycles of policy development and outcomes are essential for changes to occur.

Change and learning at meso and micro-level
The meso-level learning history and 7-S property analysis also highlight that changes in a collective stakeholder entail changes at micro level. Meso and macro-level changes entail individual learning and personnel development. The staff members interviewed indicated that the change processes of which they were part entailed changes with regard to their own personal development. Such changes may vary from getting a better understanding of one's abilities to actually changing, for example, the way one communicates with others. It is also interesting to note how sometimes someone's lack of experience may actually trigger an amplifying feedback loop for a change trajectory that others have learned to doubt or learned to regulate.

Part IV Lessons learned

In the concluding chapter the research questions and objectives are revisited. Lessons learned in the preceding chapters are related to the research questions and objectives. Overall, a social-environmental learning perspective is shown to be a useful and viable perspective for developing sustainable NRM. However, the fact that people have the potential for social-environmental learning, and that learning has the potential to contribute to realizing sustainable NRM, does not mean that social-environmental learning and its facilitation will lead to sustainable NRM. Cognitive as well as institutional factors may influence the way in which people draw on and develop their learning potential, as indicated in the summaries of Parts II and III.

Facilitating principles and future learning
On the basis of the above findings directions for improving the facilitation of social-environmental learning for sustainable NRM. Facilitation principles systems thinking, experimentation, and communicative action are re-assessed. Three additional principles are suggested for those facilitating social-environmental learning for sustainable NRM: diversity, redundancy, and resonance. Three areas for further investigation about the social-environmental learning perspective are recommended: linking of learning at micro, meso, and macro levels of interaction and analysis; comparative study of learning environments and outcomes; and development of action science approaches. In summary, a social-environmental learning perspective appears to present a viable perspective for developing sustainable NRM, as long as it is viewed as complex and evolving.

Samenvatting

In dit proefschrift wordt de betekenis van een sociaal leren perspectief met betrekking tot het realiseren van een duurzaam beheer van natuurlijke hulpbronnen onderzocht. Het gaat hier om leren door collectieve entiteiten over problemen in het beheer van natuurlijke hulpbronnen die zowel een sociale component hebben (ze zijn alleen aan te pakken door gezamenlijke reflectie en actie) als ook een natuurlijk-fysieke component (het gaat om de transformatie van een natuurlijke hulpbron).

Deel I Doel en aanpak van de studie

In Hoofdstuk 1 worden huidige dilemma's in het waterbeheer besproken ter illustratie van de noodzaak voor een duurzamer beheer van natuurlijke hulpbronnen (NRM - *natural resource management*). De complexe en dynamische aard van het beheer van natuurlijke hulpbronnen, zoals in het geval van waterbeheer, maakt dit beheer een verhaal zonder einde. Natuurlijke hulpbronnen, betrokken belanghebbenden en instituties beïnvloeden elkaar en creëren steeds nieuwe dynamiek en dilemma's. Om met deze dynamiek en dilemma's om te gaan is het noodzakelijk om voortdurend inzichten aan te passen en te innoveren. Een sociaal leren perspectief richt zich op het ontwikkelen van het potentiële leervermogen van gebruikers en beheerders. Ontwikkelingen in onderzoek en praktijk geven aan dat het faciliteren van leren kan bijdragen aan een duurzamer beheer van natuurlijke hulpbronnen. De volgende onderzoeksvragen en -doelstellingen zijn gesteld om meer te leren over waarom en de wijze waarop een sociaal leren perspectief aan een duurzamer beheer kan bijdragen.

Onderzoeksvragen
Waarom biedt sociaal leren een waardevol perspectief voor het ontwikkelen van een duurzaam beheer van natuurlijke hulpbronnen? En op welke wijze kan sociaal leren gefaciliteerd worden om een duurzaam beheer van natuurlijke hulpbronnen te realiseren?

Onderzoeksdoelstellingen
O1 Verken de grondslagen van sociaal leren als een waardevol perspectief voor een duurzaam beheer van natuurlijke hulpbronnen.

O2 Identificeer en analyseer verbanden tussen sociaal leren en de dynamiek in het beheer van natuurlijke hulpbronnen in een complexe NRM casus

O3 Stel richtingen voor om sociaal leren te faciliteren om institutionele veranderingen voor duurzaam beheer van natuurlijke hulpbronnen teweeg te brengen.

Deze onderzoeksvragen en -doelstellingen worden aan de orde gesteld in de verschillende delen van het proefschrift.

In Hoofdstuk 2 worden de stappen beschreven die in het onderzoeksproces zijn gezet. Om recht te doen aan de exploratieve aard van het onderzoek, zijn de hoe en waarom van de verschillende stappen transparant gemaakt. De kwaliteit van het onderzoek is besproken in termen van een aantal criteria voor kwalitatief onderzoek en verschillende triangulatiemethoden.

Deel II Grondslagen voor een sociaal leren perspectief (O1)

Alle wegen leiden naar...leren?

In Hoofdstuk 3 zijn vier verschillende onderzoeks- en praktijkvelden verkend om te kijken sociaal leren een betekenisvol perspectief kan bieden voor het ontwikkelen van een duurzaam beheer van natuurlijke hulpbronnen. De besproken velden zijn: sociaal dilemma onderzoek, ervaringen in en onderzoek naar het beheer van natuurlijke hulpbronnen, management van kennis en innovaties in plattelandsontwikkeling en complexiteitstheorie. Ontwikkelingen in deze velden convergeren om het idee van leren als belangrijk concept. Sociaal dilemma onderzoek maakt zichtbaar hoe mensen verstrikt kunnen raken in verschillende wederzijdse afhankelijkheidstructuren die een knelpunt kunnen vormen voor een duurzaam beheer. Het belichten van de mens als *homo discens* in plaats van als *homo economicus* brengt mogelijkheden in beeld die mensen kunnen ondernemen om dergelijke dilemma's te overwinnen. Onderzoek en praktijkervaringen in het beheer van natuurlijke hulpbronnen leggen de valkuilen van kortzichtig doel- en regelbeheer bloot. Een meer procesgerichte, adaptieve aanpak kan het benutten van de potentiële leercapaciteit van mensen bevorderen en verder ontwikkelen. Ontwikkelingen in het management van kennis en innovatie in plattelandsontwikkeling laten zien hoe leren kan worden gefaciliteerd. Verschillende methodes zijn en worden ontwikkeld die betrokkenen in staat stellen om samen te leren hoe sociale dilemma situaties overwonnen kunnen worden. Onderzoek in complexiteitstheorie levert inzichten en een taal op om de adaptieve dynamiek van complexe systemen in het beheer van natuurlijke hulpbronnen beter te begrijpen. Naast het belang van leren, bevestigen de verschillende onderzoeks- en praktijkvelden de waarde van systeemdenken, experimenteren en communicatieve actie als principes voor het faciliteren van leren voor een duurzaam beheer van natuurlijke hulpbronnen.

Leren over leren

In Hoofdstuk 4 staat leren centraal. Vier leermodellen laten zien dat leren een dynamisch, iteratief proces van cognitieve processen en gedrag. Dit proces stelt mensen in staat om zich aan te passen aan hun omgeving maar ook de omgeving aan te passen. Het vermogen om zichzelf en zijn/haar omgeving te onderscheiden, het vermogen om intentionaliteit uit te drukken in termen van doelen en prioriteiten en het vermogen om intenties te vertalen in gedrag dat bijdraagt tot het realiseren van de gewenste situatie spelen een belangrijke rol. Door deze vermogens te benutten en structuur aan te brengen in de wijze waarop men de omgeving ervaart worden kennis en vaardigheden ontwikkeld. Tevens wordt een cognitief kader ontwikkeld. Dit cognitieve kader beïnvloedt en wordt beïnvloed door de wijze waarop men de wereld ervaart en het leren dat plaatsvindt. Dit adaptieve potentieel is een fundamentele notie in een sociaal leren perspectief. Het is immers het adaptieve vermogen dat betrokkenen in staat stelt om voortdurend inzichten met betrekking tot het beheer van natuurlijke hulpbronnen aan te passen. De wijze waarop leren zich manifesteert in de interacties tussen hulpbronnen, belanghebbenden en instituties is zeer divers. Op basis van de onderscheiden aspecten van sociaal leren en inzichten met betrekking tot menselijk leren, zijn verschillende vormen van leren samengebracht in een overzicht. Dit overzicht geeft een beeld van het potentieel vermogen voor sociaal leren (zie Figuur 4.4). Het overzicht geeft aan hoe mensen uit oneindig veel repertoires zouden kunnen putten om een duurzaam beheer van natuurlijke hulpbronnen te ontwikkelen.

Leren en instituties
De rol van instituties in de interactie tussen mensen en hun natuurlijke omgeving wordt verder besproken in Hoofdstuk 5. Instituties kunnen worden gezien als een zelfde soort raakvlak in het regelen van menselijk gedrag als de (collectieve) cognitieve kaders in de leerprocessen besproken in Hoofdstuk 4. Inzicht in de totstandkoming en rol van instituties kan een handvat bieden om de wijze waarop leren en het beheer van natuurlijke hulpbronnen kunnen worden gekoppeld beter te begrijpen. Instituties worden belicht in termen van de tweeledige dynamiek die hun regulerende werking kenmerkt. Aan de ene kant leidt interactie tussen mensen tot het ontstaan van instituties. Aan de andere kant wordt interactie tussen mensen ingekaderd door instituties. Deze tweeledige dynamiek komt overeen met de dynamiek van leerprocessen zoals besproken in Hoofdstuk 4. Beide behelzen iteratieve feedbackloops waarin het creëren en delen van betekenis een belangrijke rol spelen. Inzicht in de rol van versterkende en regulerende feedbackloops tonen het belang van beide typen feedback aan. Niet alleen de regulerende aard van instituties dient in acht te worden genomen, maar ook de versterkende feedbackloops. Versterkende feedbackloops kunnen aantonen wanneer potentiële nieuwe evenwichten zich kunnen ontwikkelen tot instituties of wanneer instituties te zelf-referentieel worden. Inzichten uit de cognitieve theorie geven aan taal een bijdrage kan leveren aan leren en het veranderen van het institutionele raakvlak. Een aantal kenmerken van taal worden in dit opzicht besproken. Aan de orde komen de tweeledige dynamiek van de ontwikkeling van concepten en taallabels, de meervoudige betekenis van concepten en labels en het gebruik van taal.

Deel III Verbanden tussen sociaal leren en dynamiek van het beheer van natuurlijke hulpbronnen in een complexe casus (O2)

Aanpak van de case-studie
Op basis van de inzichten verkregen in Deel II wordt in Hoofdstuk 6 een analytisch kader ontwikkeld om verbanden tussen sociaal leren en de dynamiek in het beheer van natuurlijke hulpbronnen te analyseren in een case-studie. Gezien het leren van collectieve entiteiten centraal staat in een sociaal leren perspectief, richt het analytische kader zich op het macro- en mesoniveau. Holling's ecosysteem cyclus en het 7-S profiel en de leergeschiedenis worden voorgesteld als gereedschap en methodologie omdat zij bewezen hebben zowel de statische als dynamische kwaliteiten van natuurlijke hulpbronnen, belanghebbenden en instituties te kunnen vatten. Ze worden in dit onderzoek voor het eerst gecombineerd.

Macro-analyse van de ontwikkeling van het grondwaterbeheer in Gelderland
In Hoofdstuk 7 wordt de geanalyseerde casus geïntroduceerd, de ontwikkeling van het grondwaterbeheer in Gelderland. In dit hoofdstuk worden de bevindingen van de analyse op macroniveau besproken. De analyse laat zien hoe sociaal leren en dynamiek in het beheer van natuurlijke hulpbronnen op elkaar in kunnen werken in termen van lange termijn institutionele veranderingen. Dergelijke veranderingen kunnen worden verbeeld door middel van verschillende in elkaar verankerde Holling's vernieuwings cycli. De casus laat zien hoe leren heeft bijgedragen aan het continu inzicht verkrijgen in grondwaterdynamiek, aan beslissingen en handelingen van betrokkenen en institutionele veranderingen. Grondwaterbeheer in Gelderland heeft zich ontwikkeld van enkelvoudig, sectoraal beheer naar een meervoudige, integrale aanpak. Het overzicht in Tabel 7.1 geeft aan wat die ontwikkeling inhoudt in termen van verandering in de kwaliteiten van grondwater, belanghebbenden en instituties. De

ontwikkelingsgeschiedenis van grondwaterbeheer in Gelderland laat zien hoe doorwerking van veranderingen, d.w.z., systeemverandering, lang op zich kan laten wachten. Bijvoorbeeld, het idee van integraal waterbeheer dat domineert in het huidige waterbeheer werd al benoemd ten tijde van de eerste collectieve exploitatie van het grondwater. Echter voordat het begrip werd verankerd in het huidige institutionele kader, diende eerdere kaders eerst te worden aangepast. Zowel de conserverende als vernieuwende aard van leren, zoals besproken in Hoofdstuk 4, spelen hierin een rol.

