Information Needs in Groundwater Protection Policy: Agenda-Setting for Knowledge Development

S.K.G. Hoorens and P.W.G. Bots

Water policymaking strongly depends on expert knowledge, and yet there is a gap between policy makers and research professionals. This article addresses this issue by presenting a conceptual framework and method for identification of information needs in a particular policymaking context. The framework deduces information needs not only from pertaining laws and regulations, but also from strategic stakeholder behavior that can be anticipated in this context. The outcome is then matched with empirically observed information needs and available knowledge. Framework and method have been applied to the Dutch groundwater protection policy situation, establishing their effectiveness in exploring strategies to stimulate knowledge development to match stakeholder information needs.

Introduction

The management of water resources is directly related to a variety of complex interactions between technological, scientific, economic, and social issues that policymakers must deal with. It is the role of researchers and professionals in water engineering to support decision-makers in their

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Stijn Hoorens was educated at Delft University of Technology, Faculty of Systems Engineering, Policy Analysis and Management, specializing in water management. He recently graduated on the main subject of policy analysis (MSc in 2001). He did his thesis research project at the Netherlands Institute of Geological Science TNO—National Geological Survey. Stijn Hoorens can be contacted by e-mail at <stijn.hoorens@wanadoo.nl>.

Pieter Bots is associate professor of policy analysis at the Faculty of Technology, Policy, and Management of Delft University of Technology in The Netherlands. Educated in the field of computer science at Leiden University (MSc in 1985), his research interests have moved from decision support systems (PhD from Delft University of Technology in 1989) to methods and tools for policy analysis in general. He currently focuses on the development of Dynamic Actor Network Analysis (DANA) and a Modeling Environment for Design Impact Assessment (MEDIA). He can be contacted at <p.w.g.bots@tpm.tudelft.nl>.

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understanding of this complexity (IPTS 1999[1]). These professionals accumulate knowledge that is an important determinant for the effectiveness and efficiency of policymaking. The area and situation of protection zones around well fields for drinking water supply, for instance, is based in part on the travel time of water in the subsurface. In the Netherlands the zones are defined by the approximate distance ground water could travel towards the well in 25 years. These distances can only be determined by a method that considers the characteristics of the well, the geology of the area and the groundwater flow. Therefore, prior to delineation of a well-head protection zone, policymakers delegate assessment of the time-of-travel capture zone to professionals in the geo-hydrological field.

However, despite the importance of knowledge development and knowledge application in water resources management, recent studies reveal a gap between water-related research professionals and policy practice. This gap may be explained from both sides. On the one hand, it is observed that decision-makers are insufficiently capable of translating political problems into specific research questions. On the other hand, the knowledge development at professional and academic institutes mainly focuses on the physical system and physical effects of measures, while little attention is paid to social and political concerns (NRLO 2000). This focus is further enhanced because knowledge development, particularly in water related research institutes, is organized by discipline: ecology, hydrology, sanitation, etc.

The inherent consequence of these observations is an increasing discrepancy between the information demand in the policymaking context and the knowledge available at professional research institutes. Policymakers are almost constantly in a state of having to make hard decisions on the basis of incomplete or inconclusive scientific input. There is a need to clarify the way in which this knowledge gap comes about and how it can be alleviated (Barré 2001).

Knowledge development is not driven by policy issues. It would seem that the "policy information market" does not function properly, at the cost of decision-making performance. But it could also be that the market metaphor is not appropriate because knowledge is too elusive as a product, and policymakers too fickle as a client. Either way, the relationship between policymakers and knowledge developers deserves closer investigation. This paper specifically addresses the issue of determining the information demand in the context of groundwater protection policymaking. The ultimate goal is to identify ways in which knowledge development can be aligned with multi-actor policymaking processes.

The proposed conceptual framework and method for identification of information demand in a particular policymaking context is based on the strategies defined by Davis and Olson (1984). To demonstrate its applicability, it is used to determine information needs in the policy context of groundwater protection in the Netherlands. By way of a preliminary empirical test, the derived information demand is compared with the information needs as obtained from interviews with actors in the groundwater policy field. After making a global inventory of the available knowledge in this field, some suggestions can be made regarding agenda-setting for knowledge development in groundwater protection policy. In the concluding section of this article, the proposed framework and method and their general applicability in other policy fields are discussed.

Determining information demand for policymaking

The introduction emphasized the importance of knowledge development in water management. Dealing with information appears to be crucial for the effectiveness and efficiency of the policy process. In literature on public management, this importance has been widely recognized. In this section, two views on public management and their implications for information demand are discussed: the cybernetic view as described by Hood (1983) and the actor network view as described by De Bruijn and Ten Heuvelhof (2000).

Hood's cybernetic view uses a subject-object model to represent public policymaking. In this subject-object model, the government (subject) is considered to be steering a complex system with a multitude of interrelated social and physical aspects (object). The steering process comprises the attempts of government to affect the behavior of actors[2] in this system in order to achieve certain policy objectives. In its interaction with the object system, government uses two types of tools: *detectors* to take in information about the object system, and *effectors* to make an impact on the object system. Policy decisions may be supported with empirical studies and simulations (detectors) of the current state of the object system and the impact of policy measures (effectors). This places research professionals at the interface between government and society, facilitating the different phases of the policymaking process by supplying information.

