Motivational Indicators of Decentralised Systems Use among Householders in South East Queensland

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The Urban Water Security Research Alliance (UWSRA) is a $50 million partnership over five years between the Queensland Government, CSIRO's Water for a Healthy Country Flagship, Griffith University and The University of Queensland. The Alliance has been formed to address South East Queensland's emerging urban water issues with a focus on water security and recycling. The program will bring new research capacity to South East Queensland tailored to tackling existing and anticipated future issues to inform the implementation of the Water Strategy.

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Description: Rainwater tank at Innovation House, 2007
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FOREWORD

Water is fundamental to our quality of life, to economic growth and to the environment. With its booming economy and growing population, Australia's South East Queensland (SEQ) region faces increasing pressure on its water resources. These pressures are compounded by the impact of climate variability and accelerating climate change.

The Urban Water Security Research Alliance, through targeted, multidisciplinary research initiatives, has been formed to address the region’s emerging urban water issues.

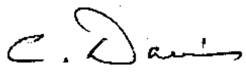
As the largest regionally focused urban water research program in Australia, the Alliance is focused on water security and recycling, but will align research where appropriate with other water research programs such as those of other SEQ water agencies, CSIRO’s Water for a Healthy Country National Research Flagship, Water Quality Research Australia, eWater CRC and the Water Services Association of Australia (WSAA).

The Alliance is a partnership between the Queensland Government, CSIRO’s Water for a Healthy Country National Research Flagship, The University of Queensland and Griffith University. It brings new research capacity to SEQ, tailored to tackling existing and anticipated future risks, assumptions and uncertainties facing water supply strategy. It is a $50 million partnership over five years.

Alliance research is examining fundamental issues necessary to deliver the region's water needs, including:

- ensuring the reliability and safety of recycled water systems.
- advising on infrastructure and technology for the recycling of wastewater and stormwater.
- building scientific knowledge into the management of health and safety risks in the water supply system.
- increasing community confidence in the future of water supply.

This report is part of a series summarising the output from the Urban Water Security Research Alliance. All reports and additional information about the Alliance can be found at http://www.urbanwateralliance.org.au/about.html.



Chris Davis
Chair, Urban Water Security Research Alliance

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EXECUTIVE SUMMARY

In South East Queensland (SEQ), extended periods of drought and unprecedented population growth have resulted in a water strategy reliant on permanent water conservation measures. There is also a greater emphasis on the installation of decentralised water systems at the household level, in particular, rainwater tanks and greywater systems. The state and federal governments, at various times, have offered short-term rebates designed to encourage and compensate individuals who chose to install a 3,000-5,000 litre rainwater tank on their property. However, despite the financial rebate, the number of existing homes that have chosen to retrofit decentralised systems on their property still remains below 50% (RWIMU, 2009). Therefore, it is likely that the decision to retrofit is driven not only by cost, but also by individuals' perceptions of water use, water shortages issues, and environmental beliefs. Marsden Jacob Associates (2007) argued that even with the inclusion of rebates, the gap between the cost of rainwater and the cost of scheme water per kilolitre suggests that households are installing rainwater tanks for indirect benefits rather than cost savings, for example, being able to water one's lawn during water restrictions.

The study had two aims. The first was to quantitatively examine potential reasons why people choose to adopt, or not adopt, a decentralised water system on their property. The underlying theoretical foundation for this empirical study was protection motivation (PM) theory (Rogers, 1983). PM theory proposes that individuals protect themselves from negative events based on the appraisal of four factors:

Factor	Appraisal
1. Perceived severity of a threat	Threat appraisal
2. Perceived vulnerability or probability of a threat	
3. Perceived efficacy of the preventative behaviour(s)	Coping appraisal
4. Perceptions of self efficacy in carrying out the appropriate behaviour(s)	

In the present context, the negative event – or threat – was defined as future water shortages in SEQ, and the potential stress associated with reduced availability of water for everyday activities. Using the protection motivation framework, the decision to install or use a decentralised water system on one's property was conceptualised as a product of perceived threat of water shortages and belief in one's ability to cope.

It was hypothesised that there would be a significant difference in protection motivation among SEQ residents who did and did not use decentralised systems on their property. Specifically, people using decentralised systems would believe there was a higher threat of water shortages and have a strong belief in their ability to cope with this threat, whereas people not using decentralised systems would perceive their ability to cope as much lower. Further, threat and coping appraisals were likely to influence adaptive coping (e.g., intentions to adopt alternative water systems at home), which in turn would predict adoption or non-adoption of decentralised water systems.

The second aim of this study was to examine how much residents were willing to pay for decentralised water technology, given their demographic background (e.g., age, income, education, etc.) and their water use attitudes and behaviours. A choice experiment study was applied to determine willingness to pay for three different types of decentralised water systems: groundwater abstraction from bores and spear pumps; rainwater harvesting from installing rainwater tanks; and reusing and recycling household greywater through the installation of greywater systems.

Results indicated that the extent to which householders intended to engage in actions that would help them adapt to, and deal with, water shortages was significantly related to how threatened they felt about future water shortages. This was also influenced by how much individuals felt that their actions could help them deal with that threat. Further, increased belief in the utility of decentralised systems in addressing water shortages led to a decrease in perceived costs associated with installing decentralised systems (e.g., financial costs, time and effort).

Results from the willingness to pay component of the study suggest that the promotion of decentralised systems would work more effectively with those who have not yet adopted any decentralised system as compared to current system owners. This highlights that the benefit of currently owning a decentralised technology is insufficient in encouraging existing owners to adopt additional systems in order to become less dependent on scheme water. Further, participants who expressed an avid interest in gardening were more willing to pay for decentralised systems than others.

This study provided general support for protection motivation as a conceptual framework for understanding the behaviour of decentralised system adoption. Both the willingness to pay and protection motivation components present implications for policy. This research suggests that targeting costs associated with the installation of decentralised systems, promoting the utility of such systems, and increasing awareness of ongoing water sustainability issues in SEQ could be an effective strategy in encouraging greater urban adoption of decentralised systems. The research also suggests that considering the styles and combinations of decentralised systems that people are willing to pay for is likely to facilitate widespread adoption of decentralised technology. Another important finding to note is the strong association between coping behaviour and future intentions to adopt decentralised systems. That is, individuals who feel that they can manage these systems well are more likely to express intentions to install decentralised systems in the future.

Based on the present findings, future research should focus on understanding potential differences in water use behaviours between people who have chosen to adopt decentralised systems and those who may have decentralised systems on their property due to government mandates and/or building regulations. The present research has shown that making a conscious *choice* to adopt decentralised water technology might result in different water use behaviours and acceptability. Therefore, the next phase of the current research is to consider the possible differences in water use attitudes between those people who voluntarily retrofit their homes with rainwater tanks, and those who install tanks to meet government mandates. It is believed that increasing social scientific knowledge of decentralised systems technology will provide solid grounds for policy formation and help to manage and prolong urban water infrastructure for the future and facilitate the adoption of sustainable water practices in urban Australia.

1. INTRODUCTION

In South East Queensland (SEQ), extended periods of drought and unprecedented population growth have resulted in a water strategy reliant on permanent water conservation measures. There is also a greater emphasis on the installation of decentralised water systems, such as rainwater tanks, at the household level. Other decentralised systems used in the SEQ region include treated and untreated greywater systems, which utilise wastewater generated from bathroom and laundry applications for non-potable applications indoors and outdoors, and to a lesser extent, groundwater bores. Decentralised systems allow households to collect, treat and reuse localised wastewater in areas where high quality water is not required. The key benefit of these systems is reducing householders' reliance on town/mains water and providing water on a fit-for-purpose basis.

As part of the Queensland Development Code (QDC), all homes built in SEQ from January 2007 must install a water saving device within the home that allows the household to save approximately 70 kL of mains water per year. The easiest and most efficient installation recommended for this purpose is a plumbed rainwater tank, with a minimum volume of 5,000L (QDC MP4.2; DIP, 2010). While most new homes are installing decentralised rainwater tanks, many existing homes in SEQ are being encouraged to retrofit a decentralised system within the home's existing infrastructure. The state, federal and local governments have, at various times, offered short-term rebates designed to encourage and compensate individuals who choose to install a 3,000-5,000 L rainwater tank on their property. However, despite the financial rebate, the number of existing homes that have chosen to retrofit decentralised systems still remains below 50% (RWIMU, 2009). The financial incentives to install a greywater system instead of, or alongside, a rainwater tank have not been comparable, with limited or nil government rebates extending to cover the expenses incurred to install greywater systems. Therefore, the decision to retrofit is unlikely to be driven by financial incentives, but rather by individuals' environmental beliefs, norms related to water use and perhaps a desire to live sustainably or self-sufficiently. Marsden Jacob Associates (2007) argued in its report on the analysis of the cost-effectiveness of rainwater tanks in urban Australia that, even with the inclusion of rebates, the gap between the levelised cost (cost per kilolitre) of rainwater and the cost of scheme water suggested that households are installing rainwater tanks for indirect benefits, other than cost savings. These indirect benefits include being able to water gardens and lawns during times of a complete watering ban.

Past qualitative research on users and non-users of decentralised water systems has identified that most SEQ residents have a high acceptance of decentralised water systems for non-potable applications, particularly for outdoor uses such as gardening. Gardiner and colleagues (2008; Gardiner, 2009) examined three groups of rainwater tank owners: urban 'retrofitters', peri-urban residents with established tanks, and 'mandated' tank owners living in greenfield estates where decentralised supplies were part of the development. The authors found systematic differences between the three groups, specifically reporting that urban households that retrofitted their rainwater tanks were the most satisfied with their system, when compared to greenfield residents with mandated tanks. Further, while all respondents expressed concern about water shortages affecting SEQ, the 'retrofitter' group demonstrated a more genuine commitment to water conservation.

Mankad, Tucker, Tapsuwan and Greenhill (2010) also conducted a study focusing on residents of greenfield developments using decentralised systems as a domestic water supply. This study, however, compared the attitudes and knowledge of these greenfield residents with matched non-users of decentralised systems within SEQ. The findings showed that within the greenfield sample, there were distinct groups of individuals whose attitudes and knowledge varied depending on the complexity of the decentralised system(s) set-up. That is, residents from developments that only had a mandated rainwater tank were very different from residents in developments that relied on decentralised systems for most or all of their domestic water supply. Residents of these latter 'eco' developments had a more environmentally-driven perspective of water use than those in the mandated tank developments. Yet, the aesthetic value of the greenfield location was still cited as the most dominant reason for choosing to live in a home that utilised any form of decentralised water. This finding was consistent among all mandated users in research by both Gardiner *et al.* (2008) and Mankad *et al.* (2010).

An interesting finding also emerged from Mankad *et al.* (2010) specific to non-users of decentralised systems. Their interview data showed that different perceptions and knowledge associated with water issues were related to individuals' desire to install a decentralised system. That is, people who were more concerned about water issues in SEQ more often stated that they would like to own a decentralised system of some sort. However, practical issues associated with decentralised system installation, such as available property space, costs, and aesthetic issues, were consistently cited as important barriers of decentralised water use among current non-users of decentralised systems.

Therefore, the two main purposes of this study are:

1. to understand why people choose to adopt, or not adopt, a decentralised water system on their property and determine the importance of psychological factors in making this distinction; and
2. to examine how much residents were willing to pay for decentralised water technology, given their demographic background (e.g., age, income, education, etc.) and their water use attitudes and behaviours.

The present study examines whether emergent psycho-social factors (i.e., perceptions of water issues, barriers to decentralised water use) are reliable predictors of decentralised water system installation and use among a wider SEQ sample. The underlying theoretical model that was used to explain adoption behaviour was protection motivation theory (Rogers, 1975: 1983). This theoretical perspective has previously been shown to explain environmentally relevant behaviours from a motivational perspective (e.g., Martin, Bender, and Raish, 2007).

1.1. Conceptual Framework

Protection motivation (PM) theory was originally conceptualised by Rogers (1975) to better understand fear appeals using cognitive appraisals of threatening/stressful events (see Figure 1 for an adapted illustration). PM theory proposes that individuals protect themselves from negative events based on the appraisal of four factors:

1. Perceived severity of a threat
2. Perceived vulnerability or probability of a threat
3. Perceived efficacy (effectiveness) of the preventative behaviour(s)
4. Perceptions of self efficacy in carrying out the appropriate behaviour(s).

In the present context, the threat could relate to one's concern about future water shortages, or the stress associated with a belief that there will be a reduced availability of water for everyday activities. Using the PM framework, the decision to install or use a decentralised water system on one's property could be seen as a product of these four cognitive principles.

1.1.1. Threat Appraisal Process

The factors of threat severity and threat vulnerability combine to form what Rogers (1983) refers to as the threat appraisal process, which is an important factor in determining whether people will protect themselves from a risk. *Threat severity* refers to the perceived seriousness or degree of harm likely to be experienced from a threat (e.g., water shortages). *Threat vulnerability* is the perceived probability of the event taking place and the likelihood that the threat will affect the individual.

