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The seven rules for hydrologists and other researchers wanting to contribute to the water management practice

E. Mostert and G. T. Raadgever

Delft University of Technology, Delft, The Netherlands

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Correspondence to: E. Mostert (e.mostert@tudelft.nl)

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Abstract

This paper addresses the question how hydrologists and other researchers can best contribute to the water management practice. It reviews the literature in the field of science and technology studies and research utilization and presents the results in the form of seven "rules" for researchers. These are (1) Reflect on the nature and possible roles of research; (2) Analyse the stakeholders and issues at stake; (3) Choose whom and what to serve; (4) Decide on your strategy; (5) Design the process to implement your strategy; (6) Communicate!; and (7) Consider your possibilities and limitations. Key notions in this paper are that research always involves selection and interpretation and that the selection and interpretations made in a specific case always reflect the values and preferences of those involved. Collaboration between the researchers and the other stakeholders can increase the legitimacy and utilization of the research and can prevent that the specific expertise of the researchers is lost.

1 Introduction

Science and policy often seem to be two different worlds (Borrowski and Hare, 2007; Bourdieu, 2001; Caplan, 1979). They have different aims, speak different languages, follow different rules and face different constraints. Whereas science aims to produce universally valid knowledge, policy is about practical action to address specific issues. Moreover, whereas science is based on mastery of scientific skills and knowledge of the scientific literature, policy requires primarily social and political skills. The major reward in science is recognition by the peers, but in policy the rewards are political power and influence.

In practice, science and policy influence each other in different ways (Buuren and Edelenbos, 2004). Science can only exist as an independent "social field" following its own rules if it enjoys the tacit support from the world of policy (Bourdieu, 2001). Quite often policy influences science directly, for instance by funding research on some topics

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and not on others. Conversely, science may influence policy, for instance by bringing new issues on the agenda and shedding a new light on old issues.

This paper addresses the question how researchers can contribute to the management practice and promote the use of their research. It focuses specifically on hydrological research and on water management, but most issues addressed in this paper also apply to other types of research and other forms of natural resources management. The paper is structured according to seven "rules" for researchers. These rules are based partly on a review of the literature in the field of science and technology studies and research use, and partly on personal involvement in a number of research projects, notably the SQR project (Sustainable and environmental Quality in transboundary River basins, 1995–1999: see Veeren, 2002; Lorenz, 1999) and the ongoing Niederrhein case study of the Newater project (www.newater.info) and the ACER project (Adaptation to Climate Extremes in transboundary River basins, www.adaptation.nl). The aim of this paper is not to lay down the law for researchers or provide a recipe for success, but to invite them to reflect on their role in water management. In the final section, the paper will reflect upon itself and give some suggestions for further research.

2 Reflect on the nature and possible roles of research

Researchers who would like their research to be used should first and foremost reflect on the nature of their research and the roles that research could play in the policy process. Much has already been written on these topics (e.g. Collingridge and Reeve, 1986; Pinch and Bijker, 1984; Bourdieu, 2001; Latour, 1987; Feyerabend, 1988; Buuren and Edelenbos, 2004). One of the first authors was Plato, who wrote *The Republic* around 375 BC. In this work, Plato distinguishes between the world of the ever changing objects and illusions and the ulterior reality of the unchanging Forms or Ideas. The latter constitute the essential structure of nature and are only accessible for the "philosophers" with years of formal training. Ruling a just society would require knowl-

edge of the Forms. Consequently, the philosophers should become kings or the kings philosophers (Plato and Lee, 1974).

The direct descendants of Plato's philosophers are today's scientists and other experts with formal qualifications. They are often seen as having privileged access to the truth, and while few would argue that the experts should rule the country, many think that they can and should provide a certain and objective basis for government (e.g. Irwin, 2006; Jasanoff, 2003).

From the 1970s onwards, these ideas have been challenged. Numerous studies have been conducted on laboratory life, scientific and technical controversies and technological decision-making, which have shown that science is less objective and certain than is often thought, that the published accounts of science do not properly reflect the much more messy practice, and that the "facts" do not resolve controversies but instead the resolution of controversies determines what is accepted as a fact. Many extra-scientific factors come into play. These include the need to secure the necessary social and political support and research funding (cf. Latour, 1987). The more autonomously science functions, the more support it needs from society and the more it will reflect the structure of society (Bourdieu, 2001). Within individual research projects many extra-scientific choices are made, such as the thematic, geographic and temporal delimitation of the research and the issue how uncertainty is dealt with or "filled in" (Frankena, 1988). These choices are influenced by the wishes of the funding agencies, the world view and values of the experts involved and their disciplinary background (e.g. Thompson et al., 1990; Douglas, 2005). Hydrologists, for example. will focus on different issues and aspects than ecologists or economist, analyse them differently and come up with different solutions (cf. framing theory: Dewulf et al., 2005a, 2005b; cf. Box 1).

