APPLYING BEHAVIOURAL STRATEGIES TO PROMOTE HOUSEHOLD WATER-CONSERVATION PRACTICES

Source: http://www.mavensphotoblog.com/2011/06/02/agriculture-in-californias-san-joaquin-valley/friant-kern-canal-at-orange-cove-1-apr-2010/

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Candidate Certification

I certify that the work in this thesis, "Applying Behavioural Strategies to Promote Household Water-conservation Practices", has not been submitted for a degree nor has it been submitted as part of the requirements for a degree to any other university or institution other than University of New England. I likewise certify that the thesis is an original piece of research and it has been written by me. Any advice and support I have gained in my research work and in the preparation of the thesis itself has been judiciously acknowledged.

In addition, I certify that all information sources and literature used are expressed in this thesis.

June 6, 2018

Abstract

Water is a critical resource to society for many reasons. Given the fact that water is an indispensable part of human survival and economic development, conserving it is important to ensure a sustainable supply. Water conservation has been a practice for millennia, with increasing recognition of the value of water to humans, in particular, for the environmental, economic and social goods and services it provides. Despite an increase in strategies for water conservation, achieving sustainability is still a goal and there are few guidelines that outline sustainable measures of water conservation to manage water resources against scarcity, climate change, and unpredictable environments where demand for water is increasing. Behavioural change and mechanisms of behavioural change are increasingly advocated for sustainable water-conservation behaviour in order to improve our understanding of households' attitudes and behaviour towards water resources.

The aim of this PhD thesis is to investigate mechanisms of water-conservation behaviour through capability, opportunity, and motivation-behaviour (COM-B system) lenses. This thesis proposes a behavioural approach to understand water conservation, and is interdisciplinary because it brings together psychology and water conservation. This approach helps to improve our understanding of behavioural change and mechanisms of behavioural change for effective water conservation strategies. Such an approach focuses on the understanding of households' attitudes and behaviours, and the linkages between behaviour mechanisms and relevant interventions that bring about behavioural change. To do this, the importance of understanding behavioural change and ways of linking behaviour mechanisms to relevant intervention functions and policy categories were studied in three papers: 1) "*Household water use and conservation behaviour: A meta-analysis*; 2) "*Barriers and drivers of household water conservation behaviour: A profiling approach*; and, 3) "*Reducing household water-use: The influence of water-conservation messages on intentions to act*".

The approach taken can advance the capacity-building and empowerment of water users to recognise, analyse and improve water conservation consciously and voluntarily to bring about sustainability. The study design and techniques employed in this thesis, the COM-B system and Behaviour Change Wheel (BCW) model, are an integrative framework of behaviour. These models have never been used to study water conservation and they bring a new, explicit perspective; they are best at linking attitudes and behaviour to behaviour change interventions.

The first paper examines the capability, opportunity, and motivation of households, as important psychological-social dimensions influencing water-conservation behaviour. A meta-analysis of the causal mechanisms of water-use behaviour was used to identify 88 correlation points from a combined sample of 15,656 participants to show how psychological-social predictors based on capability, opportunity and motivation-behaviour (COM-B) impact household water-use reduction. Results of this paper demonstrated that the behaviour mechanisms – capability, opportunity, and motivation dimensions can lead to behavioural change. These behaviour mechanisms correlate with household water-use, with opportunity being the most important mechanism. The study also found that within each dimension, correlations differed by household socio-demographic status and actual water-conservation behaviour.

The second paper identifies main drivers and barriers to household water-conservation behaviour and the manner and degree to which these drivers and barriers affect households' capability, opportunity, and motivation in water-conservation strategies. A latent profile analysis was used within the capability-, opportunity-, and motivation-behaviour (COM-B) framework to identify key barriers and drivers of household water-conservation behaviours. Participants (N = 510, mean age = 56.08 years, SD = 14.71) completed measures of psychological-social constructs related to barriers and drivers of water-conservation

behaviour. A latent profile analysis yielded a 3-profile solution in which capability (35.8%), opportunity (23.2%), and motivation (41.0%) conceptualised barriers and drivers of water-conservation behaviour. Results from the profiling groups demonstrate the reoccurring barriers and drivers inhibiting and exhibiting water conservation. Major identified barriers and drivers associated with these profile groupings were time constraints, acuity of water-efficient devices, lack of skills to adopt conservation practices, and availability of incentives/disincentives for water-saving devices. The profiling approach to understand the barriers and drivers of household water conservation in relation to behaviour change theory - the Behaviour Change Wheel (BCW) framework – influenced component parts of an intervention or strategy for effective conservation.

The third paper examines the extent to which receiving water-conservation messages could influence households' water scarcity concern and intentions to act in conserving water and tested whether this relationship was mediated via increasing capability, opportunity, and motivation. Participants completed a questionnaire assessing the extent to which receiving the water-conservation message types could influence their water scarcity concern and intentions to act in conserving water. Videos containing the water-conservation message types were then shown to participants. The effect of water-conservation message videos was assessed using the capability, opportunity, and motivation dimensions as mediating variables on water scarcity concern and intentions to act in conserving water. Pathways analysis (mediation analysis) was used as a tool for assessing these effects of the message types. The study found that specific messages about conservation strategies influence households' cognitive, affective, and behavioural responses to water conservation, perceived water scarcity concern, and intentions to act. Results from this study demonstrate the COM-B behaviour information can improve water-conservation activities by linking existing strategies to support water-conservation behaviour conditions to reduce vulnerability to environmental risks – including water crises.

