Perspectives on innovation: A survey of the Dutch urban water sector

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Perspectives on innovation: a survey of the Dutch urban water sector

R.E. de Graaf[a*], R.J. Dahm[b], J. Icke[b], R.W. Goetgeluk[c], S.J.T. Jansen[c] & F.H.M. van de Ven[a,b]

[a]*Section of Water Resources, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Stevinweg 1, 2628 CN Delft, The Netherlands*

[b]*Deltares, Rotterdamseweg 185, P.O. Box 177, 2600 MH Delft, The Netherlands, and*

[c]*OTB Research Institute for Housing, Urban and Mobility Studies, Delft University of Technology, Jaffalaan 9, PO Box 5030, 2600 GA Delft, The Netherlands*

Abstract

Despite widespread acknowledgement of the need for more sustainable urban water management and the availability of reliable technologies, implementation of new technologies remains limited to small-scale demonstration projects. The receptivity of professionals to innovations seems a determining factor for application of new technologies. An online survey of urban water management professionals in the Netherlands investigated professionals' receptivity to innovations. The results showed that professionals are well aware of innovative technologies. They expect application of these technologies in the near future. However, in general the appreciation of the potential contribution of these technologies to sustainability was moderate.

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* Corresponding author. Email: r.e.degraaf@tudelft.nl, telephone: +31 15 2784673, fax: +31 15 2785559

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1. Introduction

The need for a more integrated and sustainable approach to urban water management practice is widely recognised. In western countries, centralised end-of-pipe systems of urban water management have been successful in tackling public health problems, reducing urban flooding and solving the worst of local environmental problems (Butler and Parkinson, 1997). However, they have also caused environmental degradation, depletion of groundwater resources and are unsatisfactory with regard to nutrient recycling and water efficiency (Niemczynowicz, 1999; Berndtsson & Hyvönen, 2002). In addition, they require large investments and continuous maintenance over extended periods of time (Hiessl, Wals & Toussaint, 2001). Suboptimal outcomes have been achieved by the traditional compartmentalisation of urban water systems (Wong, 2006). More flexible systems of urban water management are required to cope with continuing urbanisation, ageing infrastructure, climate change uncertainties and changing societal demands (Pahl-Wostl, 2005; Meuleman, Cirkel & Zwolsman, 2007). Therefore, many researchers stress the need for total urban water cycle management and an integrated and cross-sectoral approach (Butler & Parkinson, 1997; Larsen & Gujer, 1997; Geldof & Stahre, 2006). Technologies at the household or community level have the potential for improving urban water management. An overview of technical options of local level distributed urban water infrastructure and their potential impact on the urban water cycle is provided by Makropoulos and Butler (2010). New concepts have been introduced over the last decades to respond to the challenges that urban water systems are facing. Examples are: Adaptive Water Management, Water Sensitive Urban Design (WSUD), Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID) and Integrated Urban Water Management (IUWM). These concepts generally represent more holistic approaches with more attention for urban planning, ecological quality and local conditions. They promote stormwater source control rather than large centralised end-of-pipe solutions. Reliable and well-documented decentralised stormwater management technologies and water recycling technologies are currently available to realise more sustainable urban water management in practice. –However, implementation remains limited to pilot projects and trophy systems (Brown, 2005; Hunt and Rogers, 2005).

Institutional obstacles are often mentioned as the main explanation for poor implementation of sustainable urban water technologies (Newman & Mouritz, 1996; Brown, 2005). Bekebrede & Mayer (2006) argue that the design of new technologies not only involves the artefacts themselves, but also have to take into account the social-political environment which has to enable them. Since this environment consists of many stakeholders with conflicting interests, communication skills, cooperation skills and a sympathetic value that supports innovation have become vital instruments for the diffusion of innovations. This suggests an important role for the practitioners in urban water institutions that implement innovative policies or technologies in practice. –Recent publications in urban water management (e.g. Butler, Memon, Makropoulos, Southall & Clarke, 2010) therefore increasingly focus on improving practitioners' understanding of the tools and techniques necessary for adopting sustainable water cycle management in new developments.

The model of receptivity (Jeffrey & Seaton, 2003) originates from technology transfer policy studies. Brown & Keath (2008) propose it as one of the concepts from social theory that may assist in understanding and promoting the mainstreaming of sustainable urban water technologies into professional practice. In order to improve understanding of the incorporation of urban water innovations in professional practice, this study was designed to investigate receptivity of urban water professionals in the Netherlands to innovative urban water management technologies. In addition, this study aims to develop insight in relations between experience, perceived level of knowledge, perceived contribution to sustainability, and expected timeframe for implementation.

