Risk perceptions and receptivity of Australian urban water practitioners to stormwater harvesting and treatment systems

M. F. Dobbie and R. R. Brown

ABSTRACT

Stormwater harvesting and treatment will be critical systems within water-sensitive cities. Although water practitioners acknowledge the importance of developing stormwater as a water source, their risk perceptions might be barriers. Risk perceptions can be understood within a receptivity framework, with awareness, association, acquisition and application components. In this study, water practitioners’ risk perceptions of stormwater harvesting and treatment in Australian cities were examined within this framework, to identify where to focus reform efforts within the water industry to improve their adoption. Analysis of data from an online survey exploring water practitioners’ perceptions of risk of alternative water systems revealed that three-quarters of respondents thought stormwater harvesting and treatment yielded at least moderate benefits, supporting fit-for-purpose use of treated stormwater and installation of the infrastructure in different contexts. Perceived general risk of each was slight, although stormwater harvesting was perceived as more risky than treatment, and this difference persisted for specific risks, e.g. public health, environmental. In terms of the receptivity framework, perceived specific risks of stormwater harvesting and treatment systems challenge, to different extents, the practitioners’ association, acquisition and application of the systems in Australian cities. In particular, reform efforts should be targeted to perceived management and cost-related risks.

Key words | receptivity, risk perception, stormwater harvesting and treatment systems, water practitioners

INTRODUCTION

Stormwater harvesting and treatment will be critical systems within the water-sensitive city, providing benefits of augmented water supply, waterways protection, urban heat mitigation, reduced drainage infrastructure requirements and enhanced visual amenity that are not associated with traditional stormwater drainage systems. Although water practitioners acknowledge the importance of developing stormwater as a water source, their perceptions of social and institutional processes and practices in the management of urban water have been identified as barriers (Brown & Farrelly 2009; Brown et al. 2009). These barriers can be understood as types of risk.

The Australian water industry is overtly risk-averse, in which risk management involves the objective assessment of risk, focussing primarily on public health (e.g. Australian Drinking Water Guidelines 2004; Australian Guidelines for Water Recycling 2008). Practitioners are known to be concerned about the public health risks of decentralised systems (Fane et al. 2002; Brown et al. 2009), although these concerns do not extend to stormwater quality treatment technologies (Brown & Farrelly 2009). However, the risk profile of stormwater harvesting and treatment systems is broader than just public health, certainly including environmental risks (Australian Guidelines for Water Recycling 2009) but also...
technological, cost-related and political risks (Pollard et al. 2004; Baggett et al. 2006; Salgot et al. 2006; Willetts et al. 2007).

Risk perception is acknowledged to have a role at the programme level of risk management, in ranking risks to set management priorities (Long & Fischhoff 2000). However, the covert risk perceptions of water practitioners need to be understood more fully, to allow critical reflection on their wider influence in risk management activities and their outcomes in relation to alternative water systems, including stormwater harvesting and treatment.

Brown & Farrelly (2009) interpreted the barriers to alternative water systems in terms of a receptivity framework developed by Jeffrey & Seaton (2003/2004), to identify where strategies might be best applied to overcome them. This study applies the same receptivity framework to understand practitioners’ risk perceptions of stormwater harvesting and treatment systems in Australian cities.

Receptivity is defined as ‘the extent to which there exists not only a willingness (or disposition) but also an ability (or capability) in different constituencies (individuals, communities, organizations, communities, etc.) to absorb, accept and utilize innovation options’ (Jeffrey & Seaton 2003/2004, pp. 281–282). Thus, receptivity analysis focuses on the attitudes and perceptions of recipients towards innovations and technologies. Developed from the literature on innovation and technology transfer to evaluate water management policy, it has four components — awareness, association, acquisition and application. In applying this framework to the question of barriers to adoption of alternative water systems, the following definitions are used.

- Awareness: recognition of a problem and the existence of possible technological and/or procedural solutions.
- Association: recognition that the proposed solution is associated with sufficient benefits to warrant the effort to implement it.
- Acquisition: easy access to the required skills, resources and support to implement the solution and overcome the problem.
- Application: exposure to appropriate and sufficient incentives, e.g. regulations and policies, to facilitate implementation of the solution.