1.1.2. Coping Appraisal Process

The coping appraisal process comprises three response-specific factors related to a perceived threat: response efficacy, self-efficacy and perceived response costs (Rogers, 1983). *Response efficacy* refers to one's belief that a particular behaviour, or set of recommended behaviours, is effective in removing or preventing the threat (e.g., belief that a tank will alleviate the effects of water shortage). *Response costs* are barriers that people perceive as being negatively associated with the adoption of recommended behaviour(s) (e.g., tanks look ugly in the yard). Finally, *self-efficacy* refers to people's belief in their ability to carry out the recommended behaviour(s), to reduce the likelihood and/or severity of the perceived threat (e.g., I am confident I could maintain a tank on my property).

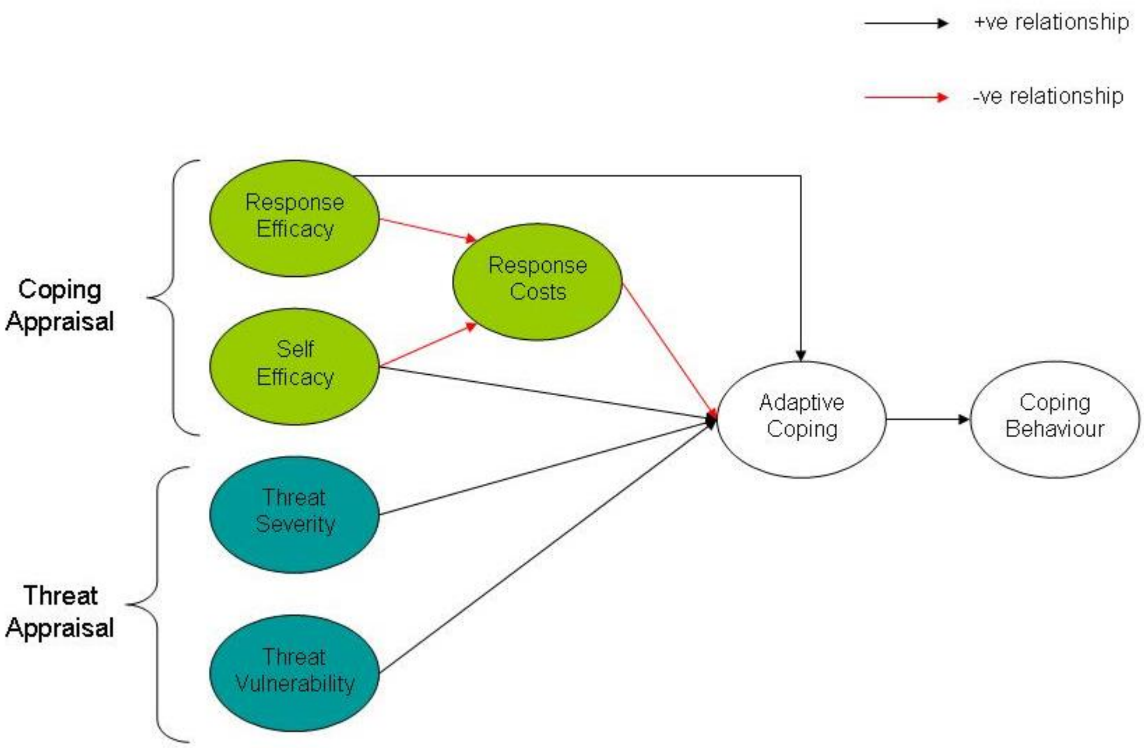

Figure 1: Protection motivation theory model utilised in this study, adapted from Rogers (1983).

1.1.3. Adaptive and Maladaptive Coping

In trying to further understand the effects of motivational factors on behaviour change, Rogers (1983) revised his protection motivation model to incorporate additional cognitive mediating processes, termed *adaptive* and *maladaptive* coping. Maladaptive responses are those that place an individual at risk and include behaviours that lead to negative consequences (e.g., wasting water) in the absence of adaptive behaviours, such as choosing to reuse wastewater.

The factors thought to increase more *maladaptive* (poor) behavioural responses to a threat include greater perceptions of response costs associated with a recommended behaviour (e.g., a rainwater tank is too expensive), as well as limited belief in one's ability (self-efficacy) to cope with the threat successfully. Conversely, a greater perception of threat vulnerability and severity is likely to facilitate more *adaptive* (beneficial) coping behaviour. Therefore, the influence of threat and coping appraisal on the final behavioural outcome (i.e., adopting a tank) is hypothesised to be influenced by adaptive or maladaptive coping.

1.1.4. Research using PM Theory

PM theory has been utilised to explain protection motivation specific to environmental hazards and environmentally protective behaviours (e.g., Vaughan, 1993; Martin, Bender, and Raish, 2007). Pelletier *et al.* (1999) argued that although people have become more aware of environmental issues and shown interest in living sustainably, this growing interest has not translated into active engagement in environmentally protective behaviours. Their study aimed to establish a measure of why people lack motivation toward the environment and focused on testing response efficacy and self-efficacy factors from the PM model. Results showed that in order to consider environmentally protective behaviours, individuals must experience some level of perceived threat. However, for this consideration to translate into action, individuals must also believe that recommended strategies are effective in solving a problem, that these strategies can be integrated into their lifestyle, and that they have the capacity to engage in the desired strategies. These findings suggest that the PM theory structure can be used to explain a lack of motivation among individuals when engaging in environmentally relevant behaviours.

Grothmann and Reusswig (2006) more recently applied PM theory in a study designed to understand why some individuals in flood-prone areas chose to protect themselves and their property from the risk of flooding, while others did not. In this study, it was believed that the PM variables would help to explain the decision-making factors among residents engaging in precautionary damage prevention on their property. This study is highly relevant to the present context due to its focus on understanding protection motivation in high risk areas, as is the focus of this study. Grothmann and Reusswig (2006) described the importance of past experiences in determining threat vulnerability and severity. They hypothesised that past experiences with flood damage could be a motivator for people to take precautionary action. Results showed that public risk communication was important for informing residents' threat appraisals, which, researchers argued, would subsequently motivate residents of flood-prone areas to engage in preventative behaviours. Further, communicating the recommended behaviours to residents, highlighting the effectiveness of these actions and outlining the cost of protecting one's property from flood, were also important issues that influenced flood protection behaviour. These findings, overall, aligned with the hypothesised relationships summarised by the PM model and provided support for the use of PM theory in the context of urban water use in SEQ.

Finally, another key study utilising PM theory in the context of environmentally relevant behaviours was conducted by Martin, Bender and Raish (2007). They measured threat and coping appraisal to try and understand what motivated residents to protect themselves and their homes from forest wildfires. In addition to using the factors in the PM model, the researchers also tested the role of subjective knowledge of wildfire risks among residents. Martin *et al.* (2007) hypothesised that individuals would vary in their decision to protect their homes from wildfires based on their level of knowledge and personal experience (i.e., subjective knowledge) related to wildfire mitigation strategies. These factors were then believed to influence residents' motivation to take preventative action by interacting with the threat and coping appraisal processes. Findings from the study supported the use of PM theory in explaining wildfire protective behaviour among home owners. Specifically, homeowners reporting greater knowledge of mitigation strategies were more likely to be driven to engage in protective behaviours based on perceptions of threat severity, whereas individuals reporting less knowledge were more likely to be motivated by perceptions of threat vulnerability. Vicarious experiences gained from neighbours and other influential individuals were also found to influence risk perception.

From a review of the relevant social science literature, researchers utilising PM theory in explaining environmentally relevant behaviours tend to agree that, by taking into account the way in which people estimate their ability to respond to a threat, and the belief in the effectiveness of the response strategies, gives a clear picture of people's decision-making process. PM theory has, therefore, been useful in understanding the public's motivation to engage in environmentally relevant behaviours at the household level. Researchers cited in this review have also acknowledged that prior knowledge of a threat situation (e.g., water shortage) may influence threat perceptions of vulnerability and severity. Simply influencing people's threat perceptions was not enough to initiate pre-environmental behaviour. Rather, measuring perceptions of response effectiveness, response costs (both financial and perceptual), and one's self belief in the responses were also important when understanding why some individuals chose to adopt protective environmental behaviours and others did not.

1.1.5. Willingness to Pay

In putting a monetary value on the influence of financial response costs, it is important to consider the level at which financial costs become a negatively motivating, or inhibiting, factor in the adoption of decentralised water technology. Willingness to pay (WTP) is the maximum amount of money a person is willing to give up in exchange for an improvement in the current state of the good, so that the individual would feel better off (or at least not worse off). Alternatively, an individual may have the willingness to accept compensation if there is deterioration in the current state of the good, so that they would not be worse off. Willingness to pay is consistent with the *Utility Maximising Theory*. *Utility* is an economic theory that tries to measure relative satisfaction. For example, an individual is faced with two choices, first, to adopt the decentralised water system and second, to do nothing. The individual will choose the option that offers more utility or satisfaction. However, the choice will be constrained by income and influenced by socio-economic characteristics and psychological factors.

In the context of decentralised water systems, we can ascertain how much an individual is willing to pay, on average, for a particular type of decentralised water technology by presenting him/her with a choice of product bundles at different prices. The individual is normally asked to choose the option he/she most prefers. By paying for a product bundle, the individual is showing that they are better off (or at least not worse off) by parting with their money because he/she will receive the product in return. It is also possible for the individual not to choose any product bundle and not have to pay. This type of elicitation technique closely mimics the decision making process an individual has to perform each day when choosing to buy a product. The elicitation technique is called choice experiments. Choice experiment posits that when an individual makes a choice among different alternatives, there is an underlying rational decision process and it can be written in the form of a function.

A number of studies in Australia have attempted to measure household preferences for treated wastewater using WTP elicitation techniques. Hurlimann (2009) found that residents in regional Victoria were willing to pay $7.66 per kL for recycled water delivered to their homes while Tapsuwan *et al.* (2007) estimated that Perth households would be willing to pay on average 59% more on their annual water usage bills for treated wastewater. However, these studies only look at the WTP for centralised water systems. There is currently a knowledge gap in the literature as to how much people would be willing to pay for decentralised water systems in Australia. As such, a study of this kind is warranted.

1.2. Objectives of the Present Study

Results highlighted within the social science literature have validated the use of PM theory in explaining differences in environmental protection behaviours and this research can be used to inform the present study. Installation of decentralised systems at the household level varies among SEQ residents, despite media encouragement from the state and federal governments, financial incentives, and clear climatic issues restricting water use in SEQ during the last decade. Therefore, the key objective for this study is to understand motivational factors that vary among residents who choose to install a decentralised system on their property (e.g., rainwater tank, greywater system) and those who do not. In the context of this study, the threatening event is conceptualised as water shortage, and adaptive behaviour is considered to be the installation and/or use of decentralised water systems.

It is hypothesised that there will be a significant difference in protection motivation among SEQ residents who do and do not use decentralised systems on their property. That is, people with decentralised systems will have higher threat and coping appraisals. However, people not currently using decentralised systems will have lower coping appraisals. Further, threat and coping appraisals are likely to influence adaptive coping (adaptive - maladaptive coping), which will mediate the prediction of decentralised water system adoption.

It is of further interest to determine how much individuals are willing to pay for decentralised water technology, given their demographics (e.g., age, income, education, etc.), as well as their water-related attitudes and behaviours. A choice experiment study will be applied to determine whether households in SEQ are willing to pay for three different types of decentralised water systems: groundwater abstraction from bores and spear pumps; rainwater harvesting by installing rainwater tanks; and reusing and recycling household greywater through the installation of greywater systems. Participants' attitudes toward water use, such as gardening, are hypothesised to influence their willingness to pay for decentralised technology.

It is believed that the results from this study will help researchers in understanding public acceptance of decentralised systems, as well as providing policy makers with information about residents' willingness to install and utilise decentralised systems at the household level in urban SEQ.

2. SOCIAL-PSYCHOLOGICAL COMPONENT

2.1. Methodology

2.1.1. Participants

The total number of participants involved in this study was 594 and the full sample was then sub-categorised based on decentralised systems ownership (n = 273 with decentralised systems; n = 321 without decentralised systems). Approximately 43% of the total sample were males and 57% were females, with approximately 63% of participants under the age of 60 years. 82% of participants were of Anglo-European descent and approximately 62% of participants had a gross annual household income below $90,000. The average number of adults per household was 2.23 (SD = 0.903) and approximately 74% of participants did not report having children living in the home.

2.1.2. Participant Recruitment

This study was carried out in June 2010. Participants were recruited through an online research panel (database) from local government areas within SEQ; potential participants were verified as SEQ residents through their self-reported postcodes. Participants initially received an invitation email to take part in the survey and, after following the survey hyperlink, were then provided with the study Information Sheet and Consent Form (see Appendix A1 and A2). Participants were required to provide their consent to take part in the survey by checking the appropriate box. Participants were also informed via the invitation email that, if they completed the survey, they would receive ‘reward points’ through the online research company as incentive for participating.

Follow-up invitation emails were sent out to those individuals who did not respond in the first round of email invitations, to ensure that all who wished to participate were given the opportunity to do so. The survey began mid-week and was ‘live’ for a period of 17 days.