The BCW and the COM-B framework of behaviour change theory are introduced to help water conservation interventions play a more prominent role in designing strategies for sustainable water-conservation behaviours. Ways for implementing and designing such a new paradigm shift are proposed and analysed by linking behaviour mechanisms to relevant intervention functions and policy categories. This has implications for understanding the profiles of households' water-conservation behaviour and associated barriers and drivers when designing intervention strategies for water conservation. This PhD thesis analyses causal mechanisms of behaviour – capability, opportunity, and motivation to provide critical insights into sources of behaviour and how these sources combine in multiple dimensions to jointly affect water-conservation behaviour for advancing our understanding of attitudes and behaviour to achieve sustainable water conservation. It is hypothesised from the research that behaviour mechanisms in the Behaviour Change Wheel framework actively influence water conservation. In addition to its contributions to the field of interdisciplinary study of water conservation, this PhD thesis also offers recommendations for government water agencies, stakeholders, and policy-makers to build intervention strategies by promoting and understanding individual behavioural change. The Command-and-control strategies to water conservation are not achieving sustainability and bridging the behavioural approach to the demand side of water supply can achieve sustainability because it increases consumers' intentions to act when individual behaviour mechanisms are considered.

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Chapter 1

WATER, CONSERVATION AND BEHAVIOUR: AN INTRODUCTION

Source: www.ecoclubmalaysia.org/wp-content/uploads/2015/10/Conserve-Water.jpg

1.1 Water conservation

Water is a critical resource to society for many reasons. It is an indispensable part of human survival and economic development (Gleick, 2003; Hoque, 2014). The value of water to human societies is depicted in the quote of Benjamin Franklin 'when the well is dry, we know the worth of water' (Epstein, 2016). Humans cannot survive without water, and once water is gone, so are most life forms (Tietenberg and Lewis, 2016). The average daily consumption of water by individuals ranges from 200 litres per person per day to less than 50 litres per person per day (Hoque, 2014). In Australia, the average water consumption in the four local regions of the Sunshine Coast, Brisbane, Ipswich and Gold Coast in Queensland is 145.3 litres per person per day.

Individual water consumption varies across multiple activities. Average water use in developed countries, on a per capita basis across a range of household activities has been recorded by Beal and Stewart (2011) to be; showers (42.7 litres per person per day: 29%), taps (27.5 litres per person per day: 19%) and clothes washers (31 litres per person per day: 21%). In domestic and municipal settings, daily activities such as drinking, bathing, laundry, dishwashing, sanitation, cooking, cleaning, sewage disposal, gardening, commercial and industrial activities all involve the use of water (Gleick, 2003; Hoque, 2014; Tietenberg and Lewis, 2016).

Domestic water use is not the dominant consumer of water; it accounts for only 8% of the total global consumption of water (Kibona et al. 2009; Rosegrant et al. 2009; Cassardo and Jones, 2011). Society uses water for a multitude of economic activities, and human enterprises such as food and power production (Gleick, 2003; Kiparsky et al., 2012). Irrigated agriculture and hydropower account for 85% and 7% of global water consumption respectively. Across domestic and economic uses, global consumption of water is currently 9,087 billion cubic

metres (2,400 trillion gallons) per year. This volume is equivalent to the annual flow of five hundred Colorado Rivers (Postel, 2017). Approximately 69% of worldwide usage of water is for agriculture, 22% for industrial purposes, 8% for domestic purposes, and 1% for recreational use (Kibona et al., 2009; Rosegrant et al., 2009; Cassardo and Jones, 2011). Irrigated agriculture is the largest consumer of freshwater globally. There is over 270 million hectares of irrigated land worldwide, or 18% of the world's arable land, and this irrigated land accounts for 40% of all agricultural production (UN Food and Agriculture Organization, 2002).

Global water resources are finite (Mehta et al., 2012). The estimated total volume of water on Earth is 1.4 billion km^3 (Shiklomanov, 1999), of which only 2.5% is freshwater on earth, 20-30% is groundwater and <1% is accessible surface water. Of this, only 200, 000 km^3 (< 1%) is available for human consumption (Gleick, 1993; Tietenberg and Lewis, 2016). Some of the groundwater is accessible as well. The United Nations Environment Program (2002) estimates that 90% of available global freshwater resources is groundwater and 2.5% is surface water (Tietenberg and Lewis, 2016). Although groundwater can be renewed by percolation of rain or melted snow, most of the volume of groundwater is accumulated over geologic time and space and cannot be fully recharged once depleted (Tietenberg and Lewis, 2016). Over-exploitation of groundwater results in depletion of the aquifer system and loss of sustainable water sources (Gaskin-Reyes, 2016). Recent studies have reported the drying-out of water bodies across the planet, causing stress and water insecurity for many communities. Cities in northern and eastern India, the Middle-East, Africa, California and Australia are hotspots where depletion of water resources has caused a serious decline in the availability of freshwater, leading to water-shortages (Barlow and Clarke, 2003; The Guardian, 2018). Depletion of groundwater and surface water resources could send at-risk regions into severe water anxiety and crisis (Vörösmarty et al., 2000), as has occurred recently in Cape Town in South Africa (The

Guardian, 2018). Thus, it is imperative to the ongoing maintenance of water supply that society prioritises the conservation of groundwater and surface water resources.

Conserving water is, and has been, a significant human activity for millennia (Vörösmarty et al., 2010). The earliest recorded dams are in Mehrgarh and Mesopotamia, and date back to the Neolithic era, ca. 7000-3200 BC (Baba et al., 2018). Humans and society conserve water in several ways to reduce risk and water insecurity. Conserving water 'is a part of the 'DNA' of humans and society' (Vörösmarty et al., 2000, Pp 284–288). Water conservation has diverse benefits to consumers, utilities, the environment, and the economy. The benefits to consumers include the reduction in monthly water bills and energy bills associated with heating water (Hoque, 2014). Actions such as reducing domestic water use on gardens and parks, and the use of recycled water have benefits in terms of monetary savings, and wider economic and environmental benefits (Clark and Finley, 2008; Graymore, 2007; Gilg and Barr, 2006; Hoque, 2014). Benefits to utilities include reduction in the cost of pumping water to collection centres or the construction and expansion of water supply and wastewater treatment facilities. Conserving water also increases volumes of surface or groundwater for environmental benefits and the provision of ecosystem services (Hoque, 2014). Conserving water can also trigger new economic activities for water-related manufacturing and service sectors to encourage and create new jobs (Hoque, 2014).

