

# Knowledge Transfer and Utilization in Water System Management

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## *Abstract*

In this paper the way knowledge is exchanged and utilized in water system management is explored. Changes in water policy required a different policy approach by water boards. The interest of various actors needs to be taken into account. The daily practice of water system management shows that knowledge exchange and –utilization between engineers and water board member is not without difficulties. When other actors are being brought into the policy implementation process, the dynamics of knowledge exchange and –utilization get more complex. Against the background of Contextual Interaction Theory a tool has been developed to monitor the social interaction processes in which knowledge exchange and utilization take place. The case of water depletion in the Twente region shows how technical and natural science based knowledge influences the stakeholders' cognitions and how that knowledge is handled and utilized in an interaction process.

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## *1. A Brief History of Water System Management in the Netherlands*

The recorded history of water management in the Netherlands starts in the 9<sup>th</sup> century. On December 26<sup>th</sup> 838 AD a storm tide caused major floods in the coastal areas of the Netherlands. Not much is known about the event, only that the absence of reliable dikes was one of the most important causes of the disaster. According to the annals of that time, the water rose as high as the peaks of the dunes and whole villages were devoured by the water. Until the 13<sup>th</sup> century the only defense people had against floods was to live on artificial hills, called *terpen*. In that same period, peaty soil was drained in the west of the country, not only causing a drop in water levels, but also causing the soil to subside. Especially the land below sea level was vulnerable to floods from the sea. By building better dikes, the people managed to protect themselves against the water. The introduction of the mill enabled a continuous use of agricultural ground as well as drainage of lakes.

Improving and maintaining dikes, mills and sluices was costly. To share the costs of improvement and maintenance, community groups were established. Within those groups, every farmer was responsible for the part of the dike that bordered his land. Since the 11<sup>th</sup> century the situation gradually changed: landowners moved to cities and leased the land to the farmers. This development caused a shift in interests between landowners and farmers. Also, building and maintaining dikes and water drainage crossed community borders. People with the same interest organized themselves and cooperation exceeded community borders. In the 13<sup>th</sup> century, water boards were established. Water boards are governmental agencies, responsible for regional water system management. People within the region elect the water board council.

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Over the centuries much more land was reclaimed, lakes were pumped dry to gain agricultural land. The first large scale engineering project in the 20<sup>th</sup> century was the closing of the Zuiderzee. Closing the open connection from the North Sea to the centre of the Netherlands would reduce the chances of flooding. Later, the catastrophic floods in 1953 led to the construction of the Delta Works. Water management in the 20<sup>th</sup> century (at least until the 1980s) can be described as controlling water by taking technical measures. Creeks were straightened out and turned into artificial waterways, water was drained away as fast as possible and dikes were build around rivers. Almost the entire water system in the Netherlands has been altered.

## 2. *Water system management is changing*

In the past two decades, water system management in the Netherlands has changed. Since the early 1980s a new policy approach was adopted, *integrated water management*. The most important reason for this shift was the broadening of the interest framework of water managers ( Raadschelders & Toonen eds., 1993). In water quality management as well as in water quantity management, landscape and nature preservation became increasingly important. Integrated water management can be described as management of surface water and groundwater as a whole, in terms of water quantity, water quality and ecology. In the policy making process, the focus shifts from water as an object to the functions of water. In the years that followed, the concept of integrated water management developed further into the *water system approach*. This new policy strategy has two keywords: coherence and cooperation. A water system does not only consists of surface water and groundwater, but also of the soil, shores, flora, fauna, dams, dikes and technical infrastructure. Furthermore, governmental organizations need to work closely together and the various policies need to be geared to one another.

An other important change in water system management is the abandonment of the traditional strategy of draining away water as fast as possible and heightening the dikes. Floods in the early nineties showed that the technical alterations in the water system were contra productive in dealing with the consequences of climate change. Instead, rivers and creeks should be able to meander again. Also, land surrounding the rivers needs to be reserved for periodical floods. By allowing catchment areas to flood periodically, and by building the dikes at a further distance from the river, the chances of an actual flood decrease.