2.1.3. Participant Screening

SEQ residents included in this study were initially screened to ensure that all participants were home owners (or paying off a mortgage) of a free-standing dwelling, and that their homes were connected to mains water. This was to prevent short-term renters, apartment owners, and rural property owners from participating in the survey. The rationale for this was that the inclusion of residents who did not engage in water supply-related decisions in the home, and those who were not reliant on mains water as their primary water source, may potentially cloud results aimed at measuring urban homeowners’ attitudes toward decentralised systems ownership. Owners of mandated rainwater tanks were also excluded from the analysis, as it was deemed that these individuals had minimal input to whether their home had a water tank or not. Both adopters and non-adopters of decentralised systems in SEQ were invited to participate in the survey as this allowed researchers to compare differences between ownership categories.

2.1.4. Study Design

A convenience sampling technique was used in this study to target a cross-section of residents in SEQ. Participants responded to an online survey, therefore, only SEQ residents with a valid email address were sampled. While the proportion of males and females was comparable to Australian Bureau of Statistics population data (ABS, 2006), the current sample comprised a higher proportion of participants over the age of 60 years (refer to Appendix B for a comparison of the present sample with ABS population data). However, this skew was expected, given the need for participants to be home owners. Therefore, this was not believed to be a problematic issue.

2.1.5. Ethics

Ethical clearance for this study was obtained from the CSIRO Human Research Ethics Committee.

2.1.6. Measures

The measures used in this study were based on the generic PM theory model (Rogers, 1983; see Figure 1). Individual items were adapted from past PM research, both in the environmental and social science literature cited in Section 1.1, as well as including items specific to the current context. As no previous research has utilised the PM model specific to understanding decentralised system adoption, these items were developed based on general PM principles.

2.1.7. Demographics

Standard demographic questions were included at the end of the online survey to establish a set of descriptors for the current sample. Variables included in this section were: year of birth, gender, income, household composition, occupation, education and cultural background.

Appendix C provides for a full suite of statistical tables for the following descriptive information:

- Number of respondents using rainwater from a tank
- Uses for rainwater
- Treatment for rainwater used in the kitchen
- Number of respondents using greywater
- Uses for greywater
- Greywater collection methods
- Number of respondents using bore water
- Number of bedrooms in the home
- Number of storeys in the home
- Number of bathrooms in the home
- Actual household water consumption during last billing cycle
- Intentions to install decentralised devices in the near future.

2.1.8. Protection Motivation Theory

The present study utilised protection motivation (PM) theory (Rogers, 1983) as the underlying theoretical model for examining whether there were motivational differences among participants who do and do not use decentralised systems on their property. The hypothesised PM model incorporates psycho-social factors and utilises decentralised system adoption as a dependent variable. Potential water shortage was defined as the environmental "threat" affecting SEQ, with the installation of rainwater tanks, greywater systems and bores serving as recommended responses to protecting homes from the threat of water shortages. Potential barriers to decentralised water use, identified through past Urban Water Security Research Alliance research (see Mankad *et al.*, 2010), were used to measure response cost perceptions.

NB. Where a 5-point Likert scale is used as a measurement for the PM items in this section, only the lowest and highest points are named. However, in the actual survey, all points were labelled in an ordered way, to avoid participant confusion and to facilitate accurate survey completion. Section 2.4.2.1 provides a full Likert label set, however, subsequent sections will only cite the scale end-points, for brevity.

2.1.8.1. Threat Appraisal

This component of PM was measured using eight items comprising threat vulnerability and threat severity questions. For the single threat severity item, participants were asked to rate when they believed that extreme water shortages would affect SEQ. Responses were made using an 8-point Likert-type scale, where participants estimated when, in the next 50 years, SEQ would experience extreme water shortages (1 = SEQ will not experience extreme water shortages; 4 = Between 21 and 30 years; 8 = SEQ is already experiencing extreme water shortages.

The seven threat vulnerability items asked participants to respond to a set of statements describing how concerned they were, if at all, about water shortages affecting SEQ in the future. Statements referred to the possibility of water shortages affecting the individual, their children, their community, and future generations. Responses were made using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). This scale was found to be highly reliable, with a Cronbach alpha coefficient (α) of 0.906.

2.1.8.2. Coping Appraisal

The coping appraisal component comprised nine response cost items, seven response efficacy items, and a single self-efficacy item. Participants responded to response cost statements using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) and indicated their level of agreement to potential barriers and/or costs associated with installing and using decentralised systems (e.g., financial cost, limited property space, time). Positively-worded items were reverse-coded, so that all items reflected higher scores for higher perceived response costs.

For the response efficacy items, participants were asked to indicate how effective they believed specific recommended decentralised system options to be in reducing the impacts of water shortages on their lives and how effective they would be in their ability to protect themselves and property from the effects of water shortages. Responses were made using a 5-point Likert scale (1 = not at all effective; 5 = very effective). For the single self-efficacy item, participants were asked, on a five-point scale to rate how confident they felt about their ability to protect themselves and their property from the effects of water shortages (1 = not at all confident; 5 = very confident).

2.1.8.3. Coping Behaviours

Items measuring adaptive and maladaptive behaviours were combined to form a single *total adaptive coping* score, where composite scores on maladaptive coping (six items) were subtracted from the composite adaptive coping scores (five items), as per Rogers' (1983) model. In this context, use of the term 'behaviour' does not refer to observed behaviour, but rather a propensity to respond to threat in an adaptive (e.g., knowledge-seeking) or maladaptive (e.g., avoidant) manner. Respondents rated their level of agreement with statements describing methods of coping specific to water conservation and shortages. Concepts covered in the adaptive coping statements included intention to install decentralised systems and active knowledge-seeking behaviour by home owners. The maladaptive coping statements included avoidance and learned helplessness behaviours among home owners, specific to water shortages in SEQ ("What I do on my property won't have any real impact on water shortages in SEQ"). The coping behaviours variable served as a mediator in the full PM model during the analysis.

2.1.8.4. Subjective Knowledge

The subjective knowledge variable was added to the study to examine whether participants' knowledge of general water issues would influence their decisions to adopt any decentralised systems. Participants were required to rate their agreement/disagreement to three of the subjective knowledge statements (1 = strongly disagree to 5 = strongly agree).

2.1.8.5. Dependent Variable

The dependent variable used in the final PM model was the adoption or non-adoption of decentralised water technology on one's property. A decentralised system was defined as including rainwater tanks, greywater systems or bores installed for indoor or outdoor use.

2.1.9. Study Procedure

After accepting the invitation to take part in the study, participants were given a link to the survey. The first page introduced participants to the study and its purpose. Contact details for the research team members were provided. Before beginning the survey, respondents were asked to formally provide their consent to take part. Before agreeing to do this, participants were encouraged to read the attached Information Sheet and Consent Form specific to the study. After reading these documents, potential respondents were asked to tick the appropriate box if they were willing to provide consent and begin the survey.

The survey took approximately 20 minutes to complete. After completing the social psychology component of the survey, participants completed the demographics section and then moved on to the choice modelling component.

Once the whole survey was completed and responses were correctly submitted to the database, respondents were thanked for their participation and informed of their points-based reward through the online research company.

2.1.10. Data Analysis

Two analytic programs were used in the current study. PASW Statistics (formerly SPSS), was used for descriptive analyses, t-tests and analysis of variance (ANOVA). M*plus,* developed by Muthen and Muthen (1998-2010), was used to perform analyses on latent variables. Specifically, the current study used M*plus* to perform confirmatory factor analyses, structural equation modelling and logistic regression.

2.2. Results

2.2.1. Descriptive Demographic Statistics

2.2.1.1. Household Composition

The majority of respondents lived in a household with either three (45.5%) or four (35.2%) bedrooms and had a one storey house (67.1%). Most households had two bathrooms (281 households) closely followed by one bathroom (203 households) and stated their garden and lawn took up around 50% of their block size (25.7% of respondents). Over half (55.2%) of respondents believed themselves to be low water users and only 3.5% of respondents believed they were high water users. Approximately half (46.2%) of the respondents used between 1 kL and 100 kL of mains water during their last quarterly billing cycle.

2.2.1.2. Rainwater Use

Nearly half of all respondents owned a rainwater tank (44.6%). Of the 265 households that did own a rainwater tank, over half (53.2%) received a rebate for purchasing it and 26% of these tanks were plumbed into the home and external fixtures. The most common uses for the rainwater were cited as gardening (86.8%), topping up the swimming pool (28.3%), washing clothes (22.3%) and in the toilet (21.5%). Of the respondents, 54 used the water to drink or cook with and over half (57.4%) of these people treated the rainwater first, using a filter (87.1%) and/or by boiling the water (22.6%).

2.2.1.3. Greywater Use

The number of participants who utilised greywater was 39.2%. Participants cited the washing machine (77.3%), shower (46.8%), laundry sink (43.8%) and kitchen sink (27%) as the most common areas for greywater collection. The most commonly cited reuse of grey water was the washing machine (56.7%) and manual bucketing of untreated wastewater (typically from the shower) onto the garden or plants (45.1%).

2.2.1.4. Bore Water Use

Only 16 participants (2.7%) reported using a bore on their property. All of these respondents primarily used the bore water in the garden, as opposed to other uses.

2.2.1.5. Future Behavioural Intentions

Nearly half of respondents without a decentralised system (46.9%) said they were likely or very likely to install a rainwater tank. However, a large majority of them said they were unlikely or very unlikely to install the following devices in the near future: a bore (94.5%), a black water (recycled effluent) system (85.7%) or a greywater system (54.7%).

2.2.2. Protection Motivation Theory Variables

Statements were used as proxies for five of the PM theory constructs in the study: perceived threat vulnerability, response efficacy, response cost, adaptive coping and maladaptive coping. Perceived threat severity, self-efficacy and subjective knowledge were measured directly from a question.

2.2.2.1. Threat Vulnerability

Table 1 shows the five threat vulnerability statements used in the study and their mean ratings.

Table 1: Perceived vulnerability statements and mean scores for each item.

Variable Name	Statement	Mean* (N=594)
Threat1	I am concerned that SEQ will experience water shortages in the future	3.86
Threat2	I worry about how water shortages will affect me personally	3.51
Threat3	I am worried about how water shortages will affect others in my community	3.57
Threat4	I worry about water shortages because many people are reliant on town/mains water	3.72
Threat5	I don't think other people in my community are concerned about future water shortages	3.05
Threat6	My friends and family are worried about future water shortages	3.45
Threat7	I worry how water shortages will affect my children and future generations	3.69

*1=strongly disagree to 5=strongly agree

Factor analysis with maximum likelihood (ML) and oblimin rotation was performed on the perceived vulnerability statements using SPSS, and two factors were produced. *Threat 1, 2, 3, 4,* and *7* loaded highly on one factor. *Threat 6* loaded highly onto both factors, indicating that it was a potentially problematic item. Meanwhile, *Threat 5* did not load onto either factor significantly and was dropped from the analysis.

The first factor which contained these five statements was further examined in M*plus*. This was to determine it's goodness-of-fit as one congeneric measurement model of participants' perceived vulnerability to the threat of water shortages. Confirmatory M*plus* results indicated that only four statements were found to well represent the latent construct, *perceived vulnerability*. As a result, *Threat 1* was removed and the remaining four statements (*Threat 2-4*, and *Threat 7*) were retained and used to form the perceived vulnerability scale (Table 2).

Table 2: Perceived vulnerability factor loadings.

Variable Name	Statement	Factor Score Coefficient
Threat 2	I worry about how water shortages will affect me personally	0.18
Threat 3	I am worried about how water shortages will affect others in my community	0.40
Threat 4	I worry about water shortages because many people are reliant on town/mains water	0.20
Threat 7	I worry how water shortages will affect my children and future generations	0.10

In order to account for the different contributions that each statement has on the perceived vulnerability construct, the current study utilised the method suggested (Holmes-Smith, 2010) to calculate the composite score. Therefore, the composite score was the sum of scores obtained from multiplying the factor score coefficient (FSE) of each statement with its response. The composite score was also rescaled to ensure the range remained the same. The following shows the formula used to calculate the perceived vulnerability composite scale:

Perceived vulnerability = (FSE for threat2 / total FSE threat2) + (FSE for threat3 / total FSE * threat3) + (FSE for threat4 / total FSE *threat4) + (FSE for threat7 / total FSE *threat7)*

Overall, higher scores in the scale indicated higher perceived vulnerability to the threat of water shortages (M = 3.61, SD = .68).

2.2.2.2. Response Efficacy

Table 3 shows the seven statements used in the study to measure response efficacy and their mean ratings.

Table 3: Response efficacy statements and mean scores for each item.

Variable Name	Solutions	Mean* (N=594)
Reseff1	Installing a rainwater tank for outdoor use in your home	3.99
Reseff2	Installing a rainwater tank for indoor use in your home	3.82
Reseff3	Installing a rainwater tank to provide water for drinking or cooking	3.49
Reseff4	Reusing greywater from your shower and laundry using buckets	3.10
Reseff5	Installing a greywater treatment system that would supply water back into your house	3.57
Reseff6	Using less water around the house and garden	3.73
Reseff7	Installing water efficient devices around the house and garden	3.78

*1 = not at all effective to 5 = very effective

A composite score was again calculated for each construct emerged from the seven response efficacy items using the method described in Section 3.2.1 (see Appendix D for more details). Descriptive statistics were later calculated for response efficacy of greywater systems ($M = 4.51$, $SD = 0.89$), response efficacy of rainwater tanks ($M = 3.47$, $SD = 1.14$) and response efficacy of water savings initiatives ($M = 3.55$, $SD = 0.89$). Higher scores on the three response efficacy constructs indicated a stronger belief in the perceived effectiveness of that particular group of actions (i.e., greywater systems, rainwater tanks, and water savings initiatives).

