

Information, public empowerment, and the management of urban watersheds

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Abstract

The management of urban watersheds has been dominated by providing technological, end-of-pipe solutions to individual environmental problems. The current technological system and management schemes are the result of a stepwise evolutionary process of solving individual problems in succession. The complexity of contemporary problems requires an integrated approach to problem solving and thus innovation. However, the longevity of infrastructure and the co-evolution of management practices and technology resulted quite often in lock-in situations. The interdependence of infrastructure, rules of practitioners and attitudes of the public stabilize the system and prevent change. More flexible systems are required that are able to adapt to changes in environmental and societal boundary conditions. In this paper it is argued that this implies a shift from constructing and managing centralized technology with centralized control, towards the intelligent design of integrated environment-technical-human systems with decentralized and integrated technical systems and distributed and flexible mechanisms of coordination and control. Citizens and stakeholder groups may become active participants of the management scheme. This poses a major challenge for system analysts and system engineers.

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1. Introduction

In the past, water resources management was characterized by clearly defined problems that society wanted solved. Urban water management had its origin in solving the hygienic problems within cities with new technologies. Environmental management needs to adopt a more integrated approach to tackle the pressing and complex problems society faces today. There is a perceived increase in the complexity of decision making in relation to environmental issues. Science and technology have become more and more entwined with socio-economic factors. Traditional methods and procedures have quite often proved inadequate to deal satisfactorily with socially sensitive and scientifically complex issues (Joss and Brownlea, 1999). However, transitions towards sustainability involve in many cases

complex processes of societal decision making that require the coordination among numerous actors. The increase in uncertainties caused for example by climate change is an additional reason for novel approaches towards management. Political authorities face increasing dissatisfaction of citizens and NGO's with expensive and non-sustainable technical end-of-pipe solutions to environmental problems. Technological innovations will change urban water management. Centralized, expensive infrastructure may be replaced by decentralized technological solutions aiming at source control at the household level (Larsen and Gujer, 1996). A more coherent holistic approach must be developed for the planning, specification, costing and evaluation of water and wastewater options in the domestic context. The overall need for a change in management practices was expressed by different authors (Beck and Cummings, 1996; Larsen and Gujer, 1997; Burkhard et al., 2000). It has been argued that citizens should actively be engaged to improve decision making processes and become active participants in processes of innovation

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(e.g. Fishkin, 1995; Fischer, 1999, Pahl-Wostl, 2002a,b; Renn et al., 1995). Citizens will have to make decisions in their roles as voters, as house-owners, as tenants, as consumers. It is important to involve citizens at an early stage in the process of technology development and application.

The role of citizens in decision making in urban water management is not well established. There is little public awareness of magnitude, complexity and functioning of the current system. In Germany or Switzerland, as in many industrialized countries, the technical systems function perfectly with hardly any technical failures. Security is of prime importance and guaranteed by technical means. The water supply system of Zürich has for example two additional security systems to provide drinking water in case of failure of the main system (Blum, 1995). The consumers of services of urban water management are used to very high standards of security and are not aware of potential risks. However, such a strategy of risk management has its price. One may question if it is economically or ecologically very efficient. It is a typical situation for subsidized public utilities where the overall costs are in general not directly related to the costs of the services provided to the customer. It can be expected that this situation will change significantly. In many countries major investments have to be made to maintain the expensive infrastructure. The costs will have to be covered by water consumers, in particular if privatization is becoming of more importance and the general tendency towards cost-efficiency is realized (e.g. Jones, 1998). The goals stated during the sustainability summit in Johannesburg to reduce the number of people without access to clean water and sanitation will pose another challenge to urban water management.

Lack of information and the lack of an ability to make decisions prevent citizens from becoming more involved in decision making processes. In contrast, empowerment implies that citizens really take an active role in defining an issue. This embraces a number of important points:

- Access to comprehensive and timely information about an issue that must provide different perspectives and uncertainties.
- Citizens have to be enabled to take over responsibility in important decisions.
- Institutional settings must permit citizens to phrase and communicate their perspective and clearly articulate their voice.
- Citizens must have a real stake in an issue to be motivated to make an active contribution.

Citizens should be involved in different areas of decision making in urban water management. On one hand, they may participate in making choices on transformation processes towards entirely new management

schemes. On the other hand they may become active participants in daily management practices. Hence, one can make a distinction of three different areas for citizen participation:

- Integrated assessment where informed citizens judge risks and benefits of different development trajectories and management schemes.
- Technology assessment where single technologies and their risks and benefits are judged.
- Risk management where citizens take an active role in assessing and managing risks on a routine base.

The role of citizens in risk management has received relatively little attention up to now, but may become of major importance in the future.