These insights were formalized in the *Room for River* policy. Rivers literally get more room. This new strategy in water system management consists of connecting water-system management and land use planning: more space around rivers is needed; water and its natural movements should be a key determining factor in land use planning. Water will also become a strong claim in physical planning; physical plans have to be assessed for water risks before adoption. The change in water system management also creates opportunities for achieving goals related to nature preservation, recreation and creating attractive residential areas.

The changes in water system management confronts water managers with an increasingly complex and dynamic policy field. Not only because various governmental organizations need to cooperate and different policies need to be attuned, but also because more actors get involved.

### 3. *More actors, interests and complications*

Water is becoming a social issue for two reasons. First, water system management has an increasing impact on citizens' interests. Those interests can conflict with water policy programs. Second, water managers (and water boards in specific) feel the need to inform, consult and involve citizens in water system management. This interactive policymaking, as we call it in the Netherlands, is a general term for all sorts of attempts made by governmental organizations to involve citizens in the policy making process. It can vary from simply asking citizens for their opinions, to co producing policy.

Interactive policy making gained ground for an ideological reason and a more pragmatic one. First, water system managers feel that if they inform and consult citizens, they strengthen their democratic legitimacy. The second reason is a more pragmatic, water managers think that if they involve citizens in the policy making process, this will result in fewer protests, written objections and appeals. Not only the interests and opinions of citizens potentially conflict with water system management. Nature preservation groups, farmers, industry, the recreation branche are actors whose interests need to be taken into account.

Because of integrated water management, the policy process becomes longer and more complex. Water managers operate in various political, governmental and social constellations. This requires a whole variety of communications styles, negotiation techniques, conflict management, knowledge exchange and knowledge utilization.

### 4. *Role of knowledge*

The Netherlands has an extensive knowledge infrastructure on water-system management, often with basis in natural or technical science. The increasing complexity of water-system management requires a new perspective on knowledge creation. For example, connecting knowledge based on natural science research to social science research. Another aspect that deserves attention is the use of knowledge by decision- and policy makers. The practice of regional water-system management shows that the available knowledge about a physical water system is often difficult to comprehend for decision- and policymakers.

Water boards are the regional water system managers in The Netherlands. Water boards are democratically elected governmental organizations. Currently there are 26 water boards in The Netherlands, the primary focus of this research is on these organizations. Water boards generate many data on water system conditions and develop knowledge in collaboration with consultancy agencies and research institutes. Concurrently, water boards receive knowledge from the scientific community (e.g. technical or natural science based knowledge). Unfortunately, knowledge exchange and the use of knowledge do not automatically yield an obstacle-free decision-making process. For reasons we do not fully understand, scientific research is not always entirely utilized in the decision-making process. Before we attempt to identify the obstacles for knowledge exchange and knowledge utilization, we need to examine the types of knowledge that can be found within water boards.

Of course, many typologies of knowledge exist. First, there is *explicit knowledge*, a type of knowledge which is expressed by using a formal system of symbols. Explicit knowledge is focal and objective. Because of those symbols, this type of knowledge is easily communicated and diffused. Boisot (1995) uses the term *public knowledge* for codified and diffusible knowledge. Public knowledge is what is considered to be “real” knowledge, it is published in journals, books and other more formal sources. Choo (1997) distinguishes explicit knowledge in *object based knowledge* and *rule based knowledge*. Object based knowledge is codified in series of symbols (words, numbers, formulas) or in physical objects (installations, documents, models). Rule based knowledge is the type of knowledge that is codified in rules, routines and standardized production methods. The same type of distinction is made by Blackler (1995). In his view, knowledge is embodied in actions and competencies of people and embedded in systematic routines and procedures.