A related issue is who counts as an expert and who does not. In his seminal 1983 paper, Thomas Gieryn examined the issue as a practical problem for the experts. Experts contrast their expertise and thereby themselves favourably to "pseudo" and "non-experts" by defining themselves in terms of their formal training and their alleged "ob-

jectivity". In this way they can acquire authority and influence, protect themselves from political interference, and exclude the pseudo and non-experts (Gieryn, 1983).

Studies such as these lead to the conclusion that science and expertise are socially constructed. However, they do not imply relativism. We may still assume that there is an objective material reality, but this reality is not directly accessible. It can be studied and interpreted in many different ways and the dominant way is shaped by many social factors. Yet, to quote Knorr Cetina (1995, p. 148), "the material world offers resistance: the facts are not made by pronouncing them to be facts but by being intricately constructed against the resistances of the natural (and social!) order."

Similarly, we may still assume that there is, or should be, something "real" behind the qualification as an expert, viz. the possession of relevant skills and information (cf. Collins and Evans, 2002). A major issue is how to recognize the relevant expertise and experts in a specific case (Rip, 2003). To simplify matters, we can distinguish between "certified experts" with formal qualifications, usually within a specific scientific discipline, such as hydrology or political science, and "lay experts", who lack formal qualifications but still possess relevant skills and information. The major issue with respect to the certified experts is to identify the relevant disciplines. For instance, is flood risk management primarily or exclusively a topic for civil engineers and natural scientists, or should the social scientists be involved as well? And if so, what should be their role? Should they support the implementation of solutions developed by engineers, contribute to defining and analysing the problems, or even take the lead? The identification of lay experts is even more difficult. They do not only lack formal qualifications, but also the social status that goes with these qualifications, and in practice their expertise is often not recognized (see for instance Scheer, 1996; Wynne, 1992). Certified experts sometimes seem to be personally challenged by the notion that lay persons can possess relevant expertise as well (Petts and Brooks, 2006).

Collins and Evans (2002) have called for a normative theory of expertise that can be used to improve the contribution of (certified) experts to technological decision-making. This theory should avoid the false choice between technocracy or "participa-

tion" (Jasanoff, 1990). Whereas technocracy denies the role of values and gives an undue influence to the experts and/or their financers, the second option relies exclusively on involving the other stakeholders and improving interest representation, denying them the benefit of the certified experts' skills and information. Instead, we need to recognize both facts and values, even if they cannot be separated completely, and include both the certified experts and the other stakeholders in our approach.

3 Analyse the stakeholders and issues at stake

The second step that experts who want to contribute to the water management practice should take is to analyse the stakeholders that play a role in water management. A stakeholder can be defined as any organisation, group or individual who can influence or is affected by a problem or its solution (cf. Freeman, 1984). Consequently, there are two categories of stakeholders: the "influential stakeholders" and the "affected stakeholders". These two categories often overlap to a large extent. Influential stakeholders need to be involved in water management for pragmatic reasons, to get anything done, whereas the affected stakeholders can be involved for ethical or democratic reasons (Mostert, 2003).

A stakeholder analysis tries to answer four sets of questions:

- Who are the stakeholders and what are the important issues?
- What are their resources?
- What are their perceptions and interests?
- How are their relations?

The stakeholders and the issues at stake are two sides of the same coin. Starting from one or a few stakeholders, one can identify the issues that are important for them, and starting from an issue, one can identity the affected and influential stakeholders. Issues

do not exist objectively somewhere “out there”: they are always an issue for someone. Yet, hydrological knowledge and other natural science knowledge is important since it may help in finding the major stakeholders for a specific issue, e.g. the major sources of pollution and therefore the major polluters of a specific water body.

The resources of the stakeholders include their legal competencies, political influence, financial means, (lay) expertise and information. These determine the contribution they can make to the solution of an issue and influence the weight they carry in the policy process. The stakeholders’ perceptions and interests determine what they see as an issue and as potential solutions for this issue. Researchers do not have to accept these perceptions and interests uncritically, but they should take them into account if their research is to be relevant for the stakeholders. Information on the relations between the stakeholders is important if some form of collaboration with the stakeholders is foreseen as part of the research or if implementing the solutions studied would require collaboration – as it usually does.

