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Motives Behind Domestic Greywater and Rainwater Collection: Evidence from Australia

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Abstract

Policy has traditionally focused on increasing water supply by investing in large scale and centralised projects. However, demand for water can be substantially decreased if households reuse greywater and/or install rainwater tanks. We investigate water use based on an internet survey of 354 households in the Australian Capital Territory and examine the relationship between socio-economic and psychological variables and the likelihood of the garden being irrigated with greywater and/or rainwater. Income, gender, age and education could not differentiate residents' by such water use. Residents who used tank water on the garden had higher self reported understanding of water supply options. Female participants and lower income residents were more likely to use greywater on their garden. Concerns about water collection and reuse, which have lead to some large scale projects being politically unacceptable, were not found to predict the use of tank water or greywater on the garden.

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HOUSEHOLD WATER COLLECTION IN CANBERRA

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INTRODUCTION

Australia is the driest inhabited continent with its population primarily distributed around freshwater river systems. A number of well-respected organisations suggest a high likelihood that south-eastern Australia will be facing escalating pressures on its water resources due to climate change, economic development and population growth.[2] In the last decade all Australian capital cities, except Darwin and Hobart, have imposed water restrictions to curtail demand and protect supplies. Current water consumption practises are widely recognised to be unsustainable (Chartres and Williams, 2006; Dillon, 2000; Quiggin, 2006; Syme and Hatfield-Dodds, 2007). Freshwater is a valuable resource with benefits extending beyond “just keeping us alive” by “quenching our thirst” (Syme, 2002). Agriculture, industry and the population at large are able to generate many different types of economic and social benefits from freshwater supplies (Roberts, Mitchell and Douglas, 2006). A lack of water can impact society in different ways; for example, limiting both population and economic growth, impacting wildlife, reducing the potential for well-being from domestic gardening and home-grown food.

Australian communities then face developing strategies to protect existing water supplies while maintaining the quality of life. Water policy tends to focus on increasing supply via large-scale centralised public projects eg. building a dam across the Mary River, Queensland and enlarging the Cotter Reservoir, Australian Capital Territory (ACT), constructing expensive desalination plants in Melbourne and Sydney. Capture and storage of stormwater is also attractive to urban centres. All of these options involve a large financial investment. Dams and desalinations plants

[2] ACT Government, 2003; Allen Consulting Group, 2005; Australian Greenhouse Office, 2003; CSIRO, 2001; Farmhand For Drought Relief Foundation, 2004; Hadley Centre, 2004; Victorian Government White Paper, 2004; Western Australian Greenhouse Task Force, 2004; World Water Assessment Programme, 2003.

can also have serious negative environmental consequences (Einav, Harussi and Perry, 2003; Hoepner and Lattemann, 2002; Ibrahim, 2004; Malmqvist and Rundle, 2002). As a result large scale and centralised water schemes have a history of generating intense political debate and polarising communities (Po, Kaercher and Nancarrow, 2003; Stenekes, Colebatch, Waite and Ashbolt, 2006).

The Australian Bureau of Statistics (2001) found that Australian households are the second largest consumer of Australia's freshwater resources (9%) after agricultural irrigation (67%). This report also found urban residents to be highly significant users in specific locations eg., consuming 54% of the water consumed in the ACT. There is then the potential for small scale and decentralised household supply initiatives to reduce the need for large scale investments eg. rainwater substituting for mains supply in Germany, see Herrmann and Schmida (1999). Urban centres reducing their use of mains water by 20% or more is equivalent to the water supplied by major projects such as a desalination (Marsden and Pickering, 2006). The ACT Government (2003) has estimated that increasing water efficiency by 3% equates to deferral of a new $100 million (AUS) dam by about 3 years, with every year of deferral saving about $1 million (AUS).

Households can augment their water supply by installing water tanks or recycling household 'greywater'.[3] Many households currently irrigate their gardens and lawns with tank water and/or greywater, and many new suburbs are being forced to install greywater or rainwater tank infrastructure. The simplest greywater systems involve diverting water from the laundry and/or bathroom directly to the garden or lawn for immediate use by a bucket or siphon. There are also more

[3] Household greywater is defined as being the wastewater from the hand basin, shower, bath, spa bath, washing machine, laundry tub, kitchen sink and dishwasher. Water from the toilet, urinal or bidet which is classified as blackwater.

sophisticated greywater systems (Jefferson, Laine, Parsons, Stephenson and Judd, 1999), but very few in Australian households. A typical water tank captures and stores rainwater that falls on the roof of a house or outbuilding (Coombes and Kuczera, 2003; Coombes, Kuczera, Kalma and Argue, 2002). Recycling household greywater has the potential to exceed supply from rainwater tanks (Karpiscak et al., 2001). For example, the typical Canberra household has been estimated to generate between 200-350 litres per day in greywater (ACT Government, 2007; Australian Bureau of Statistics, 2001). A community in Casa del Agua, Tuscon, Arizona was retrofitted with rainwater and greywater infrastructure and low-water-use appliances. Over a 13 year period this achieved a 24% reduction in total water used and a 47% reduction relative to other Tuscon residents (Karpiscak et al., 2001).