In the actor network view of De Bruijn and Ten Heuvelhof, a policymaking context is conceived as a network in which the various actors involved all are able to influence the decision-making process. Modern societies are characterized by functional differentiation and partly autonomous societal subsystems (Kenis and Schneider 1991). Private organizations own or manage important resources and have therefore become increasingly relevant for the formulation and implementation of public policies (Börzel 1997). The network of resource dependencies between actors turns a policy arena into a more level 'playing field' in which no single actor can be seen as the steering subject. The management of these networks is a form of external government steering. Public governance is the directed influencing of societal processes in a network of many other co-governing actors (Kickert and Koppenjan 1997, Marin and Mayntz 1991). The actor network view also implies that research professionals, too, are nodes in the network, participating in the policymaking process and using their knowledge and knowledge generating resources to further their own interests, which may be scientific as well as financial.

The cybernetic view and the actor network view on public policy making are incompatible only when taken to their extremes, i.e., a top-down control system versus total anarchy. For analytical purposes, they can be combined very well by viewing each actor in a policy context as a steering actor, albeit with more or less power to influence the behavior of other actors. The advantage of using the combined view is that it does justice to the multi-actor, multi-objective nature of real-life policy processes without abandoning the concept of actors as purposeful decision-makers who base their behavior on information.

The management information systems (MIS) literature typically addresses the issue of identifying information demand. Davis & Olson (1984) define four strategies for determining organizational information requirements. By mapping the actors in a policy arena onto the MIS-users (decision-makers) in an organization, these strategies can readily be translated to a policy making context:

1. *Asking*: obtain information requirements from persons in the policy arena, simply by asking what information they think they need to perform adequately.
2. *Deriving from an existing information system*: use knowledge products that have an operational history in the policy arena (or another, similar policy arena) to derive requirements for future knowledge development.
3. *Synthesizing from characteristics of the utilizing system*: obtain information requirements by means of a deductive analysis of the characteristics of the policymaking context, covering the substantive as well as the political aspects.
4. *Discovering from experimentation with an evolving information system*: introduce (newly developed) knowledge—e.g. by means of decision support systems—and determine which part of this knowledge is actually used by actors in the policy process.

In developing the conceptual model and method for identification of information demand proposed in this paper, the first three strategies have been operationalized. The policy arena of groundwater protection in the Netherlands has served as a case.

First, strategy #3 has been elaborated to deduce information demand from characteristics of the multi-actor, multi-objective policy arena. Two aspects determine this information demand: the legal context and the strategic behavior of actors within this context.

The legal context of a policy arena provides a good starting point for analysis. Laws and regulations are explicit codification of norms, and as such they provide a readily available and formal source for identifying interests and responsibilities, steering instruments, and—in the cybernetic view—the information steering actors need to make rational decisions. More specifically, the legal context creates a need for information, because in many cases it prescribes what variables policymakers must take into account, and what conditions government officials should check to fulfill their mandate to the letter of the law. For this reason, this information need will be referred to as the *normative* information demand in a particular policy arena.

But a policymaking process is not completely determined by a legal framework. Laws and regulations will always require interpretation and judgement. In multi-actor, multi-objective policy arenas, political tradeoffs must be made in a process of interaction between stakeholders. Because the interests, objectives and steering instruments in this process are actor-specific, actors will need different information in their decision-making. Assuming that actors behave strategically in the sense that they will seek out and make use of opportunities to further their interests. Analysis of the stakeholder context yields insight in this strategic behavior and may reveal additional information needs with regard to specific opportunities. These will be referred to as the *pragmatic* information demand in a particular policy arena.

The normative information demand can be deduced by analyzing relevant laws and regulations. The pragmatic information demand can be deduced by analyzing the actor network, focusing on the positions of actors relative to each other and to the substantive policy issues in this network, and anticipate their strategic behavior. The combined result of these two analyses will be referred to as the *deductive* information demand.

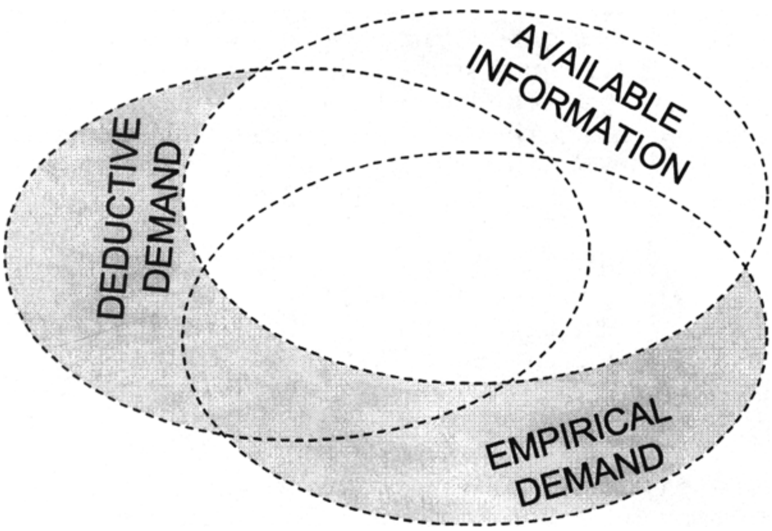
Because the elaboration of strategy #3 as outlined above is based on a number of assumptions and simplifications, the deductive information demand is expected to differ from the empirical information demand, i.e., not every piece of knowledge that may be deductively derived, will be relevant in the actual decision-making process. Therefore, strategy #3 (deductive analysis) is complemented with strategy #1 (asking) to determine the empirical information demand. Comparison of deductive and empirical information demand will provide an indication of the validity of the framework and method.