2. Methodology

2.1. Framework

Jeffrey & Seaton (2003: 281) defined receptivity as "the extent to which there exists not only a willingness (or disposition) but also an ability (or capability) in different constituencies (individuals, communities, organisations, agencies, etc) to absorb, accept and utilise innovation options". For mainstreaming of new professional practices and alternative technological options, four attributes are required according to the receptivity framework:

- Awareness: being aware that a problem exists, and that alternative options are available.
- Association: associate these options with the stakeholders own agenda and objectives.
- Acquisition: being able to acquire, implement, operate and maintain the alternative options.
- Application: having sufficient legal and financial incentives to apply the alternative options.

The understanding of the capacity of the social environment in which policies or technologies are to be implemented is crucial for the success of implementation. The technology or policy should fit into the values, knowledge and capacities of the recipients of change programs. Receptivity analysis focused on the perception of those individuals who are to implement a new technology or innovation. Jeffrey and Seaton (2003:283) argue that' it is not possible to understand the response and behaviour of people to an artefact, situation or policy instrument without understanding their perceptions, attitudes and the agendas for change that are relevant for them.' Using the receptivity framework as a guiding model the following themes were examined by this survey:

- Experience with urban water innovations (acquisition)
- Considerations to apply innovations (application)
- Perceived level of knowledge of urban water innovations (awareness, acquisition)
- Perceived contribution to sustainable urban water management (association)
- Expected implementation timeframe (application)

2.2. Study focus

This study intended to examine professional perspectives on the implementation of innovative technologies in order to achieve sustainable urban water management. Two sets of technologies were examined. The first set was defined by the respondents themselves. Respondents were asked whether they had implemented innovative technologies in the last three years. No definition of an innovative technology was given. The results therefore reflect the perception of technologies that respondents consider innovative. This approach ensured that the outcomes correspond to professional perceptions rather than a scientifically based definition. The respondents had to specify which technologies they had gained experience with. In addition, they had to assess the importance of a selected set of considerations that led to implementation of the technology. The considerations of respondents were measured using a rating scale with 11 response options, anchored by *not important at all* on the left side and *extremely important* on the right side. The considerations were based on previous research on stakeholder perceptions in urban water management (Brown & Farrelly, 2007) and literature on decision support systems in urban water management (Ashley, Blackwood, Butler & Jowitt, 2004). The considerations were adapted to Dutch circumstances through expert consultation in the Transitions SUW project. This is a Dutch collaborative research project of waterboards, municipalities and researchers to develop and implement innovative technologies for more sustainable urban water management. Table 1 presents the twelve considerations that were studied in this survey.

The second set of technologies that was examined in this survey contained five predefined technologies. Three of them were derived from case studies of the Dutch Transitions-SUW project. The technologies used in this project are: alternative local sources for residential water supply (De Graaf, Van de Ven & Van de Giesen, 2007), using the local urban water system as energy source (De Graaf, Van de Ven, Miltenburg, Van Ee, Van de Winckel & Van Wijk, 2008) and floating urbanisation (De Graaf, Fremouw, Van Bueren, Czapiewska & Kuijper, 2006). Two additional technologies were added because they are often mentioned as sustainable options among professionals in the Netherlands, these are: local stormwater retention (Beenen & Boogaard, 2007) and decentralised sanitation and reuse (Lens, Zeeman & Lettinga, 2001). To provide an example to the respondents each technology was specified with several applications of the innovative technology. Table 2 shows the specification of each technology with several applications to provide an example to the respondents.

The perceived knowledge level for each innovative technology was tested. Five answering categories were precoded ranging from *'never heard of'* to *'expert in this field'*. The respondents were also asked to rate the perceived potential contribution to sustainable water management of these predefined innovative technologies on an 11-point rating scale, anchored by *extremely poor* on the left side and *excellent* on the right side. The questionnaire also investigated the expected implementation timeframe of these technologies in the administrative area of the respondents' organisation.