Household supply initiatives can also protect residential gardens in times of drought and severe water restrictions. Syme, Fenton and Coakes (2001) conclude that home gardens are a major contributor to quality of life, provide both active and passive recreation and a personal food source. A number of psychological benefits have been noted including provision of an individually created aesthetic, an important social statement and connecting people with nature (Browne, Tucker, Johnston and Leviston, 2007; Clayton, 2007; Head and Muir, 2006). As Randoloph and Troy (2008) note, many residents are attracted to the suburbs by a verdant environment in which houses are set amongst trees, shrubs, flowers and vegetable beds; an environment enabled by assured water supplies during long dry summers. The biophilia hypothesis claims that this attraction is the result of evolution, where people are deeply attracted to living in garden environments (Kellert and Wilson, 1995).

Clearly there are a variety of potential motives for households to create alternative sources of water. In this paper we report results for socio-economic and psychological variables aiming to predict (i) whether an individual recycles household greywater on their garden/lawns or (ii) whether an individual collects rainwater for their garden/lawns. In the next section, 'Motivational Factors', we explain the role of these motives with specific emphasis on the role of psychological perceptions. In the 'Method' section we describe the approach taken for the case study design and implementation. The 'Results' section reports the statistical analysis and results. 'Discussion' concludes with a discussion and interpretation outlining implications for policy with some suggestions for future research.

MOTIVATIONAL FACTORS

The traditional approach used to investigate motives underlying consumption assumes that individual attributes (eg. education, income, age) causally influences behaviour. Statistically significant differences are then identified in terms of different costs, benefits or barriers associated with distinct characteristics (Ryan and Spash, 2008). Socio-demographic variables are therefore construed as indicators or proxies for personal capabilities (Stern, 2000). For example, a high income may increase the likelihood of installing a rainwater tank due to ease of funding the investment and lack of concern over the financial return, or education may influence an individual's ability to understand the consequences of water supply options.

In a meta-analysis, Hines, Hungerford and Tomera (1986/87) suggest that pro-environmental behaviours are more likely to be performed by younger females who are well-educated and from a wealthy nuclear family. Yet the extent to which such findings can be transferred is questionable. For example, no published results specifically analyse the relationship between socio-economic variables and whether or not residents irrigate their garden with tank water and/or household greywater. Such residents may be motivated by a simple desire to protect their garden rather than being driven by social or environmental motives. If this is the case an unexpected socio-economic profile may emerge.

A number of studies have assessed the socio-economic profile of general household water usage and acceptance of recycled water. Gregory and Di Leo (2003) measured water consumption for a year in Shoalhaven, New South Wales, and found, contrary to their expectations, that the households proactively using less water had lower income and educational levels and were older. They note that many residents were raised in an era when awareness and conservation of dam or tank water was a part of everyday life. Porter et al. (2005) report that younger people are more likely to rate a water conservation proposal positively, while no significant differences were found across education categories. Po, Kaercher and Nancarrow (2003) cite a 2003 study by McKay and Hurlimann predicting the greatest opposition to water reuse schemes from people aged 50 years and over, but also note that a 2002 study conducted by Jeffrey found no significant variation across gender, age or socio-economic groups. In a summary of ten empirical studies, Dolničar and Saunders (2005) conclude acceptance of recycled water is correlated with a high level of education, followed by being in the younger age category, while income and gender appeared significant in only one third of the studies. Thus, generalising about the influence of socio-economic variables is mitigated by the specific context involving unique cost and benefits, and population characteristics.

A comparison of psychological perceptions, unlike socio-economic variables, cannot be assumed indicative of a causal process. While particular perceptions may encourage use of alternative water supplies, regularly performing such behaviours can also alter an individual's perceptions. Rather than trying to ascertain whether perceptions cause the behaviour or the behaviour causes perceptions this study simply compares perceptual differences between households engaging in supply diversification compared to those not doing so. Three psychological variables are then addressed: (i) general concerns about water reuse, (ii) perceived appropriateness of collecting and reusing water and (iii) perceived understanding of water reuse options.

General concerns about water collection and water reuse include numerous economic, health and environmental issues (Bruvold, 1988; Dillon, 2000; Higgins, Warnken, Sherman and Teasdale, 2002; Marks, Martin and Zadoroznyj, 2006). Household greywater may contain disease causing organisms or pollute garden soils with fats, oils, detergents, soaps, salt, nutrients, food and hair derived from household and personal cleaning activities. The quality of greywater depends upon the water activities performed inside the house (Eriksson, Auffarth, Henze and Ledin, 2002; Jefferson et al., 1999). Some chemicals and salts in greywater are capable of causing serious long-term soil damage. Soils and plants are able to process many such contaminates only within certain bounds and improper use can lead to local environmental damage. Official government assessments regard the risk of transmission of disease through the use of domestic greywater on lawns and gardens as being low—subject to precautions such as not drinking or storing for more than 24 hours (ACT Government, 2007; EPA Victoria, 2008; NSW Government, 2007). Tank water can also contain specific pathogens (Brodribb, Webster and Farrel, 1995; Crabtree, Ruskin, Shaw and Rose, 1996) or breed mosquitoes. Roof catchment systems which are poorly maintained allow a build-up of leaf litter in the tank which can acidify the stored water. Many of the concerns surrounding water from rainwater tanks are avoided by appropriate practice and design and by avoiding use for drinking. Australian studies show rainwater tanks can provide an acceptable quality for outdoor water usage (Coombes, Argue and Kuczera, 2000; Coombes, Kuczera and Kalma, 2003).