Although these are listed as a sequence, it need not be linear (Jeffrey & Seaton 2003/2004).

Current attitudes and perceptions of water practitioners towards stormwater harvesting and treatment systems can be understood within this receptivity framework, by relating various risk perceptions to the receptivity components. Fourteen possible risks associated with stormwater harvesting and treatment were identified from the literature (Pollard et al. 2004; Fane et al. 2005; Baggett et al. 2006; Schäfer & Beder 2006) and related to the framework (Table 1). It was assumed that all water practitioners are aware of the water-supply challenge and the need to develop alternative water supplies such as stormwater, and so interpretation focused on association, acquisition and application components. Risk perceptions that compromised association, acquisition and application of stormwater harvesting and treatment were identified. This will allow reform efforts to be most effectively targeted and applied within the water industry to improve the adoption of stormwater harvesting and treatment systems.

### METHODS

Data were obtained from a national online survey. In a comprehensive plan to promote the survey amongst practitioners, key individuals within stakeholder organisations, e.g. government departments, water utilities and professional associations, were recruited to recruit, in turn,

<table>
<thead>
<tr>
<th>Association</th>
<th>Acquisition</th>
<th>Application</th>
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<tr>
<td>Public health</td>
<td>Technological failure</td>
<td>Capital cost</td>
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<td>Environmental</td>
<td>Management failure</td>
<td>Maintenance/operations cost</td>
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<td>Constrained future innovation</td>
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<td>Constrained future innovation</td>
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<td>Aesthetic</td>
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<td>Flooding</td>
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Table 1 | Perceived risks, drawn from the literature, related to three of the four components of the receptivity framework—association, acquisition and application. It was assumed that all practitioners were aware of stormwater harvesting and treatment and so the awareness component was not explored.
participants across Australian cities. The first section of the survey collected demographic data, including age, gender, city, primary qualifications, stakeholder group, type of work and work area within the water industry, level within the organisational hierarchy, and years’ experience. The second section explored attitudes towards risk and general risk perceptions towards a number of alternative water systems, of which stormwater harvesting and quality treatment were just two. Stormwater harvesting was not defined; stormwater quality treatment systems were elaborated by the phrase ‘(for protecting receiving waterways, i.e. wetlands and bioretention systems)’. In two questions, practitioners were asked to nominate the uses they supported for different sources of water and the development contexts they supported for each alternative water system. Multiple responses were allowed. Other questions included rating general risk of using water from different sources in different applications varying with degree of personal contact and general risk of using various alternative water systems, on a modified 4-point Likert scale. In the next section, respondents rated each water system, including existing centralised systems, for the various specific types of risk, e.g. public health, environmental, capital cost, again on a modified 4-point Likert scale. They then rated the benefit of each alternative water system, again on a modified 4-point Likert scale. The final section asked questions relating to trust, confidence, and management and ownership of the systems, liking for the technologies, and risk tolerance of organisations, groups and individuals, concluding with a question about the level of constraint imposed by the current centralised water supply, wastewater and drainage systems. In all, 620 respondents commenced the survey, with decreasing completion rates with each section. Overall completion was 40%, which is comparable to the average response rate for online surveys (Cook et al. 2000). The total survey took about 30 min to complete.

Statistical analysis was conducted with SPSS 19 (IBM, Armonk, NY, USA). Questions relating to benefit of stormwater harvesting and treatment systems, supported fit-for-purpose uses of stormwater and support for the systems in different development contexts, general risks associated with stormwater harvesting and treatment systems, and specific risks were analysed and interpreted for receptivity. Results are for the aggregated data. Frequency distributions of responses were determined for all questions, and means (\( M \)), standard deviations (s.d.) and medians for rated data. Before analysis, benefit and risk rating data were recoded so that 0 represented no benefit/risk; 1, slight benefit/risk; 2, moderate benefit/risk; and 3, significant benefit/risk. Thus, the maximum mean value possible for each was 3. In addition, the influence of the demographic variables on perceived general risk was explored by analysis of variance. Only those statistically significant differences with a moderate or large effect size (\( \eta^2 \geq 6\%: \text{Cohen} 1988 \)) are presented.