1.2 The supply and demand sides of water conservation

Conservation is safeguarding or making an efficient use of resources which involves protecting, managing and restoring natural resources (e.g., biodiversity, environment) and cultural heritage including works of art and architecture, and archaeological and historical artefacts (Ewert et al., 2004). Water conservation is defined as efficiency in use or included measures used to discuss

or curb water consumption (Yudelson, 2010). Water conservation has tended to focus on decreasing the risks and associated vulnerabilities of limited access to water using supply-side strategies. Supply-side strategies result in constant secure supply, and government water agencies and stakeholders have taken an engineering approach by building dams, water transfer schemes, rainwater harvesting systems and irrigation schemes (Gleick, 2003; Ward and Pulido-Velazquez, 2008). The world's rivers are regulated by 58,000 large dams (i.e., height of dam wall >15m) that provide water supplies to downstream communities and irrigation areas, allow navigation and produce hydropower (Poff and Schmidt, 2016). Strategies to ensure a constant supply of water to communities have varied over time with new techniques and strategies including efficient time-release drip irrigation systems (Griffin, 2006; Zetland, 2011; Ward and Pulido-Velazquez, 2008), desalination, water treatment and water-saving devices being introduced (Zhang et al., 2010; Elimelech and Philip, 2011 Hoque, 2014). An example is the South-North inter-basin water transfer scheme in China that will divert about 45x109 m^3 of water per year by 2050, from the Yangtze Basin to northern and western China (Berkoff, 2003). However, this traditional engineering approach to supply-side water conservation is costly, complex, and may result in economic, social and environmental decline (Tockner et al., 2016). For example, many sacred groves, forests and human settlements are sometimes dislocated when constructing dams and other water reservoirs for supply (Hoque, 2014).

In contrast to supply-side strategies focusing on an engineering approach, demand-side strategies offer solutions for water conservation by reducing water consumption. Strategies that address water demand are measures or initiatives that result in a reduction in the expected water-use, or water demand by the resource provider (e.g. a utility). This is commonly undertaken as part of corporate-planning and capital-investment processes (Stiles 1996). Most demand-side strategies adopted by water utilities focus on water-use efficiency, water supply

restrictions, and regulations with consequences to control-and-command water use (Bemelmans-Videc et al., 2011; Fielding et al., 2012; Farley and Bremer, 2017). For example, water tariffs show significant contributions in monetary value and water pricing structure. Hoque and Wichelns (2013) indicated that water tariff structures account for about 1.5% of household income which affects consumers' responsiveness to water price changes in a given context. Despite the reductions in demand that have been achieved through water-utility strategies, these are restrictive because they are framed as a command-and-control approach.

Command-and-control strategies are activities directly regulated by a governing entity that states what is permitted and what is illegal (McManus, 2009). The 'command' is the presentation of quality standards/targets by a government authority that must be complied with. The 'control' part signifies the negative sanctions that may result from non-compliance, including prosecution (Abbot, 2009; Baldwin et al., 2011). Command-and-control strategies have been shown to have limited long-term benefit to conserving water because they do not encourage sustained behaviour change (McGranahan, 2002). The recent water shortages in Cape Town, South Africa and Tamworth, Australia are examples of the failure of command-and-control strategies for water conservation.

In South Africa, the government acknowledged the need to support basic flows of water for the environment in its post-apartheid water laws, using cost recovery, access to water services, affordability and privatisation (McDonald and Pape, 2002; Postel, 2000; van Koppen and Schreiner, 2014). However, these strategies do not ensure long-term sustainability; and South Africa still suffers abrupt water crises. Likewise, Tamworth, an Australian city with approximately 58, 000 people, regularly faces water shortages. Winter drought conditions in 2014 led to the water storage level of Chaffey Dam, Tamworth's main water supply, dropping

below 35% (Tamworth Regional Council, 2014). A significant amount (55%) of these shortages come partly as a result of climate change, households' water-use behaviour and an increase in the city's population. Tamworth's water shortages continue, suggesting a need for alternative approaches to water conservation.

Understanding human behaviour, and attitudes to water provides an alternative demand-side approach for effective and long-term conservation of water (Wolfe and Brooks, 2003). Individual conservation behaviours can be influenced by variety of factors such as persuasion (framing effective conservation messages), communication campaigns and fostering attitudes supportive of a desired action (McKenzie-Mohr et al., 1995; Fielding and Roiko, 2014). Water-conservation outcomes may be improved through persuasion (message framing) for behavioural and attitudinal change among water consumers. The communication of conservation messages encourages behavioural changes that result in sustainable water conservation. Communication includes the framing and content of messages for household water-conservation behaviour. Households may receive information about water scarcity and specific water-saving strategies (e.g. use of dual-flush toilets) to conserve water (Seyranian et al., 2015). Such information transforms the behaviours impacting water quality and supply (Jorgensen et al., 2009), and challenges the belief that wasting water is acceptable. However, research emphasising communication of water resource conservation has not included wider psychological - social dimensions for developing and testing theories of attitudinal change and conviction (Crano and Prislin 2006).