Assuming that the information demand can be adequately determined (i.e., that the deductive and empirical information demand are found to be largely overlapping sets), the gap between information demand and information supply can be articulated by assessing the availability of knowledge related to the policy field under consideration. Here, an analogy can be made with what Davis and Olson identify as strategy #2 (deriving from an existing information systems): By making an inventory of knowledge that already exists as data sets, models and those capable of applying them to yield meaningful information, the two sets of information items defined so far (the deductive and empirical information demand) can be complemented by a third set containing the available information.

These three sets of information items can be depicted as partly overlapping ovals (see figure 1). The extent to which the ovals overlap with each other indicates the width of the gap between policy practice and professional innovation. Moreover, locating specific information items within the three ovals will help to set the agenda of knowledge development. In the following sections, the determination of these information items and their location will be demonstrated using the case of groundwater protection in the Netherlands.

Figure 1

Deductive and empirical information demand, and available information as overlapping sets leading to identification of a knowledge gap (shaded area)



Legal context: normative information demand

Within the scope of this paper, the legal context is defined as the constellation of governmental departments, with their responsibilities and instruments that are legally recognized with regard to a specific policy goal. Especially in public management of water systems, a wide range of (semi-) governmental departments have distinct responsibilities. By consequence, even when considering only the legal context, government does not function as a single entity. Still, the formal relations between higher and lower level governmental organizations largely determine the information demand of these actors.

In the case of Dutch groundwater protection policy, all laws with the specific purpose of protecting of groundwater resources are considered to be part of the legal context. These are: the Soil Protection Act, the Environmental Management Act, the Spatial Planning Act, and the Pesticides Act. According to these laws, various governmental departments have legal responsibilities as well as steering instruments, and this determines their normative information demand as illustrated by the following example:

> Provinces are mandated to delineate well-head protection zones and enforce regulation in these areas. By specifying a 25-year time-of-travel zone as the norm, the Dutch legislation generates a particular information demand: The provincial authority must obtain knowledge about groundwater flow patterns across and within the aquifer from which a particular well is extracting. Since the size of a capture zone is dependent on the discharge rate, the delineation of the well-head protection zone normatively changes with each capacity adjustment.

For each law in the legal context for groundwater protection, a similar derivation of responsibilities and their consequences for the normative information demand can be made. The result is presented in the shaded rows of the table in Appendix A.

The example also shows that normative information demand does not always express what policymakers really should know to achieve "good policymaking practice." Laws are often restricted to one policy field and tend to specify rules without considering their impacts in other sectors. Real-life policymaking must resolve conflicts of interest, which means that tradeoffs must be made. Making such tradeoffs usually calls for information that cannot be derived from the legal context only.

Stakeholder context: pragmatic information demand

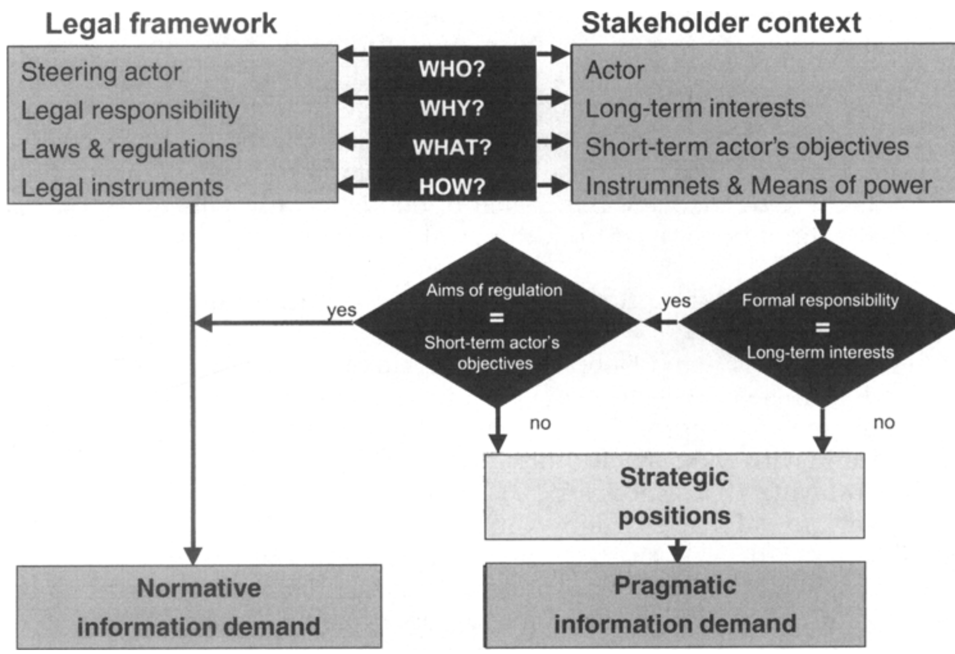
Actors are considered to be part of the stakeholder context of a policy issue when this issue interferes with, or appeals to their interests. Within the actor network approach it is assumed that each stakeholder behaves strategically with the constant intention of fulfilling his actor-specific objectives (Mayntz 1993, Rhodes 1997). Interests express general good intentions that are valid over a long time period. An objective is one of the possible paths towards satisfaction of such interests (Findeisen and Quade 1985)[1]. To give an example: private enterprises, such as farmers, are to be included in the groundwater protection policy arena, because their interests in optimizing profits conflict with groundwater protection. Their objectives within the specific policymaking context could be to be allowed to construct in currently protected areas, to use specific pesticides, etc.