**RESULTS AND DISCUSSION**

Response representativeness of a survey is more important than response rate (Cook et al. 2000). Demographic analysis showed that respondents commencing the survey were drawn from Perth, Melbourne, Sydney, Adelaide and Brisbane and regional centres in Western Australia, Queensland and New South Wales, representing predominantly corporatised government-owned water utilities, state and local governments and consultancies. Although respondents spanned the full age range from 18–24 years old to more than 65 years old, more than 75% were aged 25–55 years; 62% were male. All organisational levels were represented but middle levels predominated. Experience in the water industry ranged from less than 2 years to more than 20, with almost half the respondents having 10 years or less experience. Almost two-thirds had either a design/technical/operations role or a strategy/policy role, and almost half worked either with stormwater/waterways or total water cycle management. The most common primary qualification was engineering (30.6%) or science (25.8%). Frequency distributions were similar for respondents completing the survey.

Analysis of responses relating to stormwater revealed that 74% of the respondents (\( N = 363 \)) thought stormwater harvesting yielded at least moderate benefits (\( M = 2.03, \text{s.d.} 0.852 \)), increasing to 84% for stormwater treatment (\( M = 2.28, \text{s.d.} 0.787 \)). Support for different fit-for-purpose applications of stormwater was greatest at 72% (\( N = 444 \)) for use in public outdoor space, decreasing with increasing personal contact: outdoor household use (66%), non-potable indoor use (56%) and drinking (30%).
It also decreased slightly for industrial use (66%) and for increasing environmental flows (60%). However, 18% supported no application of stormwater. This contrasted with 68% and 70% of respondents supporting the use of stormwater harvesting and treatment, respectively, in retrofitting existing developments, which increased for redevelopments (80% and 82%, respectively) and for greenfield developments (82% and 86%, respectively). Again, some respondents did not support stormwater harvesting (6%) or stormwater treatment (3%) in any of these contexts.

The practitioners perceived the general risk of both stormwater harvesting and treatment as less than slight, although the general risk of stormwater treatment ($M = 0.61$, s.d. $0.674$, $N = 444$) was lower than that of stormwater harvesting ($M = 0.94$, s.d. $0.711$, $N = 444$). The specific risks associated with each were perceived to be less than moderate (Figures 1 and 2); again, those associated with
stormwater treatment were always lower than those associated with stormwater harvesting. For both systems, highest mean perceived risks were associated with capital costs, maintenance/operations costs and management failure, with mean values lying between slight and moderate. The practitioners perceived technological and commercial risks to be more than slight for both systems. They differed in perceiving public health, environmental, political and compliance risks and risks of loss of reputation and loss of end-user commitment as more than slight for stormwater harvesting but as less than slight for stormwater treatment. Median values for all risks were 1, except for capital cost and maintenance/operations cost risks for stormwater harvesting, which were 2. This means that for all risks associated with stormwater systems, except for capital cost and maintenance/operations cost risks for stormwater harvesting, 50% of respondents perceived the risk to be slight at most. In contrast, 50% of respondents perceived capital cost and maintenance/operations cost risks for stormwater harvesting to be moderate at least; from Figure 1, 10% at least perceived a significant risk. Nevertheless, these frequencies were only slightly less for stormwater treatment: although the median was 1, a large proportion of respondents still rated these risks as moderate at least. In general, perceived risk of the different uses of treated stormwater increased with personal contact — from toilet flushing to drinking — but all were perceived as less than moderate (Figure 3).

To interpret these results in terms of the receptivity framework, mean and median values and frequency distributions were all considered. Specific risks with a mean value $\leq 1$ (i.e. slight risk), with a median value of 1 and 5% or less of respondents perceiving a significant risk, were interpreted as not challenging receptivity of the system. This choice was based on the survey results for public health risks attributed to the traditional stormwater drainage system. Public health risks have driven the development of these systems and the water industry manages them to minimise these risks (Pollard et al. 2004). Similarly, most people are risk-averse or risk-neutral (Weber et al. 2002). Thus, it was assumed that the practitioners accepted the public health risk of these systems as they continue to implement and operate them. In this study, the mean perceived public health risk of traditional stormwater drainage systems was 1.03 (s.d. 0.712, $N = 359$), with a median value of 1 (i.e. a minimum of 50% of participants perceived no risk or only slight risk) and 4% of respondents perceiving a significant risk. These data were assumed to be the baseline values for a risk that would not adversely affect receptivity. Risks with values diverging from these were interpreted as likely to limit receptivity.