Continuity in sustainability-related water-conservation interventions has not resulted in long term behavioural change (McKenzie-Mohr 2008). This is because the incorrect behaviours have been targeted, messages have been poorly communicated (e.g. framing of messages), and

limited appreciation has been given to cultural influences (McKenzie-Mohr 2008). A person's ability to comprehend conservation messages for behavioural change varies across diverse water-consuming audiences, cultural settings, and environments (McKenzie-Mohr 2008; Russell and Green 2009). Most households have positive dispositions towards water conservation, but these are not always transformed into specific conservation actions (Dolnicar et al., 2012). Agencies implementing water conservation strategies and interventions remain ineffective in achieving behavioural outcomes, thus raising the issue of how best to convey and set conservation messages for behavioural outcomes (Hine et al. 2013).

Understanding and changing behaviour is one of the most important and emerging alternatives for conserving water in the 21st century (Gleick, 2003; Hoque, 2014). Current knowledge suggests that understanding behavioural change is a key challenge for conservation (Hine et al., 2014). Connecting behaviours to actual causal mechanisms and intervention strategies may achieve longer-term conservation success because it increases capacity-building and empowerment of people to recognise, analyse and solve environmental-related issues consciously and voluntarily by using their own and available external sources (Crisp et al., 2000). It is against this backdrop that this thesis seeks to focus on behavioural approaches on the demand-side of water conservation by investigating the mechanisms of behaviour change for water conservation.

1.3 Philosophies of behaviour change

Behavioural change refers to any alteration or renewal of individual behaviour (Glanz et al., 2005). It involves an effort or a process that has the potential to influence people's personal habits/traits, attitudes or lifestyles to achieve a desired behaviour or outcome (Glanz et al., 2005). Determinant factors, efforts or processes that have the potential to influence people's

attitudes include fiscal measures, guidelines, environmental/social planning, communication/marketing, legislation, service provision, and regulation (Michie et al., 2011).

Intentions, environmental constraints, skills, expected outcomes (attitude), norms, self-standards, emotions and self-efficacy can all influence behavioural change (Fishbein et al., 2001). For a behaviour to occur, a person must have strong positive intentions (e.g., commitment) to enact the behaviour in question, relevant skills necessary to execute the behaviour, and the environment must offer a context of opportunity, or be free of constraints, such that the behaviour can occur (Fishbein et al., 2001). These factors focus on actions that stimulate an individual or a community to adjust to reduce risks and susceptibilities (Fishbein et al., 2001).

Theories and models of human behaviour offer a body of evidence with which to understand how behavioural change can influence pro-environmental behaviour such as water conservation. Theories and models are process-oriented and aimed at changing a behaviour (Table 1.1). They show how behaviours change over time and space, diagnose, and explain the determinant factors underlying behaviour (Darnton, 2008). Theories and models are also pragmatic, developed to support interventions for changing current behaviours or encouraging the adoption of new behaviours. Theories and models of change suggest intervention techniques can be effective in bringing about change, and often incorporate explicit approaches to intervention design, implementation and evaluation which can underpin effective policy planning and delivery (Badura, 1986; Darnton, 2008).

Table 1.1. Examples of theories and models of behavioural change (Adapted from Darnton, 2008).

Theory/Model	Key factors	Application	Reference
Theory of Reasoned Action and Theory of Planned Behaviour	Values, beliefs and attitudes, contextual factors	Demonstrate desired behaviours	Ajzen, 1991; Fishbein and Ajzen; 2010.
Social Cognitive Theory	Values, beliefs and attitudes	Provide training and guidance in performing recommended action	Bandura, 1986
Health Belief Model	Values, beliefs and attitudes	Make perceived susceptibility more consistent with individual's actual risk	Rosenstock et al., 1994; Strecher et al., 1997
Elaboration Likelihood Model of Persuasion	Values, beliefs and attitudes	Provide how-to information, promote awareness, use appropriate reminder system	Petty and Cacioppo, 1986
Values Beliefs Norms (VBN Theory)	Values, beliefs and attitudes	Attitude formation subjecting to external influence	Stern et al., 1995; Stern et al., 1999
Information-Motivation-Behavioural Skills Model	Values, beliefs and attitudes	Provide training and guidance in performing recommended action	Fisher et al., 2002
Theory of Self-efficacy	Capacity, skills, motivation	Beliefs of self-efficacy and outcome expectancies	Bandura, 1977
Model of Pro-environmental Behaviour	Emotions, contextual factors	Demonstrate desired behaviours	Kolmuss and Agyeman, 2002

The use of theories and models within the context of health, public safety, education, criminology, energy, international development and conservation for behavioural change has been increasing over the last decade. Only a few models have, however, had a major impact on actual behaviour in the health arena and energy consumption behaviours (Conner and Norman, 2005; Fishbein et al., 2001). The underlying principle of the Health Belief Model (HBM), for example, is that individuals sense a threat to their health. This threat increases their perception of vulnerability and understanding of the susceptibility for serious or severe consequences. Individuals must believe that the benefits of taking preventive actions outweigh perceived barriers to and/or costs of preventive action (e.g., Becker, 1988; Janz and Becker, 1984; Montgomery et al., 1989; Fishbein et al., 2001). These beliefs influence the likelihood that a person will adopt a recommended health protective behaviour which in effect focuses on prevention of diseases to save healthcare costs (World Health Organisation, 2002).

