



## An experimental test of voluntary strategies to promote urban water demand management

Kelly S. Fielding<sup>a,\*</sup>, Anneliese Spinks<sup>b</sup>, Sally Russell<sup>c</sup>, Rod McCrea<sup>b</sup>, Rodney Stewart<sup>c</sup>, John Gardner<sup>b</sup>

<sup>a</sup>The University of Queensland, Brisbane, Queensland 4072, Australia

<sup>b</sup>Commonwealth Scientific and Industrial Research Organisation, Ecosciences Precinct, 41 Boggo Road, Dutton Park, Queensland 4102, Australia

<sup>c</sup>Griffith University, Nathan Campus, 170 Kessels Road, Nathan, Queensland 4111, Australia

### ARTICLE INFO

#### Article history:

Received 31 July 2012

Received in revised form

19 October 2012

Accepted 21 October 2012

Available online 17 November 2012

#### Keywords:

Demand management

Water conservation

Water end use

Feedback

Descriptive norms

Education

### ABSTRACT

In light of the current and future threats to global water security the current research focuses on trialing interventions to promote urban water conservation. We report an experimental study designed to test the long-term impact of three different interventions on household water consumption in South East Queensland. Participants from 221 households were recruited and completed an initial survey, and their houses were fitted with smart water meters which measured total water usage at 5 s intervals. Households were allocated into one of four conditions: a control group and three interventions groups (water saving information alone, information plus a descriptive norm manipulation, and information plus tailored end-user feedback). The study is the first to use smart water metering technology as a tool for behaviour change as well as a way to test the effectiveness of demand management interventions. Growth curve modelling revealed that compared to the control, the three intervention groups all showed reduced levels of household consumption (an average reduction of 11.3 L per person per day) over the course of the interventions, and for some months afterwards. All interventions led to significant water savings, but long-term household usage data showed that in all cases, the reduction in water use resulting from the interventions eventually dissipated, with water consumption returning to pre-intervention levels after approximately 12 months. Implications for water demand management programs are discussed.

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### 1. Introduction

Despite the fundamental role that water plays in sustaining human life and the health of the planet's ecosystems, research shows that almost 80% of the world's population is exposed to high level threats to water security (Vörösmarty et al., 2010). There is growing evidence that human activities are placing unsustainable demands on fresh water resources with ground water supplies over-extracted in many regions in the world (Postel, 1999) and many major river systems without adequate water flows (Postel, 1996). Water resources will be placed under further pressure in coming decades by population growth, urbanization and economic development (Beck and Bernauer, 2011; Güneralp and Seto, 2008; United Nations, 2009; Vörösmarty et al., 2000). Moreover, climate

change is likely to further exacerbate existing stressors on water supplies (Bates et al., 2008) and may result in increased impacts on water resources in some parts of the world (Arnell, 2004). Policy-makers therefore face a critical challenge that requires them to balance human demand for water while at the same time protecting fragile ecosystems.

Addressing future water security will require a range of adaptive approaches enacted at different levels: by individuals, communities, business, national governments, and international organizations. In urban contexts these adaptive approaches could include drought contingency planning, sourcing alternative water supplies, and promoting adoption of residential water conservation practices (de Loe et al., 2001; Postel, 2000). The latter approach, commonly referred to as demand management, is considered an essential element of future water security (Arbués et al., 2003; Brooks, 2006; Jeffrey and Gearey, 2006). de Loë et al. (2001) propose that water conservation and demand management approaches are appropriate measures for dealing with threats to water security in the near term as they promote water efficiency and reduce stress on the environment and they are consistent with existing initiatives by

\* Corresponding author. Institute for Social Science Research, The University of Queensland, Brisbane, Queensland 4072, Australia. Tel.: +61 7 3346 8725; fax: +61 7 3346 9676.

E-mail address: [k.fielding@uq.edu.au](mailto:k.fielding@uq.edu.au) (K.S. Fielding).

government agencies. Moreover, the Intergovernmental Panel on Climate Change (IPCC) has described demand management as a no-regrets solution to cope with future vulnerability of water supplies in the face of climate change impacts (Bates et al., 2008). The current study therefore focuses on demand management and in particular how we can promote residential water conservation as a method of addressing water security issues.

A comprehensive review by Inman and Jeffrey (2006) showed that demand management programs could reduce residential water consumption by 10–20% over a 10- to 20-year period. They concluded that moderate reductions could be achieved through price increases and voluntary demand management tools but more substantial reductions require large price increases or stringent mandatory policies. Similarly, Renwick and Green (2000) in a comparison of demand management approaches also conclude that voluntary measures reduce residential water demand, although more stringent mandatory approaches such as water restrictions or water use allocations result in greater reductions.