Different methods can be used for analyzing the stakeholders, such as network analysis, discourse analysis and cognitive mapping, focusing either on their resources, on their perceptions and interests or on their interrelations (Hermans, 2005). In addition, more informal approaches that require less time and expertise can be used. These can consist of an internal brainstorm session in the research organization for making a preliminary list of stakeholders, followed by a first meeting with these stakeholders to explore the issues and identify any missing stakeholders (Ridder et al., 2005). By involving them already in the stakeholder analysis, the stakeholders are invited to explore their mutual interdependencies, which can form a good basis for collaboration (Gray, 1989; Mostert et al., 2008). Moreover, the first meeting can be the start of close collaboration between the researchers and the stakeholders (see also rule 4 and 5).

4 Choose whom and what to serve

The third rule for researchers is: choose which stakeholders and which interests to serve. This rule is based on our view on the nature of research. As argued before (cf. rule 1), research always incorporates many subjective choices and always reflects different interests and world views. It is impossible not too choose. Even researchers involved in fundamental research choose, however implicitly. They may want to serve only science and not take sides on policy issues. Sooner or later, however, their research may be used in more applied research that directly affects policy. Fundamental research does not always benefit everybody equally. It benefits especially those stakeholders that have the necessary skills and knowledge to apply it to their own situation, for their own purposes, or have the necessary funds to hire others to do this.

Two other options are to work for government or to work for everybody. These are often legitimate choices, but they are choices nonetheless. Working for government usually implies working for a sectoral government body, such as a ministry, a department of a ministry or an agency. This option is relatively easy to justify – but it is never the only option – if the country involved is democratic on paper and in practice and if the client does not ignore the other stakeholders. If these conditions are not met, research for government may reinforce an unjust social system or may not be applied in practice because of opposition by the other stakeholders. Working for everybody seems a universally right choice, but further choices have to be made. If the number of stakeholders is high, some stakeholders have to be selected to work more closely with, and there may be good reasons for excluding some stakeholders, such as undemocratic stakeholders. Moreover, working for everybody implies not working specifically for particular stakeholders, such as an underprivileged group.

Researchers are not completely free to choose the stakeholders and the interests they want to serve. Their options depend on the broader social, political and institutional context and, more specifically, on the policy of their research organization and the possibilities for funding (cf. Box 1 and rule 7). Yet, researchers are not the passive

recipients of objective constraints. Each research position comes with its own constraints, but researchers can to a large extent choose the position they want to occupy and the constraints usually leave several options open.

5 Decide on your strategy

After having decided whom and what to serve, it is time to decide on the best strategy to do this. As with the stakeholders and interests to serve, the choice is not completely free but there are many choices to be made. The first issue to consider is the type of research use that is aimed for (cf. Neilson, 2001). Many researchers aim for so-called instrumental use. When they study the effects of different management alternatives, they want the stakeholders involved to use this information for deciding between the different alternatives. Much research, however, does not work in this way, for instance because the conclusions of the research do not fit in the current policy. This research may still help the stakeholders to see the issues at stake in a different light and result in fundamental innovation in the longer run. This is called conceptual use. Different researchers have argued that conceptual use is more common than instrumental use (Weiss, 1977; Amara et al., 2004).

A third type of research use is strategic use. Strategic use occurs when research is used to legitimize preferred solutions or to oppose the preferred solutions of others. An example of strategic use is Margaret Thatcher's appropriation at the end of 1988 of the concept of climate change in order to dismantle the coal industry and promote nuclear power (Carvalho and Burgess, 2005). Users may steer the research towards conclusions that favour specific solutions, for example by excluding some alternatives or effects from consideration, by imposing specific assumptions to be used in the research ("use the high scenario", "use the low scenario") or by suggesting to reformulate the conclusions. Other stakeholders – if they have sufficient expertise or funds – may then conduct or order research that studies different alternatives and effects, uses different assumptions and arrives at different conclusions. This may result a "report war"

(cf. Buuren and Edelenbos, 2004).

The second strategic issue is the type of relation between the researcher(s) and the different stakeholders. Researchers may, for instance, opt for advocacy research and support a specific client or promote a specific cause, such as nature protection or the shipping industry. This calls for close collaboration with the stakeholder or stakeholders concerned and often implies confrontation with other stakeholders and their advocates (cf. Busenberg, 1999: "adversarial analysis"). Much so-called policy-relevant research can be seen as advocacy research supporting government to implement or legitimize its policy.