The Theory of Planned Behaviour and the Theory of Reasoned Action are models which have had impact on understanding how behavioural change influences pro-environmental behaviours such as water conservation (Ajzen, 1991; Fishbein and Ajzen, 2010). These two models have been applied to understand behaviours of conservation of natural resources. For example, Ajzen (1991) used the Theory of Planned Behaviour to propose that an individual's conservation behaviour can be explained by their behavioural intentions and environmental factors, which can either limit or help actual control over a behaviour. Intentions are conceived as a product of an individual's attitudes toward the behaviour, social norms, and the perception of the degree of control they have to enact the behaviour (Ajzen, 1991). The Theory of Reasoned Action was used by Fishbein and Ajzen (2010) to show that antecedent factors contribute to environmental attitudes. This study explained that antecedent factors have a higher degree of volitional control, resulting in reasoned choices among specific pro-environmental behaviours.

Social Cognitive Theory suggests that the initiation and persistence of an adaptive behaviour depends on beliefs of self-efficacy and outcome expectancies (Bandura, 1986). To perform or undertake behaviour, individuals must believe in their capability to perform that behaviour under different circumstances, and they must have incentives and motivation to do so (i.e., expected positive outcomes of performing the behaviour must outweigh expected negative outcomes/tendencies). Incentives may involve physical outcomes, social outcomes, self-sanctions or punishment. For example, incentive strategies for replacing or retrofitting of water efficient appliances help in achieving the outcomes of behaviour change for sustainable water demand management and economic development benefits (Lee et al., 2013).

The impacts of Social Cognitive Theory, the Theory of Planned Behaviour and the Theory of Reasoned Action span the policy areas of environment, health, and transport (Darnton, 2008).

From the health perspective, Social Cognitive Theory has been used in health promotion and disease prevention (Bandura, 2000). For example, treatment of chronic diseases focuses on self-management and physical conditions using incentives (Lorig, 1996). Self-management develops cost-effective actions with high social utility which regulates human behaviour and well-being. Holman and Lorig (1992) devised a generic self-management program in which patients were taught pain control techniques, self-relaxation, and proximal goal setting combined with self-incentives as motivators to increase level of activity. Participants were taught problem-solving, self-diagnostic skills and how to take greater initiative in their dealings with health personnel. These skills were developed through modelling of self-management skills, guided mastery practices, and informative feedback. For example, in the self-management of arthritis, the use of the technique helped to slow the biological progression of disease, and raised perceived efficacy, reduced pain, and decreased medical services by 43%, and improved the quality of life. Social Cognitive Theory has produced health benefits for people suffering from chronic diseases, such as heart disease, lung disease, stroke, and arthritis (Lorig et al., 1999).

The HBM is another useful model for understanding and influencing behaviour. The HBM has been used extensively to decide relationships between health beliefs and health behaviours, and to inform interventions (Strecher and Rosenstock, 1997). Applications of HBM to breast cancer screening behaviours have proved successful to both the behaviours of breast self-examination (Champion, 1984; 1993) and mammography (Champion, 1999). The HBM predicts that women will be more likely to adhere to screening mammography recommendations if they perceived susceptibility to breast cancer, think breast cancer is a severe disease, perceive barriers to screening as lower than perceived benefits, and have higher self-efficacy for getting mammograms, and receive a cue to action (Champion, 1984; Champion and Menon, 1997;

Champion et al., 2000). Skinner et al. (1998) used the HBM to inform public education sessions for older, urban minority women. The goal was to change perceptions and practices among people regarding breast cancer and enable them to discuss mammography-related perceptions and constructs among their peers. In a longitudinal intervention study, Champion et al. (2000) compared HBM interventions in several ways such as telephone counselling and in-person counselling. There were significant intervention effects on both HBM beliefs and mammography behaviour.

Despite the success achieved through the application of theories and models of behavioural change, there have been several failures of their applications. Fishbein and Ajzen (2010) used the Theory of Reasoned Action to predict and change behaviour about the environment, but the approach did not offer the means, strategies, or techniques to carry out the actual intervention (Schwarz et al., 2012). Bandura and Watt (1996) noted that a lack of implementation models for translating theory into effective practice influenced the usefulness of the model in achieving behaviour change. However, some studies have bridged theory to practice in behaviour change (Triandis, 1977; Kolmuss and Agyeman, 2002; Darnton, 2008; Fishbein and Ajzen, 2010; Steg et al., 2012). Dzewaltowski (1989) used the Theory of Reasoned Action in exercise motivation, but the variables used did result in any variation in exercise behaviour.

The rational-choice model is, a sub-set of the Theory of Reasoned Action (Table 1.1). This theory stresses a consumer's income, the price of the goods, the consumer's tastes or inclinations, and the premise of utility maximisation (Begg et al., 2000, Jackson, 2005). This theory is restrained on the sources of the individual's choices and uses a rational approach based on isolated individuals operating in pursuit of their own interests (Darnton, 2008).

There are different theories and models concerned with human behaviour (cf. Table 1.1). While many of these examine the influence of psychological-social drivers on behaviour (Triandis, 1977; Steg et al., 2012), the causal mechanisms of these behaviours are yet to be examined (Kolmuss and Agyeman, 2002; Fishbein and Ajzen, 2010; Michie et al., 2011).

1.4 The behaviour change wheel framework

The Behaviour Change Wheel (BCW) is a recent conceptual framework for understanding behavioural change (Michie et al., 2011). The BCW framework (Figure 1.1a) links behaviour to relevant behaviour mechanisms and intervention strategies. The BCW provides a structured approach to designing or updating behaviour change interventions and strategies. The BCW promotes a systematic and comprehensive analysis of the available options using behaviour change theory and the available evidence. It facilitates application of behavioural science to ensure that component parts of an intervention or strategy act effectively (Michie et al., 2015).