Second, water system managers use *tacit knowledge* to perform their task and to understand their environment. All the things that we are not able to tell but know can be considered tacit knowledge (Polanyi, 1966). One of the characteristics of tacit knowledge is that it is difficult to write down or to formalize (Nonaka, 2001). An other feature of this type of knowledge is that it is difficult to communicate, because it cannot be reduced to general rules of routines (Choo, 1997). Tacit knowledge develops when a practitioner becomes more experienced in his working field. Over time, an individual develops a certain intuition for carrying out his tasks successfully. Examples of tacit knowledge in water system management are knowing how to deal with elected officials, how long dikes will hold under extreme pressure or how high water levels need to be to prevent water depletion.

Another knowledge typology that seems relevant is *personal knowledge* or *cultural knowledge*. This type of knowledge shapes the way people see the world and consists of norms, values, beliefs, assumptions, culture et cetera (Choo, 1997; Boisot, 1995; Nonaka, 2001). Also, groups of people create their own cultural knowledge in term of value systems, conventions and expectations. Although being aware of the dominant values, behavioral rules and explaining mechanisms can be seen as knowledge, it does seem a bit artificial to do so. I would suggest to use a broader term as *frame of reference*. A frame of reference can consist of the cognitive and affective constructions people use to observe, explain and evaluate the world around them. A frame of reference determines how the world is perceived but also influences how people value knowledge that is presented to them.

All the mentioned types of knowledge can be found within a water board. One other, more practical, distinction needs to be made. A water board uses technical or natural science based knowledge, financial-, legal- and social science research based knowledge. For carrying out the tasks of a water board (maintaining and improving the quality of surface- and groundwater, protection against floods and prevention of water depletion) mostly technical or natural science based knowledge is used. Of course, whenever a project is being designed or new policy is planned, knowledge about the financial and legal consequences is used. In some cases legislative changes or financial incentives lead to policy adjustments. But in most cases, technical or natural science based knowledge about the water system is the basis for water policy.

In this paper I will focus on the exchange and use of technical and natural science based knowledge. This technical or natural science based knowledge can be classified as explicit knowledge. Measurements and models are used to report on water system conditions or to prepare engineering projects. Of course, it takes an expert to read and interpret these reports.

Elected water boards members are rarely engineers who are able to deal with that type of knowledge, nor is the upper management. Translating these technical or natural science based reports into comprehensible pieces of knowledge, suitable for decision making, proves to be challenging. Usually there is a sufficient amount of trust between an elected official and the bureaucracy. A water board governor does not need to know every technical detail that grounds the policy proposal, he will simply trust the bureaucrat to do his work properly. That means that a water board engineer needs tacit knowledge on how to deal with water board governors and how to translate technical or natural science based knowledge.

Communicating and using technical or natural science based knowledge within a water board is already complicated enough even when the policy proposal is not controversial and the policy making process is linear and straightforward. But as described earlier, the policy field becomes increasingly dynamic and complex because more actors get involved. So, what does a policy process look like in water system management? And, what role does technical or natural science based knowledge play in the policy process?