Assuming bounded rational behavior (Simon 1957, Lindblom 1959), the information needs of an actor will be determined by his means and objectives. Not only will he want to know whether his interests are threatened (information about certain variables), he will also want to know what effect his means will have in countering this threat (information about system response to his actions). The variety of interests, objectives and means in the stakeholder context leads to a pragmatic information demand that is broader than the normative information demand derived from the legal context. Figure 2 illustrates the derivation of the pragmatic information demand. Two factors determine whether an actor takes a strategic position vis-à-vis the legal context: (1) the concurrence of actor-specific long-term interests with legal responsibilities and (2) the concurrence of actor-specific short-term objectives with the aims of laws and regulations. If one or more of these assumptions fail for a particular stakeholder, it is not possible to derive his information demand completely from the legal framework.

For analysis of the strategic positions that actors may take, it is necessary to distinguish between steering actors (typically governmental bodies) and actors in the object system (e.g. drinking water companies, farmers, and environmental organizations). Doing so, six generic types of strategic positions can be identified as is shown in Figure 2. The following elabora-

Figure 2

Derivation of pragmatic information demand



tion and illustration will show how these six generic positions help to derive and understand the pragmatic information demand.

1. *Complementary steering.* This strategic position may be observed when the interests of governmental actors concur with their legal responsibility, but their objectives go further than the aim of regulations. To achieve these more ambitious goals, steering actors will strategically seek for and use additional effectors that are not (yet) part of the legal context. In the Dutch groundwater protection policy case, for example, the national department that is responsible for environmental planning uses financial incentives and communication strategies to attain a level of pesticide usage that is lower than legally required.
2. *Substitutive steering.* Actors in the object system will be inclined to this strategy when their interests concur with long-term objectives in the legal context, while their objectives go further than the short-term objectives of the steering actors that are legally responsible. To achieve their more ambitious goals, they will use their own steering instruments and – to a certain degree – take over the policy enforcing the role of the steering actor. In the Dutch groundwater protection policy case, for example, drinking water companies would like to see much higher groundwater quality standards than those defined by law. Therefore, they gradually purchase parcels of land in the well capture zone, and offer financial rewards to other actors when they take preventive groundwater protection measures for precarious installations located within the capture zone.

Table 1

Generic strategic actor positioning

	Interests concur with legal responsibilities		Interests do not concur with legal responsibilities	
	Steering actors	Actors in the object system	Steering actors	Actors in the object system
Objectives concur with regulations	No strategic positions		Realistic steering	Call for enforcement
Objectives do not concur with regulations	Complementary steering	Substitutive steering	Tradeoff behavior	Opposition to restrictions

3. *Realistic steering.* This is a strategic position often taken by steering actors who find that their objectives in the particular policy area conflict with their interests in other policy areas. Their actual steering behavior will not meet the letter of the law, but will reflect pragmatic decisions that support the formal policy objective but minimize harm to the other interests involved. In the Dutch groundwater protection policy case, for example, the Province – being responsible for delineation of well-head protection zones – is aware that one of its effectors, annual adjustment of the well-head protection zone to match the physical capture zone which varies with the discharge capacity, will not find a social basis, since landowners would be confronted with continuously changing regulations. The Province therefore refrains from using this effector. The Province also steers realistically by delineating protection zones to match the contours of parcels in the field, to ensure that no landowner is subjected to different regimes. Obviously, there will always be conflicting interests insofar financial resources are involved: Budget limitations keep a Province from performing a frequent update of the delineation.
4. *Tradeoff behavior.* This strategic position is similar to realistic steering, but differs in that it does not focus on a single objective, but involves the general tension between multiple long-term interests of steering actors. This behavior frequently occurs for decision-makers responsible for groundwater protection, because they must make tradeoffs between economic, environmental and social interests. Unlike in a realistic steering situation, the drinking water objectives are not the primary focus of the policy process. In such cases, steering actors like municipalities frequently let economic interests prevail and will, for example, grant a permit to local enterprises to operate in a wellhead protection zone even though that may increase the risk of pollution.
5. *Opposition to restrictions.* When steering actors take their legal responsibilities by setting and striving for long-term policy objectives that may be in conflict with the interests of actors in the object system, the latter tend to fight the legal context. In the Dutch groundwater protection policy case, for example, land owners typically oppose to measures like prohibition of pesticides or restriction of fertilizer usage, since it has a direct impact on their crops and therefore their revenue.
6. *Call for enforcement.* This strategic behavior of actors in the object system is the opposite of the preceding one. It can be expected in situations when actors in the object system find that government policy does not concur with their interests, but expect that the effectors chosen by the steering

actors will contribute to the achievement of their short-term objectives. In such cases, actors in the object system will welcome these measures and encourage their implementation. In the Dutch groundwater protection policy case, for example, companies located in a well-head protection zone call for enforcement of generic groundwater protection policy. Their interests do not concur with protection policy, but generic regulations improve their competitive position.