Sociaal leren op macroniveau

Een sociaal leren analyse laat zien dat betrokkenen de neiging hebben om slechts een deel van hun lerend vermogen te benutten. Institutionele en cognitieve factoren kunnen ten grondslag liggen aan (on)mogelijkheden van mensen om hun lerend vermogen te benutten en te ontwikkelen. Sommige instituties beperken de opties voor leren. Andere instituties creëren juist voorwaarden voor verschillende vormen van leren door betrokkenen te stimuleren om zich op een meer flexibele wijze te organiseren en om te experimenteren. De tweedelige dynamiek van instituties is tevens feilbaar. Voorbeelden van oversturen, *crowding out effects* en dysfunctionele zelf-referentialiteit leggen de grenzen van het regulerende vermogen van instituties bloot. Vertragingen in feedbackloops en cognitieve valkuilen kunnen ten grondslag liggen aan dergelijke begrenzingen. De neiging om zo snel mogelijk versterkende feedback loops onder controle te brengen vermindert de mogelijkheid van mensen om te herkennen wanneer instituties te zelf-referentieel worden of potentiële nieuwe evenwichtspunten zich ontwikkelen. Daarnaast blijkt het institutionele geheugen vaak een zeef. Telkens wordt het wiel weer uitgevonden in de verschillende vernieuwingcycli.

Meso-analyse van de ontwikkeling van het grondwaterbeheer in Gelderland

In Hoofdstuk 8 ligt de nadruk op het meso analyse niveau. Met andere woorden, de wijze waarop macroniveau veranderingen collectieve belanghebbenden beïnvloeden en door hen worden beïnvloed staat centraal. Omdat dit een meer gedetailleerde analyse vergt is de analyse beperkt tot één van de fases die in de lange termijn Holling cyclus wordt onderscheiden, namelijk de reorganisatiefase. De analyse richt zich op de provinciale waterafdeling, een van de belangrijkste belanghebbende in het grondwaterbeheer in Gelderland. Veranderingen in en door deze belanghebbende worden besproken in termen van de verschillende eigenschappen van het 7-S profiel. Op deze wijze worden verbanden in kaart gebracht tussen sociaal leren en de manier waarop organisatieontwikkeling het institutionele raakvlak kan beïnvloeden. De veranderingen op mesoniveau in de provinciale waterafdeling bevestigen dat systeemverandering vereist dat complementaire veranderingen in termen van de verschillende 7-S eigenschappen plaatsvinden. Veranderingen in structuur, staf, stijl, standaarden of één van de andere eigenschappen zijn hiervoor niet voldoende. Geen enkele eigenschap heeft genoeg kracht om een systeemverandering door te voeren.

Relatie leren en verandering op meso- en macroniveau

De mesoniveau leergeschiedenis en 7-S profiel analyse geven ook aan dat veranderingen in een collectieve belanghebbende dienen te worden ondersteund door veranderingen op macroniveau. Een enkele belanghebbende kan niet het systeem op macroniveau veranderen. Systeemverandering op dit niveau vereist verandering in zowel het institutionele raakvlak als ook de betrokkenen die onderdeel zijn van het systeem. Dit lijkt voor de hand te liggen, maar in de praktijk verliezen belanghebbenden vaak de moed als andere betrokkenen niet onmiddellijk reageren op nieuwe intenties of gedrag. Echter inzicht in de wijze waarop feedback-

loops werken laat zien dat nieuwe interacties slechts nieuwe gedragspatronen en instituties teweegbrengen wanneer zij herhaaldelijk plaatsvinden. Belanghebbenden zullen hierbij rekening moeten houden met de mogelijke vertraging tussen de ondernomen actie en het effect op andere betrokkenen en het institutionele raakvlak. Zo zullen nieuwe regels en beleidsintenties niet direct effect hebben. Verschillende planningsprocedures (uitgebeeld in termen van een koker, trechter en zandloper in Figuur 8.2) tonen het belang aan van korte cycli van doelgericht handelen, een ondersteunend institutioneel kader en gezamenlijke reflectie om leren te faciliteren.

Relatie leren en verandering op meso- en microniveau
De leergeschiedenis en 7-S analyse op mesoniveau geeft ook aan dat veranderingen in een collectieve belanghebbende ook veranderingen op microniveau inhouden. Meso- en macroniveau veranderingen zijn gekoppeld aan individueel leren en personeelsontwikkeling. De geïnterviewde stafleden geven aan dat de veranderingsprocessen waar zij onderdeel van hebben uitgemaakt, veranderingen in hun persoonlijke ontwikkeling hebben betekend. Zulke veranderingen variëren van een beter begrip krijgen van het eigen vermogen om te veranderen tot het concreet ontwikkelen van vaardigheden, bijvoorbeeld, de wijze waarop iemand communiceert. Het is ook opmerkelijk dat gebrek aan ervaring een versterkende feedbackloop van een veranderingstraject kan teweegbrengen waarvan anderen hebben al geleerd het nut te betwijfelen.

Deel IV Conclusies

Sociaal leren een betekenisvol perspectief, maar geen garantie
In het concluderende hoofdstuk worden de onderzoeksvragen en doelstellingen opnieuw belicht. Op basis van de bevindingen in Deel II en Deel III kan worden geconcludeerd dat sociaal leren een betekenisvol perspectief kan zijn voor het ontwikkelen van een duurzaam beheer van natuurlijke hulpbronnen. Echter, het feit dat mensen het vermogen hebben voor sociaal leren en dat dit leren kan bijdrage aan het realiseren van een duurzaam beheer van natuurlijke hulpbronnen betekent niet dat sociaal leren en het faciliteren van sociaal leren zal leiden tot een duurzaam beheer van natuurlijke hulpbronnen. Cognitieve en institutionele factoren kunnen het potentieel leervermogen van mensen beperken. Inzicht in de wijze waarop deze factoren een rol spelen in sociaal leren en de dynamiek van het beheer van natuurlijke hulpbronnen maakt echter ook duidelijk hoe toekomstig faciliteren van leren een bijdrage zou kunnen leveren aan een meer duurzaam beheer.

Toekomstige uitdagingen
Op basis van de bevindingen worden ideeën voor het faciliteren van sociaal leren voorgesteld. Systeemdenken, experimenteren en communicatieve actie worden op een aantal punten aangescherpt als principes voor het faciliteren van sociaal leren. Tevens worden drie andere principes voorgesteld: diversiteit, overtolligheid en resonantie. Drie aandachtspunten worden voorgesteld voor verder onderzoek over het sociaal leren perspectief: het verbinden van leren op micro-, meso- en macroniveau, vergelijkende analyse van leeromgevingen en uitkomsten en het verder ontwikkelen van actieonderzoek. Als laatste wordt geconcludeerd dat sociaal leren slechts een betekenisvol perspectief kan zijn voor het ontwikkelen van een duurzaam beheer van natuurlijke hulpbronnen wanneer rekening wordt gehouden met het complexe, evoluerende karakter van dit perspectief.

Appendix 1

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle Ia: Exploitation of the first drinking water companies (mid 19th century-1910s)		**NRM dynamics Exploitation-exploitation**
In Gelderland, the first drinking water supply company was established in Nijmegen in 1879. Other municipalities in Gelderland soon followed suit. The high quality and easily available groundwater in the province was the main source of drinking water. By the early 1900s, about 22 municipal drinking water companies had been established in Gelderland (G1-5, P9, Q1)	During the second half of the 19th century, epidemiological studies identified how general lack of hygiene and use of contaminated water for drinking, cooking, and cleaning contributed to diseases such as cholera (L2, Q9). Risk of contamination was particularly associated with water taken from canals and rivers in cities and from private, unprotected water wells. Population growth and concentration often caused contamination of these water resources. At the same time, increasing population density made it feasible for municipal governments to establish drinking water supply companies to appropriate and distribute water of a standardized quality for their citizens. Engineers proved eager to develop drinking water companies and apply knowledge and experiences gained in Great Britain, France and Germany where drinking water companies had already been established (W7). Existing civil law (Burgerlijk Recht), Expropriation Act (Onteigeningswet), and Nuisance Act (Hinderwet) provided a legislative frame to establish these companies (C1). Procedures of the Expropriation Act enabled expropriation of land for the establishment or expansion of drinking water companies. The permit requirement for powered equipment under Nuisance Act provided an indirect means to manage groundwater withdrawals; and civil law provided a frame for dealing with possible damages. The national Health Act (Gezondheidswet 1901) and the Housing Act (Woningwet 1901) formally institutionalized, among other things, the responsibility of municipalities to provide clean drinking water to houses.	*Epidemics and need for improved public hygiene as trigger for exploitation of new niche.* *Crisis as trigger for learning* *Institutions: shared value* *Public hygiene becomes a shared value, single and double loop learning* *Stakeholders* • *Municipalities* • *Epidemiological researchers* *Stakeholders* • *Engineers* • *Municipalities* • *National government* *Single loop learning, learning by observation/experience* *Explotation dynamics* *Drinking water companies start to develop in new niche* *Institution to develop of drinking water companies* • *Existing national acts* • *New national acts standardizing and delegating responsibilities and outcomes*