However, pricing mechanisms and mandatory approaches have clear drawbacks for utilities and government agencies; there are equity issues involved with their implementation, limits to the price elasticity of residential demand and evidence that they do not necessarily result in long-term change (Alitchkov and Kostova, 1996; Duke et al., 2002; Espey et al., 1997). Moreover, they require political will to implement and may be resisted by the community (Fielding et al., 2011; Steg et al., 2006). In contrast, voluntary approaches that involve behavioural change may be critical to promoting long-term cultural shifts in the way community members think about and use water (Geller, 2002) and these shifts in values and behaviour can complement other demand management approaches such as the installation of water efficient infrastructure.

In light of this, the current study tests the efficacy of *voluntary* demand management strategies for producing long-term reductions in residential water consumption. As noted above, given the potential for restrictive mandatory policies and pricing mechanisms to generate resistance from the community and resulting lack of political will to implement them, it is critical to develop voluntary tools that can positively influence water demand. In their review of studies of water-related behaviour, Hurlimann et al. (2009) identified the need for research on interventions that positively influence water-related behaviour. Our research addresses this gap in the literature through conducting an experimental field study that integrates behaviour change theory with water engineering technology. The study is the first to use smart water metering technology as a tool for behaviour change as well as a way to test the effectiveness of water demand management interventions. The research therefore represents an important interdisciplinary contribution to the question of how to address water security through reducing urban residential demand. The study also tracks the outcomes of the strategies for over a year and therefore represents a strong and robust test of the long-term effectiveness of the intervention strategies. The study therefore goes some way to addressing the need for more research on interventions to positively influence water-related behaviours. Gaining an understanding of the long-term effects of voluntary water demand management strategies provides critical information to water managers to better inform their long-term planning.

## 2. Voluntary water demand management

Studies of water conservation education campaigns reviewed by Inman and Jeffrey (2006) demonstrate savings of between 2 and 12% as a result of the campaigns. For example, a study of eight

Californian water agencies showed that information campaigns reduced average household water demand by 8% (Renwick and Green, 2000). Similarly Syme et al. (2000) concluded from their review of information campaigns to promote voluntary household water conservation that savings of between 10 and 25% are possible. On the other hand, a UK water efficiency campaign that involved direct mailing as well as newspaper and radio advertising did not result in reduced demand and only a very small proportion of the population (5%) reported noticing the campaign (Howarth and Butler, 2004). One possible explanation for differences in findings may be variations in water context. Consistent with this, a study of 430 U.S. utilities found that public education campaigns only reduced water demand in the Western regions of the USA potentially because these regions have heightened awareness of water scarcity (Nieswiadomy, 1992).

Although these studies show promising results for education campaigns and are useful for gauging the effectiveness of community-level interventions they are also limited in their measurement of water use data. In the main these studies are based on data aggregated at utility or regional levels that estimates household occupancy and tests effectiveness through comparison of water demand before and after the introduction of the campaigns. Jorgensen et al. (2009) note that there is a lack of research that collects individual household water use data and Syme et al. (2000) highlight that evaluations of water saving campaigns have not demonstrated their long-term effectiveness or provided a clear indication of what aspects of the campaigns are effective. They recommend the need for experimental research to investigate the effect of information campaigns on household water use. Consistent with these recommendations, the approach of the current study is an experimental field trial of interventions grounded in behaviour change theory that are tested through measurement of accurate daily household water use collected for over a year. The experimental approach allows us to identify which aspects of the information are most effective so that they can then be scaled up to be used in community-wide programs.

There are currently very few experimental studies addressing residential water demand management (hereafter referred to as water conservation). In a meta-analysis of experimental studies focused on environmentally sustainable behaviours, only 5 of the 87 papers related to water conservation (Osbaldiston and Schott, 2012). These studies demonstrate that information that induces cognitive dissonance, that is, highlights the mismatch between behaviour and attitudes about water use (Dickerson et al., 1992), prompts that remind people to conserve water at the point of use (Kurz et al., 2005) and education about long-term consequences of wasting water as well as raising personal efficacy about water conservation (Thompson and Stoutemyer, 1991) all help to reduce residential water use. The effects of providing feedback about household water use were mixed: in two studies it did not work (Geller et al., 1983; Kurz et al., 2005) but in one study it did (Aitken et al., 1994).

The dearth of experimental studies on effective water conservation interventions means that there is a lack of robust empirical evidence to inform community-level water saving campaigns. The current study also addresses the lack of objective water use data in this area of research. In a review of studies to inform their research on water conservation behaviour, Dolnicar et al. (2012) identified only five studies that had actual measures of water use. A further limitation of research to date on water conservation is that the maximum follow-up period was two months, so the long-term effects of such interventions have not been established. For these reasons it is important to identify voluntary methods for managing water demand that have long-term effects and this study does so across a broad geographic region at the individual household level.

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