Researchers may also choose – or be asked – to facilitate learning and decision-making by the whole network of stakeholders (cf. Busenberg, 1999: "collaborative research"). They may try to cater for the information needs of all stakeholders and help them to clarify the issues and structure their discussions. Facilitative research can potentially lead to a commonly accepted factual basis for management. However, like any type of facilitation, it is not a completely neutral activity. The researcher has to decide whether he wants to facilitate a specific network of stakeholders (cf. rule 3). Moreover, his interventions will inevitably influence the process.

Finally, researchers may work in isolation from the other stakeholders. This strategy is compatible with conceptual research use and gives researchers complete freedom to develop innovative concepts and approaches that may run counter to current policy and to public opinion. Yet, there is a real danger that researchers following an isolation strategy unwittingly end up selling their subjective preferences under the guise of objective science. If it works, it is not very democratic, and if it does not work, it may be a waste of expertise because there may still be a lot of valuable expertise incorporated in the research. Researchers should, as a minimum, be explicit about the choices they made and how they made them, including a discussion of their own values (Douglas, 2005). This requires a lot of critical self-reflection (cf. rule 1).

6 Design the process to implement your strategy

The implementation of your research strategy can be helped greatly if a detailed process design is made, specifying what will be done by whom, when and how. Many different methods and techniques are available for collaborative strategies, such as participatory modelling, group model building, consensus conferences, focus groups, citizen juries, public hearings and science shops (Backstrand, 2003; Douglas, 2005; Funtowicz and Ravetz, 1990; Ridder et al., 2005; Vennix, 1999; Ubbels and Verhallen, 2000). Generally, collaboration works best if it starts early and if researchers and the other stakeholders determine the research needs together (Raadgever and Mostert, 2007). In practice, it often happens that the other stakeholders are involved only after the researchers have specified the research, based on their own perceptions of the issues at stake and following the requirements of their own discipline and of funding agencies. Such a process may lead to research that is less relevant for the other stakeholders and can reduce their willingness to participate and their acceptance of the results. Similar problems can occur if researchers collaborate with only one or a few stakeholders or if they work with representatives who do not represent their group or organization correctly.

For both collaborative and non-collaborative research, it is important to maintain as much flexibility as possible to be able to respond adequately to changing circumstances of surprising first results (Monnikhof, 2006). Major changes require the consent of the stakeholders involved in order to reduce the risk of loosing support and commitment.

Quite often, the starting point for researchers is a specific tool or approach that they are familiar with and believe to be useful for many problems. A better approach in theory is to first identify and analyze the issues at stake and then select the best tool or method to address these issues. In practice, however, most researchers master only one or a few tools. Realistically, researchers should have an open eye for the needs in a specific case and for the possibilities and limitations of their tools, and become involved only when the two match.

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7 Communicate!

Communication plays a key role in all research strategies. It is central to collaborative research, but also in non-collaborative research it is key, albeit in a different way. In non-collaborative research communication takes place only after research results have been produced and is one-directional, from the researchers to their different target audiences. Non-collaborative research usually applies the public understanding of science model, also known as the deficiency model or the scientific literacy model. This model is based on the assumption that there is a need for the stakeholders to understand particular scientific concepts and facts and that the experts should teach them these concepts and facts. The concepts and facts themselves are portrayed as fixed and certain (see for an example Stamm et al., 2000).

Despite many efforts applying this model, there is little evidence of any increase in public understanding of science (Logan, 2001; Kim, 2007; Weigold, 2001). This is often attributed to the inability of the experts to communicate clearly and to the limited background knowledge, intellectual capacities and willingness of the other stakeholders. There may be some truth in this. Many experts have difficulties speaking plain language, have no clear view of their target audience and its interests and background knowledge. In many cases the researchers could benefit from involving professional communication experts – which costs money – but this may not prevent all communication problems.

Increasingly, trust in the researchers and their research is mentioned as an important factor in science communication. As Brian Wynne (1992, 1996) pointed out, trust is not a something that the public possesses or not. Instead, it results from the interactions between the researchers and their public and the social and institutional context (Kramer, 1999; Bachman, 2001; Vangen and Huxham, 2003). Factors influencing trust include the track record of the researchers (have they been proven wrong in the past?), their consideration of the information and views of the public, their openness to criticism, their institutional affiliation and the "recognisability" of their research is. This does

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not only depend on the language that is used, but also on the concepts that are used and the values that are reflected in the research (cf. rule 1 and Box 2). In addition, the reputation of the models and methods used is important.