In the following the current urban water management system is explored to highlight the need for a change and the necessity to involve the general public and different stakeholder groups in processes of technology assessment and the participatory design of new management systems and strategies.¹

2. The system perspective in urban water management

Urban water management has a long tradition in the engineering sciences. It is mainly based on the ability to predict and to control environmental risks with technology. Urban water management in most industrialized countries is characterized by large margins of safety involving huge infrastructure and technical facilities (Tillman et al., 2004). An illustrative example is given by the design of the capacity for the water supply of a big city in Switzerland. The engineering rules which provided the basis for building the infrastructure of water-supply systems and the management rules which formed the basis for operating them were elicited from the management board of the water utility and investigated in more detail with an agent based model (Tillman et al., 1999, 2001; Tillman, 2001). An important principle is to design supply capacity to meet the maximum daily peak demand.

¹ It is important to point out that stakeholder should not be confused with the general public at large (Pahl-Wostl, 2002a; Cowie and Borrett, 2004). A stakeholder is only defined in reference to a particular issue. Numerous definitions exist. The most appropriate definition may be the one by Glicken (2000): "A stakeholder is an individual or group influenced by—and with an ability to significantly impact (either directly or indirectly)—the topical area of interest." The following distinctions can be made regarding the participation of different groups. (1) Citizen participation—involving the public at large in issues of general concern—e.g. citizens in their role as voters on energy taxes. (2) Stakeholder participation—involving specific stakeholder groups—here the different groups are addressed in their specific roles and relative to their stakes in reference to a particular environmental issue—e.g. people in an area with specific reference to air pollution.

Fig. 1 shows the development of supply capacity and average and peak demand over the last century. In 1976, an extreme and prolonged period of hot and dry weather caused an extraordinary demand peak reaching the limits of the supply capacity. At this time little attention was given to the possibility to manage demand and to break extreme peaks. Instead a major extension of supply capacity entered the planning stage. However, the trend in water demand changed from a continuous increase over the past decades to a steady decline. Hence, a huge gap between capacity and demand emerged. It caused public concern due to high financial expenses in times where the financial situation started to become critical for many cities. Excess capacity poses further a problem for water quality due to the long residence time of the water in the pipes. Similar situations can be found in many cities in former Eastern Germany where the capacity of waste water treatment plants and water supply utilities was designed to meet extremes. Generous governmental subsidies promoted the tendency to build large capacities based on forecasts that were sometimes quite unrealistic. Little consideration was given to maintenance costs, demographic and industrial development. Citizens have to bear maintenance costs and the dissatisfaction of the public is high.

This example illustrates the problems associated with the longevity of infrastructure and with management practices developed in times of constant and/or steadily changing and thus largely predictable boundary conditions. It also illustrates the problem with the role and responsibilities of different stakeholder groups in the overall process of planning, implementation and management. In today's world of fast change, new planning processes and management strategies aiming at more flexibility are to be developed. To do so the current management approach is contrasted with an alternative. The two approaches are caricatured to some extent to highlight the differences.

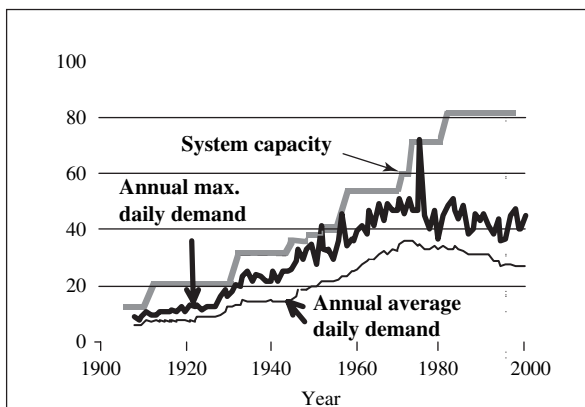


Fig. 1. Development of system capacity and average and peak demand for a big city in Switzerland. The peak in 1976 caused the development that lead to final excess capacity of about a factor of three (ratio of capacity to average demand) for the year 2000.

2.1. The (central, optimal) control paradigm

In this paradigm the idea pervades that management is control, and more specifically control by means of technology. Fig. 2A illustrates that the main focus of management activities is on the design and operation of the technical system. The boundaries between the systems are clearly delimited. Environmental systems and social systems provide external boundary conditions. They are not part of the management and design process.

The perception of systems dynamics is mechanistic and follows a machine metaphor; the system is assumed to be observable—relevant global information can be obtained; based on an understanding of system function and predictability one can interfere by targeted action to counteract deviations from a desired goal. The management control perceives itself largely outside of the system. This is classical control theory (reference). One can question if it is appropriate for solving the complex problems urban water management is facing today.