2.3. Sample

Urban water management professionals were invited to participate in an online survey by the professional organisations of the municipalities and the waterboards. In the Netherlands, waterboards are responsible for flood control, water quality management, wastewater treatment and surface water management. Municipalities are responsible for the sewer system, stormwater management and groundwater management in the public space. The focus of this research was on urban water management and urban drainage, thus water utilities were not included in the survey. The respondents of municipalities are the regional contact persons, the 'water ambassadors' for the implementation of the National Water Agreement (NBW, 2008). A number of 78 water ambassadors were invited to complete the survey. For waterboards, a different approach was chosen. All 26 waterboards in the Netherlands were invited to participate in the survey and were asked to distribute the questionnaire to urban water management experts in their organisation. The respondents are characterised by: (i) involvement in national and European water policy implementation; (ii) overview of regional urban water management issues due to their representative professional role; and (iii) their knowledge of current issues in urban water management. Thus, the respondents can be considered as policy experts who are working at local level in urban water management practice. Due to the method of selection, the results do not reflect the entire urban water management sector and should be considered as the perception of this specific group. Nevertheless, the results are considered relevant for three reasons. First, the respondents have a good overview and insight in local urban water management issues. Second, as policy experts they perform a role as representatives for the sector. Finally, as opinion leaders they influence their peers' behaviour. A number of subgroups were distinguished in the survey based on type of organisation, professional experience, level of education, experience with innovative technologies and attitude towards transformative change. This distinction was made to enable testing of significant differences in the practitioner receptivity based on these characteristics.

A common point of reference among respondents was ensured by defining sustainable urban water management as ‘the management of groundwater, surface water and stormwater in urban areas with regard to water quality and water quantity in order to successfully achieve the objectives of the European Water Framework Directive and the National Water Management Agreement. Furthermore, the urban watersystem optimally enables ecological and social functions against economically responsible costs.’ The main objective of the European Water Framework Directive (EU, 2000) is achieving good ecological and chemical status in all European water systems by 2015. The National Water Management Agreement (NBW) was signed in 2003 as a joint policy of the municipalities, waterboards, province governments and national government in the Netherlands, to reduce flooding to an acceptable level. The agreement has recently been updated (NBW, 2008).

2.4. Survey and Analysis

An online questionnaire with 83 questions was available to urban water professionals in August and September 2008. The respondents did not receive any compensation and participated voluntarily and anonymously in the survey. The data were analyzed with the Statistical Package for Social Science (SPSS) version 16.0. T-tests were executed to find differences in numerical variables based on subgroups. To find significant differences in the knowledge level of innovations based on subgroups, Mann-Whitney U test were executed. This is a nonparametric test to find an association between unrelated subgroups and ordinal data. To find significant subgroup differences in the expected implementation time, chi-square tests were used. The chi-square test was more appropriate for this variable, because the categories of implementation time can not completely be regarded as a ranking order. Finally, chi-square tests were done to find the association between experience, knowledge level, and perceived contribution to sustainable urban water management, and expected implementation timeframes. Respondents, who are convinced that the present urban water system should be replaced with new concepts and technologies to achieve sustainable urban water management, are referred to as transition thinkers in this study. Transition thinkers were identified by two questions in the survey about the necessity of replacing the current urban water system to achieve the national and European water management objectives. Respondents who had the opinion that the current system should only partially be replaced or had the opinion that the current system should be optimised, were identified as mainstream thinkers in this study. The perception of transition thinkers was examined and compared with mainstream thinkers. The case by case method of dealing with missing values was applied in this research. Thus, all valid answers to individual questions were taken into account in the results that are presented.

3. Results

Over a 30 day period, a total number of 74 urban water professionals completed the survey. The respondents were working at waterboards (n=39; 53%), municipalities (n=21; 28%), consultancy firms (n=6; 8%), branch organisations (n=4; 5%) or elsewhere (n=4; 5%). The majority (n=39; 53%) had 5 to 15 years experience in the water management sector, 20% (n=15) of respondents had less than 5 years experience, 27% (n=20) more than 15 years. A percentage of 97% (n=72) had a university degree or higher professional education (technical college) degree. More than 90% (n=67) had a background in either engineering or natural sciences. The respondents were predominantly working as policy advisor, senior policy advisor or project leader. The distribution of respondents over small municipalities (<100,000 citizens; 64%) and large municipalities (>100,000 citizens; 36%) was about comparable to the distribution of the Dutch population: 27% of the Dutch population is living in large cities (CBS, 2008).