2.2.2.3. Response Costs

Table 4 shows the mean ratings of the nine statements developed to measure participants' perceptions of the barriers, or costs, associated with installing decentralised systems at home.

Composite variables were again created for response costs' items (See Appendix D for more information about the method used).

Descriptive analysis for the two response cost scales were carried out. Higher scores on each scale indicate a greater perception of the barriers or costs associated with installing greywater systems ($M = 2.58$, $SD = 0.64$), or rainwater tanks ($M = 2.21$, $SD = 0.82$).

Table 4: Response cost statements and mean scores for each item.

Variable Name	Statement	Mean* (N=594)
RC1	I don't have time to install a rainwater tank	2.13
RC2	It takes a lot of time to achieve water cost-savings from a greywater system	2.93
RC3	I can afford to buy and install a rainwater tank (R)	3.01
RC4	I don't have the time to get a greywater system installed	2.53
RC5	I would be happy to undertake any maintenance required for my rainwater tank (R)	3.49
RC6	I cannot afford to install a greywater diversion system	3.38
RC7	A rainwater tank would make my property look ugly	2.09
RC8	I don't have the space for a rainwater tank	2.21
RC9	Rainwater tanks would yield cost-savings in my water bill almost immediately (R)	3.36

*1 = strongly disagree to 5 = strongly agree; R= reverse coded

2.2.2.4. Adaptive Coping

Table 5 shows all the adaptive coping statements used in the study and their mean ratings.

Table 5: Adaptive coping statements and mean scores for each item.

Label	Statements	Mean* (N=594)
Adapt1	I will be better able to reduce water shortages if I read or hear more about alternative water options	3.14
Adapt2	I am planning on using less town/mains water in the future	3.39
Adapt3	I am planning on only using greywater or rainwater to maintain my garden in the near future	3.15
Adapt4	I am considering installing an additional alternative water source on my property (e.g. larger rainwater tank) so that I am less reliant on towns/mains water	2.85
Adapt5	I am very conscious of installing water efficient devices around the home, and planting drought-resistant plants in the garden, to conserve my household's water use	3.81

*1 = strongly disagree to 5 = strongly agree

Details of processes used to form the adaptive coping composite variable can be found in Appendix D.

Descriptive statistics for the adaptive coping composite scale were calculated (M = 3.20, SD = 0.67). Higher scores in the adaptive coping scale indicated a greater likelihood of engaging in functional behaviours to deal with the impacts of water shortages. Participants with high adaptive coping scores were also more likely to adopt decentralised systems.

2.2.2.5. Maladaptive Coping

Table 6 shows the maladaptive coping statements used in the study and their respective mean ratings.

Table 6: Maladaptive coping statements and mean scores for each item.

Label	Statements	Mean* (N=594)
Mal1	I try not to think about the possibility of water shortages	2.66
Mal2	What I do on my property won't have any real impact on water shortages in SEQ	2.51
Mal3	Residents of SEQ will always have to rely on mains/town water despite the availability of alternative water sources	3.43
Mal4	I have stopped listening to people going on about water shortages because I am tired of hearing about the topic	2.79
Mal5	The only thing that will prevent water shortages is more rain	2.91
Mal6	Water shortages are inevitable, there is nothing we can do about it	2.28

*1 = strongly disagree to 5 = strongly agree

Appendix D details the analysis conducted to form the composite variables. In general, higher scores on the maladaptive coping construct (M = 2.59, SD = 0.66) indicated that there was a greater likelihood that an individual would not engage in specific behaviours to minimise the impact of water shortages. Participants with high maladaptive scores tended to dismiss, or deny water shortages problems in SEQ. They also did not think they could make a difference to water shortage problems facing SEQ. Participants with high maladaptive scores were, therefore, less likely to adopt decentralised systems.

2.2.2.6. Total Adaptive Coping Score

A total adaptive coping score was calculated for all participants by subtracting their maladaptive coping scores from their adaptive coping scores (*Range* = -3.63 to 4.05, M = 0.61, SD = 1.09). Participants with high maladaptive, but low adaptive scores, would end up with negative total adaptive coping score, indicating that they did not utilise coping strategies that were more adaptive to dealing with water shortages.

Likewise, participants with high adaptive scores but low maladaptive scores would have higher positive total adaptive coping score. These participants would engage in coping strategies that would help them to adapt well to water shortage problems.

2.2.2.7. Threat Severity

Table 7 shows the frequency of responses for each option presented to respondents in the threat severity question.

Table 7: Threat severity response options and percentage (%) of respondents for each option.

Option	N	%
SEQ will not experience extreme water shortages	39	6.6
Between 41 and 50 years	9	1.5
Between 31 and 40 years	7	1.2
Between 21 and 30 years	42	7.1
Between 11 and 20 years	107	18.0
Between 6 and 10 years	132	22.2
Within the next 5 years	160	26.9
SEQ is already experiencing extreme water shortages	98	16.5

Approximately two-thirds of participants (65.6%) believed that SEQ would experience extreme water shortages within the next ten years. Almost one-fifth of participants (16.5%) thought SEQ is already experiencing extreme water shortages and only a small percentage of participants (6.6%) believed that SEQ would not experience extreme water shortages in the foreseeable future.

2.2.2.8. Self-Efficacy

On average, participants felt moderately confident of their ability to protect themselves and their property from the effects of water shortages ($M = 2.87$, $SD = 1.03$).

2.2.2.9. Subjective Knowledge

Participants were asked to rate their agreement with three statements pertaining to their knowledge of water issues in SEQ (Section 2.4.2.2 for scale description). Table 8 shows the subjective knowledge statements and their mean ratings.

Table 8: Subjective knowledge statements and mean scores for each item.

Variable Name	Statements	Mean* (N=594)
Know1	I know a lot about the water issues facing SEQ	3.49
Know2	It is important to know a lot about water shortages	3.98
Know3	I would like to know more about water shortages in SEQ	3.30

*1=strongly disagree to 5=strongly agree

Mean ratings for *Know1* and *Know2* indicated that participants in the study felt they had a reasonable level of knowledge about water shortages in SEQ. Participants also thought it was important to know about water shortages affecting SEQ.

2.2.3. Group Comparison Results for Key PM Variables

2.2.3.1. Decentralised and Non-Decentralised Systems Groups

Key PM variables stated in the preceding sections (3.1 and 3.2) were analysed to examine whether significant differences existed between participants who had adopted a decentralised system and those who did not. To clearly differentiate these two groups of participants, the study defined households with decentralised systems as those who had installed either rainwater tanks, greywater systems or bore water pumps at their residence, and had made some sort of financial payment towards installing the system(s). Households who were required to install decentralised systems by Queensland Development Code MP4.2 were excluded from the analysis.

Using this definition, 280 participants in the study were considered as decentralised system participants.

Participants who did not own any decentralised systems, including participants who used manual bucketing or a flexible hose to reuse their greywater, were considered as the non-decentralised group. A total of 314 participants belonged to the non-decentralised systems group.

t-Tests revealed that participants in the decentralised systems and non-decentralised systems groups did not significantly differ in:

- their perceived vulnerability to the threat of water shortages;
- their severity assessment of the threat of water shortages;
- the perceived effectiveness of rainwater tanks and greywater systems in reducing water shortage problems; and
- their knowledge about water shortages in SEQ.

In comparison to non-decentralised systems group, *t*-Test results revealed that participants who owned a decentralised system were found to:

- perceive significantly lower costs associated with decentralised systems;
- rate water saving activities as being more effective in reducing the impact of water shortages;
- report significantly higher levels of confidence to protect themselves and their property from the effects of water shortages;
- report higher levels of interest in spending time in their garden; and
- utilise a more functional adaptive coping mechanisms in dealing with water shortages and therefore chose to adopt decentralised systems at home.

It is important to note that the significant differences reported in this section were only a matter of degree, rather than opposing views. Table 9 shows the mean ratings that were significantly different between the decentralised and non-decentralised systems groups across different key variables in the study.

Table 9: Mean scores for each variable across the two participant groups (DS and Non-DS).

Scale	DS (n=280)	Non-DS (n=314)
Response cost for rainwater tank	1.94	2.45
Response cost for greywater system	2.38	2.75
Perceived efficacy for water saving initiatives	3.64	3.48
Self-efficacy	2.99	2.75
Garden habits	3.58	3.39
Total adaptive scale	0.76	0.47

2.2.3.2. Socio-Economic Comparisons

Gender Differences

t-Tests again found statistically significant differences between males' and females' responses within the survey (see Table 10 for mean values). Note that the differences reported below were a matter of degree, rather than opposing views between them.

- Females perceived lower costs or barriers with rainwater tanks and greywater systems installation than males.
- Females rated water saving activities and greywater systems as being more effective in reducing the impact of water shortages than males.

- Females reported significantly greater perceived vulnerability toward the impact of water shortages than males.
- Females perceived the severity of water shortages threat to be higher than males.
- Females reported higher levels of interest in spending time in the garden than males.
- Females used slightly more adaptive coping strategies to deal with water shortages than males.

Table 10: Mean scores reported for each variable across the two gender groups (males and females).

Scale	Female (n=339)	Male (n=255)
Response costs for rainwater tanks	2.15	2.29
Response costs for greywater systems	2.52	2.66
Perceived efficacy for water saving initiatives	3.63	3.45
Perceived efficacy for greywater systems	3.21	2.94
Perceived vulnerability	3.67	3.52
Perceived threat severity	6.00	5.66
Garden habits	3.61	3.31
Total adaptive scale	0.68	0.52

Age Group Differences

A one-way ANOVA revealed only one significant difference between age groups across different key variables in the study. In particular, participants aged between 55 and 59 reported higher level of interests in spending time in their garden and doing gardening ($M = 3.73$, $SD = 0.95$) than those aged between 45 and 49 years ($M = 3.12$, $SD = 1.12$). No other significant differences were found for age groups across the key PM variables.

Income Group Differences

A one-way ANOVA was conducted to examine any significant differences between participants' income and key variables in the study. Participants whose households earned between $120,000 and $149,999 ($M = 3.29$, $SD = 0.99$) or more than $150,000 ($M = 3.12$, $SD = 0.92$) annually perceived water saving measures to be significantly less effective than participants who did not disclose their income ($M = 3.81$, $SD = 0.91$). Further, participants whose households earned between $60,000 and $89,999 annually reported significantly higher adaptive coping scores relative to water shortages ($M = 0.79$, $SD = 1.03$) than those who did not disclose their income ($M = 0.30$, $SD = 1.00$).

Again, the differences between these groups were only a matter of degree, rather than opposing views. No other significant differences were found across the income groups.

Education Level Differences

A one-way ANOVA revealed significant differences on subjective knowledge with different educational levels. Participants with tertiary qualifications reported more knowledge of water issues facing SEQ ($M = 3.59$, $SD = 0.85$) when compared to those who completed high school ($M = 3.35$, $SD = 0.89$) or those with trade qualifications ($M = 3.38$, $SD = 0.84$). No other significant differences were found between participants' responses across education levels.

2.2.4. Logistic Modelling Results: Predicting Adaptive Dispositions and Behaviour

A logistic regression was carried out on the full data set to analyse adoption behaviours specific to decentralised systems, in the context of protection motivation theory. Based on Rogers' (1983) conception of protection motivation, Figure 2 shows variables that are observed directly (i.e., observed variables) and indirectly (i.e., latent variables) to measure threat appraisal, coping appraisal and adaptive predisposition. Although traditionally, threat and coping appraisal were thought to be indicative of intentions to act, in the present study where access to actual behavioural data was available, a measure of coping disposition was thought more appropriate. This measure (i.e., total adaptive coping score) was intended to give a scaled measure of the likelihood that a participant would respond to a threat in an adaptive or maladaptive manner, and was based upon a meta-analysis conducted by Milne, Sheeran and Orbell (2000), lending empirical support for this methodological decision.

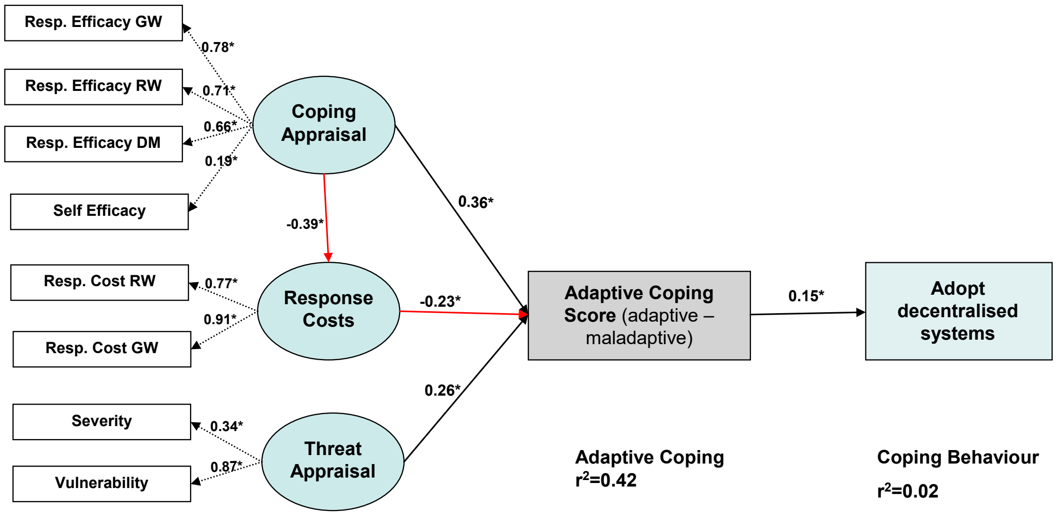

Figure 2: Observed and latent variables of the PM theory model, with calculated R2 for each relationship tested within the model, displaying the variance accounted for in each stage of the model.