The strategic positions of actors vis-à-vis the legal context have decisive implications for the information demand. This can be illustrated with the examples provided above:

- Realistic steering and tradeoff behavior tend to reduce information demand: Certain information items in the normative information demand will not occur in the pragmatic information demand set. In the example, realistically steering provinces abstain from frequent updates of time-of-travel capture zone delineation. This may explain why the delineation of most of the well-head protection zones in the Netherlands has been based on simplistic and outdated modeling studies. In other words, they choose not to use more sophisticated detectors. As a result, some administrative protection zones barely overlap with the actual capture zone. Tradeoff behavior may reduce information demand, but it may also add information items to the pragmatic information demand set. These items will be related to (detectors for) aspects in other policy areas, e.g., the expected economic benefits of a shopping center or the social benefits of recreational activities in the capture zone.
- Complementary steering and substitutive steering will add new items to the pragmatic information demand for the actors involved. In the example, drinking water companies want to know whether their own effectors, such as buying land in the capture zone, are cost-effective, and they start doing risk analyses for installations within the boundaries of the capture zone to assess the probabilities of calamities and the impacts of spills on the quality of extracted water.
- When actors in the object system oppose to restrictions or call for enforcement, it this tends to increase the information demand for those actors in the object-system. Additionally the information demand for steering actors may increase as well, because they must find an adequate political response to this strategic behavior. Similar to the tradeoff situation, additional detectors may be required to verify damage claims and justify specific policy decisions. As a result, the pragmatic information demand set will include items that are not in the normative information demand set.

The given examples show that it is useful and feasible to identify, for each actor in the policy network, their interests and objectives, anticipate their strategic behavior, and assess its implications for the information demand. A full account of the pragmatic information demand for the Dutch groundwater protection policy case is presented in the "Knowledge items" column of the table in Appendix A. For the pragmatic items in the white-colored rows, it is illustrated which generic strategic position they can be derived from.

Empirical assessment

The previous section explained the principles and application of a method to derive the normative information demand of a policy area from its legal context, and the pragmatic information demand from its stakeholder context. The union of these two results is called the deductive information demand. Although the proposed method is based on well-established views on decision-making in public management, its validity may (and should) be questioned. The deductive information demand might be different from the empirical information demand for a number of reasons.

Two phenomena may limit the validity of the normative information demand inferred from the legal context: the "implementation lag" and the "legal lag." The implementation lag occurs because in policy practice effectors may be inadequately implemented or enforced. Even though the laws and regulations formally function to stimulate certain behavior, they may not properly codify what norms are actually guiding decision-making. The legal lag occurs because laws and regulations are relatively static, while they are based on assumptions at a certain moment in time. Even though these assumptions may be outdated at some later point in time, and new regulations would be more adequate, passing new laws and changing regulations takes long. Meanwhile, the actors may tend to base their decision-making on the new insights, rather than the "fossilized" ones. Both "lags" make that actual policymaking and decision-making processes do not correspond with the formally documented procedures, and that, by consequence, the deduced normative information demand does not exactly match with the empirical information demand.

Two other phenomena will limit the validity of the pragmatic information demand inferred from the stakeholder context. First, it is difficult to construct a valid model of an actor network, because of their intrinsic closedness and dynamics (De Bruijn and Ten Heuvelhof 1995). Second, even if an in-depth analysis of an actor network would reveal in full the conflicts of interests from which strategic positions and behavior may be inferred, such inferences will always be based on the assumption that actors will behave rationally, i.e., that they will act always in their best interest, and seek for whatever information available to help them do so. In practice, actor rationality will be bounded, and actor behavior all the less predictable. By consequence, the deduced pragmatic information demand will not exactly match with the empirical information demand either (Scarpino *et al.* 1983).

The previous makes clear that the assumptions underlying the framework and method proposed in this paper cause the deductive information demand to differ from the empirical information demand. The question is: to what extent? To assess the difference, strategy #1 (asking) has been operationalized as follows: Over twenty interviews were held with representatives of actors involved in the Dutch groundwater policy network, in which they were asked to identify the types and sources of information items they found useful in their work. The outcome was used to make a list of information items that subsequently was presented to the participants in a computer-supported group meeting of representatives, who were asked to rate each item on two dimensions: whether this information would be useful in their work, and whether this information was currently available to them. Since the group meeting was not representative for the entire field, the results presented in the *Emp* and *Avail* columns of the table in appendix A are but tentative. Nonetheless, it is encouraging that the empirical information demand shows overlap with the deductive information demand.