Risk perception can play an important role in public acceptance of water projects. Large scale projects have been rejected solely on the basis of public risk perception, eg. a “toilet to tap” campaign derailed a proposed water recycling plant in Toowoomba, Queensland (Stenekes et al., 2006). Research suggests greater acceptance of risks if they are perceived as familiar, voluntary and of negligible catastrophic potential (Renn, Burns, Kasperson, Kasperson and Slovic, 1992; Smithson, 1993). Many large scale projects violate these conditions and many such water reuse schemes have been accompanied by concerns over health impacts especially on children. Small scale household projects may avoid these problems, being familiar and controllable, even though in some cases the risks of using grey or tank water are higher. Studies have found that the ‘use history’ of water affects the concerns that people have about recycling (Jeffery, 2002; Nancarrow, Kaercher and Po, 2002). Grey or treated waste water from one’s own household tends to be more acceptable than that from others or secondary sources. Rainwater harvesting from one’s own roof has been found to outrank greywater reuse in terms of acceptability, which in turn outranks treated wastewater (Nancarrow et al., 2002). We assess whether household residents who irrigate the garden with household greywater or tank water have specific concerns about collecting and reusing water.

The second psychological issue is the perceived appropriateness of water collection and recycling. People generally support water options that promote water conservation, provide environmental protection benefits, protect human health and cost-effectively treat and distribute water to those with a need (Hartley, 2006). There is a conceptual difference between being concerned about water options and assessing a given option as being appropriate. An individual may be concerned about an impact but, given the current situation in Australia, judge such schemes to be appropriate because of a pressing need to increase water supplies. Previous studies have concluded that many household residents find greywater an appropriate water source for the garden, while regarding use of recycled water as inappropriate for other activities. Marks et al. (2006) reported that over 90% of people felt greywater should be used on the garden. Po et al. (2003) summarised 8 studies and found only 6% of respondents viewed recycled water inappropriate for the garden, while a majority were against water reuse inside the home. They note the number of people actually using greywater on the garden is much smaller than those approving of such use. We investigate whether people who currently water their garden with grey or tank water are more likely to perceive other water collection and recycling options as appropriate.

The third psychological aspect is the individual's self reported knowledge. At the heart of government policymaking is the notion that increasing objective knowledge of an issue will alter behaviour for the better (Hartley, 2006). A qualitative study by Browne et al. (2007) concluded that education and marketing information influenced water usage. However, a number of limitations of knowledge campaigns are also recognised (Barr, 2003; Syme, Nancarrow and Seligman, 2000) which means careful targeting and design are required for successful communication (Reisch, Spash and Bietz, 2008). While the focus of marketing and education is to increase actual knowledge, perceived knowledge can also influence behaviour. An individual's actual knowledge and their perceived knowledge may be unrelated, eg.

see Knight (2005) on agricultural biotechnology options. People are capable of thinking that they know more or less than they do (Alba and Hutchinson, 2000). For example, an uninformed individual may believe they know a lot, while a very educated individual may feel that their knowledge base is inadequate. Selnes and Gronhaub (1986) suggest that objective measures of knowledge should be used when the research objective is related to a consumer's ability to choose the best alternative course of action, while subjective measures of knowledge should be used when the research focuses on a consumer's motivation to conduct choice-related behaviours. An individual who feels that their knowledge about a particular domain is inadequate may hesitate to take action within that domain.

METHOD

This study aims to investigate the motives behind using alternative water supplies on the garden. We analyse the relationship between greywater and rainwater tank use and the socio-economic variables of age, gender, income and education. The aim is to probe whether people who are currently using alternative water sources on the garden feel that they know more about a range of water supply options. This requires looking at the relationship between perceived knowledge of water options (eg. greywater re-use in the laundry and shower, reusing treated sewage for irrigating parks, collecting and using stormwater) and the use of greywater and/or tank water on the garden. The relationship between general concerns about water collection and reuse and the use of greywater and/or tank water on the garden are also to be assessed, along with the relationship between perceived appropriateness of water collection and reuse and the irrigation of domestic gardens with greywater and/or tank water.

The research presented in this paper was part of a social assessment project commissioned by the ACT Government to inform a major water planning program aiming to reduce the demand on the Canberra water supply by 3 gigalitres per annum (Maheepala, 2008; Measham, forthcoming; Schandl, Measham and Hosking, 2009). Participants were recruited from the ACT in 2008, which at the time of the study was under water restrictions (level 3) preventing sprinkler watering of lawns. Residents could use drippers, buckets and hand-held hoses with a trigger nozzle at specified times only. Participants were recruited via media advertising in local newspapers and radio. Four community focus groups were run where participants were asked to recruit their friends by word of mouth. Recruited participants were provided with access to an internet website that administered an online survey investigating water recycling options in the ACT. The online survey was completed by 460 participants who were resident in, or adjacent to, the ACT. The research presented in this paper specifically concentrated on those residing in a detached house (N=354)—rather than apartments, town houses or retirement villages—because of their control over installing rainwater tanks and greywater infrastructure. Table 1 compares the sample demographics with those for the ACT 2006 census. This suggests that the gender and age is representative while income and education are higher than the average ACT citizen. Recruitment methods may have caused a self-selection bias, although being a resident in a detached house also implies a higher income and education.