3.1. Experience with innovations

Nowadays there is a wide interest in the application of innovative technologies in the urban water sector. The results from the questionnaire show that 57% (n=42) of the respondents have been involved in urban water projects in which an innovative technology was applied during the last three years; 2005 - 2008. The largest group (40%; n=17) has gained experience with local water retention. The remaining respondents have experience with a variety of innovative technologies, such as water as source of energy (5%), alternative sources of water supply (5%), operational sewage management (5%), surface water retention (8%), innovative dredging (5%), management of interactions between urban and rural water management (5%) and other technologies. The proportion of transition thinkers that has experience with applying innovations is relatively high: 83%. However, due to the relative small group size the survey did not yield significant differences compared to mainstream thinkers.

3.2. Considerations to apply innovative technologies

The 42 respondents who have gained experience with innovations were asked to rate the importance of twelve considerations in the decision making process that led to application of the innovative technology. The mean results seem to show a partitioning into three groups of decreasing importance (see Table 3): i) one group of four considerations that are most important, ii) one group of six considerations showing moderate importance and iii) one group of two considerations showing the least importance.

Table 4 shows the statistical significant differences between subgroups. In general, not many differences were observed. Type of organisation seems an important factor for financial incentives. For respondents employed at waterboards, this consideration is significantly less important than for respondents working at municipalities. This may be explained by the fact that in the Netherlands, waterboards are eligible to collect taxes for water management.

Municipalities on the other hand, have to make a political deliberation to spend funds on water management or other themes.

Transition thinkers found three considerations significantly more important than the mainstream thinkers. Even though the group of transition thinkers was small, three statistically significant differences were found (see Table 4). Transition thinkers believe that current urban water systems should be completely replaced by new concepts and new technologies. Presumably, they believe that reliable technologies that organisations have experience with should be applied to achieve this purpose. In addition, this group regards connection to spatial planning and organisational experience as key considerations to choose an innovative technology. The relatively low standard deviation is an indication for a high level of consensus among transition thinkers with regard to these factors. Finally, investment costs were more important to respondents with a higher professional education compared to respondents with a university degree. The former group may be more focused on practical considerations such as costs in comparison to the more theoretical approach of the respondents with university education.

3.3. Perceived knowledge level of predefined technologies

All respondents were asked to answer questions with regard to their knowledge of the five predefined innovative technologies, including those respondents without recent experience with innovations. Five answering categories were provided: *'never heard of', 'heard of, but not familiar', 'reasonably familiar', 'well-known'*, or *'expert in this field'*. The respondents are aware of the innovative technologies. For all technologies, less than 10% of the respondents had have never heard of the technologies. However, this familiarity did not correspond to a high knowledge level. Table 5 shows the aggregated results in which *well-known'*, or *'expert in this field'* are combined to the category '*high knowledge level'* and the other categories to '*low* *knowledge level'*. Water retention is the only technology with a high proportion in the high knowledge level category.

Significant differences between subgroups and the original five knowledge level categories were found based on Mann-Whitney U tests. Respondents with experience in applying innovative technologies have more knowledge of water retention (p=0.0030) and urban water system as energy source (p=0.030) than those who do not have this experience. In addition, respondents with university education have better knowledge of water retention (p=0.012), the use of the urban water system as energy source (p=0.010) and the use of alternative water sources (p=0.024) compared to respondents with higher professional education.

Senior respondents have a significantly higher knowledge level of one technology: alternative sources of water supply (p=0.005). This could be explained by the fact that constructing a third pipe system was prohibited by the national government in 2003 after the Leidsche Rijn incident. In this new residential development near Utrecht, a misconnection between two networks occurred in 2001 (Van Geel, 2003). Since the prohibition, the debate on alternative water sources in urban water management has almost ceased in the Netherlands. Consequently, junior employees may not have been exposed to knowledge of alternative water sources and are therefore less familiar with this technology.

Notably, most respondents who qualify themselves as *'well known'* or *'expert in this field'* were not recently involved in projects in which the specific technology was applied. According to them, a high level of knowledge can be achieved without having experience with this specific technology and can be obtained by internalisation of explicit knowledge instead of experience. This suggests a high appreciation of theoretical knowledge rather than experiential or practical knowledge. It may also suggest a distance or disconnectedness to practice of this professional community. Table 6 shows that one third of the respondents, who consider themselves as *'well known'* or *'expert in the field'*, have not had recent involvement in a project which utilised innovative technologies

3.4. Potential contribution to sustainable water management

The respondents were asked to value the perceived potential contribution of innovative technologies to achieve sustainable urban water management. Local stormwater retention was given the highest rating; 7.6 on an 11-point scale (ranging from 0 to 10), thus showing the respondents' confidence in this technology to contribute to sustainability. A moderate to high appreciation was given to alternative local sources for residential water supply (7.0). A moderate rating (6.6) was given to the use of the local urban surface water as energy source. Two technologies were considered to have the lowest potential contribution: floating urbanisation and decentralised sanitation and reuse with an average of 6.3, respectively 6.2. A possible explanation might be that these are the two technologies that the respondents have no experience with. The technology that most respondents have experience with was rated highest. However, no significant differences were found between the subgroups.