A direct logistic regression analysis along with a structural equation model was run using M*plus* software (Holmes-Smith, 2010), which allowed for variables that are not measured directly (latent variables) to be incorporated into the analysis. The structural equation models analysed the contribution of three protection motivation variables to total adaptive score. The three protection motivation variables were: coping appraisal, threat appraisal and response costs. The logistic regression examined at the path between total adaptive coping score to the adoption of decentralised systems.

The full data set ($N = 594$) of participant responses was used in this analysis. A goodness-of-fit test using the difference in log-likelihood and chi-square statistics was performed to examine whether the model consists of all PM theory variables (response efficacy, response costs, coping and threat appraisals) is significantly better than a constant-only model. A significant result was found, indicating that the full PM model is a significantly better model than the constant-only model to predict ownership of decentralised systems (chi-square $(1, N = 594) = 10.44$, $p < 0.05$). This statistic indicates that the full PM model can reliably distinguish between participants who adopted decentralised systems and those who did not.

All relationship pathway coefficients were found to be significant ($p < .01$), and the variance in adaptive coping scores was large (47.5%). However, while the relationship between adaptive coping and actual adoption of decentralised systems was significant, the variance explained in ownership of decentralised systems was small (2.6%). As a summary, the structural model of the results indicated that:

- participants who perceived higher efficacy of decentralised systems tend to perceive lower costs associated with the systems. These participants were also more likely to utilise more adaptive coping strategies to deal with water shortages.
- participants who thought they were vulnerable to the threat of water shortages, and that the threat was imminent, utilised more adaptive coping strategies to cope with water shortages.
- Conversely, participants who perceived higher costs associated with decentralised system tended to use maladaptive type of coping strategies to deal with water shortages.

The logistic regression results indicated that the odds ratio for adopting decentralised systems on the predictor (adaptive behaviours) was 1.28. This implied that for every unit change in the total adaptive coping score, the odds of adopting decentralised systems would increase by 1.28. In other words, for every unit increase in the total adaptive coping score, the probability of a person adopting decentralised systems would increase by 28%.

2.2.4.1. Subjective Knowledge

Subjective knowledge of participants was later added to the full PM model to see whether it would improve the model fit. A non-significant result was found, indicating that subjective knowledge did not contribute significantly to participants' total adaptive coping score (chi-square $(1, N = 594) = 0.542$, $p > 0.05$).

3. WILLINGNESS TO PAY

3.1. Methods

3.1.1. Participants

Please refer to Section 2.1.1 for a description of participants. All respondents in the psycho-social component of the survey also took part in the willingness to pay component.

3.1.2. The Willingness to Pay (WTP) Model

This study applies a stated preference technique called choice experiments (CE) as the survey instrument. It is chosen primarily because it allows flexible alternatives and generates considerable cost savings through the ability to value a number of options simultaneously (Gordon *et al.*, 2001). In this particular study, CE is used to elicit the willingness to pay for different types of decentralised water systems. The amount of money that an individual is willing to pay can be used to reflect his or her preferences for one system over another.

For a three-option choice set plus a do-nothing option, implicitly the respondent is assumed to be comparing the utility obtained from each of the four options. The utility from choosing a particular option is determined by the levels of the four attributes in the choice sets and the individual preferences as modified by the socio-economic variables. The assumed functional form of the utility function (U_{ij}) for individual *i* of option *j* is specified in equation (1) as:

$$\begin{aligned} U_{ij} = SQ + \sum \beta_t (\, d_i * TECH_{tj}\,) + \sum \beta_d (SQ * DEMO_i\,) \\ + \sum \beta_p (SQ * PROP_{pi}\,) + \sum \beta_a (SQ * BEHAV_{ai}\,) + \beta_{pr} (PRICE_j\,) \end{aligned} \tag{1}$$

where:

SQ	is the status quo dummy variable (SQ=1 for Option IV, and SQ=0 for Options I, II and III
d_i	is the technology dummy variables (d_i =1 for people who own a decentralised technology and d_i =0 otherwise)
$TECH_{tj}$	is the decentralised technology *t* (bore, rainwater tank, greywater system)
$PROP_{pi}$	is the characteristics of the property for individual *i*
$BEHAV_{ai}$	is the behavioural variable *a* (coping and garden behaviour)
$DEMO_i$	is the vector of demographic variables for individual *i*
$PRICE_j$	is the out-of-pocket expense (in \$)

The status quo dummy represents respondents who preferred to choose none of the product bundle options presented because they would like to stay with their current system, even if they currently do not have any system.

Incorporating demographic and property characteristics interaction terms improves the model by accounting for the heterogeneity, or differences, between individual respondents. It also helps answer questions of varying preferences amongst different socio-economic groups.

3.1.3. Variable Description

The following section provides detailed descriptions of the variables in equation (1).

3.1.3.1. Decentralised Water Technology

Amongst a number of potential new sources of decentralised water supplies, the study selected three that were cited as the most commonly adopted by participants of the qualitative exploration survey (see Mankad *et al.*, 2010): rainwater tanks, greywater systems and groundwater (from the use of bores and spear pumps).

Groundwater

The questionnaire offered only one standard option for groundwater and that was to sink a bore on the property.

Rainwater

Participants were provided with more options for rainwater tanks and greywater systems.

The three rainwater tanks sizes on offer were:

1. *Small* (less than 5,000 litres)
2. *Medium* (5,000 – 25,000 litres)
3. *Large* (greater than 25,000 litres)

Respondents were given the following statement as a guideline:

"On average, an individual uses about 150 litres of water per day for everything. If they have a 5,000 litre rainwater tank as their only source of water, the tank would last them 30 days (with no rain refill)."

Greywater

The three greywater system designs on offer were:

1. *Greywater diversion device*: This system **redirects** untreated water from the shower and washing machine and diverts the water to the irrigation system. It is part of the plumbing system; therefore, a licensed plumber is required for installation. The untreated water can be stored for 24 hours in a secured storage device before being used. The water is for outdoor use only.
2. *Greywater treatment device for reuse on gardens/lawns only*: This system **treats** the water from the shower and washing machine up to a certain quality before diverting it to the irrigation system. It is part of the plumbing system; therefore, a licensed plumber is required for installation. The treated water can be stored for 24 hours in a secured storage device before being used.
3. *Greywater treatment device for reuse indoors and on gardens/lawns*: This system **treats** the water from the shower and washing up to a certain quality safe for using in the toilet, laundry and irrigation system. It is part of the plumbing system; therefore, a licensed plumber is required for installation. The treated water can be stored for 24 hours in a secured storage device before being used.

3.1.3.2. Demographics

Standard demographic questions were included at the end of the online survey, to establish a set of descriptors for the current sample. Variables included in this section were: age (based on year of birth), gender, income, and education.

3.1.3.3. Coping and Gardening Behaviour

Recent literature in economic valuation has argued the benefits of incorporating social psychological factors such as behaviour, attitudes, habits, social norms and beliefs into the economic utility function in addition to demographic variables for predicting people's choices (Ben-Akiva *et al.*, 1999; Spash *et al.*, 2009). As such, in this WTP analysis, two behavioural variables, coping behaviour and garden behaviour, were included in the utility function.

For the gardening behaviour variable, participants were asked to rate their agreement on 8 items relevant to domestic gardening habits. These questions were designed to measure participants' affinity for gardening by rating personal importance and satisfaction related to gardening, as well as measuring the importance of social aspects derived from gardening (e.g., the garden is a place for recreation, leisure). Responses to each statement were made using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree) and the reliability of this measure was found to be good ($\alpha = 0.91$).

Please refer to section 2.1.8.3 for a description of the coping behaviour measure, as this component was also used as a mediator in the PM model.

3.1.3.4. Property Characteristics

Respondents were asked to indicate the size of their property, the roof area and the estimated proportion of their garden area relative to their property size (in %). All areas were converted to one consistent unit, which is in square metres, except for proportion of garden area, which is in percentage terms, to prevent any collinearity problems with property size.

3.1.4. Estimation of Part-Worth

The coefficients estimated under the conditional logit model can be used to estimate the part-worth, or the amount the respondent would be willing to pay or willing to accept to achieve a change in an attribute that maximises their utility. Part-worth is estimated by equation (2):

$$\text{Part-worth} = \frac{-(\beta_{SQ} + \beta)}{\beta_{pr}} \qquad (2)$$

where: β_{SQ} is the coefficient of the SQ dummy variable, β_{pr} is the coefficient of the price variables and β is the coefficient of all other variables specified in equation (1).

3.1.5. Study Procedure

A statistical software package Ngene (version 1.0.2) was used to generate the orthogonal experimental design that was needed to construct the CE survey. An orthogonal design is a combination of alternatives which would allow the attribute levels to vary independent of one another, i.e. there is no correlation between the attributes (Bennett, 1999). The design resulted in 48 choice sets that were then segmented into eight blocks of six choice sets each. In other words, the survey was divided into eight versions, each with six choice sets. A target number of n = 100 respondents was set for each version of the survey. The final list of attributes is presented in Table 11.

Table 11: Attribute levels in the choice sets and coding.

Attribute	Levels
Groundwater	None Bore
Rainwater tank	None Small tank (<5,000 litres) Medium tank (5,000 – 25,000) litres Large tank (>25,000 litres)
Greywater system	None Diversion device (for outdoor use) Treatment device (for outdoor use) Treatment device (for indoor/outdoor use)
Price quote (out-of-pocket) expense	$0 (appears in Option IV only) $1,500 $5,000 $10,000 $20,000

At the beginning of the CE component of the survey, respondents were asked to consider their personal circumstances, which included their intended use of decentralised water (indoor/outdoor), the size of their roof area, the space availability on their property, and personal financial constraints. This was to make the decision-making process as realistic as possible, in other words, to reduce hypothetical bias, a situation where stated WTP is less than actual WTP (Bateman, 2002). Techniques, such as *cheap talk*, which is a process of inducing subjects to provide unbiased responses to hypothetical valuation questions, have been proven successful in non-market valuation surveys to reduce hypothetical bias (Cummings and Taylor, 1999).

In the choice sets, respondents were presented with a range of scenarios, each consisting of three product bundles that consisted of different sizes of rainwater tanks, different types of greywater systems and whether a bore was going to be installed or not. Respondents were told that choosing to purchase any of these bundles of decentralised water systems would help them become more self–reliant in the future, especially in the face of climate change, decreased rainfall and future severe water restrictions. Different combinations of the three products came at different costs. Figure 3 shows a typical choice set presented in web format. Respondents were asked to consider that the prices of each offer are quotes by different companies for completing the work. The costs were stated as one-off costs for purchase and installation of the system(s) after receiving government rebates. Hence, it was an out-of-pocket expense. There were four levels of out-of-pocket costs, ranging from $1,500 to $20,000. These costs were estimated based on the market price of purchasing and installing these technologies, ranging from purchasing only one technology, to all three technologies. Hence, an out-of-pocket cost of $20,000 implies purchasing and installing three types of technology.

	Option I	**Option II**	**Option III**	**Option IV**
Groundwater	None	Bore	None	I'd choose neither one of these and stay with my current system.
Greywater system	Treatment device (indoor use)	Treatment device (outdoor use)	Diversion device (outdoor use)	
Rainwater tank	Large tank	Small tank	None	
Price quote (out-of-pocket expense)	$1,500	$10,000	$5,000	

I choose (select only 1 offer)	○	○	○	○
	Select here for Option I	Select here for Option II	Select here for Option III	Select here for Option IV

Figure 3: Example of a choice set as seen by respondents via the online survey.

Option IV is identical in each choice experiment. It represented a 'doing nothing' or 'stay with current system' situation and consequently, there would be no out-of-pocket expenses. Respondents were reminded before every choice set to keep in mind their budget constraints and to make the choices as if they were really intending to make the purchase. Participants were also asked to think about the intended use for the decentralised water (indoor, outdoor), the size of their roof area (as it limits the size of the rainwater tank) and the space availability on their properties (to place the rainwater tank and/or the greywater system).

3.1.6. Data Analysis

The data were analysed in Stata 11 (a statistical software package) to estimate the coefficients of the conditional logit model. Two sets of model specifications arose from equation (1). Model 1 represents the decentralised attribute only specification and is specified as equation (3):

$$U_{ij} = SQ + \sum \beta_t (d_i * TECH_{tj}) + \beta(PRICE_j) \quad (3)$$

In Model 2, a number of demographic variables (including age, gender, education, income, number of children), property characteristic variables (including property size, roof area, percentage of garden size) and behavioural variables (including coping and garden behaviour) were introduced into the model as interactions with the status quo dummy (SQ).The utility function is specified in equation (1).