TABLE 1 ABOUT HERE

The internet webpage stated that the purpose of the study was to “explore options such as stormwater collection, wastewater re-cycling and groundwater storage and retrieval to supplement Canberra’s water supply”, and that the survey was “part of the social assessment of water management options, and complements other research conducted by CSIRO on physical and economic aspects of water management”. Participants were then directed through 8 web-pages.

The three psychological aspects were probed as follows. First, participants were asked “How concerned are you about the following aspects of water collection and water recycling?” and were then asked to assess (i) water quality; (ii) injury risk; (iii) odours; (iv) aesthetic impact; (v) economic viability; (iv) mosquitoes. Responses were on a 3 point scale (1 = not concerned; 2 = somewhat concerned; 3 = very concerned). Second, participants were presented with 7 options and were asked “Do you agree that the following are appropriate forms of water collection and recycling in Canberra?” The items they assessed were (i) roof water harvesting; (ii) recycling household water; (iii) collecting and using stormwater; (iv) wetlands projects; (v) reusing treated sewage for irrigating parks; (vi) ground water recharge. These items were answered on a 5-point response scale (1 = strongly agree; 2 = agree; 3 = undecided; 4 = disagree; 5 = strongly disagree) and participants were also given the option of “don’t know”. Third, participants were asked “How well do you understand the following water collection and recycling approaches?” They were then asked to assess (i) roof water harvesting; (ii) recycling household water; (iii) collecting and using stormwater; (iv) wetlands projects; (v) reusing treated sewage for irrigating parks; (vi) ground water recharge. Participants answered on a 5-point scale (1 = very high understanding; 2 = high understanding; 3 = moderate understanding; 4 = low understanding; 5 = very low understanding).

RESULTS

Exploratory analysis of psychological scales was undertaken for each of the three psychological questions. A principal axis factor analysis was run to assess the response patterns to the 6 items of concern about water collection and water recycling. A one-factor solution explained 45.20% of the variance, suggesting that all of the items had a similar response pattern. The general public assessment of different concerns (eg., water quality, economic viability, mosquitoes and aesthetics) may be based upon a general underlying concern rather than a judgement of each specific concern in isolation. The many unknowns associated with water reuse may increase the likelihood that people express a general concern rather than being able to isolate their specific concerns. Many of the concerns that participants were asked to assess are also related, and the general population may be aware of this. Poor water quality can lead to odours, unacceptable aesthetics, breed mosquitoes and reduce economic viability. 44 participants answered “not applicable” to one of the “concern” items, with 27 participants choosing this response for the “injury risk” item. Due to poor response rate, a decision was made to drop the injury risk item from the scale. The remaining 5 items were combined into a “concern” scale which reported a Cronbach’s α of .78.

All the items assessing the appropriateness of water collection and recycling had a high response rate except ground water recharge, which had 58 participants select the “don’t know” option. This suggests that many participants were not confident in their ability to assess groundwater recharge, although they were able to assess the other options. The groundwater recharge item was dropped from further analyses. A principal axis factor analysis was run to assess the response patterns to the 5 remaining items. This found a one-factor solution which explained 41.39% of the variance, suggesting that participants tend to demonstrate a similar response pattern to all five items. This indicates that there may be a general assessment of the appropriateness of water collection and recycling that underlies judgements concerning the appropriateness of specific options. If a participant assessed one of the water options as being appropriate, they were likely to assess all the options as being appropriate. For subsequent analyses the 5 items were combined into a scale. In order to do this all the items were reverse scored, so that a high score represents a high assessment of the appropriateness of water re-use. The "appropriateness" scale was found to be reliable, reporting a Cronbach's α of .77.

A principal axis factor analysis assessed the response patterns to the 6 items on understanding of water collection and recycling approaches. Once again a one-factor solution was found, this time explaining 56.76% of the variance. This suggests that an individual who believes they are knowledgeable about one water option has a tendency to believe they are knowledgeable about all the options. While there are some major differences between water options, many of the principles of how to use water wisely are the same. For example, there are strong similarities between collecting stormwater and roof water harvesting, as both are harnessing rainwater. For subsequent analyses a scale was created without the groundwater recharge items, as the "appropriateness" scale discussed above dropped this item. The remaining 5 items were reversed scores so that a high score represented a high level of understanding. This scale demonstrated excellent reliability, reporting a Cronbach's α of .87.

Next we analysed the relationship between socio-economic and psychological variables and propensity for participants to collect and use rainwater or greywater for their garden. Participants were asked whether they "collect and use rainwater for gardens/lawns" (155 indicated yes; 199 indicated no) and whether they "recycle greywater for gardens/lawns" (233 indicated yes; 121 indicated no). Table 2 shows the correlations between socio-economic and psychological variables. As expected a higher level of education was associated with having a higher income. Higher income groups also had a poor assessment of the appropriateness of various water collection and recycling schemes. Females were more likely to perceive water collection and recycling schemes as appropriate, but were less likely to feel that they understood these schemes. Consistent with the literature, younger respondents were more likely to assess various water schemes as being appropriate and were also less likely to be generally concerned about water collection and reuse.