2.2. The self-organization (distributed control) paradigm

In this paradigm environmental, technical and social systems are perceived as an integrated whole (Fig. 2B). From the perspective of system dynamics and control theory it is meanwhile common knowledge that self-organizing systems with distributed control are more flexible and more efficient in allocating resources than centrally controlled systems (e.g. Pahl-Wostl, 1995; Ferber, 1999; Roy, 1998). The central controller with global information is replaced by distributed mechanisms

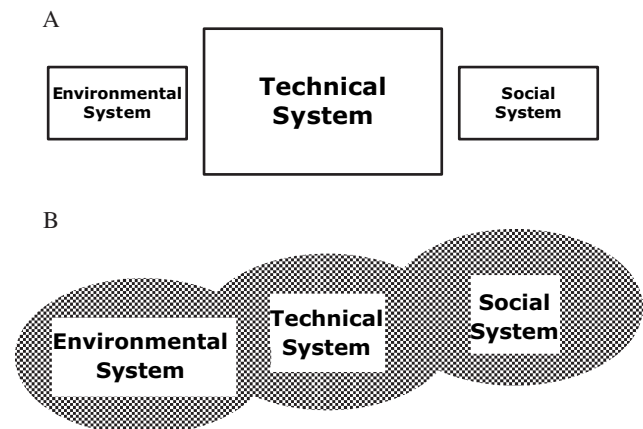


Fig. 2. (A) Emphasis of the control paradigm on management of the technical system with clearly delimited boundaries towards the environmental and social systems that are perceived as providing external boundary conditions. (B) Emphasis of the self-organization paradigm on the management of the integrated technical, environmental and social systems.

of coordination and common global constraints. Obviously this abstract notion has to be made more tangible for the management of an integrated ecological-technical-social system.

The design of environmental and social systems is part of the management strategy. Such an integrated system has more degrees of freedom to adapt fast to changes in its surroundings. The self-organization paradigm is not entirely new. It can be found in the ideas of the proponents of ecological engineering where the integration of the technological with ecosystems is put into practice (Mitsch and Jørgensen, 1989). By the intelligent design of eco-technical systems, ecosystem services can be utilized to buffer extremes and use less other resources. An illustrative example is given by the management of extreme events caused by flooding. One strategy is the generation of wetlands and floodplains whereas another relies on flood control with dams and concrete constructions. In the latter case settlements are entirely separated from the detrimental influence of the environment. Dams are built higher and higher and the next ‘century’ flood is causing the highest damage ever perceived. In times of increasing uncertainties due to climate change such a ‘concrete’ and control strategy is extremely vulnerable to an increase in extreme events and thus uncertainty and it is highly resource intensive. It may be less save than a more integrated strategy since it relies on the ability to control the effects of maximum extreme events. More recently, a pronounced paradigm shift in this respect can be observed in the Netherlands. The design of flood plains and floating houses is in practice more efficient to cope with a highly unpredictable environment. This is a design where the technology becomes part of the environmental dynamics—adaptation not control. However, there are impediments to such a design. If ecological engineering is already hampered by our lack in understanding ecosystem processes and function it is even worse for social systems. And social systems will always be less predictable than machines. As pointed out by (Johnson, 2000) simulation science encounters new challenges in the design of socio-technical systems. It is important to involve citizens at an early stage as active participants in the process of assessment and participatory design. The next section gives concrete examples on citizen and stakeholder participation in radical innovations in urban water management and the role of information and simulation tools.

3. Stakeholder participation within new management approaches

The adoption of new technologies and the transformation to new management styles will involve

complex processes of coordination and decision making in whole networks of stakeholders. Strategy changes involving paradigm shifts cannot be adopted by a single stakeholder in isolation but have to be developed and adopted in a coordinated effort. Rules of practitioners, technical skills, and consumer behavior co-evolved with the technical infrastructure. Now changes are often impeded since current infrastructure, the shared knowledge of practitioners, and expectations of stakeholders stabilize the status quo. Both the inertia in the ‘hardware’ (longevity of infrastructure and high fixed costs) and the ‘software’ (shared rules and habits) prevent change. One may talk of a lock-in situation where transitions to a system that may be better adapted to today’s needs are prevented. Such transitions will proceed in a stepwise fashion. It is argued here that in a first phase the formation of informal networks, processes of negotiation and coordination among stakeholder groups are of major importance. Such processes may be accompanied or even triggered by changes in the formal boundary conditions (e.g. legal regulations). In the final stage of a transformation process a new system will have emerged with a new technological, institutional and spatial design and a new overall paradigm governing system behavior.

Systems analysis of the urban water management scheme has thus to encompass the human dimension explicitly. Currently, new approaches for the systems analysis of social-technical-environmental systems are tested and implemented in a case study in Switzerland in the area of managing water supply. The new methodology links approaches from hard and soft systems theory. Stakeholders may (are expected to!) change their behavior and adapt their representation of reality once they are confronted with a model of their system, their reality. This is not trivial from a system theoretic point of view and supports the argument that in human systems it is appropriate to talk of management as learning rather than control (Checkland, 1993; De Geus, 1992; Pahl-Wostl, 1995).