3.2. Results

3.2.1. Demographics

Please refer to Section 2.2.1 for a summary of demographic variable statistics.

3.2.2. Adaptive Coping and Gardening Behaviour

A total adaptive coping score was calculated for all participants and analysed as per Section 2.2.2.4 For the gardening behaviour variable, participants were asked to rate their agreement or disagreement with a series of statements relating to their gardening interests. The mean ratings for all eight statements are shown in Table 12.

Table 12: Gardening behaviour statements and mean scores for each item.

Variable Name	Statement	Mean (N=594)
Gar1	I get great satisfaction from working in the garden	3.45
Gar2	Gardening is a valuable way to spend time	3.56
Gar3	Gardening is a pleasant break from the household work and routine	3.59
Gar4	I don't like gardening	2.49
Gar5	I like to grow herbs and vegetables in my garden	3.39
Gar6	I hardly ever use the garden for recreation	2.54
Gar7	Everyone in our family makes use of the garden	3.28
Gar8	The garden is an important place for my leisure activities	3.45

Results from the factor analysis with ML and oblimin rotation indicated that all eight statements loaded onto one factor well. Follow-up confirmatory factor analyses were conducted with M*plus* to determine the items' goodness-of-fit as one congeneric measurement model. Variables Gar4, 6, and 7 dropped out in the final model, and the remaining variables (Gar1, 2, 3, 5, and Gar8) fitted together as one congeneric measurement model of garden behaviour. It is important to note, here, that error terms of Gar2 and 3 were correlated in the model, as they measured something in common other than the latent variable (refer to Table 13).

Table 13: Gardening behaviour construct and factor loadings for each item.

Variable Name	Statement	Factor Score Coefficient
Gar1	I get great satisfaction from working in the garden	0.74
Gar2	Gardening is a valuable way to spend time	0.11
Gar3	Gardening is a pleasant break from the household work and routine	0.09
Gar5	I like to grow herbs and vegetables in my garden	0.02
Gar8	The garden is an important place for my leisure acitivites	0.06

A composite scale for garden behaviour was created using the factor score coefficients. The gardening behaviour composite was derived in the same way as those composites cited in Section 2.2.2; please refer to this section for a detailed explanation of the procedure. Higher scores in the scale indicated higher levels of importance and satisfaction related to one's garden and gardening. The mean value for the garden behaviour scale (M = 3.48, SD = 1.08) indicated that participants, overall, assigned a moderate to high level of importance to their garden and gardening.

3.2.3. Property Characteristics

The average property size for the sample is 1,990 m^2 with a standard deviation of 7,000 m^2. The average roof size is 250m^2 with a standard deviation of 163 m^2. The average proportion of garden area is 47% with a standard deviation of 18%.

3.2.4. Model 1: Attribute Only Specification

The negative and significant coefficient on the status quo variable suggests that, in general, respondents prefer not to buy any technology and would need to be compensated by the amount of $7,650 to make any changes (see Table 14). The compensated amount is the part-worth specified in equation (2). The high amount of compensation required to adopt any technology, in this case, may be attributed to 'status quo bias' or 'status quo inertia' (Samuelson and Zeckhauser, 1988). This explains a situation where people prefer not to make any changes to their current behaviour unless the incentive to change is compelling. The inertia to change is higher in respondents who currently have decentralised technology, as shown by the negative coefficient of all technology variables, excluding bores.

In contrast, respondents who currently do not own any technology show a positive WTP for all types of technology except for bores. The WTPs for small and medium size rainwater tanks are higher than large rainwater tanks. This outcome is expected because the majority of households (87%) with rainwater tanks in the survey reported that their rainwater tank sizes are 25,000 litres or less, which indicates that larger rainwater tanks are not as popular in the SEQ area. The WTP for greywater is higher as the technology becomes better, which is consistent with expectations.

Despite the positive response of non-technology owners towards adopting new technology, they still hesitate to purchase rainwater tanks and greywater diversion devices as the utility for doing nothing is higher than adopting these two types of technology. This is evidenced by the coefficient of the SQ variable being more negative than the coefficient of the $TECH_{tj}$ variables for rainwater tanks and greywater diversion devices.

On the other hand, they will not hesitate to buy greywater treatment devices as the utility they receive from making the purchase is higher than doing nothing. Non-technology owners will only purchase rainwater tanks if they are paired with greywater devices (e.g. small rainwater tank with greywater diversion device, or small rainwater tank with greywater treatment device for outdoor).

Table 14: Parameter estimates of Model 1.

Variable description	Variable	Coef.	Std. Err.
Status quo - Stay with current system (or do nothing)	*SQ*	-1.2753 ***	(0.0921)
Respondents with existing technology	$d_i=1$		
Bore	d_i*TECH_B	0.1808 *	(0.1072)
Small rainwater tank	d_i*TECH_{RS}	-0.1145	(0.1269)
Medium rainwater tank	d_i*TECH_{RM}	-0.1122	(0.1410)
Large rainwater tank	d_i*TECH_{RL}	-0.1630	(0.1477)
Greywater diversion for outdoor	d_i*TECH_{GD}	-0.8161 ***	(0.1947)
Greywater treatment for outdoor	d_i*TECH_{GTO}	-0.3112 **	(0.1287)
Greywater treatment for indoor/outdoor	d_i*TECH_{GTI}	-0.1911	(0.1290)
Respondents without existing technology	$d_i=0$		
Bore	$TECH_B$	-0.2801 ***	(0.0769)
Small rainwater tank	$TECH_{RS}$	0.5725 ***	(0.0948)
Medium rainwater tank	$TECH_{RM}$	0.5841 ***	(0.1031)
Large rainwater tank	$TECH_{RL}$	0.3988 ***	(0.1028)
Greywater diversion for outdoor	$TECH_{GD}$	1.0771 ***	(0.1266)
Greywater treatment for outdoor	$TECH_{GTO}$	1.2922 ***	(0.1018)
Greywater treatment for indoor/outdoor	$TECH_{GTI}$	1.3921 ***	(0.0987)
Price quote (out-of-pocket expense)	*PRICE*	-0.0002 ***	(7.35-E06)

***, **, * significant at the p<0.01, p<0.05 and p<0.1 level, respectively.

3.2.5. Model 2: Impact of Demographics and Behavioural Variables

Income, age and gender were the only statistically significant demographic variables, while education and number of children were not statistically significant (see Table 15). The results indicated the following:

- The positive income coefficient shows that, as income increases, WTP increases. However, the coefficient of only one income group (where income is $90,000-$119,999) is significant higher than the baseline group (<$30,000). Other income groups did not show a significantly different WTP than the baseline group.
- Age is negative and significant, which indicates that respondents aged greater than 25 years were willing to pay less than respondents aged between 18 and 24 years (the base line group).
- Men are willing to pay higher costs than women.

Only one out of three property characteristic variables is statistically significant. Property size and roof area are not significantly different from zero. Hence, they have no impact on WTP. The percentage of garden size is significant but it has a negative sign. Consequently, respondents with larger gardens relative to their property size are less willing to pay than respondents with smaller gardens. This is counter-intuitive but suggests that physical characteristics of a property may not be a good indicator for predicting decentralised technology adoption.

Table 15: Parameter estimates of Model 2.

Variable description	Variable	Coef.	Std. Err.
Status quo - Stay with current system (or do nothing)	*SQ*	2.0063 *	(1.1476)
Behaviour			
Adaptive behaviour	$SQ*ATT_A$	0.4707 ***	(0.0508)
Garden behaviour	$SQ*ATT_{GB}$	0.0854 *	(0.0495)
Property			
Property size (m^2)	*SQ*AREA*	-4.5E-06	(1.03E-06)
Roof area (m^2)	*SQ*ROOF*	0.0003	(0.0003)
Percentage of garden	*SQ*GAR*	-0.0072 ***	(0.0028)
Demographics			
Number of children	*SQ*CHIL*	0.0909	(0.0666)
Male	*SQ*GEND*	0.2644 **	(0.1079)
Income $30,000-$59,999	*SQ*INC2*	-0.1230	(0.1594)
Income $60,000-$89,999	*SQ*INC3*	0.0984	(0.1642)
Income $90,000-$119,999	*SQ*INC4*	0.3931 **	(0.1885)
Income $120,000-$149,999	*SQ*INC5*	0.3303	(0.2197)
Income > $150,000	*SQ*INC6*	0.2166	(0.2698)
Education-high school	*SQ*EDU2*	0.4303	(0.3153)
Education-trade/TAFE	*SQ*EDU3*	0.2270	(0.3202)
Education-tertiary undergraduate	*SQ*EDU4*	0.2853	(0.3234)
Education-tertiary postgraduate	*SQ*EDU5*	0.4575	(0.3288)
Age 25-35 years	*SQ*AGE2*	-4.3457 ***	(1.0901)
Age 36-44 years	*SQ*AGE3*	-4.1408 ***	(1.0871)
Age 45-49 years	*SQ*AGE4*	-4.2830 ***	(1.0854)
Age 50-54 years	*SQ*AGE5*	-3.9449 ***	(1.0834)
Age 55-59 years	*SQ*AGE6*	-3.9921 ***	(1.0875)
Age over 60 years	*SQ*AGE7*	-4.1255 ***	(1.0865)
Respondents with existing technology	$d_i=1$		
Bore	d_i*TECH_B	0.3549 **	(0.1391)
Small rainwater tank	d_i*TECH_{RS}	0.0400	(0.1652)
Medium rainwater tank	d_i*TECH_{RM}	-0.0372	(0.1789)
Large rainwater tank	d_i*TECH_{RL}	-0.3388 *	(0.1962)
Greywater diversion for outdoor	d_i*TECH_{GD}	-0.9548 ***	(0.2440)
Greywater treatment for outdoor	d_i*TECH_{GTO}	-0.3235 *	(0.1686)
Greywater treatment for indoor/outdoor	d_i*TECH_{GTI}	-0.2697	(0.1715)
Respondents without existing technology	$d_i=0$		
Bore	$TECH_B$	-0.3540 ***	(0.1033)
Small rainwater tank	$TECH_{RS}$	0.5299 ***	(0.1272)
Medium rainwater tank	$TECH_{RM}$	0.6175 ***	(0.1351)
Large rainwater tank	$TECH_{RL}$	0.4408 ***	(0.1388)
Greywater diversion for outdoor	$TECH_{GD}$	1.2581 ***	(0.1649)
Greywater treatment for outdoor	$TECH_{GTO}$	1.2707 ***	(0.1361)
Greywater treatment for indoor/outdoor	$TECH_{GTI}$	1.3739 ***	(0.1334)
Price quote (out-of-pocket expense)	*PRICE*	-0.0002 ***	(1.01E-05)

***, **, * significant at the p<0.01, p<0.05 and p<0.1 level, respectively.

Both coping and garden behaviour variables were positive and significantly different from zero at the $p > 0.1$ level. Respondents with high total adaptive coping scores were willing to pay more than those with lower total adaptive coping scores. In other words, respondents who utilised adaptive coping strategies to deal with water shortages were more willing to pay than those who used maladaptive coping strategies. Additionally, respondents who believed themselves to be avid gardeners were willing to pay more than those who did not report gardening as an important pastime.

3.2.6. Willingness to Pay for Decentralised Water Systems

Table 16 reports the part-worth or WTP for a combination of rainwater tanks and greywater systems for non-technology owners, as they are the group of people who had positive WTP for decentralised technology. The part-worths are estimated according to equation (2) and are based on the parameter estimates in Table 18. Here, we only consider the WTP for a purchase of two types of technology at one time. This is because respondents are averse to taking any actions to adopt unless they are buying more than one technology (refer to Section 5.4).

Table 16: Willingness to pay of non-technology owners for various product bundles.

	Rainwater Tank		Greywater System	Willingness to Pay
1	Small (<5,000ltr)	&	Diversion device	$2,246
2	Small (<5,000ltr)	&	Treatment device for outdoor	$3,537
3	Small (<5,000ltr)	&	Treatment device for indoor/outdoor	$4,136
4	Medium (5,000-25,000ltr)	&	Diversion device	$2,316
5	Medium (5,000-25,000ltr)	&	Treatment device for outdoor	$3,606
6	Medium (5,000-25,000ltr)	&	Treatment device for indoor/outdoor	$4,206
7	Large (>25,000ltr)	&	Diversion device	$1,203
8	Large (>25,000ltr)	&	Treatment device for outdoor	$2,494
9	Large (>25,000ltr)	&	Treatment device for indoor/outdoor	$3,093

The WTP level ranges from $1,000 to $4,000, depending on the combination of technology being purchased. Currently, the market price for a domestic cylindrical tank starts from $700 for a 2,000 litre tank and goes up to $3,000 for a 25,000 litre tank (source: www.rainwatertankco.com). In addition, the cost of installation, which may include the cost of pouring a concrete foundation, is approximately $2,500 (source: www.originenergy.com.au). Hence, the capital outlay of installing a rainwater tank is approximately $3,000 to $6,500. It is evident that the market price for just the rainwater tank is markedly higher than the respondents' WTP for rainwater tank and greywater system combined.

4. GENERAL DISCUSSION

4.1. Protection Motivation Theory

Good support for the PM theory model was found, with threat and coping appraisal influencing the way people engaged with, and subsequently adopted, decentralised systems. The influence of the PM variables is summarised below.