In response to the poor performance of the public understanding of science model, an alternative model has been developed, called the contextual or interactive model (Logan, 2001; Kim, 2007; Weigold, 2001). Its starting point is not science, but the needs and interests of the public and the context in which they have to or can use the science. It acknowledges the subjective or "constructed" character of science and pays as much attention to the production as to the consumption of knowledge. Communication in this view is not one-way transfer of knowledge from researchers to the other stakeholders, but a continuous interaction between the two groups.

Researchers using an isolation strategy necessarily have to rely on one-way communication, but also in more collaborative strategies many instances of one-way communication may occur because researchers can interact directly with only a limited number of people. To reach more people, they have to rely on books and reports, the mass media, word of mouth dissemination and intermediaries such as communication officers of research institutes and journalists (Weigold, 2001). One-way and two-way communication do not necessarily conflict but may complement each other.

8 Consider your possibilities and limitations

Last but not least, researchers should consider their possibilities and limitations. These are partly of a personal and partly of an institutional nature. While some researchers like to solve difficult but well-defined problems, others prefer to analyse complex and ambiguous problems and interact with different stakeholders. The first group are good candidates for more fundamental research, which requires especially very good analytical skills and stamina to work independently, whereas the second group may be better in more collaborative research. This requires good social skills, flexibility and the ability to cope with change and uncertainty, in addition to analytical skills.

The institutional constraints that researchers face include the reward structure in science and the research policy of funding agencies. The academic world generally rewards publications in journals with a high impact factor. These are mostly monodisciplinary journals reporting about fundamental research and targeting experts from the same discipline. Popularization of science is often frowned upon (Jacobson et al., 2004; Boer et al., 2006). Funding agencies, however, increasingly demand that the research is "policy relevant". By this they often mean research that studies officially recognized issues and alternatives and not research that critically reviews the current policy and puts new issues on the agenda.

The constraints from the academic world and funding agencies often work in opposite directions. The relative importance of each constraint depends on the type of research organization – governmental, commercial or academic – and more specifically on the organization's career policy. Researchers facing both constraints can try to sell their research to funding agencies, and possibly also to themselves, in terms of policy relevance, yet, after they have secured funding, pursue their scientific interests. They may also redefine their concept of science and do action research with and for different stakeholders.

Not only researchers, but also the other stakeholders face constraints. For instance, an individual policy maker may want to avoid a "report war", but he or she may be forced to react when someone else starts such a war. Moreover, constraints are not given once and for all. Individuals may follow training, develop new interests and gain new experiences and skills. Scientific journals may review their publication policy and research organizations their personnel policy. Moreover, organizations and interorganizational networks may evaluate and change how they function, but this is quite hard (cf. Argyris and Schön, 1996). In the long term there is more possible than in the short term.

9 Discussion

The aim of this paper was to stimulate reflection on the role of researchers in the policy process. To this end, seven rules for researchers have been formulated, based on a literature study and on experiences in a number of research projects. These rules do not constitute a recipe for success and leave room for different types of research. Moreover, they have not been proven in a strict sense. More cases studies should be conducted, describing research processes and research impact, using the seven rules as hypotheses to be tested. Interesting cases would be cases where at first sight all rules seem to have been followed and cases where research seems to have had a large impact. In addition, action research can be undertaken in which the researchers apply the rules themselves, observe the impact and reflect on the experiences gained. This may then lead the researchers to refine, complement or replace the seven rules, to new practical applications, new observations, etc. (cf. Kolb's experiential learning cycle: Kolb, 1984).

The rules leave room for different types of research, but in between the lines it is possible to read a preference for collaborative research. To complicate matters, this paper argues that research is always subjective and can be understood in terms of personal interests and institutional factors (cf. rules 1 and 7). If correct, what does this imply for the paper itself? Is the preference for collaborative research just a subjective preference of the authors that is no more valid than any other preference, or is there something substantive behind it?

There are several reasons for conducting collaborative research. First, compared to "pure", monodisciplinary research, it offers far greater possibilities for interdisciplinary cooperation. This is scientifically interesting and important for the first author, who has a social science background and works at a water management department. Secondly, there are ethical and democratic reasons for conducting cooperative research. If research always reflects values and interests, whose values and interests should that be: the researchers', the client's or all stakeholders'? And thirdly, collaborative re-

search can be very pragmatic. By catering for the needs of the different stakeholders, the chances that research is used are maximized.

Yet, collaborative research does not solve all problems and sometimes other types of research may be called for (cf. rule 3). The main point of this paper was not to provide universal solutions, but food for thought. Each situation requires a different solution, depending on the stakeholders, the issues at stake, the state-of-the-art in science concerning these issues and the interests, and skills of the researchers.