Fig. 3 shows in a schematic fashion the combination of modeling and stakeholder participation. The steps of the novel methodology comprise:

- Analysis and representation of stakeholder networks, level and type of organization, scale of activity and institutional settings.
- Design of a participatory process with the stakeholders involved. Establishment of an actors’ platform with representatives from different stakeholder groups.
- Elicitation of mental models and the development of a shared problem perception.
- Development of an agent based model to account for processes of institutional change in the stakeholder network at the scale of the system as whole

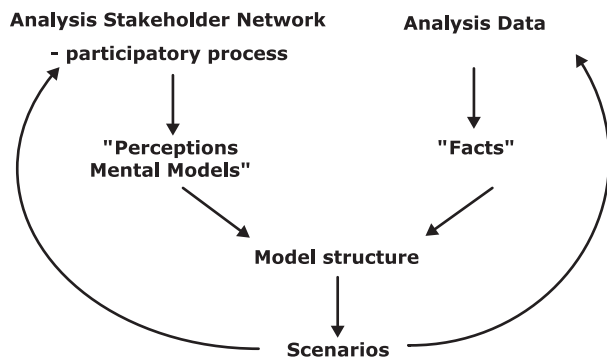


Fig. 3. Combination of hard and soft systems methodology for analyzing stakeholder networks and for participatory model development and application. The development of the model is informed both by traditional methods of analyzing data and developing systems categorizations based on abstract notions and by the elicitation of mental models and subjective categories derived from individual stakeholders.

(representation of institutional and other actors with a wide sphere of influence).

- If required involve specific stakeholder groups in more detail (e.g. consumers by employing focus groups or surveys).
- Extension of the agent based model to a multiscale modular structure where certain processes (e.g. adoption of new technologies, opinion formation in consumer networks) are represented in more detail.
- Participatory model development and application. Elicitation of sets of options for action based on scenarios derived from models.

The combination of agent based models and stakeholder participation results in models that allow linking the subjective perceptions of individual stakeholders, the knowledge elicited from the stakeholder group and the factual knowledge derived from data. Hence the models facilitate learning processes in such a stakeholder network. Learning involves the development of a shared understanding of the system under consideration and management objectives, a change of mental models and the adoption of novel attitudes and strategies. The scenarios derived from such a modeling framework will assist the development of common strategies that are supported by all stakeholders involved. The combination of role playing games and agent based models prove to be particularly useful to explore the institutional settings. Whereas agent based models allow a better control of the social processes represented, role playing games improve the understanding of the contents of agent based models and are a means to elicit implicit tacit knowledge from the stakeholder group (Barreteau et al., 2001). Hence the combination of both methods offers an interesting approach for supporting processes of negotiation and self-reflection, for facilitating the

process of developing ‘ownership’ for the models in the stakeholder group.

The method outlined above is useful to develop new strategies and scenarios. The establishment of an actors’ platform may serve the establishment of a permanent stakeholder network and thus of a new institutional setting that might be essential for the management process during the transformation period to induce changes in formal rules and regulatory, bureaucratic structures impeding change. The importance of informal networks is quite well established for the management of companies and organizations (e.g. Nooteboom and Six, 2003; Wenger, 1998). They have not entered areas such as the management of urban watersheds. One reason is that the coordination of stakeholders is far more complex in these cases.

The establishment of an actors’ platform including representatives from major stakeholder groups should be complemented by invoking the public at large. This was explored for a shift from supply to demand management in the case study introduced in the previous section (Fig. 1).

The shift from supply to demand management is one important issue in the actors’ platform that was established for the Swiss case study of the European project FIRMA (Freshwater Integrated Resource Management with Agents – <http://firma.cfpm.org>). The shift from supply to demand management and the required overall change in strategies implies a profound shift in the attitude of the stakeholders involved towards the role and application of models. Supply management is largely control by technical means in the conventional sense. Demand management involves the management of a social system, the management of consumer behavior. It would be fatal to transfer the management and modeling concepts developed for supply management in a straightforward manner to demand management. There is a profound difference between managing consumers and operating a water utility plant.

Demand management involves two components—the management of average, and in particular the management of peak demand. One of the most straightforward strategies is the management by technical means. On one hand one may introduce water saving technologies, on the other hand decentralized technologies, e.g. local storage tanks for water supply may provide local storage volumes to buffer peak demand. The latter technical solution invokes problems regarding water quality and hygiene. Currently the water utility is responsible for the quality of the water delivered to the consumer. In case of local storage tanks the individual household would have to take care of maintenance and quality assurance of household reservoirs. Such a transfer of responsibility seems rather unlikely at the current stage. Hence, the management of consumer behavior will be of prime importance. It is likely that information

campaigns and price incentives will increase the awareness and thus the responsibility of the consumers. They will have an effect on behavioral and technological options related to water demand. The most comprehensive experience up to date has been gathered in the city of Frankfurt (Cichorowski, 1996). The objectives and roles of the involved groups can be expected to change as summarized in Table 1.