Thus, the practitioners associated benefits with stormwater harvesting and treatment. Association-related risks were less than slight, except for perceived public health risk associated with stormwater harvesting systems. Although most respondents supported fit-for-purpose use

![Figure 3](https://iwaponline.com/ws/article-pdf/12/6/888/417065/888.pdf)

**Figure 3** | Frequency distribution and mean values for perceived general risk of different uses of treated stormwater in Australian cities.
of treated stormwater, almost one-fifth did not support its use for any purpose. Support for the implementation of stormwater harvesting and treatment systems in different development contexts was similar, with many fewer withholding support for its implementation in any context. However, receptivity relating to acquisition and application components is likely to be weaker. Perceived capital cost and maintenance and operations cost risks might affect receptivity for stormwater harvesting and quality treatment systems, in addition to management failure, commercial and technological risks for both systems, and compliance and political risks for stormwater harvesting. Technological, management failure and compliance risks relate to the acquisition component of receptivity, capital cost, maintenance and operations cost and commercial risks to the application component, and political risk to each of association, application and acquisition. The perception of these risks suggests that the practitioners feel that they do not have the skills to manage stormwater harvesting and treatment systems, nor variously the technological, regulatory, strategic and financial support to implement them in Australian cities.

Water practitioners have previously identified costs as barriers (Brown & Farrelly 2009) to the implementation of urban stormwater quality technologies. Brown & Farrelly (2009) did not explore stormwater harvesting and stormwater treatment systems separately. Hence, their results are not directly comparable with this study. However, they did identify capital and maintenance costs as barriers. Reform efforts, thus, should be targeted to valuing non-monetary benefits of stormwater harvesting so that practitioners can incorporate those values into risk management. If details of all benefits and costs could be quantified and made available to practitioners, these cost-related risks might lessen when considered against the non-monetary benefits the systems provide.

Overall, while some association risks that have been reported elsewhere as stifling innovations in the water sector appear to be an issue here for water practitioners in relation to stormwater harvesting, the value of the receptivity framework is the identification of considerable perceived ‘acquisition’ and ‘application’ risks. However, this raises the possibility that it is the perception of risk by regulatory organisations, e.g. state departments of health, outside the water industry that is constraining the full application of these stormwater systems. In this study, the practitioners also felt constrained by the current traditional stormwater drainage system.

For stormwater harvesting and treatment systems, a low general risk, in fact, hid a complexity of 14 specific risks. Understanding this complexity is important to understanding fully the practitioners’ receptivity to the systems. Preliminary analysis suggests that risk perception varies with different demographic variables of the practitioners, but only some interactions had a large enough effect size (Cohen 1988) to be noteworthy. Thus, perceived general risk of stormwater harvesting systems varied with work area \( F(5,438) = 5.959, P = 0.000, \eta^2 = 6.4\% \): sewerage practitioners perceived higher risks for stormwater harvesting systems than did land developers and total water cycle managers. Similarly, it also varied with primary qualification \( F(6,333) = 2.681, P = 0.015, \eta^2 = 7.6\% \): both engineers and biologists perceived higher risks for stormwater harvesting systems than did environmental scientists and urban designers, architects and/or landscape architects. Further analysis will focus on demographic influences on perceived risks related to the acquisition and application components of receptivity, to determine if this group of people is likely to act on this issue or if they need more support in advocating the case for stormwater to decision makers within the industry.

**CONCLUSION**

This research demonstrates that the receptivity of Australian urban water practitioners towards stormwater harvesting and quality treatment systems is challenged by perceived management failure, capital cost and maintenance/operations cost risks. Although the practitioners associate benefits with these stormwater systems and generally support the fit-for-purpose use of treated stormwater and implementation of the systems in different development contexts, these perceived management and cost-related risks impede the practitioners’ acquisition of skills, resources and support to implement these systems, and their application through insufficient policies and regulations. Reform efforts must target these acquisition- and application-related perceived risks, necessitating changes
to the administrative and institutional structure of the Australian water industry.

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