Risk Perceptions of Water Practitioners towards Sustainable Urban Water Systems

M. Dobbie* and R. Brown

Centre for Water Sensitive Cities, Monash University, Victoria 3800, Australia
**Corresponding author, e-mail meredith.dobbie@monash.edu*

ABSTRACT
Deeply embedded risk perceptions associated with public health and fear of failure have impeded the implementation of sustainable water systems in Australian cities. Technical risk assessment guides risk management in the water industry. Although risk perception has an acknowledged role in this process, in ranking risks to set management priorities, 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. Research suggests that there are numerous non-technical assessment factors, e.g. emotion, cultural disposition, which influence risk perceptions, but these are yet to be formally investigated as there is no analytical framework. This paper develops such a framework from a meta-analysis of the literature including over 250 papers on theoretical, conceptual and empirical studies in risk perception. The framework sets out a typology of inter-related human phenomena, from the psychological/physiological level to social and cultural systems, which influence risk perception and suggest how risks associated with new water approaches, such as wastewater recycling, might be perceived. This framework is the first significant step in conducting risk perception studies of water practitioners across multiple contexts.

KEYWORDS
Analytical framework, risk perception, urban water management, water practitioners.

INTRODUCTION
Urban water systems in Australia have focused on centralized infrastructure and management of water supply, sewerage and flood mitigation. The dual pressures of climate change and population growth are now challenging the capacity of these systems to meet societal needs, prompting the call for more sustainable systems involving multiple water sources, both centralized and decentralized, operating at multiple scales. Although the technology is currently available, implementation is impeded by water practitioners' perception of its risk to public health (Brown *et al.* 2009) and concerns for loss of support for alternative water systems in the event of system failure (Farrelly and Brown 2011). The water industry has an overt risk-averse culture, in which technical risk assessment guides risk management. Risk management science is broadening its perspective beyond public health risk from pathogenic and chemical hazards to include other risks at the operational, programme and strategic levels, including engineering, socioeconomic and ecological risks (Pollard et al. 2004). Although risk perception is acknowledged to have a role at the programme level, in ranking risks to set management priorities (Long and Fischhoff 2000), 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.

Early scholars of risk perception were interested in public perceptions of risk, to inform hazard management e.g. Fischhoff *et al.* (1978). Public perceptions were characterised as subjective "false beliefs" (Jasanoff 1998, p. 92), attributed to ignorance and misunderstanding of the objective risk assessed by experts. More recent research challenges these earlier notions and suggests that the risk perceptions of both the public and experts are subjective, influenced by their knowledge, values, beliefs and attitudes, e.g. Slovic (1999).

There has been very little examination of the role of risk perceptions in the water sector in relation to advancing more sustainable supply management. Thus, the aim of this paper is to provide the first significant step of developing a robust analytical framework of the range of factors that can influence risk perception to enable a critically informed and reliable basis for conducting subsequent empirical studies of water practitioners' risk perceptions across different contexts. The paper concludes with a suggested research agenda for applying this analytical framework in an empirical research context to identify current risk perceptions and the possible pathways for influencing them.

RESEARCH APPROACH

This research focuses on scoping and developing an analytical framework for enabling the systematic assessment of risk perceptions in the water sector. The framework was developed using a literature meta-analysis approach (Leach and Pelkey 2001) involving the critical review and synthesis of theoretical, conceptual and empirical studies in relation to risk and water management, published in developed countries in the English language. Environmental and social science electronic databases, such as Current Contents Connect, Web of Science ISI, Scopus SciVerse, ProQuest, were searched for papers that might suggest how water practitioners perceive risk. Keyword meta-searches of such terms as 'risk', 'risk perception', 'sustainable water systems', 'decentralized systems', 'risk management' and 'risk assessment', alone or in combination, located over 250 relevant papers. Few publications related directly to water practitioners. Others were selected because they explored risk perception theory, decision making involving risk, public risk perceptions of alternative water systems, and practitioners' perceptions of risk associated with other issues, e.g. alternative energy sources. Possibly relevant papers amongst cited references were also consulted. The literature search was a snowball process, which continued until reference lists of newly located papers included papers already returned through the database searches. Only key references are cited in this paper.

RESULTS AND DISCUSSION

Construction of risk

All risks are construed. Slovic (2001) concluded that there is no such thing as a real risk, as attributed to experts, only real danger. Both lay people and experts perceive risk in terms of multiple factors, with quantitative and qualitative characteristics (e.g. Fischhoff *et al.* 1978; Siegrist et al. 2005). Both shared a two-factor structure of risk perception, involving familiarity with the hazard and the degree to which it evoked dread, associated with controllability and size of the risk (Slovic *et al.* 1980). Water practitioners might be expected to perceive risk on similar factors.