Groundwater management in GL, NL	*Context*	*Comment*
Subcycle 1b: Consolidating drinking water company development (1910s-1920s)		**NRM dynamics Exploitation-conservation**
As an increasing number of municipalities had established their own companies to supply drinking water for their citizens, the drinking water provision of Gelderland had become rather fragmented. Moreover, steady supply of necessary water of acceptable taste, smell, bacteriological reliability, and purity proved no easy matter. In particular, smaller companies had difficulties meeting technical and operational criteria such as quality of material and knowledgeable management and personnel (C1). The collective drinking water supply of thinly populated rural areas also proved problematic. The low number of possible connections in such areas made it too expensive for municipalities to invest in drinking water supply companies (G1-5, L2, P9, Q1). To both counter the fragmented development of the drinking water supply and stimulate inter-municipal provision of drinking water in rural areas, the provincial government of Gelderland regulated establishment and expansion of drinking water supply companies by means of a Water Supply Ordinance (Waterleidingverordening 1927) (G1-5, P1-3, P9, Q1). From that point a drinking water company could only be established by permit issued by provincial government. A permit was also required for those companies wishing to expand their supply area. Three inter-municipal water supply companies were founded. In 1928 municipalities Groesbeek and Ubbergen established the Water supply company 'Berg & Dal' in the form of a foundation. Water supply company 'Oost Gelderland' (WOG 1934) was established as a company limited by shares (naamloze vennootschap). Municipalities Eibergen, Groenlo and Haaksbergen and province were stockholders and provided members of the board. On a similar basis, the municipalities Beesd, Deil, Brakel, Pederoijen and Hedel established the Water supply company Gelderland (WMG 1936). For the first twenty years of their existence, the director of WOG was concurrently director of WMG (G1-5, L2, P9, Q1).	As their numbers grew, directors of drinking water companies established the Association for Drinking Water Supply Interest Netherlands (VWN, Vereniging Waterleidingbelangen 1899) This would give its members an opportunity to share and test their knowledge and experience (L2, Q5). Successful establishment of a regional water supply company in Zuid-Beveland, a region in the southwest of the Netherlands, in 1910 in which several rural municipalities shared investment costs was reason for national government to install the State Committee for Drinking Water Supply (Nationale Commissie voor de Drinkwatervoorziening 1910). This committee was to promote such initiatives elsewhere in the country (G1-5, L2). The committee recommended the establishment of the Central Committee for Drinking Water Supply (CCD, Centrale Commissie voor de Drinkwatervoorziening 1913) and the State Bureau for Drinking Water Supply (RID, Rijksbureau voor de Drinkwatervoorziening 1913) to aid provinces and municipalities to cooperate in establishing and exploiting regional water supply companies (C1, Q5). Amendment of the Health Act in 1919 further established the advisory role of the national Health Council (Gezondheidsraad) and the Health Inspection's (Inspectie der Volksgezondheid) task to monitor the quality of distributed water and protection of water supply areas.	*Stakeholders* *Drinking water companies link up in sectoral network* *Experimentation, learning by doing/observation* *Institutions- strategy* *Adhoc development of drinking water companies results in quality differences and uneven development of water supply network* *Innovation as trigger for learning* *Stakeholders* *• National advisory committees provide means to adopt experience elsewhere to overcome local/regional level dilemmas* *Institutions* *Provincial ordinance to regulate development of drinking water companies* *Exploitation dynamics* *Connectedness increases as intermunicipal drinking water companies are established.* *Exploitation dynamics/ Stakeholders* *Drinking water companies of a diverse organizational structure fill in niche.*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle Ic: The first conflicts of groundwater interests & WWII (1920s-1930s)		**NRM dynamics** **Exploitation-release**
The city of Amsterdam proposed the Veluwe region in Gelderland (see Box 7.2) as a groundwater extraction area for the water supply of the new water-net (L2). Anticipating damaging consequences of large-scale groundwater withdrawals in the area such as desiccation of cultivated lands and of water wells, inhabitants protested against this proposal. Subsequently, the Ministry of Interior Affairs & Agriculture (BIZA, Ministerie van Binnenlandse Zaken & Landbouw) established the Veluwe Committee (Veluwe Commissie 1927) to research potential effects of groundwater withdrawals in the area. Representatives of the National Forestry Service (Staatsbosbeheer), RID, the State Bureau for Drainage (Rijksbureau voor Ontwatering) and the State's regional agricultural advisor (Rijkslandbouw-consulent) were able to voice their respective interests as members of the Veluwe Committee (C15).	As demand for drinking water increased, drinking water supply companies started to look beyond the boundaries of their original supply area both to withdraw groundwater and expand provision possibilities. Subsequently, the first groundwater related interdependencies became visible within the drinking water supply sector as well as among drinking water supply, agriculture and environment. For example, in April 1926 the municipal government of Amsterdam decided that the city needed a new water supply network to meet growing water needs of its citizens (C1).	*Spillover effects* *Competing interests within drinking water sector as well as competing interests across sectors start to emerge.*
	Although Amsterdam abandoned the idea of appropriating groundwater from the Veluwe, the geo-hydrological, agricultural and forestry studies were continued. The final report indicated that unlimited withdrawal would indeed negatively affect economic, cultural and natural interest in the area (C15). The committee recommended development of a new statutory regulation to compensate damages resulting from groundwater withdrawals, in particular damages to agricultural lands. Permits for powered equipment required by the Nuisance Act did not provide an instrument to manage these types of conflicts of interest. Moreover, there was no legislative basis for long-term planning of groundwater management. Subsequently, the Committee Groundwater Withdrawal (COWABO, Commissie inzake Wateronttrekking aan de Bodem 1934) was established to advise national government and permit- granting organizations regarding possible damaging consequences of groundwater withdrawals for all stakeholders involved as well as on steps to prevent or overcome such consequences (C1, L2).	*Research of national advisory committee indicates interconnectedness of resources and capital flows. Although different interests are represented on this committee, the scientific approach dominates.* *System thinking* *Call for revision of institutional arrangements to consolidate drinking water interests.* *Single loop learning* *Institutions* *No possibilities for strategic planning*
	Research to propose a strategy to resolve the water supply problem of the western part of the Netherlands also brought to light increased interdependence among those interested in exploiting groundwater (C6). Taking into account actual and predicted growth of population, industrialization and urbanization, and furthermore, an overall increase in water use per person, the report indicated that in the near future groundwater exploitation for drinking water supply would be competing with agricultural, forestry, industrial and environmental interests.	*Additional research reveals growing pressure on water resources and questions future development possibilities* *System thinking*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle Ic: The first conflicts of groundwater interests & WWII (1920s-1930s)		**NRM dynamics** **Exploitation-release**
During the war, damage to drinking water companies and scarcity of (replacement) materials restrained maintenance and expansion. Badly damaged in Gelderland were WOG, municipal drinking water companies of Arnhem- Zutphen, Lochem, and to a lesser extent Nijmegen (G1-5, P9).	A crisis of a different nature interfered with developments that were proving to be a source of dilemmas in groundwater management dynamics and their management. World War II (1940-1945) disrupted life in general and trajectories of plans for the future. Organizations and committees tried to continue their activities as normally as possible, but, as the war progressed, surviving the circumstances had the priority. This was visible in other sectors as well. Industrial and agricultural production diminished. Production was directed at providing the basic necessities or was capitalized by the occupying forces to contribute to the war effort. Existing organizations and institutional structures were broken down, worked at half-power or became instruments of the new regime.	*Disruption of learning cycles* *Spillover effects of violent political conflict disturb further developments of groundwater exploitation.*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle Id: Getting back on our feet (1940s)		**NRM dynamics** **Exploitation-reorganization**
Rehabilitation of the drinking water supply was taken on with renewed energy. Instead of repairing damaged water wells and rainwater cisterns, the goal to connect every household to a water supply network was once again focused on. Existing primitive connections in war-damaged areas were to be replaced with the help of a national subsidy to help bridge yearly budget shortages in the drinking water supply exploitation (C7, G1-G5, L2, P9, Q1).	After the war, damages were assessed. Preparation and management of operations regarding the recovery of infrastructure, reclamation of flooded lands and technical aspects of the reconstruction were concentrated in the newly established Ministry of Water Management & Reconstruction (Ministerie van Waterstaat & Wederopbouw 1945) (B1). After two reorganizations the ministry was split into the Ministry of Transportation & Water Management (V&W, Ministerie van Verkeer & Waterstaat 1947) and the Ministry of Reconstruction & Housing (Ministerie van Wederopbouw & Volkshuisvesting 1947). The former had responsibility for water management and infrastructure, the latter for public hygiene related matters (B1, W12).	*Exploitation dynamics/Institutions- shared value* *Reconstruction spirit gives renewed impulse to exploitation* *Institutions/stakeholders* *Centralization of responsibilities in sectoral ministries*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IIa: Reconstruction & self-sufficiency (1940s-1950s)		**NRM dynamics** **Conservation-exploitation**
With regard to the drinking water supply, a ten-year plan was developed to connect remaining areas to the water supply with financial support of municipal and national government (P9). The provincial Ordinance Drinking Water Supply Grants (Verordening regelende de toekenning van renteloze voorschotten ten behoeve van de drinkwatervoorziening in Gelderland 1950) further stimulated rationalization and amalgamation of the drinking water companies (G1-G5, P4-5, C12). It established a Drinking Water Supply Fund that granted rent-free loans to drinking water companies so they could pay a municipality the demanded goodwill costs when taking over its municipal water supply company. This ordinance proved effective in realizing amalgamation of drinking water companies. With the financial support of the Ordinance both WOG and WMG in particular were able to incorporate a number of smaller municipal companies.	Pre-war national drinking water supply organizations and those imposed by the occupying forces were adapted to meet growing demands for drinking water and further professionalize the sector. The State Bureau for Water Supply was modernized into the National Institute of Water Supple (RID, Rijksinstituut voor Drinkwatervoorziening). In order to provide quality assessments the quality of drinking water the Water Supply Articles Institute (KIWA, Keuringsinstituut voor Waterleidingsartikelen 1946) was established. Quickly, more and more drinking water companies were convinced to make use of KIWA's services instead of maintaining their own laboratories. The Association of Drinking Water Companies (VEWIN, Vereniging van Exploitanten Waterleidingbedrijven 1952) was established to represent the economic interests of the sector. Together these organizations formed a network that would prove effective in promoting the interests of the drinking water sector, starting with the collective publication of the professional journal at the beginning of the 50s (C1, Q5).	*Institutions/stakeholders* *Development of a self-sufficient network of drinking water sector umbrella organizations.* *Single loop learning- improving practices* *Conservation dynamics* *Further amalgamation and rationalization of drinking water companies*
In order to ensure food production to meet the needs of a growing Dutch population, large-scale land consolidation projects were undertaken. In Gelderland, the Rivierengebied (G6, Q6) and large parts of the Achterhoek were brought into cultivation. In addition infrastructure was greatly improved in these areas. These regional development projects would take ten years to complete. The process involved multi-disciplinary teams with technical, economic, and sociological expertise.	In the spirit of recovery and renewal, foundations of the consensus approach or, as applauded today, the 'polder model', were built in The Netherlands. Labor relations were renegotiated, both willingly and unwillingly, resulting in joint responsibility of management and laborers for the realization of a healthy economy (W13). As the most pressing needs were met, mid-term and long-term priorities could be addressed: improving housing, production capacity, employment rates and general standard of living. The financial impetus of the Marshall Plan helped to jumpstart an era of growth and development that (in hindsight) greatly influenced management of groundwater.	*Institutions- shared value* *Reconstruction and production as triggers for capital growth* *System thinking* *Conservation dynamics/ stakeholders* *• Drinking water, agriculture, industry, infrastructure, building sectors expand interests in groundwater*
Improving agricultural production necessitated draining land so it could carry heavy machinery and provide an optimal growing environment for crops (Q1). Subsequently, water boards, centuries-old local water management organizations responsible for surface water management in terms of drainage and flood management, lowered groundwater levels in line with the agricultural interests represented on their boards (V3).	From 1950 to 1973, the national economy grew at a rate higher than ever known before. Real national income tripled and The Netherlands experienced the highest population growth in Europe (W13). The booming national and international economy proved a conducive impetus for further growth and diversification of industrial activities. Industry and agriculture, much like the drinking water sector, organized into various sector-oriented organizations to represent their respective interests, undertake research and exchange relevant information, developing their respective knowledge systems (G10, V2).	*Conservation dynamics* *Amalgamation and rationalization in other sectors as well.* *Increase connectedness of sectors in terms of groundwater use.*
A number of industrial activities increasingly made use of groundwater resources (P28). Copper and paper mills, and the laundry industry benefited from quality groundwater and the driving power of surface water. In addition, brickyards and textile and leather industries increasingly made use of the province's groundwater resources.		

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IIb: Scaffolding public hygiene and drinking water interests (1950s-1960s)		**NRM dynamics** **Conservation-conservation**
To protect groundwater extraction areas from bacteriological pollution that posed a threat to public health, provincial government started to develop a regional Facet Plan Waterwingebieden (Facet-plan Waterwingebieden 1960) in 1953 in accordance with the national Temporary Act for National and Regional planning (Voorlopige wet inzake het nationale plan & streekplannen 1950) (P6). The facet-plan introduced the system of first and second order protection areas containing more and less strict zoning measures. Together with a sanction ordinance and compensation ordinance, it formed the Protection Regulation (Regeling bescherming waterwingebieden 1962), aiming to create a system of measures for the protection of drinking water provision and quality of groundwater withdrawn (P7).	As more parties with divergent interests were affecting groundwater resources and thereby potentially affecting public health and drinking water provision, two national acts were developed and installed to provide structural safeguarding for the public drinking water supply sector (G9, G10). The Groundwater Act Water Supply Companies (Grondwaterwet Waterleidingbedrijven 1954) was developed to safeguard groundwater resources for drinking water supply (G9, G10, Q3, Q5, Q7, V1, V3). The act required drinking water companies to obtain a permit for groundwater withdrawals from the Ministry of Social Affairs & Public Health (Ministerie van Sociale Zaken & Volksgezondheid). This ministry had been given responsibility for public health when Cabinet Drees took office in 1951 (B1, W13). Permits were issued only after other interests affected by groundwater withdrawals were heard and provincial government was consulted. The Act obligated stakeholders whose interests were affected to tolerate (gedogen) the withdrawal, subject to compensation. Members of COWABO were also installed as the Commission Groundwater Act Water Supply Companies (COGROWA, Commissie Grondwaterwet Waterleidingbedrijven) to advise the minister regarding the issuance of permits. The Drinking Water Supply Act (Waterleidingwet 1957) established national sanitary criteria for the drinking water supply and regulated compliance with these criteria (G9, G10, Q3, Q5, Q7, V1, V3). The previously mentioned national Inspection of Public Health was assigned the task to monitor compliance. The act also enabled reorganization of drinking water companies where historically unfavorable situated groundwater extraction areas had developed. Enforcement was avoided as long as voluntary cooperation could realize the desired result. The Act came fully into effect in 1961. The Land Consolidation Act (1955) ensured that the interests of the agricultural sector were guaranteed. This act provided a legal framework for the realization of agriculture land improvements (Q1,Q6, Q7, V2).	*Exploitation dynamics/Institutions- shared value* *Reconstruction spirit gives renewed impulse to exploitation* *Institutions/stakeholders* *Centralization of responsibilities in sectoral ministries* *Conservation dynamics* *Competing interests of other sectors & pollution as triggers to consolidate drinking waetr interests* *Maintenance of positions as trigger for learning* *Conservation dynamics/ institutions* *Conservation of drinking water and public hygiene interests through:* • *National sector acts* • *National permit system* • *Provincial spatial planning* *Single loop learning* *Stakeholder/institutions* *More national advisory committees* *Institutions* *Prohibitive regulations* *Institutions* *Scaffolding other interests*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IIc: The bath starts to overflow (1960s)		**NRM dynamics** **Conservation -release**
Despite national regulations, local level dilemmas with regard to the quantity of groundwater withdrawn for the supply of drinking water that had already been recognized before WWII re-emerged. In general, groundwater in Gelderland is found right up to ground level (maaiveld). Thus, groundwater influences flora and fauna in most regions, and, in some, the water supply of brooks and streams. This means that agriculture, forestry, natural environment and recreation are affected by changes in levels of groundwater tables. In other words, groundwater withdrawals for drinking water supply that affect the groundwater table may negatively influence these interests. Extensive groundwater withdrawals may also lead to drawing up salt water from deeper ground layers, affecting the quality of future withdrawals (Q1). In the same year that 93% of households in Gelderland were connected to a drinking water supply network, the Central Bureau of Statistics warned of the costs of pollution (C13). As different sectors such as agriculture, transportation, industry, housing as well as different administrative levels, namely, national, provincial and municipal competed for scarcer space, growing land use interdependencies started to affect the quality of groundwater. Consequences of land use decisions and actions increasingly threatened existing and the few potentially available areas for groundwater withdrawal with pollution, making it more difficult to find suitable groundwater extraction areas. The Protection Groundwater Extraction Areas Regulation tried to counter these developments.	When the Temporary Act for National & Regional Planning was officially approved by parliament as the Spatial Planning Act (WRO, Wet Ruimtelijke Ordening 1962), the capacity of regional facet-plans to protect groundwater extraction areas decreased (G9, Q1). The act designated municipalities as the responsible authority regarding zoning. Regional plans were to indicate future developments with regard to real estate and infrastructure developments only. Regional plans could no longer prescribe zoning measures and did not contain prohibitions against actions such as dumping or spilling solid or fluid wastes. Overall, bacteriological pollution was mainly taken into account, while chemical pollution was only partially addressed. Moreover, protection was limited to within the boundaries of groundwater extraction areas. Areas that were important for future withdrawals could not be protected. As a result, protected zones were rather small (G9, P9). The growing importance of spatial planning was underlined in the name change of the Ministry of Housing & Building Industry (Ministerie van Huisvesting & - Bouwnijverheid) to the Ministry of Housing & Spatial Planning (Ministerie van Huisvesting & Ruimtelijke Ordening 1951) (B1). In the meanwhile, at national level VEWIN lobbied about the insufficiency of spatial planning measures and ordinances to cope with existing management. In a letter to the Ministry of Social Affairs & Public Health VEWIN states: 'the protection of well fields must be viewed together with water management in its broadest sense. General water management, agriculture, industry, shipping, and tourism are involved as well. It would be a mistake to view watermanagement, and in particular the drinking water supply, solely as an aspect of spatial planning. As water is a primary life necessity, water management involves more than the allocation of land and water. Thus water management problems should be viewed in their own right. If the essence of existing measures does not change principally, the drinking water supply will be greatly threatened in the near future' (C1). Subsequently, the Ministry of Social Affairs & Public Health commissioned the CCD to undertake a study to investigate the necessity for and development of possible guidelines for future drinking water supply.	*Competing interests start to lead to overuse.* *Systems thinking. Growing realization of interconnectedness of system of groundwater users.* *Institutions* *Spatial measures fail to protect groundwater (lack of system perpsective, lack of legislative force).* *Drinking water sector lobbies effectively to get consolidation of interests on political research agenda.* *Systems thinking*