3.5. Expected implementation period

This part of the survey intended to develop insight into the expected implementation period of innovative technologies. Questions focused on application of the innovations in the administrative area of the respondents' employer, for instance in a pilot project. Table 7 shows that all innovative technologies have already been implemented in at least some areas. The implementation of floating urbanisation is least common. Local stormwater retention is the most widespread innovation. Chi-square tests provided two significant statistical differences. Waterboards have a higher expectation of decentralised sanitation compared to municipalities ($p=0.033$). Respondents with recent professional experience with innovative technologies are more positive about the implementation period of the water system as energy source (p=0.025). Although transition thinkers seem more positive about the implementation of innovations than mainstream thinkers, the size of this group did not allow for significant differences to be found. For local stormwater retention (p= 0.053), the use of the local urban water system as energy source (p=0.025) there is a significant correspondence between experience with innovation and the expected implementation period. Respondents with experience expect faster application than those without this experience. Most innovative technologies show a significant correlation between the perceived knowledge level and expected implementation period. For water retention the chi-square test could not be executed because the number of respondents who do not expect application of this technology is insufficient. Results are presented in table 8.

4. Discussion

The respondents in this survey are well aware of the innovative options that are available in current water management. Most of them have heard of the innovations that were studied in this survey. The first component of the receptivity framework, awareness, seems well developed. The respondents predominantly foresee application of these technologies in the administrative area of their current employer in the near future. Despite having these positive expectations, the respondents generally have a low knowledge level of the surveyed technologies, with the exception of local water retention. Capacity building by improving the knowledge could contribute to mainstreaming of these innovations. It improves the third component of the receptivity framework acquisition and also seems to improve application. The results of this survey provide support for this. A positive relationship between knowledge level and expected implementation time was found. Improved knowledge of innovations could further decrease the expected implementation time. This is important since expectations in a professional community is a factor that can enable, shape or prevent further development of a specific technology (Van Lente & Rip, 1998).

The respondents had a moderate appreciation of the potential sustainability contribution of the technologies. The second component of the receptivity framework, association, indicates barriers to further diffusion of the technologies. The exception is local stormwater retention that received a high rating. Technologies that improve water quality, such as decentralised sanitation, and technologies that decrease fossil fuel dependency, such as using the local urban surface water as energy source, received moderate ratings. A possible explanation is the lack of experience respondents have with these technologies. With the exception of local stormwater retention, the personal experience level with innovative technologies in urban water management was low. However, the respondents do not see professional experience as an essential condition to achieve a high level of knowledge. The majority of the respondents, that gave a high qualification to their own knowledge level for a specific technology, had no recent experience with this technology. One possible explanation might be that the professionals who participated in this survey prefer explicit knowledge above tacit knowledge. In their role of regional contact persons and policy experts, explicit knowledge is probably more useful than tacit knowledge. Explicit knowledge is knowledge in the form of books, guidelines and report whereas tacit knowledge is personally bound and gained by personal experience in practice. Nonaka and Takeuchi (1995) found that western organisations are often more focused on explicit knowledge rather than tacit knowledge. However, in the same book, the authors demonstrate that both types of knowledge are essential in innovation processes. Explicit knowledge is needed to be able to apply most recent technologies and distribute knowledge. Tacit knowledge is essential when the step from vision to implementation is made. The lack of experience with innovations among the respondents could imply a lack of appreciation of tacit knowledge which can be an obstacle to innovation in the urban water sector.

The results provide indications that building experience is necessary to advance innovations in urban water management. The respondents who had recent professional experience with innovative technologies showed a more positive attitude towards the expected implementation timeframe for two technologies. Possible measures to enhance the receptivity of professionals should therefore include increasing the exposure of professionals to innovative practice to strengthen tacit knowledge. Organisational reward mechanisms to encourage employees to be involved in the actual application of innovations could be a possible way to accomplish this objective. Demonstration projects should be started in order to build more experience with these technologies. This is in correspondence with the observation of Brown, Farrelly & Keath (2009) who listed well-designed demonstration projects as a way to improve receptivity of professionals. Demonstration projects can also contribute to improving the reliability of technologies, which in this survey appeared to be one of the most important considerations for application. Demonstration projects should be combined with capacity building programs, evaluation and monitoring to allow for improvement and replication of these technologies on a wider scale. Without this condition, the application of innovative technologies will remain limited to showcases and demonstration projects, with no significant impact on the overall performance of urban water systems.