Relational theory of risk and risk perception

Although the cognitive structure of perceived risk is shared by lay people and experts, the evaluation of that risk can differ, leading to different perceptions of risk. Boholm and

Corvellec (2011) have developed a useful framework for understanding risk perception as a social phenomenon, through which people perceive something as a risk. The relational theory of risk relates a risk object, e.g. an innovative water system or technology, to an object at risk, e.g. public health, reputation or environment. The relationship of risk between the two results from "culturally situated cognition and social practice" (p. 176) of the percipient. These, in turn, have been identified in a model of landscape perception, developed by Gobster et al (2007), as "human phenomena" (p. 963), extending from physiological systems within an individual to social and cultural influences operating on that individual from without. Together, the relational theory of risk and the landscape perception model provide the basis of an analytical framework for understanding risk perceptions of water practitioners in this paper (Figure 1). This framework illustrates the risk relationship between the risk object and the object at risk, which is established through perception, based on individual characteristics, operating at personal, social and cultural levels, expressed as cultural preferences.

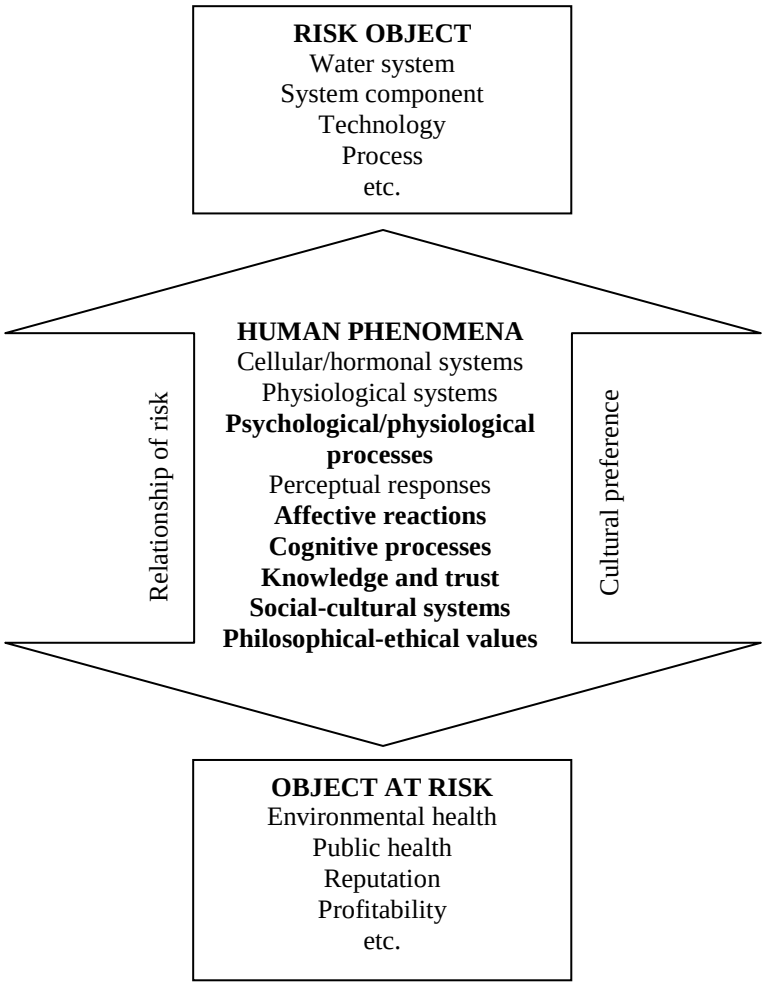

Fig. 1. Analytical framework for risk perceptions of water practitioners towards alternative water systems, based on Boholm and Corvellec (2011) and Gobster *et al.* (2007).

The meta-analysis of the risk perception literature is interpreted in terms of this framework, to identify possible influences on practitioners' risk perceptions. Phenomena that the literature identifies as an influence on risk perceptions are highlighted in the framework. The literature is discussed under section headings drawn from this framework, except for psychological/

physiological phenomena and philosophical-ethical values, which are discussed with social-cultural systems, knowledge and trust.