Groundwater management in GL, NL	*Context*	*Comment*
Subcycle IId: Containing dilemmas (1960s - early 1970s)		**NRM dynamics** **Conservation -reorganization**
Because of growing and competing groundwater needs, the provincial government had installed a number of committees to research the possibilities and limits of existing groundwater resources for drinking water provisions, namely the Committee to Study the Fresh Water Needs of Gelderland Agricultural Land (Commissie tot bestudering der zoetwaterbehoefte van de Gelderse landbouwgronden 1957) and the Technical Committee Drinking Water Provision (TCD, Technische Commissie Drinkwatervoorziening 1959) (C17, T1). Findings of the latter pointed out that in Gelderland drinking water demands of industry had started to exceed withdrawals of the drinking water companies. Consequently, the committee recommended the development of a provincial ordinance to oblige appropriators of groundwater for purposes other than drinking water to register and measure withdrawals. The committee also called for further collaboration among the province's drinking water companies. In 1961 the province established the Provincial Drinking Water Companies (Provincial Gelders Contact-orgaan Waterleidingbedrijven) to improve consultation among drinking water companies regarding the coordination of decisions and actions concerning extraction areas and groundwater withdrawals (Q1). A Groundwater Ordinance (Grondwaterverordening 1963) was issued that required groundwater withdrawals over 10m3 per hour for purposes other than drinking water supply to be registered in the groundwater withdrawal register of the provincial Registrar Office (P8). Withdrawals of more than 2000m3 per month for agriculture were also required to be registered and measured. The ordinance also required registration of drainage measures for excavation that lasted longer than 6 months. In addition, the ordinance gave provincial government the authority to designate areas for which permits were required for withdrawal of water; to specify withdrawal volumes; and to designate areas where groundwater may be withdrawn for drinking water supply purposes only. In 1969 the Ordinance Drinking Water Supply Grants was discontinued. Provincial government felt that there was little reason to continue provision	In 1967 the Central Committee for Drinking Water Supply published its findings and recommendations regarding the future drinking water supply of the Netherlands (C1). A number of these findings are summarized: • Total groundwater supply in country: 1.5 billion m3 per year (half is withdrawn at time of publication). In principle this meant that withdrawals could be doubled. Increased withdrawals will require expansion and establishment of new well fields and pumping stations that are proving to be increasingly difficult as experiences with Groundwater Act Drinking Water Supply indicate. • Expansion of groundwater withdrawal will have consequences for groundwater table levels. This fact restricts the use of groundwater as a strategic reserve or buffer for the drinking water supply. Groundwater must be protected against chemical and bacterial pollution. Possibilities of surface water as a source of drinking water need to be investigated. • Quantitative and qualitative aspects of drinking water resources are becoming increasingly important. Therefore drinking water supply management needs to be viewed in light of general water management measures. This will require changes in both drinking water supply and water management policies and regulations. • Most acute problems in drinking water are quite different from the ones that triggered existing provincial water supply ordinances and the Water Supply Act. It is thus necessary to address future drinking water supply besides soundness and size of drinking water supply companies • Public health can no longer be the only criterion for management decisions. Other issues involved in water management will have to be taken into account, in particular economic ones due to the necessary infrastructure investments. • The notion of base plans is welcomed as future management will increasingly require regional and interregional approaches because of the multiplicity of stakes involved and limited available space. Development of such plans will involve struggles among stakeholders. Current administrative law needs to address implementation issues of plans developed in order to ensure their realization.	*Release dynamics* *National research forecasts brittleness of current groundwater management and calls for change of values and practices.* *Stakeholders/institutions* *Regional research committees investigate limits of groundwater use in GL.* *Monitoring* *Stakeholders/institutions* *Establishment of provincial drinking water companies network for consultation regarding policy and regulations affecting the sector* *Communcative action* *Institutions* *Provincial regulations to manage groundwater withdrawals* *Single loop learning*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IId: Containing dilemmas (1960s - early 1970s)		**NRM dynamics** **Conservation -reorganization**
of interest-free loans as most smaller municipal drinking water companies had been taken over. Further amalgamation, including financial measures, was also becoming more a national matter to be addressed in the review of the Water Supply Act (P9, Q1).	The committee further recommended development of a separate statutory regulation to protect groundwater and bring national level interests more to the forefront where provincial and municipal governments fail to do so. This legislation should also protect areas where in future groundwater could be withdrawn from pollution. In this light the legislation would counteract the limits of existing regional spatial plans with regard to groundwater protection.	
	Some of these recommendations found their way in the Water Management Memorandum (NW1, Nota Waterhuishouding 1968). For the first time a national ministery presented a national strategy in which new developments in water policy and management were taken into account (M6). Although the memorandum linked quantity and quality management issues of ground and surface water and took into consideration the need to unify their management, it still particularly addressed the need for water infrastructure investments and the need to meet growing demands for fresh water. Moreover, implementation of new management practices would require a great deal more insight into relationships between the different aspects of the water system as well as restructuring of existing regulations.	*Institutions* *First national strategic water management plan takes interconnectedness of water management sectors into consideration, but mainly advocates water infrastructure investments.*
	At this time, The Netherlands at large was changing from a rather traditional, small scale, closed and authority-abiding society to a more freethinking, open one (Q6, W13). Student protests, women's emancipation broke down existing barriers and diversified influence and participation in collective decision making. Consequences varied from the rejection of formal forms of address to changes in formal decision-making structures, including the water boards that had been uncontested for centuries.	*Transition to release dynamics/ style* *Wave of democratizatoin sweeps the country* *Communicative action, double loop learning*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IIIa: Environment starts to raise its voice (1970s)		**NRM dynamics** **Release-exploitation**
Insights from the research committees CBZ and TCD motivated the provincial government to install the Gelderland Water Management Research Committee (Commissie Bestudering Waterhuishouding Gelderland 1970). The committee was to undertake a scientific investigation into optimal management of surface and groundwater in the province, from both a quantitative and qualitative point of view (C2, P10, P12, Q1). The provincial water management department was responsible for the research, but the project would grow to involve stakeholders and other research institutes. The province, the national water management service, and a number of drinking water companies co-financed the research. After a year of orientation, the first research period (1971-1976) focused on developing a systems approach and modeling dynamics of the water system to improve regional water management.	Although only indirectly affecting groundwater resources, institutionalizing the 'polluter pays' principle that holds polluters directly responsible for the consequences of their decisions and actions in the Surface Water Pollution Act (WVO, Wet Verontreiniging Oppervlaktewater 1970) was a groundbreaking step in qualitative water management and, for that matter, environmental management (G10, M30, V1, V3, Q3, Q5). In addition, the act brought in a new player in the water management field, namely, water purification authorities (zuiveringsschappen) These were responsible for purifying waste water in line with national and developing EU norms. When Cabinet Biesheuvel took office in 1971, increasing attention on environmental aspects of public health matters was the reason for the formation of the Ministry of Public Health & Environmental Hygiene (Ministerie van Volksgezondheid & Milieuhygiene 1971) (B1, W13). Responsibility for the former was moved from the Ministry of Social Affairs, disconnecting the link between labor and health protection. Responsibility for environment was newly institutionalized in a ministry to ensure strategic management at ministerial level. A worldwide oil crisis in the seventies further added to society's uneasy feeling about the future. While in 1969 people had marveled at the seemingly endless possibilities of technology when the first man stepped on the moon, it was becoming clear that the world was not a cornucopia of natural resources to be infinitely transformed for the benefit of humankind. Publication of the report Limits to Growth in 1972 signaled awareness of the global environmental effects of unlimited economic growth and use of natural resources (M1). Similar consequences of economic development were confirmed for the Dutch environment (W14). As environmental problems intensified and societal dynamics created space for different stakeholders to voice their various interests, it was rapidly filled in. In the early seventies a number of environmental organizations became active, both nationally and in the province (G10, Q4, Q8). For example, nationally environmental interests were organized in the Environmental Protection Association (Vereniging	*Institutions* *Polluter pays principle institutionalized in water surface management act.* *Double loop learning* *Stakeholders* • *Water purification boards* • *Polluters* *Institutions* *More scientific research to investigate water system at provicial level* *Learning by abstraction* *System thinking* *Institutions* *Environmental hygiene becomes shared value for action* *Release dynamics* *Crisis in different sectors, trigger for learning* *Stakeholders* *Environmental groups exploit new niche* *Communicative action*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IIIa: Environment starts to raise its voice (1970s)		**NRM dynamics** **Release-exploitation**
	Milieudefensie), among others. Existing groundwater flows and stocks in the Netherlands were further mapped by Department of Groundwater Exploration (Dienst Grondwaterverkenning TNO) (D1).	