Notably, none of the considerations for application of innovations in urban water management received a high rating. Perhaps, the twelve pre-defined considerations do not cover the whole range. Follow up research is necessary to obtain improved insight into the considerations to apply innovative solutions in practice. Transition thinkers in the survey regard reliability of new technologies, organisational experience and effects on spatial planning as key considerations to apply new technologies. This small group has a strong internal consensus on the importance of these factors. Recent research on water management transitions has also suggested that these key factors are essential (Van der Brugge, Rotmans & Loorbach 2005; Brown et al., 2009). The strongly differing opinion of the transition thinkers compared to mainstream thinkers seems remarkable. Although the authors expected to find a group with the opinion that the current urban water system should be replaced, it was not expected that such a small group would have a significantly different opinion on considerations to apply innovations. The transition thinkers in particular value the reliability of the technology, the effects on spatial planning and the organisational experience with a particular technology. Moreover, the results provide indication that there may be a strong internal consensus on these considerations within the group of transition thinkers. In addition, almost all transition thinkers have experience with applying innovations. Limitations of the research results are found in the small group size. However, the results suggest a strongly differing opinion of this subgroup. This should be investigated in more detail in follow up research to allow for more general conclusions.

Our current urban water systems have been successful in dealing with public health problems (Butler & Parkinson, 1997). However, for applying new technologies, public health impact was considered unimportant. It seems that one of the main functions of urban water management and sewer systems (Larsen & Gujer, 1997) is not an issue when implementing innovative technologies. A possible explanation could be that the respondents feel that major public health problems are already solved, and consequently, they do not focus on the health impact of new technologies. This would imply that the urban water system will continue to function as current systems, which can only be the case when incremental changes are applied. Innovations that are not compatible with the current centralised system and potentially pose a threat to public health have hardly been applied by the respondents.

Current urban water systems are technologically and institutionally locked in the conventional paradigm. The most important question is how to make a transition from the existing systems to more sustainable systems (Kotz and Hiessl, 2005). The institutional capacity to implement and maintain innovations is an important element for the transformation of urban water systems (Söderberg and Johansson, 2006; Wong, 2006). Pahl-Wostl (2005) stated that the shared knowledge of professionals combined with expectations of stakeholders causes a status quo in the water system. The inertia in the technical system and the social rules and habits are obstacles to change. Brown and Farrelly (2009) conducted an extensive international literature review on socio-institutional obstacles that prevent urban water management from changing. They found 12 barrier types that were mainly related to insufficient capacity and commitment of urban water management stakeholders to change their way of working. This study adds support and provides empirical evidence that is in line with the observations of the international commentators above. The results on Dutch professional perspectives demonstrates the lacking association, knowledge and capacity of professionals to mainstream urban water management innovations. The institutional capacity for transforming urban water management infrastructure is lacking.

There is a lack of comparable research on receptivity of professionals in the urban water sector. However, the results of the Dutch survey corresponds with the results of an Australian survey on professional perceptions on social and institutional barriers to implementing sustainable urban water management (Brown, Farrelly & Keath (2009)). Also according to the professionals in the Australian survey, insufficient association and acquisition skills were the main barriers to mainstreaming of diverse water source technologies. Comparing the Dutch research findings of this survey with international literature may allow for further generalisations to be made. Indications of the importance of demonstration projects to improve receptivity of professionals were found in this survey but were also found in previous research in a different geographical and socio-political context (Brown, Farrelly & Keath (2009)). The survey provides indications of the importance of learning and tacit knowledge which also has been described in the international management literature (Nonaka en Takeuchi, 1995). This seems even more important because a third of the respondents thought they were experts on urban water management innovations although they had no recent experience with applying innovations.