A more thorough, survey-type investigation is planned to allow statistically based conclusions with respect to the divergence between the deductive information demand and the empirical information demand. If the observed overlap between these two sets is confirmed, it would seem that the framework and method proposed in this paper may be effective in other (water-related) policy fields as well.

Knowledge context: information availability

Current availability of information is an important consideration in agenda-setting for knowledge development. When translated to the policymaking context, Davis and Olson's strategy #2 (deriving from an existing information system) suggests that an inventory of available knowledge pertaining to the particular policy field should be made. Unfortunately, as observed in the introduction of this article, the water-related communities of research professionals can be characterized as'stove pipes': Knowledge development occurs mainly within disciplinary fields; there is little inter-disciplinary communication and integration. Therefore, determining information availability requires a survey across disciplines: the disciplines involved in groundwater protection: geo-hydrology, geo-chemistry, geology, etc. For all but the most focused and specialized policy field, this constitutes a time-consuming task.

An alternative approach to compare the deductive information demand with the information that is available to conduct an expert-based survey in interaction with professionals involved in the research field of groundwater protection. This approach assumes that these professionals are able to judge to which extent the required knowledge is available. For each of the information items in the union of the deductive and empirical information demand, professionals are asked to assign an availability score:

A. This information is available in a report, database or model application;
B. Knowledge and technology is available to generate this information, but it has not been applied yet;
C. The development of the technology suggests that the information can be theoretically generated by creative combination of existing knowledge tools;
D. With the current state of technology it is not (yet) possible to make this information available;
E. It is theoretically impossible to generate this information.

In the case of Dutch groundwater protection policy, both approaches were used. The group meeting mentioned in the previous section provided indicative results that were largely confirmed by a survey conducted by the first author (Hoorens 2001). The scores displayed in the last column (*Avail*) of the table in appendix A are based on the availability of two aspects in knowledge development for water-related policy-making: models and data. The survey of groundwater models and data principally revealed the availability of methods and specific codes for modeling groundwater flow and contaminant transport.

Groundwater flow modeling, especially in the Netherlands, has strongly taken shape: a wide variety of numeric and semi-analytical packages is available. Modeling water quality, however, is relatively underdeveloped. In modeling practice, it appears hardly feasible to predict the behavior of contaminants in the subsurface while taking into account chemical and biological processes. This inability is not primarily caused by deficient modeling, but more by the uncertainty of input data. That is, the heterogeneous characteristic of the subsurface implies that, due to insufficient data, groundwater modeling will always be characterized by a particular extent of uncertainty. The possibilities for physically based modeling of qualitative aspects of the physical groundwater system are thus restricted. Nonetheless, some useful conceptual empirical models exist. Such methods use a black-box approach of the physical system. In this way, validated empirical relations can be used to make certain predictions about impacts of specific forms of contamination, for instance. Despite their usefulness, professionals so far have paid but little attention to these methods.

The survey of the existing tools for knowledge development for specific items shows to which extent knowledge supply in groundwater protection policy fails to meet the information demand. For the purpose of integrated risk assessment, for instance, knowledge with respect to contaminant transport is lacking. Even though, with the development of promising conceptual-empirical methods, a vast part of the information demand may be addressed in future. These observations are shown in appendix A.

Aligning knowledge demand and knowledge development

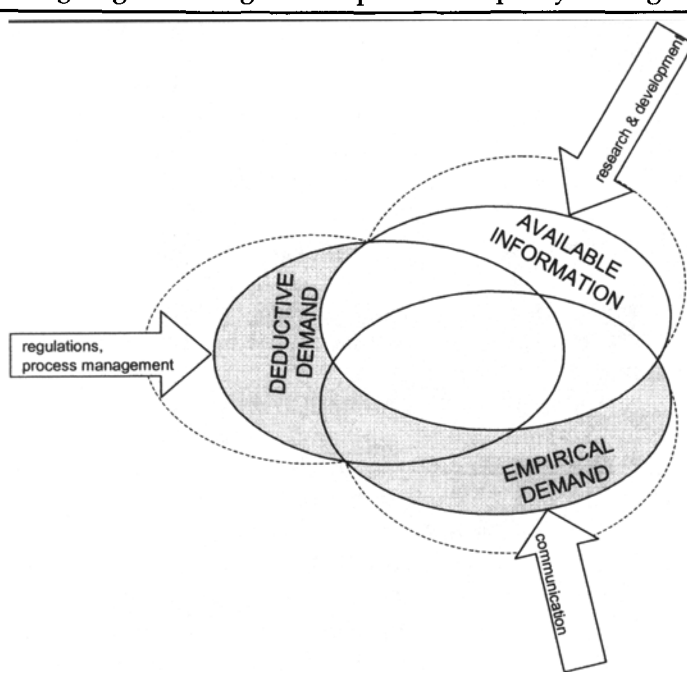
The previous section has shown how deductive information demand, empirical information demand, and information availability can be determined and then used to define the knowledge gap for a particular policy field. The application of the conceptual framework and method to the case of Dutch groundwater protection policy shows that such a gap indeed exists. This section explores in what ways the framework can help in setting the agenda for professional knowledge development in future.