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IIIb: Re-scaffolding groundwater management (1970s)		**NRM dynamics** **Release -conservation**
Regionally, drinking water supply interests had no longer without question the highest priority as industry and agriculture claims gained weight. In order to guarantee effective groundwater management in the province, further geo-hydrological research was deemed necessary. In addition, the Groundwater Ordinance was amended in 1973 to include a permit system for large groundwater abstractions (Q1, P11).	Increasing demand for groundwater and experienced scarcity polarized interests involved in the drinking water supply. In the course of time, the COGROWA had started to weigh agriculture, forestry, environment, and infrastructure interests more heavily in their advice regarding permits for groundwater withdrawals for drinking water supply required by the Groundwater Act Drinking Water Supply (C4). As a result, the Act started to have side-effects opposite to its original objective. The permit requirement for drinking water supply companies unintentionally weakened the position of drinking water companies vis à vis other groundwater withdrawers, as these were not restrained by permits.	*Release dynamics/institutions* *Drinking water legislation undermines its own interests.* *Single loop learning* *Amplifying feedback*
	Together with the recommendations of the CCD study, further recognition of groundwater limits was the reason why Parliament discussed a Groundwater Act proposal (Voorontwerp Grondwaterwet 1975) that considered groundwater withdrawals in a wider water management context (G9, G10, Q3, Q5, Q7, V1,V3). The act was to replace the Groundwater Act Drinking Water Supply Companies and counter its side-effects. However, as environmental stakes started to play a greater political role, water management was no longer the exclusive terrain of water managers, and approval of the act was, among other things, delayed by a competence question as to whether the legislation should be primarily a water management act or an environmental act.	*Release dynamics* *Effort to consider groundwater management in wider context breaks down in competency struggles between water and environmental sectors*
	The Water Supply Act, in its turn, had so far failed to decrease fragmentation of the drinking water supply organization as it mainly addressed sanitary	*Release dynamics/institutions* *National legislation aiming to concentrate drinking water companies proves breeding ground for conflicts.*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IIIb: Re-scaffolding groundwater management (1970s)		**NRM dynamics** **Release -conservation**
	measures versus quantitative management or organizational matters (G9, G10, Q3, Q5, Q7, V1,V3). The Act was amended to give provinces the authority to reorganize drinking water companies (Wijziging Waterleidingwet 1975), strengthening its organizational leg. Despite the Water Supply Act Amendment in 1975 reorganization of drinking water companies remained difficult, both nationally and in Gelderland. Two styles of organizing drinking water supply organizations could be distinguished, namely, larger regional water supply companies and a number of smaller water providers, who were also responsible for gas and electricity.	*Single loop learning, double loop learning*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IIIc: Spillovers: Reinforcing dilemmas (1970s-1980s)		**NRM dynamics** **Release- release**
The summer of 1976 proves to be an extra dry one. Farmers desired to sprinkle their lands, but were limited to do so. In addition, the drinking water proved conflictuous as Drinking Water Company Winterswijk refused to be consolidated. In Gelderland, the rising number of requests for permits for groundwater withdrawal, as a result of the provincial Groundwater Ordinance, increasingly drew on the resources of the provincial water management department. Moreover, when multiple permits were requested for the same, a more systematic approach was required to weigh interests and consequences (P17-19). However, such strategic planning needed statutory backing (Q1). Water pollution, that in earlier decades had proven problematic for drinking water companies relying on surface water, started to play a role for drinking water companies that mainly relied on groundwater. Although spatial planning measures existed to protect groundwater extraction areas, diversity in measures, responsibilities and interests made implementation and enforcement difficult (Q1). For example, by law municipalities were assigned responsibility for zoning measures. However, depending on the municipality, municipal interests could differ greatly from the public hygiene of drinking water companies and responsible government organizations. To improve uniformity of municipal measures, provincial government developed a Model Provision Protection (Modelbepaling bescherming waterwingebieden 1978) to extend protected areas for groundwater to secure drinking water supply for the short and mid term. The Model Provision proved ineffective. In 1984 only 25% of municipalities had revised their zoning plans, 25% were in the process of revision, and 50% had not undertaken any steps to revise plans G9).	A second oil crisis on the brink of the eighties continued to reinforce existing problems. The economic crisis that overtook the globe left governments struggling for control. In the early eighties economic growth was the lowest since WWII. Unemployment and inflation soared. In The Netherlands, budgets for public spending were cut drastically (W13). Decentralization was viewed as a means to both ease pressure on government budgets and improve implementation of policy and measures. At the same time, the workload of government increased as collective decision making and action required to resolve dilemmas in groundwater management and in NRM in general were taken on as government responsibility. Discovery of polluted soils under the housing in a neighborhood in Lekkerkerk, a municipality in the west of The Netherlands, near Rotterdam, in 1980 alarmed the entire nation. Rubbish dumps, manure and fertilizers were viewed as main dangers for groundwater and soil pollution (C5, R3, W12). So far, pollution control and protection of measures had failed to ensure the quality of groundwater resources. Parties involved seemed trapped in deadlocks or even unable to be traced, leaving national and provincial government with the responsibility to overcome existing deadlocks and develop and monitor new regulations (G10, Q1, Q2).	*Release dynamics* *Crisis upon crisis: scarcity, pollution, management issues, triggers for learning, amplifying feedback* *Release dynamics* *Disintegration of capital structures* *Release dynamics* *Double sworded solutions:* • *Decentralization as means to cut public budgets and improve policy implementation* • *Government responsible for NRM dilemmas increasing government workload.* *Pollution seeps into groundwater* *Release dynamics* *In conflicts of interests, groundwater loses out* *Single loop learning*

Groundwater management in GL, NL	*Context*	*Comment*
Subcycle IIId: A bridge too far: Integration caught in sectoral legislation and management (1980s)		**NRM dynamics** **Release - reorganization**
The Gelderland Water Management Research Committee developed an integrated water management approach that emphasized internal and external linkages in the water system (C2, Q1). Internal coherence of the water system emerged as surface and groundwater as well as quality and quantity aspects were linked. External coherence came about by embedding water system management issues in policy fields such as environmental management, agriculture, economic development. In this approach, the ecosystem and the water system it depends on were viewed as stakeholders in their own right. In order to balance and coordinate different aspects involved in integrated water management, the research team developed multi-criteria models in which different issues could be weighed As the research was being carried out, the nature of the provincial water management department changed. Where earlier the department was mainly implementation oriented, it had now developed a significant research group. Accordingly, the department was reorganized, formally institutionalizing its research expertise as a sub-department (Q1). The provincial Groundwater Ordinance 1983 was amended in line with national legislation (P20, Q1). It issued further rules with regard to reporting, monitoring and issuing of permits for groundwater withdrawals according to size and type of withdrawal equipement. In response to groundwater pollution problems that had developed in the seventies, Gelderland had already developed a Soil Protection Ordinance (Verordening Bodembescherming 1980) (P15). The ordinance proved to be little used in practice (G9). It was a rather general ordinance and developed particularly to take action against excessively polluting behavior.	At national level, the aggravated water situation spurred RWS, together with the American RAND Corporation, to undertake an in-depth policy analysis taking into account the interest of society as a whole and of individual interest groups (R11). Recommendations were to contribute to the preparation of the Second Water Management (NW2, Tweede Nota Waterhuishouding 1984). In line with the notion of integrated water management, a Water Management Act (Wet op de Waterhuishouding 1989) was initiated in 1979 to coordinate all water management in one integrated law. A Design Water Management Act (Ontwerp Wet op de Waterhuishouding 1982) was presented to Parliament in 1982 and in 1985. Despite acknowledgement of the value of integrated water management, there proved to be too little political support to formally institutionalize the integrated water management approach into a single water management law. A constitutional change, however, did formally lay the broader responsibility to ensure 'habitability and protection and improvement of the environment' in the hands of the government (art 21, Dutch Constitution 1983). While integration of legislation was realized for environmental management, responsibility for groundwater quantity and quality management was translated into a number of different sectoral acts. • Groundwater quantity management (G10, M30, Q3, Q5, Q7, V1, V3) Groundwater Act (Grondwaterwet 1981) developed by V&W was approved to provide a national statutory framework for balanced weighing of interests with regard to groundwater withdrawals and infiltration. The act replaced the Groundwater Act Drinking Water Supply Companies, increasing the level at which groundwater withdrawals and artificial recharge were forbidden unless a permit had been granted. This did not include withdrawals of groundwater for water level management or drainage. In line with existing decentralized groundwater management practices for permits for groundwater withdrawals other than drinking water supply, the Act delegated issuance of permits for groundwater withdrawals for drinking water supply to provincial governments. Permits were to be issued on the basis of groundwater plans.	*Learning by abstraction* *Institutions* *Integrated water management gains ground as management value, double learning, systems thinking* *Learning by abstraction* *Institutions* *Integrated legislation stuck in sectoral, political decision making.* *Institutions* *Environmental values and responsibility constitutionally anchored, double loop learning* *Stakeholders/institutions* *Changes in values, demands and own competencies lead to structural, internal changes in provincial water management department, double loop learning.* *Institutions* *Sectoral national laws to regulate groundwater quantity and quality management* *Single loop learning*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IIId: A bridge too far: Integration caught in sectoral legislation and management (1980s)		**NRM dynamics** **Release - reorganization**
	• Groundwater quality management (G9, G10, M30, Q3, Q5, Q7, V1, V3) The Soil Protection Act (Interimwet Bodembescherming 1983, Wet Bodembescherming 1986) and Soil Sanitation Act (Wet Bodemsanering 1986) were developed by VROM. The former provided a statutory basis for integral protection of soil and groundwater. The latter provided measures for soil sanitation to ensure a speedy clean up of the polluted soils and water bottoms identified. By preventing and limiting groundwater polluting activities on and in the soil and to counter their consequences, the Soil Protection Act aimed to protect soil functions for plants, animals and people. Responsibility for qualitative management in terms of groundwater protection areas and soil protection areas was delegated to the provinces, in particular, the environmental management departments. Provinces could designate groundwater protection areas and take measures for these areas, for example, limit the spreading of manure or pesticides. Furthermore, the act required provinces to develop a groundwater protection plan, a groundwater protection ordinance and a program of intentions.	

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IVa: Planning becomes the fashion (1980s)		**NRM dynamics** **Reorganization exploitation**
The Follow-up Memorandum Integration Water Management Gelderland (Vervolgnota Integrate van Waterbeheer Gelderland 1981) elaborated on content and development of water plans as a means to realize the integral water management (P16). This policy document aimed to highlight the research result of the provincial research committee that had still failed to gain weight on the political agenda (Q1). In line with the statutory obligation of the Groundwater Act, the province started to develop a Groundwater Plan (GWP, Grondwaterplan 1986) in 1984 to realize and maintain different functions that groundwater could fulfill for various interests (P28). The provincial water management department was in charge of working out the plan. Its	V&W developed NW2 to review water policy and management in terms of aforementioned changes in approaches to water management and changes in societal dynamics (M8). The PAWN Study initiated in 1976 greatly impacted its content (R11). The extensive policy study proved 1,5 billion guilders investment in water infrastructure unnecessary. Furthermore, in the NW2 fresh water was acknowledged as a finite natural resource that was growing scarcer. In line with the emerging notion of integrated water management, overall emphasis changed from infrastructure to management issues. The integrated approach drew attention to environmental interests in their own right, next to the interests of other stakeholders, and called for cautious and balanced management. Groundwater desiccation problems, particular-	*Institutions/shared value* *Integrated water management is adopted as shared value for policy and action, double loop learning, systems thinking* *Institutions* *Strategic shift from infrastructure to management issues in national water management strategy* *Single loop learning, double loop learning*