Affective reactions and cognitive processes

Risk perception involves both affective (i.e. emotional) reactions and cognitive processes, operating together. Three theories linking affective reactions and cognitive processes have been suggested. Slovic with others, e.g. Finucane *et al.* (2000a) and Slovic and Peters (2006), suggest that an affect heuristic guides cognition. Images associated with a cognitive evaluation of risk are affectively tagged. The stronger the affective tagging, the more affect will influence cognition. This was evident in the recent controversy to supplement potable water supplies with recycled water in Toowoomba, Australia (Price *et al.* 2010). Powerful media campaigns dubbing Toowoomba as 'Poowoomba', supported by images of sewage as drinking water, evoked affective reactions that overwhelmed cognitive responses to the ongoing drought and dwindling water supply. The proposal was defeated at a referendum. In contrast, risk evaluation might evoke anticipatory and anticipated emotions (Loewenstein *et al.* 2001). Anticipatory emotions, such as fear, anxiety and dread, occur immediately in response to a risk, whereas anticipated emotions are expected in the future, as part of the outcome of the risk. The anticipatory emotions, which might mediate the cognitive response, can be influenced by situational variables, such as vividness of the risk imagery and time scales. Again, the example of Toowoomba is relevant here. The risk imagery was extremely vivid - drinking sewage! And fear of the risk increased as the time of the referendum approached, leading to "chickening out" (Lowenstein et al. 2001, p. 278) of supporters and rejection of the proposal. The third process involves consequential and ethical evaluation of risk, associated with different types of emotion (Böhm 2003). The predominant type of emotion suggests which evaluative basis is more important to an individual, either consequentialist or ethical. This process introduces the possibility of philosophical and ethical values in the perception of risk of alternative water systems.

The role of affect in experts' risk perception is not known. Experts did not evaluate risk on any of the qualitative risk characteristics used in their cognitive representation of risk (Slovic *et al.* 1980) but evaluated risk in terms of annual mortalities (Slovic 1987), a consequentialist perspective only. However, Slovic (1999) believes that affect influences risk-related judgements of scientists. Thus, it might well guide water practitioners' risk perceptions of alternative water systems such as direct potable reuse of recycled water and sewer mining.

Social-cultural systems, knowledge and trust

Risk assessment by experts has been regarded traditionally as an objective exercise in contrast to subjective lay judgements. Of the many variables that might influence risk perception of water practitioners as a subjective response, the most important relate to beliefs, values, attitudes and knowledge (e.g. Rohrmann 1994; Boholm 1998; Finucane *et al.* 2000b). Sociodemographic variables have been shown to be relatively unimportant direct influences, e.g. Boholm (1998) and Stedman (2004), evident only in the 'white male effect', described below.

Cultural Theory

Cultural Theory has provided a framework for exploring the influence of these variables on risk perception, relating it to the type of social relations that a percipient adopts, corresponding to cultural biases. There are four cultural types – hierarchists, individualists,

egalitarians and fatalists. Each differs in its preferred organisational structure of society and the way it perceives nature and makes judgements, reflected in the response to risk (Wildavsky and Dake 1990; Douglas 1992). Each is neither always risk-averse nor always risk-taking but assesses risk selectively, depending on the situation. Ideology and associated trust in institutions, rather than knowledge, underpin risk perception.

The relevance of Cultural Theory to risk perception is debated. Some studies support the idea that societal categories with particular professional, cultural and political orientations differ in their risk perception, e.g. Boholm (1998), although whether an individual adopts a single cultural bias throughout life or adopts different biases associated with different institutions with different social organisations in different aspects of life or over time is unclear (Marris *et al.* 1998). Others disagree, e.g. Sjöberg (1996). However, it does explain the 'white male effect' in which higher-educated, well-paid, politically conservative white males perceive technological and environmental risk to be lower than do females or other males (Slovic 1999; Finucane *et al.* 2000b; Sjöberg 2003; Kahan *et al.* 2007).

Specific beliefs, values, attitudes and knowledge

Differences in specific beliefs, values, attitudes and knowledge might be more important influences on risk perception than cultural biases. Once formed, personal beliefs change very slowly, despite the provision of new information. Existing beliefs, values, attitudes and knowledge structure how new information is processed and interpreted, acting as a filter and impeding changes, despite the presentation of empirical evidence that challenges them (Slovic *et al.* 2000; Weible and Sabatier 2009). In addition, personal beliefs might lead to misinterpretation of motivations for attempting to reduce a hazard (Slovic *et al.* 2000). Consequently, the provision of additional technical information about hazards and risks might not change risk perceptions.

Differences in risk perception between experts and others might be attributable to different attitudes (Sjöberg 2002). Attitudinal differences can also exist between experts and are subject to the same influences as the public (Slovic 1999). Experts cannot be regarded as an homogeneous group. Risk perceptions of technical experts in North America differed with field of study and institutional affiliation, e.g. Barke and Jenkins-Smith (1993) and Stedman (2004). The direction of the influences, though, varied with context. Similarly, Rohrmann (1994) found that risk perceptions of engineers, accountants and ecologists all differed. Water practitioners include planners, policy makers, engineers, scientists, ecologists, economists and land developers (Brown *et al.* 2009). Thus, multiple risk perceptions could exist within a single organisation. Such multiple perceptions were identified in a study of risk perceptions of managed aquifer recharge for indirect potable drinking water in Perth, Western Australia (Browne *et al.* 2007). Water industry employees were variously 'confident', 'sceptical', 'defiant' or 'doubtful'.