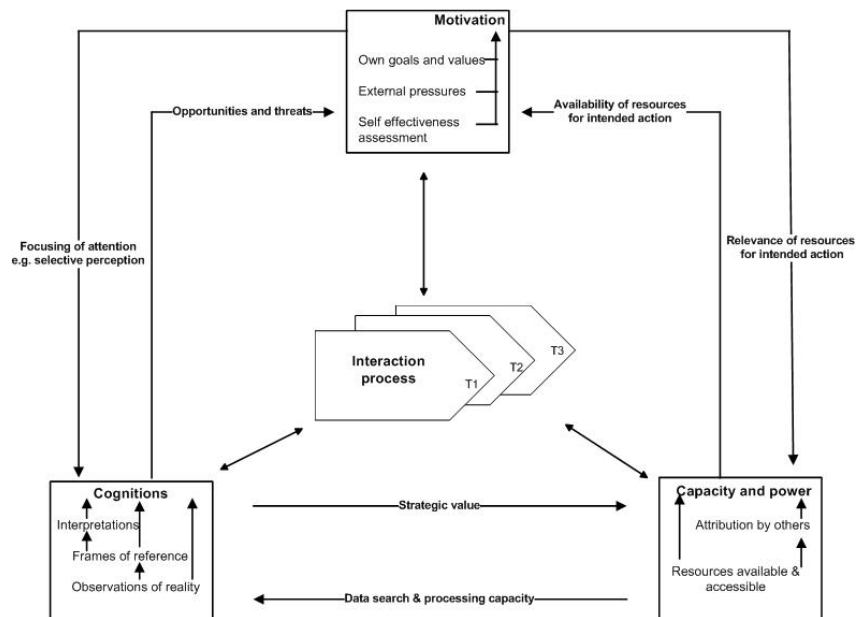
##### 5. *The Role of Knowledge in the Policy Process*

Water boards are responsible for regional water system management. Most water policy is established on the provincial, national or European level, Application of that policy takes place on a lower governmental level. This application of policy, or policy implementation, is done by water boards. Of course, water boards have room to maneuver when implementing policy. They tailor general policy goals and -measures to the regional water system, taking into account the specific system conditions and requirements. This means that to a certain extent, water boards do make their own policy.

The policy implementation process is typically characterized by the interaction between the governmental organization and the target group(s) of the policy (Bressers, 2004). In the case of water boards this is clearly visible. For instance, the national government has decided that water depletion is an urgent problem. Water boards have to take measures to ensure that groundwater stays at the right level and that seepage is strong enough to sustain the ecological value of the area. This can be done by heightening the water levels in streams. But changing the water levels has a significant impact on the interests of industry (which needs higher water levels), farmers (who need lower water levels), drinking water suppliers, citizens, nature preservation groups et cetera. A water board can choose to just carry out its own plan, but it can be sure to receive a lot of (formal) protest. These protests, especially when they are formal, cause delays in policy implementation. Also, ignoring actors' interests creates problems in the relationship between a water board and its social environment. This may have a negative impact on future cooperation or negotiations.

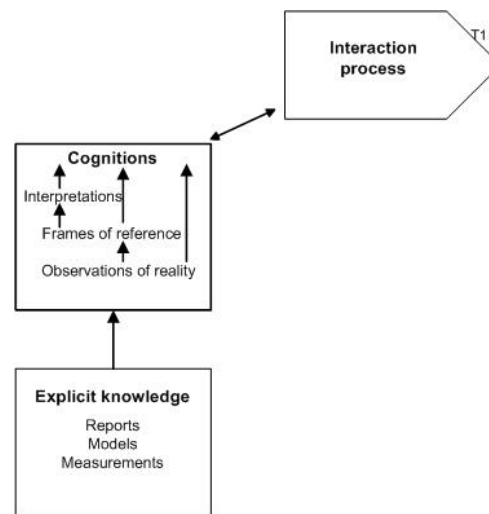
As discussed earlier, cooperation and interaction with various stakeholders has become increasingly important because of new insights that led to a shift in policy paradigm. So, social interaction is an important element in water policy implementation. This means that the dynamics and the outcomes of a policy process not only depend on inputs, but more crucially on the characteristics of the actors involved, particularly their motivation, cognitions and power. Other factors may influence the policy process, but they do so because they influence the characteristics of the actors involved (Bressers, 2004). This is the basic assumption of *Contextual Interaction Theory*.