The final analyses investigate the relationship between socio-economic/psychological variables and use of greywater and/or tank water on the garden. The socio-economic and psychological motives were treated separately because (i) policy based on psychological perceptions often has a different focus and (ii) there is a clearer causal relationship between socio-economic variables and behaviour than psychological variables and behaviour.

TABLE 2 ABOUT HERE

Logistic regression analyses assessed the influence of socio-economic variables on whether (i) rainwater is collected and used for gardens; and (ii) greywater is recycled on the garden. The socio-economic variables employed were income, education, gender and age. Table 3 defines each of these variables for the logistic regression and displays the number of responses in each category.

TABLE 3 ABOUT HERE

Table 4 displays the logistic regression assessing the relationship between socio-economic indicators and tendency to collect rainwater. This model was not found to be significant X^2 (4) = 5.14, $p > .05$. Furthermore, none of the socio-economic indicators were found to have a significant relationship with tendency to collect and use rainwater on the garden. Table 4 also displays the logistic regression assessing the relationship between tendency to recycle greywater and socio-economic indicators. This model was found to be significant X^2 (4) = 23.18, $p < .05$. A significant relationship was found between gender and tendency to recycle greywater, with females being more than twice as likely to recycle. A significant relationship was found between income and tendency to recycle with higher income participants being almost half as likely to recycle as lower income participants.

TABLE 4 ABOUT HERE

A logistic regression analyses was employed to assess the relationship between water reuse on the garden and the three psychological factors: (i) concern about water collection and recycling; (ii) perceived appropriateness of water option (iii) perceived knowledge of water options. Table 5 describes the descriptive statistics for the 3 scales used in this analysis. Table 6 displays the results of the logistic regression predicting tendency to collect and use rainwater on the garden from the psychological scales. This model was found to be significant, X^2 (3) = 20.98, $p<.01$. The only significant predictor of tendency to collect and use rainwater was perceived understanding, with each additional score on the perceived understanding scale resulting in a 91% chance of collecting and using rainwater. Table 6 also displays the results of the logistic regression predicting tendency to recycle greywater on the garden. This model was found to be significant, X^2 (3) = 19.81, $p<.01$. The only significant predictor of tendency to recycle greywater was perceived appropriateness, with each additional score on the perceived appropriateness scale more than doubling the chance that an individual recycles greywater.

TABLE 5 ABOUT HERE

TABLE 6 ABOUT HERE

DISCUSSION

Our principal axis factor analysis suggests that people demonstrate consistency when expressing (i) their concerns about water recycling and reuse options, (ii) their assessment of the appropriateness of water options, and (iii) their perceived knowledge of various water options. A large portion of respondents indicated that they did not know how to assess the appropriateness of groundwater recharge. Porter et al. (2005) looked at areas such as cost, health, safety, responsibility, risks, perceptions, uncertainty in a group discussion about the preferences for water supplies. They found that participants would not consider any aspect of the possible future water supply systems in isolation, but took a more holistic approach. The results of the factor analysis provide support to the notion that participants assess water options with a holistic approach.

Results show the predictors of tank water use to be different from those for greywater use. The four socio-economic indicators failed to differentiate participants who were using tank water to irrigate their garden from those who were not. Other socio-economic variables (eg. property size, roof size and garden type) might have proven more successful. Old laws that once made rainwater tanks illegal and the possibility that some residents may have inherited their tank from previous owners may have also reduced the influence of the four socio-economic indicators used in the current study. Residents who used tank water on the garden were found to believe that they have a greater understanding of a range of water options. Operating a rainwater tank may help residents understand concepts of water recycling and reuse. Some residents may purchase a rainwater tank because they believed they have a higher understanding of supply-side options. The perceived appropriateness of various water reuse options was not found to be related to water tank usage. A possible reason for this is water collected in tanks is often perceived as being higher quality than greywater, stormwater and sewage water, so residents may have been less concerned about the quality of tank water.

Female participants and lower income residents were more likely to use greywater on their garden. Lower income residents may resort to using greywater because they cannot afford other water saving options or they may be more conscious of wastage and the social need for extra water sources. Psychological indicators showed those who irrigated the garden with greywater were more likely to judge various water collection and recycling proposals as appropriate. Many residents may be reusing household greywater because they believe that a range of alternative water options such as wetlands, using treated sewage for irrigating parks and stormwater projects that reuse water are appropriate. Conversely, having experience irrigating the garden with greywater may lead many residents to a positive assessment of other alternative water supply options. That perceived knowledge has no influence on greywater usage may be because collecting greywater in a bucket or using a hose to siphon water outside is technically simply. Installing and operating a rainwater tank is technically more difficult. The relevance of perceived knowledge might therefore be higher for those operating complicated greywater systems.

Citizen concerns have the potential to undermined large scale projects. Concerns about water collection and reuse, however, were not found to predict tank water use or greywater use. People may be less concerned about water quality, odours and aesthetics because they have direct control over how this water is used. The use of household water and rainwater is voluntary and people are often familiar with the use history of these water sources. While concern may still be expressed about water collection and reuse, this may have no influence on behaviour if there is personal control over water use. This supports arguments that the ‘use history’ of water affects the concerns that people have about recycled water (Jeffery, 2002; Nancarrow et al., 2002).