The three sets in Figure 1 are derived from the legal context, the stakeholder context and knowledge context for a particular policy field at a certain moment in time. As these contexts are dynamic, the contents of these sets, deductive information demand, empirical information demand, and knowledge availability, are susceptible to different steering strategies. Figure 3 shows that aligning knowledge development and policymaking can be approached from three perspectives:

1. The availability of knowledge can be actively steered by setting explicit research goals. The aims of making knowledge more available should be derived from the identified gaps in current knowledge supply. For enabling a policy-relevant knowledge development it is important to realize that not only fundamental research is vital, but creatively combining existing tools can generate desired knowledge as well.
2. The empirical information demand can be actively steered by communication. Professionals are well aware of the state-of-the-art knowledge that is useful for addressing particular research questions. Therefore, informed guesses should enable them to make particular information al least cognitively available (Kahneman *et al.* 1982) to policymakers. Knowledge development and policymaking can thus be aligned by promotion of useful and available knowledge.
3. The deductive information demand can be actively steered by review of existing regulations and procedures, and incorporation of state-of-the-art knowledge tools in policymaking. Analysis of the processes in policymaking reveals the extent to which regulations are adapted to the current state of knowledge supply. An update of these regulations can align the normative information demand in line with the empirical demand and the current available knowledge. The pragmatic information demand can be steered by process management, which provides an incorporation of the multi-objective characteristics of these policy arenas in the policymaking process.

Figure 3

Aligning knowledge development and policymaking



These *different* perspectives show that identification of knowledge availability, empirical and deductive information demand can initiate alignment of policymaking and knowledge development in the future. The purpose of this article was to provide a structured approach to facilitate such alignment; elaboration of specific strategies for knowledge development for groundwater protection policy is beyond its scope, although this particular case has served quite well to elaborate the conceptual framework and method and to test their feasibility.

Discussion and conclusion

This paper has started with the proposition that a gap can be observed between water-related research professionals and policymakers, and that a conceptual framework and method for identification of information demand in a policymaking context would serve to determine the extent and the characteristics of this gap. It has addressed the difficulties in articulating information demand in a policymaking context, emphasizing the distinction between the normative information needs that can be derived from documented legal procedures, and the pragmatic information needs that originate from strategic actor behavior. This concept has been operationalized for the case of groundwater protection policy in the Netherlands, resulting in a set of information requirements. By confronting this information demand deduced from the analytical framework with the empirical information demand (1) and the availability of knowledge (2) these conclusions can be drawn:

1. Preliminary empirical assessment has shown that the majority of items in the information demand can be traced to strategic positions that are more difficult to observe and analyze than laws and regulations. Nonetheless, the overlap between deductive and empirical information demand seems to confirm the validity of the deductive approach. However, this does not warrant its general validity. A validation process using only one case study (i.e. groundwater protection) is methodologically weak. Therefore, the case of groundwater protection may not yet be used as representation for the entire water sector.
2. For this case, the gap between information demand and supply was determined through assessment of the availability of knowledge items. This assessment revealed several information gaps in groundwater protection policy in the Netherlands (the elements in the *Avail*-column of Appendix A with scores from C to E). In particular, knowledge development in integrated risk analyses for drinking water wells apparently fails to meet the demand for these analyses. Such a discrepancy between knowledge development and information demand suggests an imperfect functioning of the 'policy information market'.

The market metaphor has been used to elucidate the concepts of knowledge supply and demand. A single case study cannot explain why the policy information market is not functioning perfectly, but it may serve to direct future research. Poor communication and articulation of information demand by policymakers and stakeholders might be causes, but the results from the deductive analysis fit well with the observations from the assessment of the empirical information demand. This suggests that policymakers are well aware of their information demand. It is true that many actors in the policy context have a background in the academic or professional scientific field; they know what they need to know. Thus, it seems that not the inadequate formulation of research questions on the policy side causes the policy information market to fail.

On the other hand, for professionals being unfamiliar with policymaking, the information demand may be hardly visible. This may be a reason why they do not respond adequately to this demand. And perhaps economic incentives affect the market as well. Professionals, especially in academic knowledge development, may be focused more on direct and indirect government funding for fundamental research than on funding for policy advice.

Although hard conclusions cannot be drawn from the case study, it shows how the conceptual framework presented in this paper can help to improve the use and development of knowledge in a policymaking context. Deduction of information demand in a policymaking context can indeed be approached from different complementary perspectives (normative information and pragmatic information demand), yielding interesting results. The overlap between empirical and deductive information demand seems to confirm the validity of the framework, but a more thorough empirical assessment is needed

Notes

1. European Commission. Joint research Centre—Institute for Prospective Technological Studies.
2. An actor is regarded as an individual, organization or a group of individuals or organizations with common interests and objectives. Without intending any gender bias, an actor will be referred to with a singular masculine pronoun, i.e., with "he," "him" and "his."
3. Findeisen and Quade distinguish high-level and low-level objectives, similar to interests and objectives.