In the new management scheme consumers will adopt an active role. The following steps will be involved to change the role of consumers

- Provide information to consumers about individual water demand and costs.
- Provide information to consumers about behavioral and technological options affecting water demand.
- Enable consumers to make choices affecting their water demand.
- Provide information to individual consumers how their behavior affects the behavior of the system as a whole (e.g. total costs, peaks).

Such comprehensive information will provide the base for consumers to adopt a changed role regarding the management of both long-term trends and short-term events. In particular, in times of peak demand active participation and awareness is crucial since it cannot be expected that the management of peaks will be effective via price incentives only. Being active participants in the management scheme will also change the awareness of the consumers with respect to potential failures and incidents. An accidental interruption of water supply is perceived as a major disturbance. If

consumers become active participants of the water supply management scheme they will realize the trade-offs between absolute security and efficiency. Hence, their willingness to accept a non-perfect system will increase.

4. Citizen participation in the assessment of technological innovations

Citizen participation is now explored in more detail for a profound innovation in urban water management—a change from end-of-pipe solutions to source control in wastewater treatment, from centralized technology to decentralized technology as advocated for example by Larsen and Gujer (1997). Implicit in this shift is the implementation of decentralized technology at the household level. Citizens play thus an important role and gain a higher responsibility. They are involved in the:

- introduction of new technologies both in their role as citizens participating in public decision making and in their role as consumers making choices on the adoption of technologies;
- adoption of new rules and daily routines once the technologies are introduced at the household level. Due to the co-evolution of technology and human habits, the introduction of new technologies may interfere with habits deeply embedded into the routines of the daily life (Kauffmann-Hayoz et al., 1996);
- daily management practices by participating actively in the management of risks and demand.

The attitude of citizens to such a paradigm shift was explored for one important new technology, the separate management of anthropogenic nutrient solutions and urine separation at the household (Pahl-Wostl et al., 2003). This new system was proposed as alternative to the conventional systems currently in use (Larsen and Gujer, 1996; Larsen et al., 2001a,b).

Fig. 4 shows a comparison of the current and the new technology from a system perspective emphasizing the establishment of an urban rural link. In today's system urine is treated in the wastewater treatment plant. Nutrients and endocrine substances, remnants of drugs enter the aquatic environment. The role of endocrine substances in the aquatic environment is a controversial theme. Presumably they have a negative effect on the reproductive capacity of fish and thus on the aquatic ecosystem as a whole (Burkhardt-Holm and Studer, 2000). Conventional agricultural production is resource intensive and uses too much fertilizer that may pollute the groundwater. The groundwater has to be purified to be utilized for drinking water in the households. In the new system urine is separated at the household level. It is converted to fertilizer to be used in ecological farming.

Table 1
Comparison of the change in management paradigm and the role of different stakeholder groups for a shift from supply to a balanced supply and demand management

Kind of objectives and roles	Current management scheme	New management scheme
Overall paradigm governing the water supply/demand system	Maximum supply security irrespective of economic and ecological costs	Economic and ecological efficiency in meeting demand
Objectives and role of water utility	Provide sufficient supply capacity to meet peak demand at any time. Maximum security	Manage the balance between supply and demand. Reduce fluctuations
Objectives and role of consumers	Expect sufficient water at any time. Little knowledge about the system. Little responsibility	Be aware of objectives of the system as a whole. Active participant in making conscious choices regarding water demand options