The static comparison of variables associated with the use of alternative water supply sources on the garden is able to differentiate the socio-economic profile and perceptions of household residents who are performing particular behaviours. We cannot distinguish whether people adopt an alternative strategy because they have a certain psychological outlook or whether once a strategy is adopted the psychological outlook changes. A longitudinal study could address the question of whether perceptions influence behaviour or behaviour influences perceptions and the effectiveness of interventions such as rebates, marketing or water restrictions.

The dependent variable for the current study asked whether participants use household greywater on the garden. There is, however, great variety in the sophistication of greywater options. Some participants may simply collected greywater in a bucket, other residents would have connected a pipe from the washing machine to outside, while a small minority might have installed a technologically advance purifying device. Future studies could be more specific about what type of greywater is used and how it is funnelled to the garden.

Policy can be advanced by understanding the demographics and psychological perceptions of household residents who are using alternative water strategies. Conserving water resources is a high priority for Australian communities and small scale voluntary strategies have the potential to offer a more cost effective solution than their large scale public project counterparts. If household use of untreated greywater requires management (eg. preventing build-up of salts) then knowing the type of people who are using such schemes will aid in changing their behaviour. Demand side management and small scale voluntary water supply options should be seriously researched to develop a combination of strategies. This study indicates how research might proceed and offers some initial results addressing the psychological and socio-economic drivers behind domestic water use behaviour.

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REFERENCES

ACT Government (2003) *Our water future: Beyond the drought and water restrictions.* Paper presented at the Community Summit, Canberra, Australia, 27 August 2003.

ACT Government (2007) *Australian Capital Territory greywater use: Guidelines for residential properties in Canberra*. Canberra: ACT Government.

Alba, J. and Hutchinson, J.W. (2000) Knowledge calibration: What consumers know and what they think they know. *Journal of Consumer Research* 27: 123-156.

Allen Consulting Group (2005) *Climate change risk and vulnerability: Promoting an efficient adaptation response in Australia*. Report to the Australian Greenhouse Office, Department of the Environment and Heritage, Canberra ACT.

Australian Bureau of Statistics (2001) *Water account for Australia*. Canberra: Australian Bureau of Statistics.

Australian Greenhouse Office (2003) *Climate change: An Australian guide to the science and potential impacts*. Canberra: Australian Greenhouse Office.

Barr, S. (2003) Strategies for sustainability: Citizens and responsible behaviour. *Area* 35(3): 227-240.

Brodribb, R., Webster, P. and Farrel, D. (1995) Recurrent Campylobacter fetus subspecies bacteraemia in a febrile neutropaenicpatient linked to tank water. *Communicable Disease Intelligence* 19: 312-313.

Browne, A.L., Tucker, D.I., Johnston, C.S. and Leviston, Z. (2007) *Sustainable water use at the household level*: A scoping report. CSIRO Water for a Healthy Country National Research Flagship.

Bruvold, W.H. (1988) Public opinion on water reuse option. *Journal WPCF* 60: 45-49.

Chartres, C. and Williams, J. (2006) Can Australia overcome its water scarcity problems? *Journal of Developments in Sustainable Agriculture* 1: 17-24.

Clayton, S. (2007) Domesticated nature: Motivations for gardening and perceptions of environmental impact. *Journal of Environmental Psychology* 27: 215-224.

Coombes, P.J., Argue, J.R. and Kuczera, G.A. (2000) Figtree Place: A case study in water sensitive urban development (WSUD). *Urban Water* 1(4): 335-343.

Coombes, P.J. and Kuczera, G.A. (2003) *Analysis of the performance of rainwater tanks in Australian capital cities*. Paper presented at the 28th International Hydrology and Water Resources Symposium, Wollongong, NSW, 10-13 November 2003.

Coombes, P.J., Kuczera, G.A. and Kalma, J.D. (2003) Economic, water quantity and quality impacts from the use of a rainwater tank in the inner city. *Australian Journal of Water Resources* 7: 111-120.

Coombes, P.J., Kuczera, G.A., Kalma, J.D. and Argue, J.R. (2002) An evaluation of the benefits of source control measures at the regional scale. *Urban Water* 4: 307-320.

Crabtree, K., Ruskin, R., Shaw, S. and Rose, J. (1996) The detection of Cryptosporidium Oocysts and Giardia custs in cistern water in the U.S. Virgin Islands. *Water Research* 30(1): 208-216.

CSIRO (Commonwealth Scientific and Industrial Research Organisation) (2001) *Climate change: Projections for Australia*. CSIRO.

Dillon, P. (2000) *Water reuse in Australia: Current status, projections and research*. Proceedings of Water Recycling Australia 2000, Adelaide, 19-20 October 2000.

Dolničar, S. and Saunders, C. (2005) Marketing recycled water: Review of past studies and research agenda. In *Integrated concepts in water recycling*. S.J. Khan, A.I. Schäfer and M.H. Muston (eds.). Wollongong: University of Wollongong.

Einav, R., Harussi, K. and Perry, D. (2003) The footprint of the desalination processes on the environment. *Desalination* 152 (1-3): 141-154.