This article also gives a possible explanation or hypothesis for future research for the observation in international literature (Brown, 2005; Hunt and Rogers, 2005) that innovative urban water management technologies remain limited to demonstration projects. This might be partially explained by the fact that the professionals expect these innovations to remain isolated. In this survey, most respondents expect implementation of innovative technologies in the near future. However, they had a low expectation of the potential contributions of these technologies to achieve the objectives of sustainable urban water management. The respondents might have a low expectation of the effectiveness of urban water management innovations, or they might expect that urban water management innovations will only be applied on a small scale, thus lacking the potential to have impact on the wider urban water system. It would be useful to examine the expectations of professional urban water management communities in other countries in order to further study these observations.

5. Conclusion

Urban water systems are facing the challenges of ongoing urbanisation, climate change and increasing societal demands. Over the last decades, various approaches have been developed to respond to these challenges. These approaches generally focus on source control and local solutions of dealing with stormwater and water supply. Reliable technologies for a more sustainable urban water management are currently available. However, as observed by many scientists, their application remains limited to either incremental improvement of the current system or demonstration projects. Research in urban water management has shown that demonstration of technical and economic feasibility will not necessarily lead to widespread application. Stakeholder receptivity to innovative technologies is a key factor to further advance sustainable urban water management. The objective of this study was to gain insight in the receptivity of professionals in the Dutch urban water sector to innovative technologies. The study addressed five themes; experience with innovations in general, considerations to apply innovations, current knowledge level, perceived contribution to sustainability, and expected implementation timeframe. The results showed that the respondents are well aware of the technical innovations and expect application in the near future. However, in general their knowledge level of innovations is low. Most respondents that had a high knowledge level of a specific innovation, have not had recent involvement in projects in which this innovation was applied. Moreover, the respondents have a moderate appreciation of the potential contribution of these technologies to sustainable urban water management. The results reflect significant obstacles to mainstreaming of innovations for sustainable urban water management. Professionals are not yet convinced that innovations are essential to achieve sustainable water management. For most of the technologies their level of knowledge is low. They are not convinced that personal experience in the practical application and further development of these innovations is required to achieve a high knowledge level. It is therefore recommended that future reform interventions to transition to more sustainable urban water management are more targeted at improving association and acquisition.

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Table captions

Table 1. Considerations for the application of innovative technologies that were tested in this survey

Table 2. Some illustrative applications of the innovative technologies

Table 3. Considerations to choose innovative technologies to achieve sustainable urban water management

Table 4. Statistical differences of importance of considerations (scale 0-10) to choose innovative technologies according to subgroups (WB=Waterboard, MU=Municipality, TT=Transition Thinker, MT=Mainstream Thinker, HPE=Higher Professional Education, UE=University Education)

Table 5. Knowledge level of innovative technologies among subgroups, bold font is used for statistically significant subgroup differences.

Table 6. Cross tabulation of experience and knowledge level of respondents who classified their knowledge level as *'well known'* or *'expert in the field'*.

Table 7. Perceived implementation period of innovative technologies among subgroups

Table 8. Significant correlations from chi-square tests between knowledge level of technologies and expected implementation period

Tables

Social considerations	Economic considerations	Ecological considerations	Technical considerations
Effects on spatial planning	Investment costs	Environmental impacts	Inadequacy of conventional technology
Acceptability to citizens	Operational costs		Organisational experience with innovative technologies
Effects on public relations	Availability of financial incentives and subsidy schemes		Expected implementation timeframe
Public health impacts			Reliability of technology

Innovative technology	**Applications**
Water retention	Green roofs Water retention square Infiltration facilities
Decentralised sanitation and reuse	Separate collection of urine and other wastewater stream
Source of energy	Aquifer Thermal Energy Storage (ATES) Local surface water as energy source
Alternative sources of water supply	Rainwater and stormwater Local surface water Local groundwater
Floating urbanisation	-

Considerations	Mean (n=42)	St. Dev
Reliability of innovative technology	7.1	0.31
Effects on spatial planning	7.1	0.34
Environmental impacts	7.0	0.38
Investment costs	7.0	0.30
Inadequacy of conventional technology	6.5	0.39
Acceptability to citizens	6.3	0.33
Operational costs	6.3	0.30
Effects on public relations	6.3	0.29
Organisational experience with innovative technologies	6.3	0.34
Expected implementation timeframe	6.1	0.32
Public health impacts	5.3	0.33
Availability of financial incentives and subsidy schemes	5.1	0.43