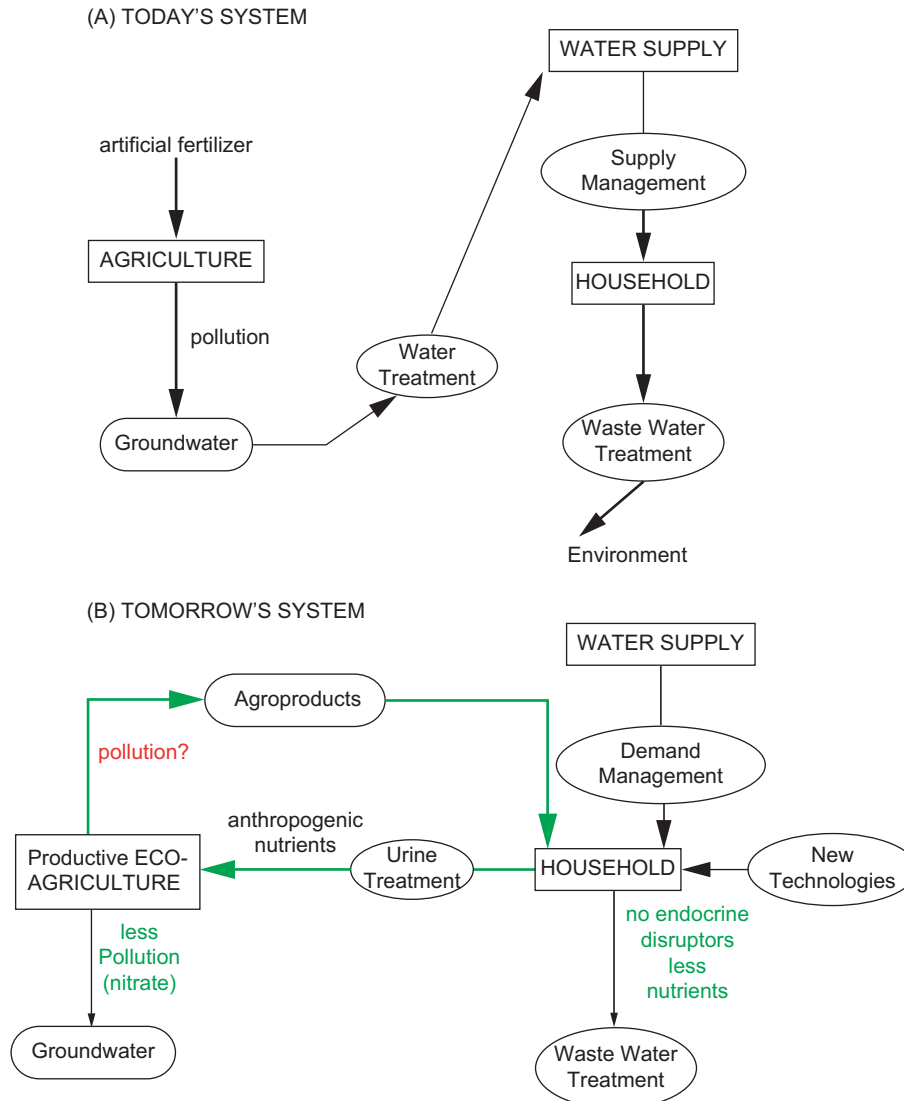


Fig. 4. Comparison of today's (A); and tomorrow's (B) system with urine separation regarding the flows of nutrients, drugs and hormone active substances in a combined urban rural setting. The introduction of new water saving technologies and demand management is also reducing the required supply capacity considerably.

Hence, the nutrient cycle will be closed. Less polluting substances (drugs, endocrine disruptors) will enter the aquatic environment. The new technology leads to considerable water savings. A potential risk is given by the use of urine derived fertilizer for ecological farming. In order to be able to introduce this new technology into an existing system with established infrastructure (sewer network) one intends to use the existing sewer systems to transport the urine from households to the collections side at the wastewater treatment plant. This adaptation of the system to the current infrastructure would be an alternative to a direct collection at household sites in settlements. Up to now the urine separation technology has not been introduced at large scale in modern urban settings.

Currently the new technology of urine separation and the concept of anthropogenic nutrient (AN) reuse in ecological farming are developed and investigated in more detail at EAWAG, Switzerland, in the interdisciplinary project 'NOVAQUATIS' (<http://www.novaquatis.eawag.ch>) (Larsen et al., 2001a,b). Different aspects of the AN technology are explored in a number of projects dealing with engineering, natural science and socio-economic issues. In the context of the NOVAQUATIS project, it was investigated how informed citizens judge risks and benefits of the AN technology.

Consumer attitudes towards no-mix toilets and the idea of anthropogenic nutrients were investigated using the IA-focus group method. The focus group methodology is widely used in public opinion research and in

marketing. Focus groups are based on a group of people being exposed to some common stimulus. The stimulus usually is a television speech, a prototype of a new product, or some similar experience. The focus group method has been further developed for Participatory Integrated Assessment (Jaeger et al., 1999; Dürrenberger et al., 1997). IA-focus groups are deliberative group discussions that make use of computer tools to support the discussion and assessment (Schlumpf et al., 1999, 2001). In general they meet more than once to achieve an in depth discussion of the topic under consideration. The discussions and the social processes in a group are particularly important for the assessment of complex issues where opinion formation plays a major role.

The main issues that were addressed in this study include:

- Elicitation of consumer preferences regarding product attributes such as use, maintenance or design of no-mix toilets in comparison to current technology.
- Assessment of citizens' perception of risks (chronic and failures) arising from pharmaceuticals in urine for the environment today and potential risks in agricultural products in the new system.
- Assessment of citizens' perception of nutrient recycling and its contribution to sustainable development.
- Assessment of citizen's attitudes towards their changed role in a new management scheme.