EPA (Environment Protection Authority) Victoria (2008) *Greywater use around the home*. Melbourne: EPA Victoria.

Eriksson, E., Auffarth, K., Henze, M. and Ledin, A. (2002) Characteristics of grey wastewater. *Urban Water* 4: 85-104.

Farmhand for Drought Relief Foundation (2004) *Talking water: An Australian guidebook for the 21st century*. Surry Hills, NSW: Farmhand for Drought Relief.

Gregory, G.D. and Di Leo, M. (2003) Repeated behavior and environmental psychology: The role of personal involvement and habit formation in explaining water consumption. *Journal of Applied Social Psychology* 33(6): 1261-1296.

Hadley Centre (2004) *Uncertainty, risk and dangerous climate change*. Exeter: UK: Department of Environment Food and Rural Affairs.

Hartley, T. (2006) Public perception and participation in water reuse. *Desalination* 187: 115-126.

Head, L. and Muir, P. (2006) Edges of connection: Reconceptualising the human role in urban biogeography. *Australian Geographer* 37: 87-101.

Herrmann, T. and Schmida, U. (1999) Rainwater utilisation in Germany: Efficiency, dimensioning, hydraulic and environmental aspects. *Urban Water* 1: 307-316.

Higgins, J., Warnken, J., Sherman, P.P. and Teasdale, P.R. (2002) Survey of users and providers of recycled water: Quality concerns and directions for applied research. *Water Research* 36*:* 5045-5056.

Hines, J.M., Hungerford, H.R. and Tomera, A.N. (1986/87) Analysis and synthesis of research on environmental behavior: A meta-analysis. *Journal of Environmental Education* 18: 1-18.

Hoepner, T. and Lattemann, S. (2002) Chemical impacts from seawater desalination plants - A case study of the northern Red Sea. *Desalination* 152: 133-140.

Ibrahim S.A. (2004) Environmental impact of seawater desalination plants. *Environmental Monitoring and Assessment* 16(1): 75-84.

Jefferson, B., Laine, A., Parsons, S., Stephenson, T. and Judd, S. (1999) Technologies for domestic wastewater recycling. *Urban Water* 1: 285-292.

Jeffery, P. (2002) Public attitudes to in-house water recycling in England and Wales. *Journal of Chartered Institution of Water and Environmental Management* 16: 214-217.

Karpiscak, M.M., France, G.W., DeCook, K.J., Brittain, R.G., Foster, K.E. and Hopf, S.B. (2001) Casa Del Agua: Water conservation demonstration house 1986 through 1998. *Journal of the American Water Resources Association* 37(5): 1237-1248.

Kellert, S.R. and Wilson, E.O. (1995) *The biophilia hypothesis.* Washington, D.C.: Island Press.

Knight, A.J. (2005) Differential effects of perceived and objective knowledge measures on perceptions of biotechnology. *AgBioForum* 8(4): 221-227.

Maheepala, S. (2008) *Canberra integrated waterways: Feasibility study*. CSIRO Water for a Healthy Country National Research Flagship.

Malmqvist, B. and Rundle, S. (2002) Threats to the running water ecosystems of the world. *Environmental Conservation* 29(2): 134–153.

Marks, J.S., Martin, B. and Zadoroznyj, M. (2006) *Comparing attitudes to recycled water: The difference between generalized and salient options*. Paper presented at the International Sociological Conference (ISA), Durban, South Africa, 23-29 July 2006.

Marsden, J. and Pickering, P. (2006) *Securing Australia's urban water supplies: Opportunities and impediments*. Camberwell, Victoria: Marsden Jacob Associates.

Measham, T.G. (forthcoming) Social transitions in water management: A case study from Canberra. *Society and Natural Resources* (in press).

Nancarrow, B.E., Kaercher, D. and Po, M. (2002) *Community attitudes to water restriction policies and alternative water: A longitudinal analysis 1988-2002*. CSIRO Land and Water.

NSW Government (2007) *NSW guidelines for greywater reuse in sewered, single household residential premises*. Department of Energy, Utilities and Sustainability, Sydney.

Po, M., Kaercher, D. and Nancarrow, B.E. (2003) *Literature review of factors influencing public perceptions of water reuse*. CSIRO Land and Water.

Porter, N.B., Leviston, Z., Nancarrow, B.E., Po, M. and Syme, G.J. (2005). *Interpreting householder preferences to evaluate water supply systems: An attitudinal model*. CSIRO Water for a Healthy Country National Research Flagship.

Quiggin, J. (2006) Urban Water Supply in Australia: The option of diverting water from irrigation. *Public Policy* 1(1): 14-22.

Randoloph, B. and Troy, P. (2008) Attitudes to conservation and water consumption. *Environment Science and Policy* 11: 441-455.

Reisch, L.A., Spash, C.L. and Bietz, S. (2008) Sustainable consumption and mass communication: A German experiment. CSIRO Socio-Economics and the Environment in Discussion Working Paper Series 2008-12.

Renn, O., Burns, W., Kasperson, J.X., Kasperson, R.E. and Slovic, P. (1992) The social amplification of risk: Theoretical foundations and empirical applications. *Journal of Social Issues* 48(4): 137-160.