Coping Appraisal

People who thought that decentralised systems were effective, and felt that they could easily adopt such systems were more likely to:

- Hold adaptive attitudes relating to water conservation; and
- See lower costs associated with decentralised systems.

Response Costs

People who perceived high costs associated with the adoption of decentralised systems were more likely to:

- Hold maladaptive attitudes towards water conservation.

Threat Appraisal

People who felt that water shortages were a real threat to SEQ and personally, were more likely to:

- Hold adaptive attitudes relating to water conservation.

Adaptive Coping

People holding more adaptive attitudes towards water conservation were more likely to:

- Adopt decentralised systems.

These results are in keeping with the theory of protection motivation. While the results do show that actual adoption behaviour is more difficult to predict from PM variables than are adaptive attitudes towards water conservation, this adaptive coping did significantly affect adoption of decentralised systems, and was very strongly influenced by the PM variables.

4.1.1. Model Implications

Results from the model have a number of potential implications for policy makers, particularly relating to education and the role of knowledge on water conservation.

Increasing general awareness of potential future water shortages in SEQ may increase people's threat appraisal, which, results suggest, would increase adaptive attitudes towards water conservation. However, it is important that information be targeted to be most effective. For example, while research (Mankad *et al.*, 2010) indicates that perceptions of water shortages have decreased in SEQ as rainfall increases and water restrictions decrease, the importance of equitable access to water emerges as an issue in many community studies (Gardiner, 2009; Gardiner *et al.*, 2008; Mankad *et al.*, 2010). It is important to consider this while educating the public about water shortages. The results of this study suggest that perceived threat of water shortages generally could increase adaptive attitudes, however, it is not certain that other threats associated with water shortages, such as equity and fairness in sharing resources, would have the same impact.

Therefore, education and information should be aimed specifically at increasing personal threat perceptions, increasing awareness of the functionality and utility of decentralised systems, and finding ways in which to overcome perceptions of the barriers to decentralised system adoption.

4.1.2. Socio-Demographic and Adaptive Behaviours

Generally, very few significant differences were found between participants on socio-demographic measures and scores on PM items. Specifically, responses to PM items did not differ based on participant's income, age or education levels. Where differences did exist, they were small and represented differences in degree of response, as opposed to direction. A clear exception, however, was the impact of gender, with females generally responding in a way that predicted greater adaptive capacity. That is, females perceived lower costs (e.g., time, money) associated with installing decentralised systems, felt more vulnerable to water shortages, and thought they would be more severe (water shortages will occur in the near future), and believed themselves to be more capable of protecting their person and property from the effects of these future water shortages. Differences in gender are largely in line with previous research, which suggests that men and women differ in their perception of risk (Gustafson, 1998) and threat vulnerability (McCool, Morgan and Robinson, 2009). It is possible that women feel more comfortable expressing vulnerability than men and therefore are more likely to report that they believe a threat exists. However, as Gustafson points out, when we reduce perceptions of risk and threat to simple statements, there is the possibility that we oversimplify, and therefore, potentially magnify differences between groups which may or may not exist in real life situations. This is a possible limitation of a quantitative study design, where even small differences in pre-determined statements can be found statistically significant.

The results derived from the socio-demographic comparisons are informative for two reasons. Firstly, it is unlikely that differences in adaptive coping are due to differences in socio-demographic factors, which lends further support to the validity of the PM theory model. This is particularly relevant from a policy formation perspective. While it is generally not possible to change people's demographic background, psycho-social factors are more modifiable and can be changed with appropriate techniques. The lack of differences between participants based on demographic information also indicates that these findings can be extrapolated to represent the wider community with some degree of confidence. Research into risk perceptions generally shows females to have greater levels of risk perception, therefore, future research could examine the role of gender in a more targeted manner.

4.1.3. Potential Limitations and Future Research

While the relationship between PM theory variables and decentralised system adoption was found to be significant, the variance in actual behaviour explained by PM theory was small. There are two possible explanations for this.

One possibility is that the measurement of the adoption of decentralised systems was inaccurate. However, there are a number of factors indicating that this is unlikely to be the case. The behavioural measure was sensitive to differences in other variables and items measured in the survey. Particularly, a number of statistically significant differences were found between adopters and non-adopters on items related to perceived costs, response efficacy, habitual gardening behaviours and adaptive coping mechanisms. In and of themselves, these differences present interesting considerations for policy-makers. In addition, these results support the validity and sensitivity of the dependent variable, suggesting an alternative cause of the overall model's apparent insufficiency.

An alternative explanation for the lack of prediction in actual adoption behaviour is the possible presence of a feedback loop within the PM model, which the measurement and analysis could not account for. That is, having already adopting decentralised systems, it is possible that people no longer feel threatened by future water shortages or feel compelled to react to such shortages. Past research has indicated that such feedback loops are an important part of understanding behaviours (e.g. health related behaviours; Anderson, 1995).

4.2. Willingness to Pay

Results from the willingness to pay component of the study suggest that the promotion of decentralised systems would work more effectively with those who have not yet adopted any decentralised system as compared to current system owners. This highlights that the benefit of currently owning a decentralised technology is insufficient in encouraging existing owners to adopt additional systems in order to become less dependent on scheme water. This idea is strongly supported by results showing that participants already with decentralised systems in their homes were not willing to pay for additional systems. Similarly, amongst non-owners, despite showing positive support for rainwater tanks and greywater diversion devices, the WTP level is not enough to cover the costs of purchasing the technology. This is due to the status quo inertia (see Samuelson and Zeckhauser, 1988, for explanation), a situation where people prefer not to make any changes to their current behaviour unless the incentive to change is compelling. A possible solution that would result in a more favourable evaluation of adoption for non-owners is when they are presented with the opportunity to concurrently adopt more than one system, specifically, a product bundle of rainwater tank and greywater system. Thus, while current adopters are unlikely to be persuaded to purchase additional systems, non-adopters are more willing to pay for multiple systems than they are a single system. Similarly, bore systems were not viewed favourably in isolation, however, they were slightly more acceptable to current adopters, perhaps suggesting that attitudes towards, and perceptions of, bores are different to those of rainwater and greywater systems.

Further, participants who expressed an avid interest in gardening were more willing to pay for decentralised systems than others; however, the size of one's garden was not shown to be a good indicator of gardening habits. Therefore, garden and/or block size is not necessarily a good proxy for gardening habits.

4.3. Summary of Policy and Research Implications

Results from the PM component of research provide general support for PM theory as a conceptual framework to understand adoption behaviours. This is in support of both previous research within the health domain, as well as more recent research specifically looking at decentralised systems adoption. The results also provide direction for future research, for example the role of choice in adoption, and subsequent behaviours. As of January 2007, the Queensland Development Code required that all houses applying for development licenses meet specified water savings targets. In most cases for SEQ, these targets are met by households installing a 5 kL rainwater tank connected to 100 m^2 roof area and plumbed internally to the toilet and cold water washing machine tap and an external tap for outdoor irrigation. Given that the present study was focusing on the choice to adopt or not adopt decentralised systems, it was unable to assess any possible differences between those who had adopted voluntarily and those who had adopted in line with government mandates. Simply adopting a decentralised system does not ensure water conservation. Water use behaviours subsequent to installation are also important. Therefore, the next phase of the current research is to consider the possible differences in water use attitudes between those people who voluntarily retrofit their homes with rainwater tanks, and those who install tanks to meet government mandates.

In summary, results of both the protection motivation study and the willingness to pay study component suggest that approaches to increase adoption of decentralised systems should take into account the following:

- Increases in perceived threats of water shortages are likely to increase adaptive attitudes towards water conservation.
- The perceived effectiveness of decentralised systems, and people's ability to install them, are important in both decreasing perceived costs of systems and also increasing adaptive attitudes towards water conservation.
- Increasing adaptive attitudes towards water conservation increases likelihood of decentralised system adoption.
- Current users are unlikely to pay for additional systems or to expand their current system. Hence, this market may have reached saturation. Therefore, more emphasis should be placed on increasing adoption by current non-users.
- Some form of financial assistance, such as rebates, may have to be put in place to encourage adoption as respondents show high level of reluctance to move away from their current state.
- Respondents show higher preferences for medium size tanks (5,000 to 25,000 litres) than small size tanks (<5,000 litres). This may suggest that the size of mandated tanks may be able to be increased as this is not only preferred more but also allows for more water storage.
- Decentralised systems could be marketed as a package, combining more than one type of system.

- An individual's coping behaviour and gardening behaviour shows more positive effect on WTP than physical characteristics of the home, such as property and roof area. Hence, promotion of technology adoption should be linked with gardening habits and green behaviour more than with the characteristics of the home.

The present research has shown that making a conscious choice to adopt decentralised water technology might result in different water use behaviours and acceptability. Further, increasing social scientific knowledge of decentralised systems technology will help to manage and prolong urban water infrastructure for the future and facilitate sustainable water practices in urban Australia.

APPENDIX A1 – Information Sheet

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

CSIRO

INFORMATION SHEET

A socioecomonic study of decentralised water supplies and community preferences in South East Queensland

The purpose of this study is to understand your thoughts and opinions about decentralised water systems, so that we can better understand community perspectives regarding alternative water sources. We are also interested in your opinions about South East Queensland's (SEQ) water supplies, as well as issues related to water conservation and water shortage. This information will be used to inform researchers and water policy makers about the factors potentially influencing community views related to rainwater tanks and greywater systems.

What are decentralised water systems?
For those unfamiliar with the concept of "decentralised" water systems, these are localised water sources that involve the collection, treatment and use of rainwater, stormwater, wastewater, or groundwater on-site at various housing levels, such as individual homes, groups of homes, or communities. These systems can provide water independently, or they can be integrated with a centralised water system, such as "mains" water. With the increasing demand for water and decreasing availability of water, decentralised systems are being implemented to reduce pressure on centralised water systems for various applications around the home that do not require drinking-quality water (e.g., toilet flushing, gardening, etc.). In the present study, we will be focusing on decentralised rainwater tanks and greywater systems.

What is involved in this research?
Your participation involves completing a 20-minute online survey to the best of your ability. There are no wrong or right answers, as we are only interested in your opinions about water, as well as descriptions of the water sources you may have on your property and the uses for this water. Even if you are not very familiar with using alternative water sources, your opinions are still very important to the study. Throughout the survey, there will be 'progress' screens, indicating your progress through the survey questions. We will also ask you to complete an anonymous and confidential "Demographics" section, which will give us information about the people who are participating in the survey (e.g., age, gender, occupation). This demographic section is purely for descriptive purposes.

Please note, you must be 18 years or over to participate.

Participation and withdrawal
Participation in this study is completely voluntary and you are free to withdraw from this study at any time without prejudice or penalty. If you wish to withdraw, simply close the active window and the survey information that you have provided up to that point will be confidentially discarded.

Risks
Participation in this study should involve no physical or mental discomfort, and no risks beyond those of everyday living. If, however, you should find any question or procedure to be invasive or offensive, you are free to omit answering that question. If you have any concerns about any aspects of the study, please contact Dr Aditi Mankad (see next page for contact details).

Confidentiality
All information collected in the survey will be anonymised using a coding system, so that there can be no association between your identity and the data you provided. The data will only be seen by members of our research team in an aggregated format (i.e., all participant responses will be combined into one file) and will

be stored in a secure area that is not accessible to any individuals other than the research team. Your information will only be used for research purposes.

Will I receive any payment for taking part in the study?
Yes, as a thank you gift for your participation, you will receive a token to enter into a cash prize draw.

How will my information be used?
The information you provide to us in the survey will be used to write a general report on community views and preferences regarding decentralised water systems. The information will also be used to prepare manuscripts for academic publication. Your personal information will not be identifiable at any stage of the writing process.

How can I find out more about the study?
This research is being funded by the Urban Water Security Research Alliance, a research partnership between CSIRO, University of Queensland, Griffith University and the Queensland Government (http://www.urbanwateralliance.org.au/). If you would like to receive a summary of the findings of the study, please tick the box at the end of the survey. In addition, please feel free to contact any of the researchers involved in this study.

Ethical clearance and Contacts
This study has been cleared in accordance with the ethical review processes of CSIRO, within the guidelines of the National Statement on Ethical Conduct in Human Research. If you have any questions concerning your participation in the study feel free to contact the researchers involved. If you would like to speak to an officer not involved in the study, please contact the CSIRO Human Research Ethics officer, Cathy Pitkin, at cathy.pitkin@csiro.au or on (07) 3214 2905.

Thank you for your help with this very important research.

Yours sincerely,

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APPENDIX A2 – Consent Form

CONSENT FORM

A socioecomonic study of decentralised water supplies and community preferences in South East Queensland

Your involvement in this research is highly valued. Please review the information below and tick the appropriate box if you agree to participate in the study.

I acknowledge that:

- I have agreed to participate in the project.
- I will not be identified personally at any stage of the project and all data will be kept confidential and only seen by researchers involved in the research project.
- I can obtain further information from the research team at any time during the project.
- I understand that this study has been cleared in accordance with the ethical review processes of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). If I have any questions concerning my participation in the study I should feel free to contact the researchers involved. I understand that I can also speak to an officer of the University not involved in the study, by contacting the University of Queensland Ethics Officer on 07 3214 2905.
- I have been provided with the contact details of the investigating officers (see Information sheet).
- I understand that I am able to stop taking part in this study at any time without penalty and without giving an explanation for my withdrawal.
- I understand that if I do withdraw from the study, all of my data will be removed from the study without penalty or explanation. Data that is removed will not be included in any further analyses.
- I understand that each adult who completes a survey will receive a token to enter into a cash prize draw.