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Appendix A

Table with (origin of) knowledge items, empirical assessment and availability survey

Actors		Regulations/ Objectives	General principle	Strategic positions[1] a	b	c	d	e	f	Knowledge items	Emp[2]	Avl[3]
National Gov.	Normative	Soil Protection Act	Norms setting							1. Impact of specific components to groundwater quality	+	B
	Normative	Environmental management Act	Risk Assessment							2. Risks for groundwater quality of activities in installations	-	C
										3. Effect of general technical guidelines for groundwater contamination	0	C
	Normative	Fertilizer Act	Norms setting							4. Impact of specific components in fertilizers to groundwater quality	0	A
	Normative	Pesticides Act	Precautionary principle							5. Hazard of specific pesticides to human health	0	A/B
	c	***Environmental health***	Stimulation		X					6. Impact of diffuse contaminant sources to groundwater quality	0	B
										7. Effectiveness of incentives to behavioral change	+	C
	c	Spatial planning	Combining spatial functions			X				8. Risks of various spatial functions to drinking water quality	+ +	B
Province	Normative	Environmental management Act	Zoning							9. Time-of-travel capture zones at 60 days and 25 years	-	A/B
	Normative		Risk Analysis							10. Groundwater quality risks of activities within well-head protection zones	+ +	D
										11. Effectiveness of general regulations for groundwater quality	+	C
	Normative	Soil Protectiion Act	Monitoring							12. Up-to-date about each contaminant passing protection zone contours	-	E
	Normative	*Spatial Planning Act*	Zoning							13. Optimal spatial zoning within influence area	+	B/C
	Normative		Cost-benefit analysis							14. Quantification of claims within influence area of province	+	B
										15. Cost and benefits of different spatial zonings	+	C
	Pragmatic	Groundwater quality protection	Stimulation		X					16. Contaminant sources risk analysis for each well-field	+	D
										17. Effectiveness of incentives to behavioral change	+	C
	Pragmatic	Continuity of policy	Protection zone update				X			18. Time-of-travel capture zones	0	A/B
										19. Contaminant load within current and proposed protection zone	+ +	C
										20. Well-field's vulnerability to contamination from field-level	+	B
	Pragmatic	Acceptance	Problem description			X	X			21. Trends in groundwater quality	+	B/C
										22. Effectiveness of groundwater protection policy	+	B
	Pragmatic	Social basis	Scope for policymaking		X	X	X			23. Effects of pragmatic guideline application for drinking water supply risks	+ +	C
Municipality	Normative	Environmental management Act	Risk Analysis							24. Risks of planned activities in installations to groundwater quality	0	C
										25. Effectiveness to potential contamination of regulations in permit grants	-	B
	Normative	*Spatial Planning Act*	Zoning							26. Optimal spatial zoning within influence area	+	B
	Normative		Cost-benefit analysis							27. Quantification of claims within influence area of municipality	+	B
										28. Cost and benefits of different spatial zonings	+	C
	Normative		Stand-still/step forward principle							29. Environmental impact of current situation	0	C
										30. Environmental impact of future alternative(s)	0	C
	Normative	Environmental management Act	Enforcement							31. The occurrence of norms exceeding	+ +	D
	Pragmatic	Environmental & economic health	Judgement of Applications				X			32. Survey of processes which include or produces components that threat drinking water quality	+ +	B
										33. Assessment of acceptable risk allowance	+ +	B
	Pragmatic	Spatial planning	Trade-off			X				34. Spatial claims in area of interest	0	A
										35. Quantification of ineterests in are of interest	+	B
										36. Specific spatial functions risks for drinking water quality	+ +	B/C
										37. Optimal spatial zoning	+	B

Appendix A (cont.)

Actors		Regulations/ Objectives	General principle	Strategic positions[1]						Knowledge items	Emp[2]	AvI[3]
Environmental Inspection Agency	Norm.	Fertilizer Act	Minerals-accountancy							38. Extent of use and production of fertilizer per production unit	0	A/B
General Inspection Agency	Norm.	Pesticides Act	Sanctioning							39. Contaminant concentrations in groundwater in time and space 40. Origin of contaminants	+ + +	C C
Drinking Water Companies	Pragmatic	Groundwater protection	Systems knowledge	X						41. Groundwater flow towards well 42. Prediction of contaminant transport towards well	0 + +	A/B C/D
		Groundwater protection	Monitoring	X						43. Contaminant concentrations in groundwater in time and space 44. Contaminant concentrations in extracted water in time	+ +	C A
		Precautionary protection	Stimulation and compensation	X						45. (time-of-travel) capture zones 46. Vulnerability of well fields 47. Capture zone uncertainty 48. Drinking water quality risks of activities within capture zone 49. Effectiveness of measures to behavioral change	0 + 0 + + + +	A A/B C D C
		Spatial planning	Combining spatial functions	X						50. Potential risks of spatial functions for drinking water quality	+ +	B
Agriculture & Private companies	Pragmatic	Less government	Opposition to restrictions					X		51. Trends in groundwater quality 52. Origin of contaminants 53. (Un)certainty of well-head protection zone's location 54. Effectiveness of groundwater protection policy	+ + + + +	B/C C C C
		Fair competition	Equality/ Soundness					X	X	55. Uncertainty of well-head protection zones 56. Vulnerability to field-level contamination of well-fields	+ + +	C A/B
		Economic development	Conditions for establishment					X		57. Drinking water quality risks of processes in installations 58. Effectiveness of protection measures	+ +	C C