Figure 1. Contextual Interaction Theory (Bressers, 2004, 2007)



Policy processes are considered to be actor interaction processes. Various factors may have an influence on the interaction process, but only and as far as they change the relevant characteristics of the actors involved (Bressers, 2004). In the boxes of the figure, a first layer of such factors is specified, including how they influence the core actor characteristics. These factors can be influenced by other factors from within or outside the process. The core characteristics of the actors are their *motivations*, their *cognitions* and their *capacity and power*. These three characteristics are influencing each other. Restricting those characteristics to two of one cannot be done because much insight in the process will be lost. The actors' characteristics shape the process but are in turn influenced by the course and experiences in the process. Therefore they can gradually change during the process. Also, the external of the governance regime influences the actor characteristics. Finally the broad (societal) context has some influence on the actor characteristics (Bressers 2004, 2007). To examine the role of technical or natural science based knowledge in the policy process I will focus on the actors' characteristic *cognitions*.

Figure 2. Cognitions as main focus



To achieve successful policy implementation all actors need to have sufficient knowledge about the problem at stake or the policy objective. More importantly, cognitions is about the information that is considered to be true. There needs to be some consensus about what reality looks like. When people observe reality, they use their frames of reference to interpret it. Also, when explicit knowledge is presented, people will (unconsciously) use a frame of reference to make sense of that knowledge. When explicit knowledge passes the through those mental filters that we call frames of reference, we have interpretations.

#### 6. *Tracing the Knowledge*

Against the background of Contextual Interaction Theory, a observation tool has been developed. This tool helps to monitor the way knowledge “travels” when knowledge is exchanged and utilized between a water board and the actors. The tool consists of items that need to be observed and analyzed. The first item deals with the explicit knowledge that is being brought into the process. The way the knowledge is shaped and presented is examined, and which actor presents what knowledge is also of importance. The second observation issue is about how the knowledge is processed by the various actors. This means that not only the degree to what actors internalize the information is observed, but also whether the knowledge fits the actors’ way of thinking. Third, attention is paid to the number of different interpretations given to the knowledge presented. What is being left out? How much is simplified? A fourth items that needs to be observed is the direct (visible) influence of knowledge in the interaction process. What images and story lines are constructed based on the knowledge presented. To what degree are actors speaking in terms of knowledge (this is how it is), in terms of motives (this is what I want) or in term of power (this is how it is or else..). More relevant observation items have been identified, but they apply to the other actor characteristics within Contextual Interaction Theory. This observational tool was used to monitor the social interaction process between the water board Regge en Dinkel and its stakeholders in the case of implementing water depletion policy.

## 7. *The Case of Water Depletion in the Twente Region*

The changes in water system management challenge water boards to operate in an increasingly complex and dynamic policy field. When implementing water policy, they have to cooperate with other governmental organizations, as well as with various non – governmental stakeholders. In those interaction processes, cognitions play an important role. Explicit knowledge, mostly technical or natural science based, grounds most of the water policy that water boards implement. Technical or natural science based knowledge proofs to be difficult to comprehend for decision –and policy makers within a water board. When dealing with technical or natural science based knowledge in a interaction process with various stakeholders, things can be expected to become more complex. The case of water depletion in the Twente region shows how technical and natural science based knowledge is handled and utilized in an interaction process.

As mentioned earlier, preventing water depletion is an important policy goal. An area suffers from water depletion if the groundwater levels are too low or the seepage is not strong enough to sustain the ecological value of this area. An area can also suffer from water depletion if in order to compensate for low groundwater levels, water from other areas needs to be let in. Water depletion is by definition linked to areas that have a nature function. However, water depletion does not only exist in nature reservations, it also occurs in farming land. In those cases we speak of damage through water depletion. This means fewer crop per hectare. Water boards have two ways to prevent of influence water depletion. Since a water board is in control of the water levels, they can decide to let more water into the water system. Or, they can physically modify water streams for instance, reshape straight water streams into streams that meander, and allow the surrounding land to be periodically flooded.