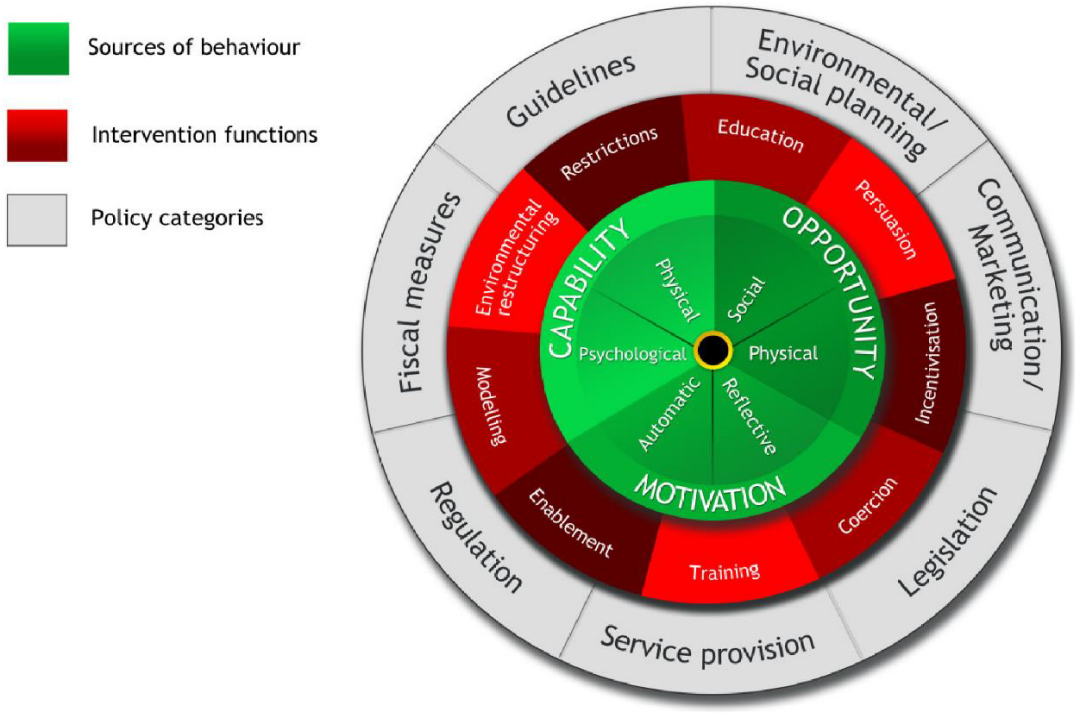

Figure 1.1a. The Behaviour Change Wheel (Adapted from Michie et al., 2011).

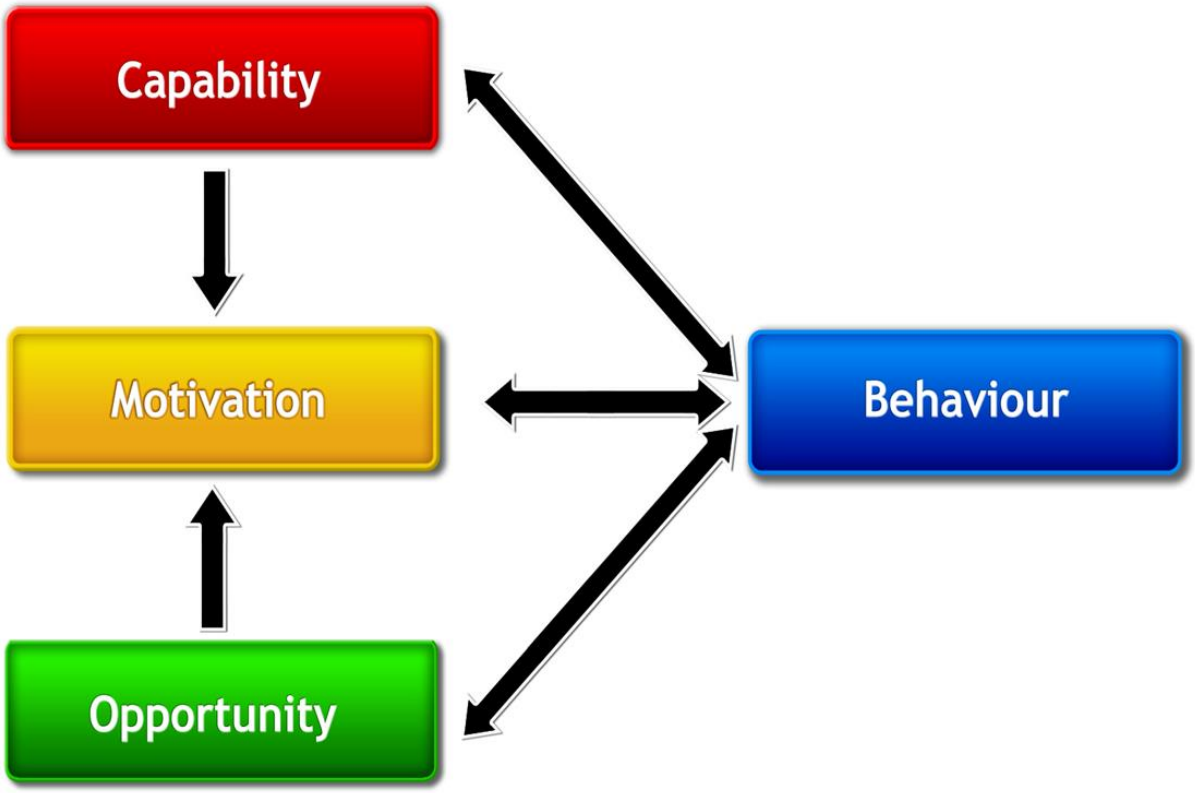

Figure 1.1b. COM-B system – a framework for understanding behaviour (Adapted from Michie et al., 2011).