Specific attitudes might include those towards risk. The terms 'risk-averse' and 'risk-seeking' are now commonly used to describe an individual's risk attitude as though it were a personality trait (Weber *et al.* 2002). Although risk-taking and risk perception are likely to change with the risk domain and its contextual characteristics, most people are mildly or significantly averse to risk-taking across all domains. Any difference in risk taking has been

related to differences in perceived risk and benefits of choice, not to differences in risk attitude (Weber *et al.* 2002). Consequently, water practitioners might not be always risk-averse nor always risk-seeking but vary in this attitude depending on the specific context of each situation and their risk perception.

Trust and knowledge

Trust is also critical to risk perception (Renn 2008). As suggested in Cultural Theory, the relationship of trust and risk perception can be influenced by cultural or social identity (Earle *et al.* 2007; Kahan *et al.* 2007). Trust might be especially important when a hazard is caused by agents that cannot be directly sensed (Sjöberg and Drottz-Sjöberg 2001), as might apply with water systems. Trust is not necessarily one-dimensional. It can lie in the water authorities to provide safe water, in scientists to provide accurate information about safety of recycled water, and in the technology to ensure an acceptable water quality (Po *et al.* 2003). Studies have demonstrated the relationship of trust in water suppliers and risk perception for drinking water quality in Western Australia (Syme and Williams 1993) and Portugal (Doria *et al.* 2005) and acceptance of recycled water in various Australian states (Po *et al.* 2005; Gardiner *et al.* 2008; Hurlimann *et al.* 2008; Price *et al.* 2010).

Knowledge can be important in engendering trust (Po *et al.* 2005). However, different sources of information are trusted to different degrees. Baggett *et al.* (2006) found that managers and regulators within the water industry trusted themselves and each other the most and the public the least. Practitioners' lack of trust in the public might increase the perceived risk of decentralized water systems, which would necessarily involve co-operation with the public in the systems' design, implementation and management.

'Yuck' factor

An attitude specific to the issue of recycled water that influences public risk perceptions is the 'yuck' factor, which can be a strong negative emotion (Po *et al.* 2003). Rather than the anticipated emotion of disgust, this is an anticipatory emotion that mediates the evaluation of risk. It can also be interpreted in terms of the affect heuristic, and as a psychological, perhaps even a physiological, process in the analytical framework. The 'yuck' factor cannot be considered independently of other beliefs, values and attitudes of an individual (Russell and Lux 2009) and is likely to be influenced by the opinions of others (Po *et al.* 2005). Females are more likely to experience the 'yuck' factor than males (Po *et al.* 2005). Consequently, it might not be a universal fixed response but a product of cultural context (Russell and Lux 2009), to which water practitioners might also be susceptible.

Analytical framework for future research

The literature meta-analysis suggests that knowledge and trust, philosophical and ethical values, and beliefs and attitudes associated with social and cultural systems are likely influences on practitioner risk perceptions of sustainable water systems, evoking psychological/physiological processes, affective reactions and cognitive processes. The role of perceptual responses is unclear. The human phenomena in the analytical framework were adopted from a model describing landscape perception. As risk perception differs from landscape perception in not being predominantly visual, perceptual responses might be minimal in risk perception.

This analytical framework is being used in a research program designed to identify current risk perceptions and the possible pathways for influencing them, to facilitate the transition to sustainable water management in urban Australia. One project uses an online survey to explore the risk relationship that water practitioners perceive between risk objects (i.e. centralized and decentralized water systems and technologies) and objects of risk (e.g. environment, public health, reputation). A second project explores the meaning of risk to water practitioners. A central tenet of the relational theory of risk is that people make sense of the world by categorizing and classifying all the objects that constitute the experienced world (Boholm and Corvellec 2011). It is through this categorization and classification that meaning is created, which will vary with personal attitudes, values, beliefs and knowledge and the social-cultural system occupied. Thus, the meaning of risk will be explored by an exploratory method that reveals how risk objects are categorized and classified by Australian urban water practitioners, to reveal the cognitive structure of their risk perceptions.

CONCLUSIONS

An analytical framework for understanding urban water practitioners' risk perceptions, derived from a relational theory of risk and a model of landscape perception, suggests that risk perceptions will vary with beliefs, values, attitudes and knowledge, generating different cognitive and affective responses to alternative water systems. These are likely to be important influences on advancing more sustainable supply management. A research program is proposed to identify current risk perceptions and the possible pathways for influencing them, to facilitate sustainable water management in urban Australia.

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