Groundwater management in GI, NL	Context	Comment
Subcycle IVa: Planning becomes the fashion (1980s)		**NRM dynamics** **Reorganization exploitation**
development proved a technocratic, internal process (Q1). Contentwise, the plan gave an overview of current and expected legislation, an extensive geographic and geo-hydrological description, the interests involved in groundwater management, and goals and points of departure for groundwater management. Based on multi-criteria models developed by Cbwhgl, three different scenarios were developed in which agriculture interests were weighted equal to, greater and less than nature and environmental interests. Overall, the province chose to weigh nature and environmental interests more heavily in its measures, with the provision that groundwater resources and effects of measures on the interests involved needed to be further researched for the different regions. Costs of research, compensation for damaging effects and permit administration were to be financed by a levy on groundwater withdrawals, a possibility provided by the Groundwater Act. After public consultation and review rounds, provincial government approved the plan in 1986. Part of the Environmental Policy Plan (Milieuhygienischbeleidsplan) (P23), the Groundwater Protection Plan (Grondwaterbeschermingsplan 1987) (P29), also required by the Soil Protection Act, addressed protection of soils, and accordingly, groundwater in Gelderland. Main themes were the problems of acidification and over-fertilization, both negatively affecting groundwater quality. In phases, drinking water supply protection was to be extended by increasing the number and size of protected extraction area. The Ordinance Protection Groundwater Extraction Areas (Verordening Bescherming Grondwatergebieden 1988), containing measures to designate and protect, was received with mixed feelings (P21). Farmers lodged 850 objections, mainly against proposed compensation measures and fertilization norms (G9).	ly in higher areas such as Gelderland, were viewed as caused by sprinkling in agriculture and groundwater use by industry and drinking water companies. Groundwater withdrawals would need to be limited to prevent their negative consequences on the environment (C10). Limits were to be articulated in groundwater management plans, taking into account importance of withdrawal, possible alternatives, effects on groundwater table, consequences for natural environment, landscape, brooks, buildings, among other things, in the trade off. With regard to drinking water, plans also continued to be developed at the national level (M29, Q5, V5-8). In the former the preference to reserve groundwater for drinking water purposes, in particular households and high grade industrial uses, was set down as policy. An amendment of Water Supply Act (Wijziging Waterleidingwet 1986) formally institutionalized the Policy Plan Drinking and Industry Water (BDIV, Beleidsplan Drink & Industrievoorziening) as a broad long-term policy plan for water supply. As the plan had to indicate physical consequences of policy measures, it contained national physical planning policy, subjecting approval of the plan to the complex and lengthy spatial planning decision procedure. Responsibility for mid-term planning was formally delegated to a representative organization of drinking water supply companies. This entailed VEWIN continuing to be responsible for developing the Ten Year Plan.	*Groundwater withdrawals need to be limited* *First provincial groundwater plan mainly descriptive and technical.* *Institutions* *Planning is mainly insiders' story and process* *Institutions* *Environmental interests start to be weighed in policy decision making* *System thinking* *Strategy/skills* *Sectoral plans address groundwater quality separate from quantity management* *Single loop learning* *Reorganization dynamics/ institutions* *Measures to protect groundwater extraction areas meet with resistance from the agriculture sector*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IVb: Integrating fragmentary legislation and policy through integrated water management based planning (1980s)		**NRM dynamics** **Reorganization - conservation**
Developments in integrated water management and environmental management in general were the reasons for the reorganization of the provincial civil service (Q1). Environment and water management tasks were brought together in the same management group. The water management department was to further accommodate the growing weight of policy making and environmental affairs. In line with the Water Management Act and Third Water Management Memorandum, provincial government approved the Provincial Water Management Plan 1991-1995 (WHPI, Provinciale Waterhuishoudingsplan 1991) (P34). With the WHPI, provincial government aimed to 1) provide an integral water policy program by indicating which claims on water will be met in light of the possibilities of the water system; 2) integrate and coordinate policy of state, province, municipalities water boards and water purification authorities, as well as water management policy measures with spatial planning and environment; 3) provide water policy plans of lower government organizations. Development of the plan proved a highly technical, internal affair of the provincial water management department, with some consultation of water boards. Development of a system of different functions of the provinces water resources prescribed by NW3 was very time-consuming. As a result, the groundwater management plan that was to be integrated in WHPI was brought out separately to avoid further postponement of the WHPI (P35, P39, Q1). The groundwater policy measures were included at the last minute.	While NW2 radiated a sense that The Netherlands was finished water managementwise and acknowledged the need for a more integrated approach to water management, it had not been able to fully realize the latter (G10, M30, Q2). In addition, relations with other environmental issues were only briefly touched on. The memorandum Living with Water (Omgaan met water 1985) was developed to give an impetus to further translate the notion of integrated water management into decisions and actions (M8). Taking linkages in the water system as the point of departure, it looked at how human action could fit ecologically. Internationally the publication of Our Common Future introduced the concept of sustainable development (W1). The Dutch government was quick to subscribe to the importance of environmental values and acknowledge that there were environmental limits to development (M18). In preparation for the Third National Water Management (NW3, Derde Nota Waterhuishouding 1989) integral water management and sustainable development were further addressed. Around 17 preparatory studies were undertaken (I1, I2, R8). With regard to groundwater, government more and more acknowledged desiccation as a growing groundwater management problem. As desiccation involved different aspects of water management as well as coordination of different sectors, an integrated approach was called for. V&W VROM, LNV, National Forest Management, RIZA and RIVM established the Interdepartmental Working Group Desiccation (Interdepartmentale Werkgroep Verdroging 1986) to explore the problem of desiccation and different policy measures (V11). The working group defined desiccation as negative consequences caused by dropping groundwater tables due to lack of moisture as well as mineralization and changes in seepage (kwel) and precipitation. Because measures already existed for desiccation damage to agricultural lands, these were not taken into account in the development of desiccation policy. Two NW3 preparatory studies were commissioned to gain insight into the desiccation problem. A more general preparatory study was also undertaken concerning administrative and legislative bottlenecks in resolving existing groundwater management dilemmas such as upkeep of	*Reorganization dynamics/ stakeholders/structure* *Provincial civil service is reorganized to match changes in tasks and responsibilities* *Single, double loop learning* *Innovation as trigger for learning* *Reorganizatoin dynamics/ institutions* *Steps are taken at national level to further translate principle of integrated water management into actual policy measures.* *Translation remains at strategic level.* *Institutions/shared values* *International introduction of principle of sustainable development provides support in shift to more environmentally, system based water management.* *Reorganization dynamics/ institutions* *Again translation of integrated water management into more concrete implementable policy measures proves difficult and time-consuming. Groundwater management is last in line.* *Institutions* *Water boards are consulted in planning process, but, overall, development is a technical and internal affair. Attempts at communicative action* *Desiccation recognized as intersectoral groundwater management problem in preparation of new national water management plan.* *Interdepartmental workgroup takes on issue.* *Single, double loop learning, systems thinking*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IVb: Integrating fragmentary legislation and policy through integrated water management based planning (1980s)		**NRM dynamics** **Reorganization - conservation**
	water supply, water floods, pollution and desiccation (G9). In light of the importance of groundwater for both human and natural activities, the study argued the need for more strategic groundwater management at national level and additional administrative instruments to realize this strategic policy in coordination with other policy fields	
	Based on the findings and recommendations of the groundwater studies, among others, NW3 translated the notion of sustainable development into a number of target scenarios and end-goals (M9). For groundwater this meant, among other things, stabilization of desiccation for 2000 based on the situation in 1985, improvement of groundwater quality in conformity with the norms in the National Environment Plan (Nationaal Milieubeleidsplan 1989), halving the size and seriousness of groundwater problems in urban areas (M23). Provinces would need to determine desired groundwater situations per region, to develop an action plan to implement anti-desiccation policy, and coordinate different withdrawals to reduce their negative effects on the natural environment and future drinking water supply.	*Scientific study calls for more strategic approach to groundwater management.* *Institutions* *National plan links integrated water management and sustainable development into number of scenarios. Also linkage with other sector plans.* *Systems thinking, learning by abstraction* *Institutions* *Provinces assigned task of translating policy into more concrete action plans.* *Single, double loop learning*
	Parallel to the development of NW3, the Water Management Act was finally approved in Parliament in 1989 (G10, M30, Q3, Q7, V1, V3). The act ended up having a twofold purpose: a planning framework for integrated water management and instruments for quantitative surface water management. The planning scheme obliged responsible national government, provincial government, and operational water managers (i.e., water boards) to develop integrated water management plans for the area under their jurisdiction. These plans had to take into account strategic policy prescribed by higher level water management policy plans, policy plans of related policy fields as well as the statutory obligations for stakeholder consultation and appeals. Otherwise, the content of the plans was left up to provinces and responsible water management organizations. The act also contains instruments for quantitative surface water management.	*Institutions* *Integrated water management act partly integral in its integrated planning system. In part also sectoral surface water quantity management act.* *Planning is advocated as a means to realize integrated water management*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IVc: Integrated water management based planning proves no cure-all (1980s-1990s)		**NRM dynamics** **Reorganization - release**
Evaluations of national and provincial plans indicated that integrated water management based planning proved no cure-all for groundwater management problems. Establishment of plans, their content and implementation generated management dilemmas of their own in terms of competence questions, pseudo-participation, definition problems, articulation of realistic and measurable goals, and management deadlocks that proved barriers to realizing sustainable groundwater management. In addition, integrated water management based planning and legislation was not able to resolve problems regarding reorganization of drinking water sector (Q1). Overall, establishment of plans followed administrative rules and guidelines for stakeholder participation. In addition to competency based conflicts and negotiations between policy fields at departmental level, personal competency issues played a role in policy making and the reorganization of water management department. It also became clear that quality research on integrated management required different skills than quality policy making and planning based on integrated water management. In the establishment of plans, more passive interests such as agriculture and nature were consulted to avoid and limit damages of withdrawals instead of actively involving them in the policy making. Moreover, provincial policy makers felt that links with political decision makers needed to be strengthened to avoid disappointment when politicians ignored policy measures or unexpectedly opposed them (Q1). With regard to their content, national and provincial plans were mainly, descriptive and technical (L1, M11, P40-41, P43-46)). Most groundwater management dilemmas were well analyzed and increasingly acknowledged, but lacked clear measurable steps for their resolution. Differences in definitions of groundwater management problems proved to have their consequences in terms of goals articulated. For example, depending on the definition of desiccation used, the size of the surface affected and the goals to be realized differed. Similarly, WHPI and GWP lacked clearly defined strategy. Instead, strategy formed the tail end rather than the principal part of the policy plans. Limits were set, for example for	Groundwater management issues increasingly involved complex interdependencies among different aspects of the water system as well as among related policy fields involved in its use and management. In addition to competing water uses, this entailed competition among competencies representing different interests in water management as well as different policy fields. Such compentency signified part of an organization's identity and its personnel and budget. Policy plans of different policy fields extended their influence to groundwater management (M2-5, M21-24). Similar dynamics and problems occurred in national level policy making and planning. Where possible, sector organizations such as VEWIN lobbied in the interest of their sector, with the consequence that sectors that were well organized had more influence than those less organized (Q5). Those affected by intended measures were heard. However, this occurred after measures were formulated. After review, political decision makers in national government, i.e. ministers and Parliament, approved the plans. Accordingly, planning based on integrated participation of stakeholding interests occurred mainly through different government organizations and sector umbrella organizations representing the various interests, making developments of plans a highly internal affair. Moreover, evaluations indicated that goals articulated lacked a clear time horizon, measurable parameters and demarcation of responsibilities. During the discussion of NMP and NMP+ (Nationaal Milieuplan + 19xx) in September 1990, the intention to stabilize desiccation based on the situation in 1985 was sharpened to a 25% reduction by 2000 by a motion of Parliament (M22). Provinces and other water management organizations would have to take this change into account in their water management plans. Evaluation of desiccation policy also made it clear that the 25% measure was chosen rather arbitrarily (Q1, V11). The bottlenecks in establishment and content of national and provincial water management plans had repercussions on their implementation.	*Competition over groundwater use continues* *Competition over groundwater management issues prove barriers to integration* *Stakeholders/skills* *Competency questions involve core values of organizations and people, single, double learning* *Focus on planning and management requires different skills* *Communicative action* *Realization that stakeholder participation after plans are made fail to create support for plans* *Need to ensure link with political system* *Single loop, double loop learning* *System thinking* *Content of plans* *Plans are descriptive and technical* *Problem of different problem definitions* *Need to articulate measurable and realizable goals*

Groundwater management in GI, NL	*Context*	*Comment*
Subcycle IVc: Integrated water management based planning proves no cure-all (1980s-1990s)		**NRM dynamics** **Reorganization - release**
groundwater withdrawals, but were done so rather modestly, within the reserve space of permits With regard to taking responsibility or action for groundwater management, stakeholders tended to point accusing fingers at each other, i.e., supported by research (Q1, Q4, Q8). Different interests involved accused each other of causing the current groundwater management problems, resulting in deadlocks as to who should take action to resolve them. Desiccation, necessity to limit groundwater withdrawals, water saving measures, compensation measures, groundwater pollution, development of alternative production techniques and subsequent expertise required, led to government's decision to push towards one drinking water company in the province (P50-51, W8-11). In line with national policy, two end situations were deemed possible. On the one hand, there was the possibility of founding a new utility company composed of existing companies. On the other hand, the possibility existed to assign all drinking water supply tasks to an existing drinking water company. However, practice defied both these scenarios. In Gelderland, two pure regional water drinking water companies appeared compatible, namely WOG and WMG. The largest remaining mixed utility company was unwilling to become a pure drinking water company and even expanding by taking over some smaller municipal drinking water companies.	Implementation of policy measures proceeded slowly making it questionable whether proposed goals would be achieved. With regard to the desiccation goal of 25% reduction there was no clear change in sight. Desiccation was not unequivocally measurable and locally appropriate reference points were often missing. All in all, local inventories of desiccated areas proved very time consuming. The reorganization of water boards, more and more recognized as playing an important role in groundwater management in their water level management, proved troublesome. In line with the notion of integrated water management, the Water Board Act (Waterschapswet 1992) promoted the formation of all-in water boards (C16, S1, V1,V3,W6). This entailed merging of existing water boards and water purification authorities on a regional watershed basis. This met with resistance, in particular in regions that had experienced failure in earlier provincial attempts to bring about amalgamation of water boards to take into account a broader set of interests, next to agriculture. This strained relationships in development and implementation of plans and legislation	*Single, double loop learning* *Implementation of plans* *Deadlocks in regional strategy formulation and implementation when things get more concrete* *Reorganization dynamics/ institutions/stakeholders* *Uniform reorganization, i.e., amalgamation of drinking water companies and water boards remains breeding ground of conflict.*