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References

Allan, J. A.: Virtual water – the water, food, and trade nexus; useful concept or misleading metaphor? Water Int., 28, 4–11, 2003.

Amara, N., Ouimet, M., and Landry, R.: New evidence on instrumental, conceptual, and symbolic utilization of university research in government agencies, Sci. Commun., 26, 75–106, 2004.

Argyris, C. and Schön, D.: Organizational learning II. Theory, method and practice, Addison-Wesley, Reading, Massachusetts, 1996.

Bachman, R.: Trust, power and control in trans-organizational relations, Organ. Stud., 22, 337–365, 2001.

Backstrand, K.: Civic science for sustainability: Reframing the role of experts, policy-makers and citizens in environmental governance, Global Environmental Politics, 3, 24–41, 2003.

Boer, Y. d., Gier, A. d., Verschuur, M., and Wit, B. d.: Building bridges; researchers on their experiences with interdisciplinary research in The Netherlands, RMNO, KNAW, NWO, COS, 2006.

Borrowski, I. and Hare, M.: Exploring the gap between water managers and researchers: Difficulties of model-based tools to support practical water management, Water Resour. Manag., 21, 1049–1074, 2007.
Bourdieu, P.: Science de la science et réflexivité: Cours du collège de France, 2000–2001, Collection “Cours et travaux”, Raisons d’agir, Paris, 2001.
Bruijn, K. M. d.: Resilience and flood risk management, Water Policy, 6, 53–66, 2004a.
Bruijn, K. M. d.: Resilience indicators for flood risk management systems of lowland rivers, Int. J. River Basin Management, 2, 199–210, 2004b.
Busenberg, G.: Collaborative and adversarial analysis in environmental policy, Policy Sci., 32, 1–11, 1999.
Buuren, A. v. and Edelenbos, J.: Conflicting knowledge, Science and Public Policy, 31, 289–299, 2004.
Caplan, N.: The two-communities theory and knowledge utilization, Am. Behav. Sci., 22, 459–470, 1979.
Carvalho, A. and Burgess, J.: Cultural circuits of climate change in uk broadsheet newspapers, 1985–2003, Risk Anal., 25, 1457–1469, 2005.
Clarke, L., and Short, J.: Social organization and risk: Some current controversies, Annu. Rev. Sociol., 19, 375–399, 1993.
Collingridge, D. and Reeve, C.: Science speaks to power: The role of experts in policy making, St. Martin’s Press, New York, xi, 175 pp., 1986.
Collins, H. and Evans, R.: The third wave of science studies: Studies of expertise and experience, Soc. Stud. Sci., 32, 235–296, 2002.
Dewulf, A., Craps, M., Bouwen, R., Taillieu, T., and Pahl-Wostl, C.: Integrated management of natural resources: Dealing with ambiguous issues, multiple actors and diverging frames, Water Sci. Technol., 52, 115–124, 2005a.
Dewulf, A., Gray, B., Putnam, L., Aarts, N., Lewicki, R., Bouwen, R., and Woerkum, C. v.: Disentangling approaches to framing: Mapping the terrain, 18th IACM Conference, Seville, 12–15 June 2005, 2005b.
Douglas, H.: Inserting the public into science, in: Democratization of expertise? Exploring novel forms of scientific advice in political decision-making, edited by: Maasen, S. and Weingart, P., Sociology of the sciences 24, Springer, Dordrecht, 153–169, 2005.
Feyerabend, P.: Against method, Rev. ed., Verso, London, New York, 1988.
Fischhoff, B., Watson, S., and Hope, C.: Defining risk, Policy Sci., 17, 123–139, 1984.