The BCW framework (Michie et al., 2011) has three distinct behaviour dimensions: capability-, opportunity-, and motivation-behaviour (the COM-B system) which can influence conservation-related issues (Figure 1.1b). Capability is defined as gaining psychological and physical ability/self-efficacy to adopt specific behaviours or actions, including having suitable insight, knowledge and skills. Opportunity explains external factors to the individual that make the behaviour conceivable or prompt it, such as a social surrounding or physical environment that permits or prohibits a behaviour. Motivation describes the cognitive processes that vitalise and guide behaviour, such as habitual responses, emotional responses, and rational decision-making. These cognitive processes involve reflective motivation, such as making a good intention or doing appraisals, and automatic motivation, involving emotional and impulse responses. Pro-environmental behaviour can be sustained when intervention activity targets one

or more conditions within this behaviour system (Michie et al. 2011). The model posits that motivation influences opportunity and capability, while enacting a behaviour can alter capability, motivation, and opportunity (Figure 1.1b). To be successful, interventions need to change one or more of these conditions to enact the desired behavioural change (Michie et al. 2011).

The BCW framework and COM-B system has been applied in several disciplines and contexts (e.g. Alexander et al., 2014; Barker et al., 2016; Jackson et al., 2014; McLeod et al., 2015). Moore et al. (2014) used the BCW framework with health-related behaviours to develop a guide that links identified barriers and intervention activities to behaviour change theory. The study concluded that the approach allows policy-makers and implementers to identify potential strategies to overcome barriers to health-related behaviours. Barker et al. (2016) used the BCW framework in developing an intervention which aims to promote regular, long-term use of hearing aids by adults with acquired hearing loss. The study found that behavioural planning might be more likely to occur if audiologists' psychological capability, physical and social opportunity, and reflective and automatic motivation were addressed. Despite the potential for the BCW framework to assist in promoting behavioural change, it is yet to be applied to the area of water conservation.

1.5 Philosophical explanation

Applying paradigms, theories and models in different contexts is an interdisciplinary endeavour. Interdisciplinary approaches may facilitate a new understanding of water conservation by bridging dominant paradigms from individual disciplines. Many disciplines are often brought together to solve water problems. These include the scientific disciplines of hydrology, geomorphology, ecology and chemistry, and other disciplines such as engineering,

social science, economics and psychology (Thoms and Parsons, 2002). However, the integration of disciplines is fraught with challenges that can potentially reduce the effectiveness of interdisciplinary approaches to environmental problems. Pickett et al. (1994) identify three consequences of disciplinary progress:

1. gaps in understanding appear at the interface between disciplines;
2. disciplines focus on specific scales or levels or organisation; and,
3. as sub disciplines become rich in detail they develop their own view points, assumptions, definitions, lexicons and methods.

These consequences impede the integrated disciplines producing a single applied understanding of water conservation because attempts to produce an interdisciplinary outcome tend to remain dominated by the paradigms familiar to component disciplines. Successful interdisciplinary approaches to water conservation requires the 'explicit joining of two or more areas of understanding into a single conceptual-empirical structure' (Pickett et al., 1994). Integration of disciplines can be additive or extractive. In additive integration, two areas of understanding are combined more or less intact into a new composite understanding. In extractive integration, two or more areas of understanding may provide components that are combined to yield new understanding. As a mix of solutions, human behaviour focused water conservation represents the integration of the disciplines of water conservation and psychology, and the BCW provides a framework to undertake this integration. Strategies of behavioural change are important paradigms in psychology (Ajzen, 1991, Bandura, 1986, Jackson, 2005; Stern, 2000; Triandis, 1977), but studies examining water conservation and behavioural change together are limited.

1.6 Water conservation and behavioural change

The thesis proposes that long-term sustainable water conservation requires a behavioural approach. The application of the Behaviour Change Wheel and the COM-B system provides a conceptual framework for understanding behavioural change (Michie et al., 2011) to bring about sustainable water conservation. The thesis adopts an interdisciplinary approach to enhance our understanding of water conservation by drawing philosophically from the discipline of psychology and applying this to water conservation. The behavioural approach is in direct contrast to traditional linear command-and-control water conservation strategies which use regulation and compliance to achieve water conservation outcomes. The thesis uses the Behaviour Change Wheel (BCW) and the COM-B system (Michie et al., 2011); a framework used in psychology, and with immense potential for the interdisciplinary study of water conservation to help in designing and implementing intervention strategies for water conservation (Figure 1.1). Connecting these disciplines adds breadth and may integrate knowledge, information and methods to improve long-term adoption of water conservation.

The philosophical gaps associated with this thesis – to investigate mechanisms of water-conservation behaviour through the COM-B system - can be positioned into three main areas. The first relates to how psychological-social factors predict household water-conservation behaviour and how these predictive relationships vary with the household's capability (psychological and physical skills), opportunity (physical and social cues), and motivation (automatic and reflective response) in water conservation. This is important for understanding sustainability. The second area relates to understanding the barriers to and drivers of household water conservation capability, opportunity and motivation and the manner and degree to which these barriers and drivers can strengthen or inhibit effective water conservation strategies. This

is important for understanding how households decide upon intervention strategies to better influence water-conservation behaviour. The third area relates to water conservation communication; the effectiveness of a set of messages on intentions to act, and whether these messages are mediated by household capability (self-efficacy), motivation, and opportunity. This is important for framing conservation messages for predicting responses to behavioural change in water conservation, or for targeting specific conservation messages that appeal to behavioural change. The BCW and COM-B framework underpin these research areas by relating intervention strategies and policy categories to water conservation facilitating the way to understand attitudes and behaviours when designing intervention strategies.