Especially regarding the water levels within a water system, there are many competing interests. For instance, farmers would like the water levels to be a bit low, so that they can farm their land earlier in spring, but in the summer they want to use water from the same water system to sprinkle the land. Industries need higher water levels because they need water that is not too warm. The shipping trade needs deep water in order to be able to sail. Drinking water companies would like to extract groundwater for drinking water because that is cheaper than purifying surface water.

The Twente region is situated in the eastern part of the Netherlands. Water board *Regge en Dinkel* is responsible for the implementation of water policy in that region. In the region of Twente, more than 70 percent of the area is used for agriculture. Nature reservations take up 15 percent of the area, a considerable part of that nature area (over 10,000 ha.) is a groundwater protection area. The Regge en Dinkel domain covers 135,000 hectare and 2,527 kilometers of water. The number of inhabitants of the area is 600,000.

Twente, like many other regions, suffers from water depletion. Also, damage through water depletion occurs every year. Water board Regge en Dinkel wants to enlarge the amount of retention<sup>2</sup> in the “vascular system” of the water system. This policy is will save an estimated 6,7 million euro in damage by water depletion. On the other hand, this policy will cause 4,9 million euro water damage<sup>3</sup> (in terms of too much water). This means that enlarging retention

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<sup>2</sup> Retention means temporary storing water in the water system and catchments areas.

<sup>3</sup> Water damage (or *vernattig, natschade* in Dutch) refers to a situation where the soil is too wet. Wet soil causes problems and financial damage in farming land. In this paper, water damage does not refer to damage by floods.

will result in 1,8 million euro less damage net. Regge en Dinkel built a groundwater model that predicts the changes in groundwater levels when various interventions in the water system are being done. Combined with data about the water system, models on precipitation and data about actual groundwater levels in Twente, the water board has a decision support model that they use to test intended policy. The natural ground water situation from 1850 in that region is used as a reference. Specifically for agriculture, other factors (land use, crop, soil) that have an impact on ground water levels are included in the model.

Enlarging the amount of retention in the vascular system of the water system means that the water levels in small creeks and ditches bordering agricultural land will rise. Ground water levels under agricultural land will rise too. Farmers are very much opposed to higher groundwater levels. Because of higher ground water levels, the soil stays wet longer after the winter season. As a consequence, farmers will have to wait longer when they want to work the land in springtime. Generally, farmers focus on water damage, not on damage because of water depletion.

Traditionally, farmers have a significant influence on the water board Regge en Dinkel. Many elected water board members are farmers. Also, farmers have a well organized lobby and have considerable influence on the provincial government. This means that Regge en Dinkel, in order to run things smoothly, needs to convince farmers that water depletion is a bigger problem than water damage. If the water board wants to take a step further, they need to convince farmers that more retention (leading to higher groundwater levels) will be profitable. Water board Regge en Dinkel decided to organize a conference about water depletion.

The conference Regge en Dinkel organized for farmers took place in November 2006. It was an open conference, all interested stakeholders were welcome, but the conference was specifically aimed at farmers. The main aim of the conference was to create consensus about water depletion being a problem for farmers.

The water board chose an “objective approach” in order to avoid accusations of being biased or manipulative. The conference was moderated by a consultant from a well known engineering consultancy firm. A policy maker from Regge en Dinkel presented the method used by the water board to measure whether water depletion causes damage and what type of interventions in the water system would be suitable to deal with water depletion damage. The explicit knowledge that was shared with the farmers consisted of a technical description of the groundwater models, the models linked to the groundwater model and the decision support system. Also, the much attention was paid to loss of earning because of water depletion, the difference in the nature of the damage between water depletion and humid soil and the long term effects of water depletion. The presentation was a solid display of what the water board perceived to be facts, very technical with use of many formulas, maps and graphs.