Frankena, F.: The emergent social role and political impact of the voluntary technical expert, Environ. Impact Asses., 8, 73–82, 1988.
Freeman, R. E.: Strategic management : A stakeholder approach, Pitman series in business and public policy, Pitman, Boston [Mass.], London, 1984.
Funtowicz, S. O. and Ravetz, J. R.: Uncertainty and quality in science for policy, Theory and decision library, Series a. Philosophy and methodology of the social sciences, Vol. 15, Kluwer, Dordrecht, 229 blz. pp., 1990.
Gieryn, T.: Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists, Am. Sociol. Rev., 48, 781–795, 1983.
Gouldby, B. and Samuels, P.: Language of risk, available at: http://www.floodsite.net/, 2005.
Gray, B.: Collaborating : Finding common ground for multiparty problems, 1st ed., Jossey-bass management series, Jossey-Bass, San Francisco, 1989.
Hermans, L. M.: Actor analysis for water resources management putting the promise into practice, Eburon Publishers, Delft, 2005.
Hoekstra, A. and Chapagain, A.: Water footprints of nations: Water use by people as a function of their consumption pattern, Water Resour. Manag., 21, 35–48, 2007.
Irwin, A.: The politics of talk: Coming to terms with the "new" scientific governance, Soc. Stud. Sci., 36, 299–320, 2006.
Jacobson, N., Butterill, D., and Goering, P.: Organizational factors that influence university-based researchers' engagement in knowledge transfer activities, Sci. Commun., 25, 246–259, 2004.
Jasanoff, S.: The fifth branch: Science advisers as policymakers, Harvard University Press, Cambridge, Mass., 1990.
Jasanoff, S.: (No?) accounting for expertise, Science and Public Policy, 30, 157–162, 2003.
Kim, H.: PEP/IS: A new model for communicative effectiveness of science, Sci. Commun., 28, 287–313, 2007.
Knorr Cetina, K.: Laboratory studies: The cultural approach, in: Handbook of science and technology studies, edited by: Jasanoff, S., Markle, G. E., Petersen, J. C., and Pinch, T., Sage Publications, Thousand Oaks, Calif., 140–166, 1995.
Kolb, D. A.: Experiential learning: Experience as the source of learning and development, Prentice-Hall, Englewood Cliffs, NJ, 1984.
Kramer, R. M.: Trust and distrust in organizations: Emerging perspectives, enduring questions, Annu. Rev. Psychol., 50, 569–598, 1999.

Latour, B.: Science in action : How to follow scientists and engineers through society, Harvard University Press, Cambridge, Mass., 1987.
Logan, R.: Science mass communication: Its conceptual history, Sci. Commun., 23, 135–163, 2001.
Lorenz, C. M.: Indicators for sustainable management of rivers, Vrije Universiteit, Amsterdam, 1999.
Monnikhof, R. A. H.: Policy analysis for participatory policy making, Delft University of Technology, Delft, 2006.
Mostert, E.: The challenge of public participation, Water Policy, 5, 179–197, 2003.
Mostert, E., Craps, M., and Pahl-Wostl, C.: Social learning: The key to integrated water resources management?, Water Int., in press, 2008.
Neilson, S.: Knowledge utilization and public policy processes: A literature review, IDCR, Ottawa, 2001.
Petts, J. and Brooks, C.: Expert conceptualisations of the role of lay knowledge in environmental decisionmaking: Challenges for deliberative democracy, Environ. Plann. A, 38, 1045–1059, 2006.
Pimentel, D., Harman, R., Pacenza, M., Pecarsky, J., and Pimentel, M.: Natural resources and an optimum human population, Popul. Environ., 15, 347–369, 1994.
Pinch, T. J. and Bijker, W.: The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other, Soc. Stud. Sci., 14, 399–441, 1984.
Plato and Lee, D.: The republic, Penguin classics, Penguin, Harmondsworth, 1974.
Raadgever, G. T. and Mostert, E.: The role of expert knowledge in collaborative water management, International Conference on Adaptive and Integrative Water Management (CAIWA), Basel, 12–15 November 2007, 2007.
Rip, A.: In a third wave of science studies?, Soc. Stud. Sci., 33, 419–434, 2003.
Scheer, S.: Communication between irrigation engineers and farmers; the case of project design in North Senegal, Wageningen University, Wageningen, 1996.
Sjoberg, L.: The allegedly simple structure of experts' risk perception: An urban legend in risk research, Sci. Technol. Hum. Val., 27, 443–459, 2002.
Sjöberg, L.: Factors in risk perception, Risk Anal., 20, 1–11, 2000.
Slovic, P.: Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield, Risk Anal., 19, 689–701, 1999.