Considerations	WB (n=12)	Std Dev	MU (n=19)	Std Dev
Availability of financial incentives, subsidy schemes	3.9	2.50	6.1	2,83
	TT (n=5)		**MT (n=36)**	
Reliability of innovative technology	8.4	0.55	6.9	2.06
Effects on spatial planning	9.2	0.84	6.7	2.40
Organisational experience with innovative technologies	7.4	0.90	6.1	2.20
	HPE (n=24)		**UE (n=15)**	
Investment costs	7.9	1.50	6.3	1.9

			Employer		Professional experience		Experience with innovations		Attitude towards change		Level of education	
Innovative technology	Classification	General (n=71)	WB (n=37)	MU (n=21)	<10 years (n=42)	> 10 years (n=29)	Yes (n=40)	No (n=31)	TT (n=6)	MT (n=65)	HPE (n=33)	UE (n=37)
	Knowledge Level	%	%	%	%	%	%	%	%	%	%	%
Water retention	Low	28	29	29	33	20	**15**	**44**	17	29	**46**	**14**
	High	72	71	71	67	80	**85**	**56**	83	71	**54**	**86**
Decentralised sanitation and reuse	Low	65	67	62	67	62	59	72	67	65	62	68
	High	35	33	38	33	38	41	28	33	35	38	32
Urban water system as a source of energy	Low	75	86	76	79	70	**68**	**84**	50	77	**82**	**68**
	High	25	14	24	21	30	**32**	**16**	50	23	**18**	**32**
Alternative sources of water supply	Low	57	62	60	71	37	48	69	67	56	**70**	**46**
	High	43	38	39	29	63	52	31	33	44	**30**	**54**
Floating urbanisation	Low	71	76	74	77	63	68	75	50	73	78	62
	High	29	24	26	24	37	32	25	50	27	21	38

Innovative technology	Respondents who have a high perceived knowledge level of a specific technology	High perceived knowledge level and recent experience with this specific technology	High perceived knowledge level, recent experience with other technologies	High perceived knowledge level, no recent experience with innovative technologies
Water retention	n=52	30.7%	34.6 %	34.6%
Decentralised sanitation	n=25	0%	64.0 %	36.0 %
Water system as a source of energy	n=18	5.6%	66.7 %	27.8 %
Alternative sources of water supply	n=31	6.5%	61.3 %	32.3 %
Floating urbanisation	n=21	0%	52.0 %	38.0 %

			Employer		Professional experience		Experience with innovations		Attitude towards change		Level of education	
Innovative technology	Classification	General (n=71)	WB (n=37)	MU (n=21)	<10 years (n=42)	> 10 years (n=29)	Yes (n=40)	No (n=31)	TT (n=6)	MT (n=65)	HPE (n=32)	UE (n=37)
		%	%	%	%	%	%	%	%	%	%	%
Water retention	Already implemented	62	71	60	62	62	75	45	83	60	53	68
	Near future	24	29	24	24	24	13	39	17	25	28	22
	Future	6	0	8	2	10	5	7	0	6	6	5
	No expectation	9	0	8	12	3	6	10	0	9	13	5
Decentralised sanitation and reuse	Already implemented	19	**34**	**11**	21	14	18	19	50	16	19	19
	Near future	29	**38**	**21**	26	32	26	32	17	30	32	24
	Future	29	**14**	**38**	26	32	33	23	33	28	32	24
	No expectation	24	**14**	**30**	26	21	23	26	0	27	16	32
Urban water system as a source of energy	Already implemented	30	30	24	24	38	**40**	**16**	50	28	16	41
	Near future	37	35	52	36	38	**30**	**45**	33	37	41	32
	Future	21	19	19	24	17	**25**	**16**	17	22	31	14
	No expectation	13	16	5	17	7	**5**	**23**	0	14	13	14
Alternative sources of water supply	Already implemented	21	14	11	17	28	28	13	17	22	16	41
	Near future	35	43	27	38	31	33	39	50	34	40	32
	Future	24	29	32	21	28	23	26	33	23	31	14
	No expectation	20	14	30	24	14	17	23	0	22	13	14
Floating urbanisation	Already implemented	17	29	16	12	24	20	13	33	15	19	16
	Near future	30	38	35	29	30	35	23	67	26	28	32
	Future	28	24	24	31	28	18	42	0	31	28	27
	No expectation	25	9	24	29	25	28	23	0	28	25	24

Innovative technology	Value	Chi-square significance level p
Water retention	n/a	n/a
Decentralised sanitation	7.060	0.070
Water system as a source of energy	12.01	0.070
Alternative sources of water supply	16.04	0.001
Floating urbanisation	7.97	0.047