An interactive citizen information tool (ICIT) was developed for the focus group discussions (Fig. 5). The ICIT serves as information for a broader public via the internet. ICITs are computer-based interactive information tools for citizens. Their purpose is to make decision oriented expert knowledge on complex problems accessible and utilizable for citizens. ICITs can be composed of a combination of deliberative expert judgments and

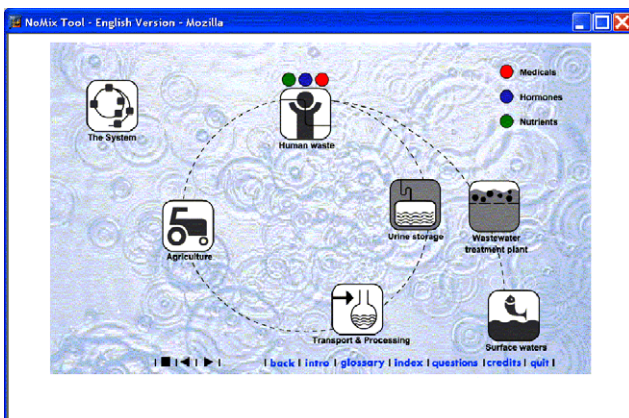


Fig. 5. Graphical user interface of interactive citizen information tool (ICIT). The flows of drugs (red) hormones (blue) and nutrients (green) are symbolized by an animation. The user can get access to additional information from this information tool.

formal simulation models in the form of texts, graphs, images, animations and interactive simulation models and calculation tools. They provide structured, interactive and descriptive access to this expert knowledge.

The information in this system was based on subjective expert judgments and literature surveys. In collecting expert knowledge we followed the experience made in the CLEAR project on participatory integrated assessment of regional climate change (Schlumpf et al., 2001; Pahl-Wostl et al., 2000). In an iterative exchange with experts scientific information was produced that represents the state of the art of knowledge in a field and is accessible and relevant for a lay public. This requires the formation of a network of experts from related disciplines to facilitate the collection of information for the ICIT. The publication of the ICIT via internet allows other scientific experts to check the information provided to the citizens. It informs also an interested public. Fig. 6 shows the whole process of information production and transfer.

The participants for the focus groups were chosen at random but overall the prevailing attitude of participants proved to be environmentally friendly. It was not a trivial task to motivate citizens to participate in such focus groups. The topic of wastewater treatment is not very high on the agenda of a typical Swiss citizen. Information input was provided by the ICIT. Questionnaires were used for evaluation. A short summary of the major results is quite illustrative. A more detailed description and analysis of the results will be described elsewhere (Pahl-Wostl et al., in prep). The complex idea of nutrient recycling and a paradigm shift was not well understood. Citizens were mainly interested in the practical aspects of household/bathroom technology and in the whole issue of drug removal. In particular direct threats to environmental and human health proved to be the main focus of interest. Citizens made their judgments on fragmented aspects of evidence

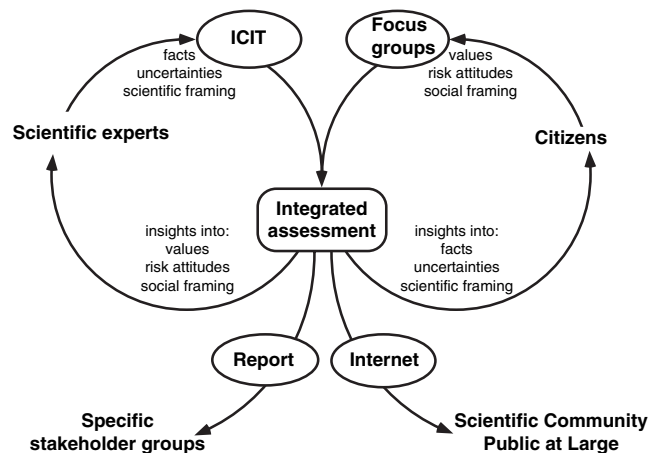


Fig. 6. Process of information production and transfer in the focus group methodology.

rather than on a holistic perception of the system as a whole. The notion of closing nutrient cycles, in particular anthropogenic cycles, is currently associated with a negative bias. Focus group participants made associations to the idea of closing cycles in animal feeding and mad cow disease. Many practical recommendations were made regarding pilot studies for the introduction of the new technology and potential risks (e.g. pollution of fertilizer and thus vegetable, introduction of the technology in hospitals with high drug turnover). Common sense thus proved to be very useful. However, concerns were raised regarding the chances for the technology to be really introduced at a large scale. Even when most participants expressed willingness to introduce the technology in their household they did not consider it plausible for the technology to be introduced in Switzerland as a whole. Here a typical statement:

“Overall I think that the separation technology is a good thing. But I have difficulties to imagine how to put the new philosophy into practice. I am interested to find out how to communicate the idea and how to translate it into action. How many generations will be required—the whole thing is very remote. To be honest, I do not give the whole new philosophy a real chance. Human beings are comfortable and complacent. Often a message is not communicated in the right fashion and to the right audience at the right moment (designer, age 56).”