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IVd: Integrating planning and action fields (1990s)		**NRM dynamics** **Reorganization-reorganization**
For groundwater management to become more sustainable, both planning and action water management and related fields needed to be further integrated. This involved improving policy-action-evaluation linkages in terms guiding policy principles, stakeholder participation, and legislative scaffolding.		*Experimentation* *Active experimentation of integration of policy-action-evaluation linkage* *Institutions, systems thinking* *Area-oriented policy principle provides linking concept (natural-human system approach)*
Taking the physical scope of groundwater management dilemmas as the point of departure helped to bridge sector policy and action boundaries and to bring together all relevant stakeholders. With regard to planning it gave a basis to integrate planning for different policy fields such as in the case of the provincial, regional, environmental and water management plans in Gelderland. In 1996 these were jointly presented and approved by provincial government (P47).	In order to improve the basis for integrated water management and coordination of interdependent policy fields in a specific area area-oriented policy (gebiedsgericht beleid) was introduced (M2).	*Single, double loop learning* *Institutions* *Physical scope of groundwater management dilemma as point of departure vs administrative/ sectoral boundaries*
Recognition of the importance of regionally anchored problems versus administrative boundaries to guide policy making, planning and action was also the reason for the initiative and success of the Middle Netherlands Groundwater project (GMN, Grondwater Midden Nederland) (P53, Q1). This joint project of the provinces North-Holland Utrecht, Gelderland and Flevoland aimed to optimize the groundwater system and identify possibilities and conditions regarding use of groundwater and surface water for the different users. Drinking water provision was the point of departure, and nature was an important value. The project developed to include five water boards and drinking water companies.	A similar open planning process, or interactive policy making, was used in developing the Fourth Water Management Nota (NW4, Vierde Nota Waterhuishouding 1999) (M13). Besides a trajectory of evaluation research of policy measures of NW3, police formulation of NW4 was undertaken through an open planning process (M12-13). In addition, government took on a more facilitating role in resolving groundwater management dilemmas. In this role, the focus was more on creating conditions for cooperation than actual formulation of rules and norms (C3, I4, M30, Q2, V10). National REGIWA and COBEVE subsidies have been developed specifically to allow experimental projects to develop. Policy, action and evaluation have been linked more closely by taking a more experimental approach to policy development (P49). In this approach, existing (national) policy frameworks are questioned on an on-going basis, and policy and management practices are adapted to changing circumstances and new insights as these are obtained in the planning and implementation process. Other stakeholders also took on leading roles, sometimes outside their usual field of action. For example, the Association of Waterboards (UVW, Unie van Waterschappen) developed an action plan for desiccation, taking into account national environmental plans. Moreover, it would take the lead in coordinating agreements concerning damages due to increased water levels (vernattingsschade). These developments have co-evolved with supporting changes in legislative frameworks for water management.	*Institutions* *Subsidiarity: deal with problem at level of problem* *Institutions* *Interactive planning process to involve stakeholders earlier in planning process* *Institutions* *Active breaking down of admistrative/water sector boundaries* *Institutions* *Facilitation versus control* *Experimentation* *Learning by doing* *Institutions/stakeholders* *Other parties in water management take initiative/facilitating role*
Stakeholder participation was also particularly addressed in the process design of the second Provincial Water Management Plan (WHP2, Tweede Provinciale Waterhuishoudingsplan 1996) (P47-48, Q1). A broad group of political representatives and stakeholders was involved in setting the agenda and formulating policy objectives for the WHP2 through workshops early in the planning process. The discussions formed the input for a smaller working group to formulate measurable policy objectives and actions. Having played a role in the formulation of problems to be addressed, stakeholders were more prone to implement measures for their resolution. In addition, monitoring and enforce-		

Groundwater management in Gl, NL	*Context*	*Comment*
Subcycle IVd: Integrating planning and action fields (1990s)		**NRM dynamics** **Reorganization-reorganization**
ment attained increasing prominence (Q1). With regard to monitoring, the setting up of multi-stakeholder monitoring groups with possibilities for collaborative monitoring and exchange of information was explored as a way to improve measurability of policy objectives. Improved monitoring could increase awareness of consequences of decisions and actions, improve progress towards realizing policy goals, and contribute to enforcing regulations. Changes in policy and policy making had their consequences on the organization of stakeholders involved in groundwater management, and vice versa (Q1). More participatory, open policy making required a more transparent organization. The provincial water management department was once again reorganized in 1993 to adapt to and adapt a changing working environment. Moreover, a more flexible policy-making and implementation approach required project management that could anticipate evolving conditions. In line with monitoring demands, activities needed to be translated into measurable products. The provincial water management department collaborated with national and regional stakeholders to develop monitoring working groups to develop databases and share information. Technological possibilities such as e-mail, Internet and more readily available computer power created possibilities to adapt information management and communication. For example, policy documents were more frequently made available on the Internet, computer software made it easier to make maps and visualize complex relations in the water management system.	For example, the permit system was complemented with a system of general rules. In addition to the permit system that required a detailed procedure for each groundwater appropriation it was now possible to create general rules for similar types of categories of withdrawers. General rules aim to increase standardization where relevant, increase transparency, and improve monitoring and sanctioning. Acceptance of policy coordination by non-legal agreements such as covenants makes it possible to enter working agreements when the grounds for collaboration have contributed to exploring possibilities for action strategies and cooperation before legally binding agreements can be articulated (G9, Q3, Q5, V1, V3). Review of the Water Supply act (Wijziging Waterleidingwet), started in 1996, made it clear that the article giving provinces the authority to oblige drinking water companies under their jurisdiction to reorganize, changed the relationship between these two (Q3, Q5, V1, V3).	*Institutions* *Developments in institutional arrangements that support more open and flexible way of working* • *Interactive policy making* • *Project management* • *Non-legally binding agreements* • *General rules* • *Product thinking* • *Information sharing* *Single, double, triple loop learning* *Learning cycles* *Collective monitoring by stakeholders throughout the groundwater transformation chain* *Stakeholders/ institutions* *Again change in internal structure of provincial water management department to match and bring about new groundwater management dynamics*

Appendix 2: Learning history sources

1 National laws

Year	*Law*
1879	Burgelijk recht
	Onteigeningswet
	Hinderwet
1900	Waterstaatwet
1901	Woningwet
	Gezondheidswet
1919	Gezondheidswet
1940	Waterstaatswet
1950	Voorlopige wet inzake het nationale plan en streekplannen
1954	Grondwaterwet Waterleidingbedrijven
1955	Ruilverkavelingswet
1957	Waterleidingwet
1962	Provinciewet
	Bestrijdingsmiddelenwet
1965	Wet op de ruimtelijke ordening
1970	Wet Verontreiniging Oppervlaktewater
1971	Voorontwerp van Wet inzake de Bodemverontreiniging
1975	Ontwerp Grondwaterwet
	Wijziging Waterleidingwet
1976	Wet Chemische Afvalstoffen
1977	Afvalstoffenwet
1981	Grondwaterwet
	Wijziging Hinderwet 1981
1982	Ontwerp Wet op de Waterhuishouding
1983	Grondwet
1984	Grondwaterwet Wijziging
1985	Wijziging WRO
	Landinrichtingswet
1986	Wijziging Waterleidingwet
	Wet Bodembescherming
1989	Wet op de Waterhuishouding
1990	Wijziging Burgelijk recht
1991	Wijziging Grondwaterwet
1992	Wijziging grondwaterwet
	Wet Milieubeheer
	Waterschapswet
1993	Wijziging grondwaterwet
1995	Wijziging van Grondwaterwet 1995-1996
1996	Herziening Waterleidingwet

2 Documents

Refcode *Resource*

B1 Breunesse, J.N. & L.J. Roborgh 1989. *Ministeries van algemeen bestuur*. Leiden: Spruyt.

C1 CCD (Centrale commissie Dirnkwatervoorziening/Committee for the Drinking Watersupply) 1967. *De toekomstige drinkwatervoorziening in Nederland.*

C2 BWHHGL (Commissie Bestudering Waterhuishouding Gelderland/ Study Committee Water Management Gelderland), 1982. *Een systeembenadering voor de waterhuishouding van Gelderland. Grondslagen voor integraal waterbeheer.* (A system approach for water management in Gelderland). Arnhem: Province Gelderland.

C3 CLM, Nationaal Onderzoeksprogramma Verdroging (NOV) 1998. *Boeren met water: aanpak van verdroging.*

C4 CROWA 1977. *Onderzoek ten behoeve van belangen betrokken bij het grondwater.*

C5 Commissie Bescherming Waterwingebieden (RID) 1980. *Richtlijnen en aanbevelingen voor de bescherming van waterwingebieden.*

C6 Commissie Drinkwater Westen des Lands 1940. *Rapport van de Commissie Drinkwater Westen des Lands.*

C7 Commissie Drinkwatervoorziening Getroffen Gebieden 1946. *Subsidieregeling aansluiting door oorlogsgeweld getroffen gebieden.*

C9 Commissie Grondwaterbeheer 1989. *Groen licht voor grondwaterbeheer.*

C11 Commissie Infiltratie Veluwe 1977. *Rapport van de Commissie Inflitratie Veluwe.*

C12 Commissie Rijkssteun Drinkwatervoorziening 1951. *Tienjarenplan aansluiting onrendabele gebieden.*

C13 Commissie Rijkssteun Drinkwatervoorziening 1962. *7% - plan.*

C14 Commissie tot bestudering der zoetwaterbehoefte van de Gelderse landbouwgronden 1967. *Onderzoek naar de landbouwwaterhuishouding met hulp van wederopbouwgelden Marshall Plan.*

C15 Commissie Veluwe1933. *Eindraport Veluwecommissie.*

C16 Commissie Waterschapsbestuur, voorzitter Merx 1978. *Het bestuur van het waterschap*

D1 Dienst grondwaterverkenning TNO 1973. *Grondwaterkaart van Nederland.*

D2 Dienst grondwaterverkenning TNO 1985. *Grondwaterkaart van Nederland.*

E1 Erasmusuniversiteit Rotterdam 1997. *Mogelijkheden tot marktwerking in de Nederlandse water-sector.* Rotterdam: EUR.

G1 Gelders Jaarboek 1950. Arnhem: Van der Wiel.

G2 Gelders Jaarboek 1951. Arnhem: Van der Wiel.

G3 Gelders Jaarboek 1952. Arnhem: Van der Wiel.

G4 Gelders Jaarboek 1953. Arnhem: Van der Wiel.

G5 Gelders Jaarboek 1955. Arnhem: Van der Wiel.

G6 Gelderse Komgronden Commissie, Stichting Komgronden 1951. *Komgronden in het Rivierengebied.*

G8 Glasbergen, P., J. Wessel, J.H.P. Baltissen, C.J. Compaijen, M.C. Groenenberg, C.B.F. Kuijpers 1988. *Samenhang en samenspel in het waterbeheer. Het streven naar integraal waterbeheer.* Delft: Delftse Universitaire Pers.

G9 Glasbergen, P., M.C. Groenenberg & F.A. Roorda 1989. *Naar een strategische grondwater beheer.* Den Haag: VUGA.

G10 Grijns, L.C. & J. Wisserhof 1992. *Ontwikkelingen in integraal waterbeheer: Verkenning van beleid, beheer en onderzoek.* Delft: Delft University.

I1 Instituut voor Milieuvraagstukken, Ministerie van VROM 1987. *Vedroging in Nederland: probleemverkenning.*

I2 Instituut voor Milieuvraagstukken, Centrum voor Milieukunde Leiden, Rijksinstituut voor Natuurbeheer, Dienst Grondwaterverkenning/TNO 1989. *Verdroging van natuur en landschap in Nederland: beschrijving en analyse.*

I4 IPO 1991. *Grondwaterbeheer in beweging: actief, strategisch of gericht op een duurzame ontwikkeling*

L1 Landbouwuniversiteit Wageningen, vakgroep Cultuurtechniek 1987. *Grondwaterplannen: een eerste verkenning van de technische onderbouwing en belangenafweging.*

L2 Leeflang, K.H.W. 1974. *Ons drinkwater in de stroom van de tijd.* Nijmegen: VEWIN.

M1 Meadows, D.H., D.L. Meadows, J. Randers, & W.W. Behrens 1972. *Limits to growth.* New York: New American Library.

M2 Ministerie van Landbouw, Natuur &Visserij 1992. *Structuurschema Groene Ruimte. Het landelijk gebied de moeite waard.*

M3 Ministerie van Landbouw, Natuur &Visserij 1989. *Natuurbeleidsplan.*

M4 Ministerie van Landbouw, Natuur &Visserij 1990. *Structuurnota Landbouw.*

M5 Ministerie Landbouw & Visserij 199. *Meerjarenplan Gewasbescherming.*

M6 Ministerie Verkeer & Waterstaat 1977. *Naar een nieuw waterschapsbestel?*

M7 Ministerie Verkeer & Waterstaat 1968. *Nota Waterhuishouding.*

M8 Ministerie Verkeer & Waterstaat 1985. *Omgaan met Water.*

M9 Ministerie van Verkeer & Waterstaat 1989. *Derde Nota Waterhuishouding. Water voor nu en later.*

M10 Ministerie Verkeer & Waterstaat 1989. *Verlaging van de grondwaterstanden in Nederland: analyseperiode 1950-1986.*

M11 Ministerie Verkeer & Waterstaat, mede namens VROM, LNV 1994. *Evaluatienota Water*

M12 Ministerie Verkeer & Waterstaat 1997. Watersysteemverkeningen 1996. Beleidsanalyse WVS. Thema verdroging en grondwater.