Roberts, R., Mitchell, N. and Douglas, J. (2006) *Water and Australia's future economic growth*: Australian Government - The Treasury.

Ryan, A. and Spash, C.L. (2008) Measuring awareness of environmental consequences: Two scales and two interpretations. CSIRO Socio-Economics and the Environment in Discussion Working Paper Series 2008-10.

Schandl, H., Measham, T.G. and Hosking, K. (2009) *Canberra integrated waterways feasibility study - Social processes report*. CSIRO Water for a Healthy Country National Research Flagship.

Selnes, F. and Gronhaug, K. (1986) Subjective and objective measures of product knowledge contrasted. *Advances in Consumer Research* 13: 67-71.

Smithson, M. (1993) Ignorance and science: Dilemmas, perspectives and prospects. *Knowledge: Creation, Diffusion, Utilization* 15(2): 133-156.

Stenekes, N., Colebatch, H.K., Waite, T.D. and Ashbolt, N.J. (2006) Risk and governance in water recycling. *Science, Technology and Human Values* 31(2): 107-134.

Stern, P.C. (2000) Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues* 56: 407-424.

Syme, G.J. (2002) *Balancing Community Values, Needs and Water-Use.* Paper presented at the Water Symposium Session, Societal Value Systems for Water Resources in WA Overview, Water Symposium. Parliament House, Western Australia, 7-9 October 2002. http://www.ourwaterfuture.com.au/community/symposiumpres/Syme%20paper.pdf

Syme, G.J., Fenton, M.D. and Coakes, S. (2001) Lot size, garden satisfaction and local park and wetland visitation. *Landscape and Urban Planning* 56(3-4): 161-170.

Syme, G.J. and Hatfield Dodds, S. (2007) The role of communication and attitudes research in the evolution of effective resource management and arrangements. In *Managing Water for Australia: The Social and Institutional Challenges.* K.K. Hussey and S. Dovers (eds.).Collingwood, Victoria: CSIRO Publishing.

Syme, G.J., Nancarrow, B.E. and Seligman, C. (2000) The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review* 24(6): 530-578.

Victorian Government White Paper (2004). *Securing 0ur water future together*. Victorian Government Department of Sustainability and Environment.

Western Australian Greenhouse Task Force (2004) *Western Australian greenhouse strategy*. Western Australian Greenhouse Task Force.

World Water Assessment Programme (2003) *Water for people, water for life: A joint report by the twenty three UN agencies concerned with freshwater / World Water Assessment Programme*. New York: UNESCO Publications.

Table 1. Demographic for survey and ACT based on 2006 census

	Survey Demographics	ACT Demographics
Gender	52% female 48% male	51% female 49% male
Age	71% < 55 years 29% >= 55 years	75% < 55 years 25% >= 55 years
Education	51% no post-grad degree 49% post-grad degree	88% no post-grad degree 12% post-grad degree
Income	Personal income 54.8% < $75,000 45.2 >= $75,000	Median household income $78,463

Table 2. Correlations for demographic variables and psychological variables

	Income	Education	Gender	Age	Concern	Appropriateness
Education	.28**					
Gender	-.09	.09				
Age	-.08	-.04	-.10			
Concern	.09	-.03	.02	.09		
Appropriateness	-.11*	-.07	.11*	-.21**	-.18**	
Understanding	.03	.07	-.17**	.07	-.10	.12*

* Significant at the .05 level (2-tailed)
** Significant at the .01 level (2-tailed)

Table 3. Summary statistics for socio-economic categories

Variable	Definition	Number of No responses (coded "0")	Number of Yes responses (coded "1")
Income	Greater or equal to $75,000	187	154
Education	Post-graduate level	181	173
Gender	Female	169	183
Age	55 years or older	250	101

Table 4. Logistic Regression for rainwater and recycling

	B	SE B	e^B
Rainwater			
Constant	-.17	.23	.85
Income	-.26	.23	.78
Education	-.18	.23	.84
Gender	.33	.25	1.39
Age	-.14	.25	.87
Number of obs = 337			
Nagelkerke R^2 = .02			
Recycling			
Constant	.56*	.24	1.75
Income	-.64*	.25	.53
Education	.15	.25	1.16
Gender	.83**	.24	2.29
Age	-.33	.26	1.75
Number of obs = 337			
Nagelkerke R^2 = .09			

* Significant at the .05 level (2-tailed)
** Significant at the .01 level (2-tailed)

Table 5. Summary statistics for psychological variables

	N	Mean	Standard Deviation	Min	Max
Appropriateness	335	4.48	.62	1	5
Concern	354	1.99	.53	1	3
Understanding	351	3.81	.75	2	5

Table 6. Logistic Regression for rainwater and recycling

	B	SE B	e^B
Rainwater	-3.48**	1.18	
Constant	.23	.19	1.25
Appropriateness	-.13	.22	.88
Concern	.65**	.16	1.91
Understanding			
Number of obs = 333			
Nagelkerke R^2 = .08			
Recycling	-4.09	1.28	
Constant	.86**	.21	2.36
Appropriateness	.29	.24	1.33
Concern	.10	.17	1.10
Understanding			
Number of obs = 333			
Nagelkerke R^2 = .08			

* Significant at the .05 level (2-tailed)
** Significant at the .01 level (2-tailed)

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