Regarding the application of urine derived fertilizer in ecological farming many participants expressed severe concerns even when they were favorable towards buying ‘urine-fertilized’ agricultural products. Citizens were worried about risks (chronic and incidental) that cannot be controlled and perceived. In conclusion, citizens did not show a major interest to take more responsibility unless they were provided with facts providing more insight into the functioning of the current system and potential problems. Immediate threats to health proved to be of more importance than considerations related to sustainable management of resources (nutrients).

The focus groups were a first step to involve citizens actively into the process of adopting new technologies. The methodology does not address the public at large and is not supposed to provide a means for the dissemination of information to a wider audience. It is supposed to produce feedback from a selected group of people and to foster creative group discussions for raising novel and imaginative ideas. The results of the project are important for producers of sanitary technology to assess the market potential of no-mix toilets. They are of interest to ecological farmers who have to know if and under which conditions consumers would accept products from ecological farming using

AN-fertilizer. The results provide information for research regarding the type of information required from science to support citizens in their risk assessment.

Citizens will receive more and more responsibilities in their roles as tenants and house-owners once household technologies start to replace centralized technologies. This has to be a stepwise process. From a control point of view, the introduction of household storing devices is useful for breaking the peaks that are the reason for the high capacities of technical facilities. The importance of peaks was already discussed for the design of water supply utilities. It applies as well to the design of wastewater treatment plants where capacities are largely determined by peak loads. New approaches may remove urine peaks by implementing local storage tanks in households and combine them with real time control strategies (Larsen et al., 2001a,b). Instead of allowing peak loads of urine to be delivered to the wastewater treatment plants, intermediate storage will provide a buffering capacity to distribute and thus equilibrate urine loads over a larger time period. However, as pointed out by Larsen et al. (2001a,b) the control of a large number of privately owned small tanks is different from operating one large centralized system. Citizens will receive a higher responsibility in the aspects of daily management and control of failure. The introduction of such household storing devices could be one important first step towards an increased awareness of citizens, consumers regarding their changed role in urban water management in a system where more and more technology and responsibility is delegated to the household level. In the first stage of introducing the urine separation technology, the urine collected in the household storage tanks is supposed to be transported overnight as a flush using the present sewerage system as transporting device. There is a risk of an accidental pollution of the aquatic ecosystems due to heavy rain events during urine flush. Citizens have to be aware of all the risks and benefits and the prospects for change of the new technology to be able to make their choices and judgments in full responsibility. Simply the fact of being confronted with such knowledge and the responsibility to make judgments will start to change the role of citizens.

However, real paradigm shifts require changes in a whole network of stakeholders, and will often involve groups of stakeholders that usually do not communicate.

5. Conclusions

Innovation in urban water management requires an improved understanding of the dynamics of integrated socio-technical systems. The future of urban water management will most likely witness shifts towards more distributed control and new management schemes where the social system becomes part of the management

objectives. Centralized control by a single technological system may be replaced by an increasingly decentralized technology and mechanisms of coordination among stakeholders. New formal and informal institutional settings involving stakeholder networks will increase the flexibility of decision making. This may for example be achieved by the introduction of markets which obviously will be facilitated by a small-scale decentralized technology.

The internet as information source opens entirely new possibilities to include citizens as active participants into management schemes. On line information about relevant data can provide up-to-date and comprehensive information to all stakeholders involved in an issue. Information is essential for the empowerment of citizens in participating in decision making and risk management. However; one has to be aware that such information competes for the time of the general public with an increasing supply of all kinds of distraction.

It is also known that public opinion and the media respond fast and very strongly to extreme events. Investigations about the media coverage of extreme events showed that the effects of such events disappear as fast as it has emerged. It is further well known from research in marketing and voting behavior that citizen choices are often based on the perception of some image of an issue rather than on the rational processing and evaluation of individual facts (see also [Fath and Beck, 2004](#)).

Why should citizens check online information about water quality, for example? From their perspective it must have a meaning in their daily life. Hence, it will be important to carefully consider and explore in a participatory process what type of information should be provided and what the role of informed citizens should be in a new management scheme. On one hand citizen may build up a new image of their urban water management system as a complex and dynamic system changing on many time scales. On the other hand they may learn to perceive themselves in a new role with possibilities for specific action. Providing information without a clear strategy how citizens should become involved in the management processes will be without enduring impact.

Empowerment is not only an aspect that warrants more attention due to procedural justice ([Joss and Brownlea, 1999](#)). It is also an issue of practicality to develop more efficient and flexible management schemes. However, there are yet major efforts to be undertaken to increase the awareness of decision makers, stakeholders groups and the public at large ([Pahl-Wostl, 2002b](#)).

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