M13 Minister Verkeer & Waterstaat 1999. *Vierde Nota Waterhuishouding.*

M14 Ministerie VROM 1981. *Tweede Structuurschema Drink en Industriewatervoorziening.*

M15 Ministerie VROM 1984. *Meer dan de som der delen.*

M17 Ministerie VROM 1986. *Indicatief Meerjarenprogramma water 1985-1989.*

M18 Ministerie VROM 1987. *Regeringsstandpunt over het rapport van de World Commission on Environment and development.*

M19 Ministerie VROM 1987. *Grondwaterbehandeling bij bodemsanering.*

M20 Ministerie VROM 1987. *Milieuprogramma voortgangsrapportage 1988-1991.*

M21 Ministerie VROM 1988. *Vierde Nota Ruimtelijke Ordening.*

M22 Minister VROM 1989. *Nationaal Milieubeleidsplan+.*

M23 Minister VROM. 1989. *Nationaal Milieubeleidsplan Kiezen of verliezen.*

M24 Minsiterie VROM 1993. *Nationaal Beleidsplan 2- Milieu als maatstaf.*

M25 Ministerie VROM 1996. *Beleidsplan Drink & Industriewatervoorziening. Naar een glasheldere toekomst.*

M28 Ministerie Volksgezondheid & Milieuhygiene 1972. *Structuurschema Drink & Industriewatervoorziening.*

M29 Ministerie Volksgezondheid & Milieuhygiene 1981. *Nota Drink en Industriewatervoorziening.*

M30 Mostert E. 1997. *Water policy formulation in the Netherlands.* Delft: Delft Technical University.

P1 Provincie Gelderland 1917. *Waterleidingverordening 1917.*

P2 Provincie Gelderland 1927. *Waterleidingverordening 1927.*

P3 Provincie Gelderland 1928. *Waterleidingverordening 1928.*

P4 Provincie Gelderland 1950. *Verordening regelende de toekenning van renteloze voorschotten ten behoeve van de drinkwatervoorziening in Gelderland.*

P5 Provincie Gelderland 1953. *Verordening regelende de toekenning van renteloze voorschotten en bijdragen a fonds perdu ten behoeve van de drinkwatervoorziening in Gelderland.*
P6 Province Gelderland 1960. *Facet-streekplan waterwingebieden provincie Gelderland.*
P7 Provincie Gelderland 1962. *Regeling bescherming grondwatergebieden.*
P8 Provincie Gelderland 1963. *Grondwaterverordening.*
P9 Provinciale Waterstaat 1970. *Nota inzake de drinkwatervoorziening in de provincie Gelderland.*
P10 Provincie Gelderland 1973. *Het toekomstige waterbeheer op provinciaal en regionaal niveau.*
P11 Provincie Gelderland 1973. *Grondwaterverordening 1973.*
P12 Provincie Gelderland 1974. *Nota integraal waterbeheer.*
P13 Provincie Gelderland 1978. *Modelbepaling bescherming waterwingebieden.*
P14 Provincie Gelderland 1978. *Eindnota inzake de integratie van het waterbeheer in Gelderland en de bestuurlijke aspecten daarvan.*
P15 Provincie Gelderland 1980. *Verordening bodembescherming.*
P16 Provincie Gelderland 1981. *Nota integraal waterbeheer.*
P17 Province Gelderland, 1981. *Grondwateronttrekking in Nijmegen e.o. Nota ten behoeve van de afhandelingen van vergunningsaanvragen in Nijmegen in het kader van de grondwaterverordening voor de provincie Gelderland.*
P18 Provincie Gelderland 1981. *De invloed van de grondwateronttrekkingen op de grondwaterstanden en de afvoeren van de beken op de zuidelijke Veluwezoom.*
P19 Provincie Gelderland 1983. *Beleid op korte termijn voor het onttrekken van grondwater in Renkum en Wageningen.*
P20 Provincie Gelderland 1983. *Grondwaterverordening.*
P21 Provincie Gelderland 1984. *Bescherming grondwatergebieden.*
P23 Provincie Gelderland 1985. *Raamwerknota met betrekking tot het milieuhygienisch beleidsplan.*
P24 Provincie Gelderland, Dienst Waterbeheer, Stichting Proefstation voor de rundveehouderij, schapenhouderij en paardenhouderij 1985. *Rendabiliteit van beregening op melkveebedrijven en waterbehoefte van Gelderse landbouwgronden*
P25 Provincie Gelderland, dienst Waterbeheer, Landbouwhogeschool Wageningen, vakgroep Cultuurtechniek 1986. *Technische en wetenschappelijke aspecten van planvorming: gezien vanuit de provincie.*
P26 Provincie Gelderland 1986. *Gelderse waterwingebieden: kaarten grondwaterbeschermingsgebieden vastgesteld voor 1-, 10-, en 25-jaarsbeschermingsgebieden.*
P27 Provincie Gelderland 1986. Subsidieverordening beperking mestgebruik in waterwingebieden .
P28 Provincie Gelderland 1986. *Grondwaterplan 1987-1995.*
P29 Provincie Gelderland 1987. *Grondwaterbeschermingsplan.*
P30 Provincie Gelderland 1987. *Instelling schadefonds grondwaterwet Gelderland .*
P32 Provincie Gelderland 1989. *Grondwateroverlast in het stedelijk gebied: technisch en/of bestuurlijk probleem.*
P34 Provincie Gelderland 1991. *Waterhuishoudingsplan 1991-1995.*
P35 Provincie Gelderland 1991. *Gelders grondwater schaars goed: hoofdlijnennotitie ten behoeve van het op te stellen grondwaterkwantiteitsbeheersplan.*
P36 Provincie Gelderland 1991. *Verordening Waterhuishouding Gelderland.*
P37 Provincie Gelderland 1991. *Grondwaterheffingsverordening.*
P38 Provincie Gelderland 1991. *Verordening egalisatiefonds grondwaterheffing Gelderland.*
P39 Provincie Gelderland 1991. *Gelders grondwater, schoon goed.*
P40 Provincie Gelderland 1992. *Verdroging grijpt ! (in Gelderland).*
P41 Provincie Gelderland 1993. *Notitie 'Grondwaterafhankelijke natuur in Gelderland'.*

P42 Provincie Gelderland 1994. *Ontwikkelingen in de energiesector en de gevolgen voor de drinkwatervoorziening in Gelderland.*
P43 Provincie Gelderland 1994. *Uitvoeringsperspectief Waterbeleid.*
P44 Provincie Gelderland 1994. *Milieu-Waterverkenning.*
P45 Province Gelderland 1994. *Waterbesparingsplan Gelderland 1995-2000.*
P46 Provincie Gelderland 1995, *Themawerkgroep 'Monitoring', Onderweg naar morgen. Evaluatie activiteiten Waterhuishoudingplan 1991-1995.*
P47 Province, 1996a. *Provincial water management plan 1996-2000.* Arnhem: Province Gelderland.
P48 Province Gelderland 1996. *Actieprogramma Waterhuishouding Gelderland 1996-2000.*
P49 Province Gelderland, 1996. *Plan van aanpak Bestrijding verdroging in Gelderland Aan de (water)gang (Action plan combating desiccation).* Arnhem: Province Gelderland.
P50 Provincie Gelderland 1997. *Ontwikkelingen in de energiesector en de gevolgen voor de drinkwatervoorzie-ning in Gelderland.*
P51 Provincie Gelderland 1997. *De toekomstige rol van de provincie mbt NUON.*
P52 Provincie Noord-Holland, Utrecht, Gelderland & Flevoland 1989. *Grondwater Midden Nederland.*
R3 RID 1983. *Vuilstortplaatsen en hun effect op de kwaliteit van het grondwater: een literatuurstudie.*
R4 Rijksgeologische Dienst, Provincie Gelderland (opdrachtgever) 1995. *Karakterisering hydreologische opbouw van de provincie Gelderland.*
R5 Rijksuniversiteit Utrecht, Instituut voor Staats- en bestuursrecht 1990. *Evaluatiebeheersinstrument Grondwaterwet: onderzoek naar de toepassing van de instrumenten registratie en vergunning.*
R7 RIVM 1985. *Zorgen voor Morgen. Nationale Milieuverkenning 1985-2010.*
R8 RIVM 1989. *De kwaliteit van het grondwater in Nederland.*
R9 RIZA, ministerie V&W 1991. *A groundwater model of the Netherlands: basisrapport derde nota waterhuishouding: water voor nu en later.*
R10 RIZA, RIKZ 1996. *WaterSysteemverkenningen.*
R11 RWS, RAND 1980. *Beleidsanalyse voor de waterhuishouding in Nederland.*
S3 Studiecommissie Waterschappen 1974. *Het waterschap en zijn toekomst.*
T1 Technische commissie drinkwatervoorziening provincie Gelderland 1961. Rapport inzake de mogelijke samenwerking van de waterleidingbedrijven in de provincie Gelderland en het kwantitatieve beheer van grondwater.
U1 Unie van Waterschappen 1997. Denktankrapport.
U3 Unie van waterschappen, Dienst Landelijk Gebied, Projectgroep Waternood 1998. *Grondwater als leidraad voor het oppervlaktewaterbeheer: een op het grondwater georienteerde aanpak voor inrichting en beheer van oppervlaktewatersystemen.*
V1 Van den Berg, J.T. & A. Van Hall 1997. Waterstaats- en waterschapsrecht. Deventer: Tjeenk Willink.
V2 Van der Ven, G.P. (ed.) 1994. *Man-made lowlands: History of water management and land reclamation in the Netherlands.* Utrecht: Uitgeverij Matrijs.
V3 Van Hall, Alfred 1997. Reader Waterstaats- en waterschapsrecht. Utrecht: Faculty of Law.
V4 VEWIN 1978. *Tienjarenplan 1978.*
V5 VEWIN 1981. *Tienjarenplan 1981.*
V6 VEWIN 1984. *Tweede Tienjarenplan.*
V7 VEWIN 1989. *Tienjarenplan 1989.*
V8 VEWIN 1991. *Milieuplan 1991.*
V9 VEWIN, KIWA 1989. *Verdroging en grondwaterwinning.*
V10 Voorbereidingscommissie Verdroging 1993. Nationaal Onderzoeksprogramma Verdroging.

W3 WECD 1987. Our common future.
W5 Werkgroep Markt en Overheid, voorzitter professor Cohen 1997. Eindrapport Markt en Overheid.
W6 Werkgroep Waterschapsfinancieen, voorzitter Elferich 1983. Waterschapsfinancieën.
W7 Wijmers, Sacha 1992. Water om te drinken. Rijswijk: Vewin.
W8 WMG 1995. Zo klaar als water: visie van de WMG op de reorganisatie van de drinkwatervoorziening van de provincie Gelderland.
W9 WMG, WOG 1991. Ontwikkeling in de drinkwatersector in Gelderland: visie van de WMG en de WOG, 1 maart 1991.
W10 WMG, WOG 1991. Natuurontwikkeking in waterwingebieden in Gelderland.
W11 WMG. WOG 1996. Werken aan zuiver Gelders water: perspectief en aanpak van de drinkwatervoorziening in de provincie Gelderland.
W13 Woltjer 1992.
W14 WRR 1987. Ruimte voor groei. Kansen en bedreigingen voor de Nederlandse economie in de komende tien jaar.
W15 WRR 1988. Milieu en Groei.

3 List of resource persons

Refcode *Resource*

Q1 Province Gelderland, Water Management Department
- 5 month internship
- Reflective interviews with department members
- Department staff meetings
- Stakeholder meetings
- Provincial Council meetings

Q2 Members Thales (Water Managers discussion group)
Q3 Dhr Van Hall, professor Watermanagement Law, University of Utrecht & Waterboardchairman
Q4 Dhr Rob Janmaat, former Council Member Province Gelderland
Q5 Dhr Martijn, former head of Vewin
Q6 Dhr Jan van den Ban,
Q7 Dhr Van den Berg, expert water management
Q8 Dhr. Leo Vogelenzang, Stichting Natuur en Milieu
Q9 Water professionals meetings

About the author

Marleen Maarleveld was born on June 9, 1969 in Schaarbeek (Brussels), Belgium. She grew up in Grimbergen (Belgium) and Cincinnati (USA). After finishing high school, she went to study Social- & Organizational Psychology at Leiden University in The Netherlands. She became an assistent researcher at the Department of Communication & Innovation Studies at Wageningen University in 1995. In 2000, Marleen started to work for the Service for Land & Water Management. She works for the Department of Innovation & Knowledge Management as a facilitator of learning processes in the field of planning and governance.