By ticking the relevant box, I confirm that I have read and understood the information sheet and note that my involvement in this research will include participation in the decentralised water survey.

Thank you for your participation.

Yours sincerely,

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APPENDIX B – Comparison of Sample Age and Gender against ABS Data

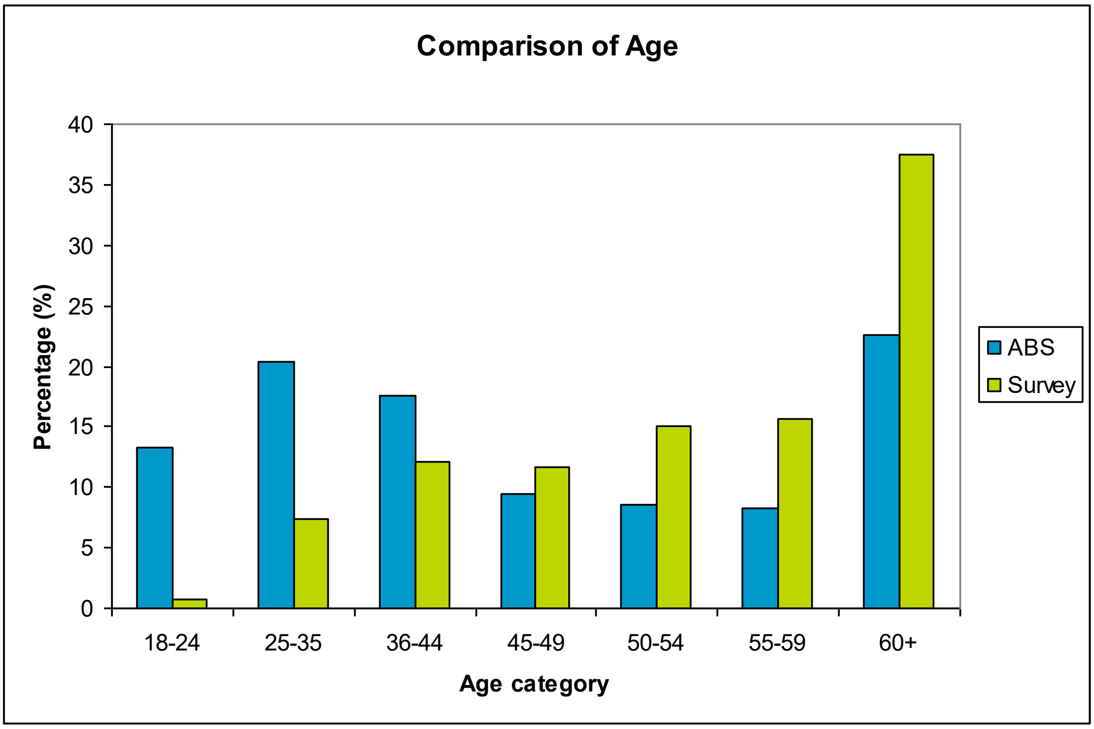

Figure 4: **Comparison of age of sample to ABS data (2006).**

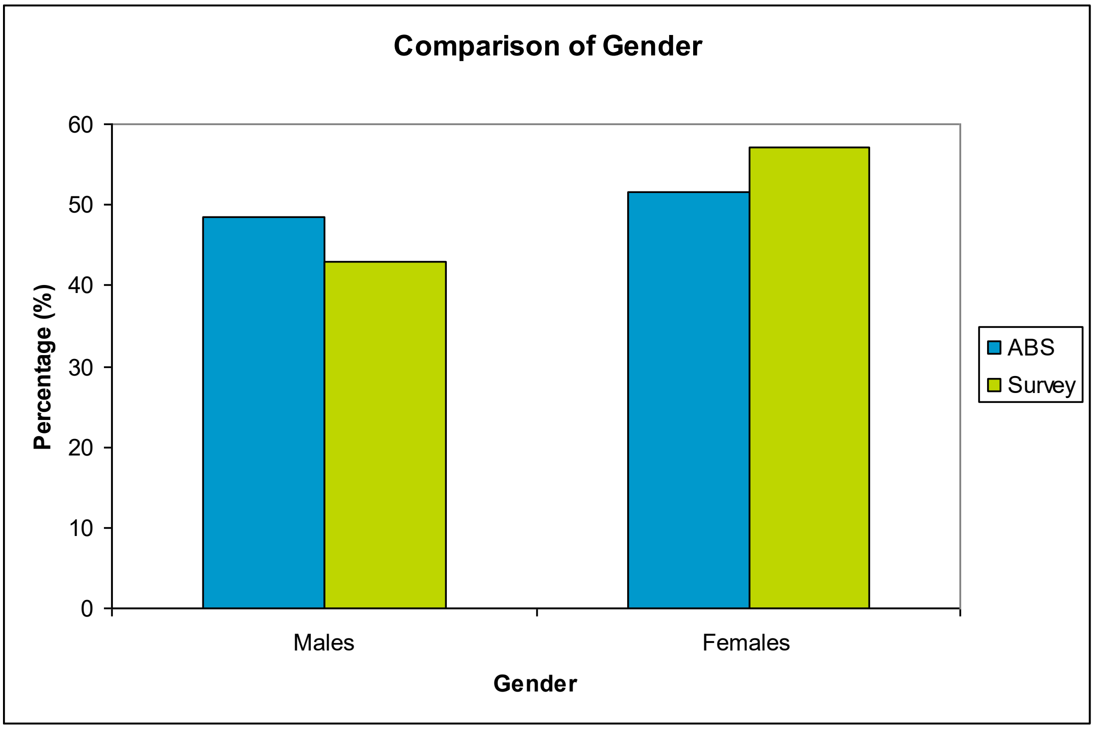

Figure 5: **Comparison of gender of sample to ABS data (2006).**

APPENDIX C – Household Demographic Information

Table 17: Number of respondents surveyed who own a rainwater tank.

	(N = 594)
Yes	265
No	323
Not sure/Don't know	6

Table 18: Number of respondents surveyed who received a rebate for purchasing a rainwater tank.

	(N = 265)
Yes	141
No	105
Not sure/Don't know	19

Table 19: Cited uses for rainwater tank water.

	(N = 265)
Garden	230
Other	82
Pool	75
Clothes	59
Toilet	57
Drink/Cook	54
Bath	20

Table 20: Treatment for rainwater used in the kitchen.

	(N = 54)
Filtered	27
Not treated	23
Boiled	7

Table 21: Number of respondents surveyed who used greywater.

	(N = 594)
Yes	233
No	357
Not sure/Don't know	4

Table 22: Cited uses for greywater.

	(N = 233)
Flexible hose to washing machine outlet	132
Manual bucketing of untreated wastewater	105
Treated grey water device for reuse on gardens/lawns	24
Grey water diversion device	11
Treated grey water device for reuse indoors and on gardens/lawns	1

Table 23: Cited collection points for greywater.

	(N = 233)
Washing machine	180
Shower	109
Laundry sink	102
Kitchen sink	63
Bath	59
Bathroom sink	49

Table 24: Number of respondents surveyed who have a bore.

	(N = 594)
Yes	16
No	574
Not sure/Don't know	4

Table 25: Number of bedrooms.

	(N = 589)
Three bedrooms	270
Four bedrooms	209
Two bedrooms	48
Five bedrooms	48
Six bedrooms	8
Seven bedrooms	3
One bedrooms	2
Eight bedrooms	1

Table 26: Number of storeys.

	(N = 593)
One storey	398
Two storeys	179
Three storeys	9
Four storeys	1
None	6

Table 27: Number of bathrooms.

	(N = 588)
Two bathrooms	281
One bathroom	203
Three bathrooms	93
Four bathrooms	10
Five bathrooms	1

Table 28: Household water use.

	(N = 594)
Low water user	328
Medium water user	245
High water user	21

Table 29: Actual household consumption during last billing cycle (in kL).

	(N = 589)
1 to 100	271
101 to 200	26
201 to 300	13
301 to 400	3
401 to 500	3
501 to 600	3
601 to 700	2
701 to 800	3
901 to 1,000	50
1,001 to 2,000	4
2,001 to 3,000	3
3,001 to 4,000	1
4,001 to 5,000	1
5,001 to 6,000	1
9,001 to 9,998	1
Don't know	202

Table 30: Plans to install devices in the near future (*N* = 594).

	Rainwater tank	Grey water system	Groundwater/ bores	Black water system
1 Very unlikely	128	233	507	443
2	36	91	45	71
3	86	103	20	42
4	75	64	3	13
5 Very likely	109	37	6	8
Have already installed	160	66	13	17

APPENDIX D – Details of Statistical Analysis for Composite Variables

Response Efficacy

An exploratory factor analysis with ML and oblimin rotation was performed on the seven statements to determine any underlying constructs. A one-factor structure was produced and all statements significantly loaded onto one factor.

When using confirmatory factor analysis in M*plus*, reseff1 was dropped as it was highly correlated with all other variables. The remaining six statements were found to fit better when explained in terms of a three-factor solution. These three factors corresponded with our theoretical expectations. All six statements measured participants' response efficacy towards decentralised systems, but on three different dimensions: 1. Rainwater tanks, 2. Greywater systems, and 3. Water savings initiatives.

Table 31 below show the items under each construct and their factor score coefficient.

Table 31: Response efficacy constructs and factor loadings.

Variable Name	Statement	Factor Score Coefficient
Construct 1: response efficacy for rainwater tanks		
Reseff2	Installing a rainwater tank for indoor use in your home	0.02
Reseff3	Installing a rainwater tank to provide water for drinking or cooking	0.56
Construct 2: response efficacy for greywater systems		
Reseff4	Reusing greywater from your shower and laundry using buckets	0.22
Reseff5	Installing a greywater treatment system that would supply water back into your house	0.52
Construct 3: response efficacy for water saving initiatives		
Reseff6	using less water around the house and garden	0.215
Reseff7	Installing water efficient devices around the house and garden	0.542

Response Costs

Exploratory factor analysis with ML and oblimin rotation found a three-factor structure underlying the response cost statements. The two factors which had more than one item loading on to them were further analysed in M*plus* to determine their goodness-of-fit as two separate, but correlated, congeneric measurement models of response costs.[1]

The two-factor structure was found to fit the data well and the two factors were labelled *response costs for rainwater tanks* and *response costs for greywater systems*. *RC3, 6* and *9* had to be removed from the analysis as they had residual variances of more than 90%.

Table 32 shows the statements that measured response costs for rainwater tanks and greywater systems, as well as their factor score coefficients.

[1] Variable *RC5* loaded onto one factor by itself.

Table 32: **Response cost constructs and factor loadings.**

Variable Name	Statement	Factor Score Coefficient
Construct 1: response costs for greywater systems		
RC2	It takes a lot of time to achieve water cost-savings from a greywater system	0.18
RC4	I don't have the time to get a greywater system installed	0.19
Construct 2: response costs for rainwater tanks		
RC7	A rainwater tank would make my property look ugly	0.48
RC8	I don't have the space for a rainwater tank	0.24

Adaptive Coping

Exploratory factor analysis with ML extraction and oblimin rotation was performed on the statements. All five statements loaded onto one factor well. When conducting a confirmatory factor analysis using M*plus*, only four of the statements were found to fit the congeneric measurement model of adaptive coping. These four statements, *Adapt1, 2, 3* and *4* were therefore retained to form a composite scale for adaptive coping behaviours.

Factor score coefficients used to form the composite scale are in Table 33.

Table 33: **Adaptive coping construct and factor loadings.**

Variable Name	Statement	Factor Score Coefficient
Adapt1	I will be better able to reduce water shortages if I read or hear more about alternative water options	0.14
Adapt2	I am planning on using less town/mains water in the future	0.24
Adapt3	I am planning on only using greywater or rainwater to maintain my garden in the near future	0.12
Adapt4	I am considering installing an additional alternative water source on my property (e.g. larger rainwater tank) so that I am less reliant on towns/mains water	0.14

Maladaptive Coping

Exploratory factor analysis with ML extraction and oblimin rotation was again performed. All six factors loaded onto one factor significantly.

Mal5 and *Mal3* had to be dropped in the M*plus* confirmatory factor analysis due to high error variance; these two statements also had the lowest factor loadings. The remaining four statements (*Mal1, Mal2, Mal5, Mal6*) were found to fit well as a single congeneric measurement model of maladaptive coping behaviours and were, therefore, used to form a composite scale for maladaptive coping behaviours.

Table 34 shows factor score coefficients used to form the composite scale.

Table 34: **Maladaptive coping construct and factor loadings.**

Variable Name	Statement	Factor Score Coefficient
Mal1	I try not to think about the possibility of water shortages	0.19
Mal2	What I do on my property won't have any real impact on water shortages in SEQ	0.13
Mal4	I have stopped listening to people going on about water shortages because I am tired of hearing about the topic	0.22
Mal6	Water shortages are inevitable, there is nothing we can do about it	0.10

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Urban Water Security Research Alliance

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