Stamm, K., Clark, F., and Eblacas, P.: Mass communication and public understanding of environmental problems: The case of global warming, Public Underst. Sci., 9, 219–237, 2000.
Thompson, M., Ellis, R., and Wildavsky, A. B.: Cultural theory, Political cultures, Westview Press, Boulder, Colo., 1990.
Ubbels, A. and Verhallen, J. M.: Suitability of decision support systems for collaborative planning processes in water resources management, Riza-rapport 99.067, RIZA, Lelystad, 2000.
Vangen, S. and Huxham, C.: Nurturing collaborative relations; building trust in interorganizational collaboration, J. Appl. Behav. Sci., 39, 5–31, 2003.
Veeren, R. J. H. M. v. d.: Economic analyses of nutrient abatement policies in the Rhine Basin, Vrije Universiteit, Amsterdam, 2002.
Vennix, J.: Group model-building: Tackling messy problems, Syst. Dynam. Rev., 15, 379–401, 1999.
Weigold, M.: Communicating science: A review of the literature, Sci. Commun., 23, 164–193, 2001.
Weiss, C.: Research for policy's sake: The enlightment function of social research, Policy Anal., 3, 531–545, 1977.
Wichelns, D.: The role of "virtual water" in efforts to achieve food security and other national goals, with an example from Egypt, Agr. Water Manage., 49, 131–151, 2001.
Wynne, B.: Misunderstood misunderstanding: Social identities and public uptake of science, Public Unders. Sci., 1, 281–304, 1992.
Wynne, B.: Misunderstood misunderstandings: Social identities and public uptake of science, in: Misunderstanding science? : The public reconstruction of science and technology, edited by: Irwin, A. and Wynne, B., Cambridge University Press, Cambridge, New York, 19–46, 1996.

In their article "Water footprints of nations", Hoekstra and Chapagain (2007) calculate the water footprint of the different countries of the world. They define the water footprint of a country as the total freshwater volume that is used to produce the goods and services consumed by the population of that country. Contrary to traditional water use indicators, the water footprint includes the "virtual water" (Allan, 2003) embedded in the goods and services that are in or exported. Using some simplifying assumptions, they calculate the global average water footprint to be 1240 m^3/cap/yr, ranging from a mere 700m^3/cap/yr for China to 2480 m^3/cap/yr for the USA. Moreover, they discuss the factors that determine the water footprint and the means to reduce the water footprint. These are more water efficient production methods, changes in consumption patterns (e.g. less meat) and moving production to regions where water efficiency is higher.

Without challenging the quality of the article in any way, it is possible to identify some subjective aspects, starting with its scope. The article is mostly limited to technical water management issues, and as such reflects the water management background of its authors. Secondly, the basic concept used - water footprint - frames the water scarcity issue in a specific way, implicitly suggesting virtual water trade as a possible solution. There is no discussion of the economic and political aspects of virtual water trade. Virtual water is not a solution for poor farmers without alternative sources of income, who cannot buy imported food from more water efficient regions. Moreover, the official policy of some countries is to be self-sufficient in food supply and minimize food imports in order to reduce dependence on other countries, to promote national agriculture or to support their water claims in an international dispute (e.g. Wichelns, 2001). Thirdly, since the water footprint is expressed in per capita figures, the effect of population size on water use gets out of sight (e.g. Pimentel et al., 1994). Population policy is not discarded as a water management measure, it simply is not discussed at all.

Box 1. Analyzing the article "Water footprints of nations: Water use by people as a function of their consumption patterns" (Hoekstra and Chapagain, 2007).

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A large body of literature exist on communicating risks, such as flood risks. Technical experts usually define risk in terms of the probability of an adverse event and the consequences of this event (e.g. Jonkman et al., 2002; Bruijn, 2004a, 2004b; Gouldby and Samuels, 2005). This has also been called "objective risk" and is contrasted with subjective risks perception (Clarke and Short, 1993). The main task for risk communication in this view is to educate the public about the objective risks, but the public do not always accept the assessments made by the experts.

Different reasons have been given for the risk communication problems, such as the communication skills of the experts and the issue of trust (this section). Moreover, the assessments by expert uses many assumptions that reflect the values of the experts and their clients (Sjoberg, 2002; Douglas, 2005; cf. rule 1;). Even the risk indicators used reflect value judgements (cf. Fischhoff et al., 1984). Flood risks, for example, may be assessed in terms of individual risk - e.g. probability of drowning - or in terms of collective risks - e.g. expected average number of casualties in a specific area. Whereas the first option favours equal flood protection for all, the latter favours higher flood protection for flood-prone areas with a larger population. The main value judgment in this case is whether everybody in a country is entitled to the same level of flood protection or not.

An important reason for risk communication problems are the different risk concepts used. Technical experts usually distinguish between risk assessment on the one hand, and risk acceptability and risk management on the other. Lay persons do not make this distinction and use a more holistic risk concept of risk. Their assessment of risks includes factors such as their trust in risk management, their own degree of control, their vulnerability to the risk, the voluntary or involuntary character of the risk, their attitude towards the risky activity or situation, and the benefits they derive from this activity or situation (e.g. Slovic, 1999; Sjöberg, 2000). Without a proper dialogue between the researchers and their public, there is a high probability that the research results are neither relevant not accepted by the public.

Box 2. Communicating "risk".