Most of the audience seemed to be very able to comprehend the knowledge presented. Farmers are familiar with groundwater models and modeling in general and asked specific questions about scales of measurement and applications. The main discussion was about the way the models were constructed, according to the farmers the calibration needed improvement. There was a distinct difference in reasoning between farmers and the water board. Farmers draw from their own practical experience, knowledge about the farmland and business economics. The water board primarily argues from a hydrological and technical

approach. It seems difficult to reach some agreement about the value of certain measurements. The main criticism on the models from the farmers' point of view was that negative side effects of enlarging retention were not taken into account. Those negative side effects were mostly described in terms of business economics. The farmers brought much technical knowledge into the discussion about the models. Although they reason economically, their arguments are founded on technical knowledge.

During the conference the farmers repeatedly gave economical and technical or natural science based arguments about why the models the water board uses are incomplete. Also, they expressed their doubt about the claim that water depletion causes more damage to their business than swampy soil. Strangely enough the conference moderator and the water board representatives listened politely to the farmers' arguments, but then continued their story. Since water boards are very aware of the difference in interests and frames of reference between the water board and the farmers, one would expect the water board to address the different views on reality. Instead of seeking consensus, it seemed like the water board tried to force its own arguments.

This lack of response on the farmers' objections led to the development of some storylines that had a negative impact on the dynamics of the conference. Instead of discussing water depletion in term of knowledge (as happened in the earlier stage of the conference) the discussion stirred into the direction of repeating old sores. Instead of convincing farmers that water depletion causes serious damage, the water board had broadened the gap between them and the farmers. At the end of the conference, the only thing the water board could do was promise to take all the arguments into account.

## 8. *Conclusions*

In this paper the way knowledge is exchanged and utilized in water system management is explored. Changes in water policy required a different policy approach by water boards. The interest of various actors needs to be taken into account. The daily practice of water system management shows that knowledge exchange and –utilization between engineers and water board member is not without difficulties. When other actors are being brought into the policy implementation process, the dynamics of knowledge exchange and –utilization get more complex. Against the background of Contextual Interaction Theory a tool has been developed to monitor the social interaction processes in which knowledge exchange and utilization take place.

The case of water depletion in the Twente region shows that explicit knowledge like groundwater models, and their underlying assumptions are not easily accepted. Farmers are very capable of dealing with technical and natural science based knowledge. Furthermore, many arguments made by farmers against the models and the underlying assumptions are grounded in technical or natural science based knowledge. So, the fact that farmers do not accept the models is not a result of misconceiving the knowledge presented. If misconceiving is not the problem, then what is? The case shows that farmers have a different frame of reference than the water board. Farmers perceive water depletion and water damage in business economical terms. The water board approaches the problem from a hydrological and technical point of view. Farmers reject the water boards ground water models because variables of which they think they are important are left out. The water board persisted in hydrological and technical arguments during the discussion. Farmers, on the other hand,

combined their technical arguments with arguments based on tacit knowledge about their farmland and the region.

The water board failed to respond adequately to the arguments presented by the farmers. Instead of stirring the discussion back to the central theme, damage through water depletion, they repeatedly tried to resume their line of argumentation. Both the explicit knowledge and the tacit knowledge presented by the farmers was not addressed. During the interaction process it seemed that the water board had more problems fitting the farmers' point of view in their frame of reference than the other way around. This is curious because the water board is well aware of the difference in interests and the different frames of references. This had a negative impact on the interaction process. Instead of reaching consensus about the problem at stake and the way of measuring that problem, the farmers pulled themselves out of the discussion.

What we can learn from the water depletion case in the Twente region, is that problems with knowledge exchange and utilization do not necessarily lie in misconceiving the knowledge presented. On first sight, a clash of frames of reference is an obvious explanation. Yet, the water board was aware of the difference in frames of reference. So, maybe the water board was mistaken about the frames of reference of farmers? Or maybe the water board was mistaken about its own frame of reference? Even so, in this particular case ignoring explicit and tacit knowledge presented by stakeholders was a deathblow for the interaction process. Further examination of frames of reference is necessary for a better understanding of how knowledge exchange and utilization takes place in policy implementation.

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