The research undertaken in this thesis proposes that behaviour towards water conservation is important, and understanding behavioural change is a key factor in the design of intervention programs for water conservation. Understanding behavioural change is necessary for three reasons: first, attitudes and behaviours need to be understood before undertaking intervention strategies in water conservation – a stronger understanding of attitudes and behaviours to bring about behavioural change in water conservation can contribute to sustainability of the water resources. Second, it is important to make informed choices about which behaviour mechanisms bring about behavioural change and which are the most worthwhile to target in water conservation. Third, the primary framing of water conservation as a command-and-control approach can lead to short-term responses. This has ramifications for forecasting household water-conservation behaviours over the long-term and maintaining them to achieve sustainable conservation behaviour. Thus, from the psychological viewpoint, understanding and changing behaviour are two detached but interdependent systems with great potential to the interdisciplinary study of water conservation.

I argue in this thesis that the potential to understand behaviours in relation to water conservation has been scarce. This is because: 1) conserving water has been primarily focused on command-and-control strategies, with a partial understanding of the causal mechanisms for behaviour; 2) there is a lack of understanding about psychological-social dimensions influencing water-conservation behaviours and linking these behaviours to relevant intervention strategies; 3) there is inadequate understanding of how attitudes and behaviours influence water conservation and water-conservation messages. These issues are discussed and addressed in this thesis by using the Behaviour Change Wheel and COM-B framework.

Applying the BCW and COM-B framework in water conservation determines specific intervention strategies to target more effective measures and solutions that promote sustainable water-conservation behaviour. The BCW and COM-B framework links distinct behavioural mechanisms with relevant intervention strategies and shows how a group of people respond to their environment within a specific domain of behaviours (Michie et al., 2011). The content and focus of that intervention helps with the individual's behavioural change, choice of conservation measures and best fit within the environment. The benefits ensuing from the use of the BCW and the COM-B framework may include raising the interest of an individual's sustainability initiatives, providing solutions to sustainability problems, building trust among household water users and providing meaningful opportunities and positive attitudes for water-conservation actions.

1.7 Thesis aim and structure

Current approaches and paradigms of water conservation are limited, therefore limiting, because of the lack of awareness about attitudes and behaviours towards water conservation. To have sustained water conservation, greater emphasis should be placed on changing behaviour. The psychological-social factors of capability, opportunity, and motivation are the mechanisms of changing behaviour. The aim of this thesis is to investigate mechanisms of water-conservation behaviour through the lenses of capability, opportunity, and motivation-behaviour (COM-B system); thus, from an interdisciplinary perspective. Understanding water conservation using the COM-B system links drivers of, and barriers to, behavioural change with intervention strategies and policies which may cause effective and sustainable water-conservation behaviour. Three objectives were used as research questions addressed by this thesis.

1. What are the key psychological-social predictors of household water-conservation behaviour, and how do these predictive relationships vary with a household's capability, opportunity, and motivation in water conservation?
2. What are the barriers to, and drivers of, water conservation in terms of capability, opportunity, and motivation, and what is the manner and degree to which these barriers and drivers can strengthen and inhibit effective water-conservation behaviours?
3. What is the effectiveness of conservation messages on the intentions to act and engage in water conservation, and do the relationships of these messages change with capability, opportunity, and motivation in terms conserving water?

There are five chapters to this thesis: an introductory chapter, three manuscripts (all of which have been submitted for publication in international journals) and a synthesis chapter (Figure

1.2). *Chapters* 2, 3 and 4 comprise three empirical investigations into the mechanisms of water-conservation behaviour using the COM-B framework. *Chapter 2* (Manuscript 1) is a research article entitled "*Household water use and conservation behaviour: A meta-analysis*". This manuscript examines the capability, opportunity, and motivation of households as important psychological-social dimensions influencing water-conservation behaviour. The study asks: What are the main psychological-social predictors influencing household water conservation, and do they vary with households' water conservation capability, opportunity, and motivation? This study uses a meta-analysis to review the associations between psychological-social predictors and household water-use reduction. It provides a review of 88 correlation coefficients from a combined sample of 15,656 participants, to show how psychological-social predictors based on capability, opportunity and motivation-behaviour (COM-B) impact household water-use reduction. It also tests whether the effect of these predictive relationships varied as a function of COM-B subtypes, participant gender and study location. This manuscript has been revised and resubmitted to the international journal *Water Resources Research*.

Chapter 3 (Manuscript 2) is a research article entitled "*Barriers and drivers of household water conservation behaviour: A profiling approach*". This manuscript identifies the main drivers and barriers to household water-conservation behaviour and assesses the manner and degree to which these drivers and barriers affect households' capability, opportunity, and motivation in conservation strategies. The study asks: How can the Behaviour Change Wheel framework be enlisted to better understand households' main perceived barriers to and drivers of water-conservation behaviour? It uses a latent profile analysis (LPA) of the capability, opportunity and motivation dimensions to find key barriers and drivers of household water-conservation behaviour. This has implications for understanding the profiles of households' water-

conservation behaviour and associated barriers and drivers when designing intervention strategies for water conservation. This manuscript has been submitted for review to the *Journal of Environmental Management.*

Chapter 4 (Manuscript 3) is a research article entitled "*Reducing household water-use: The influence of water-conservation messages on intentions to ac*t". This manuscript measures the extent to which receiving water-conservation message types could influence households' water scarcity concern and intentions to act in conserving water. This study asks: Can communications about water conservation and water deficit encourage households to take sustainable actions to tackle these issues? Are the effects of these messages moderated by households' capability, opportunity, and motivation? It uses pathways analysis (mediation analysis) as a tool for assessing the effects of the message types using capability, opportunity and motivation as mediating variables on water scarcity concern and intentions to act in conserving water. This manuscript has been submitted for review to the *Water Resources Management*.

Chapter 5 of the thesis is a synthesis of the research undertaken in the three preceding chapters. It discusses the overview of the key findings of the three studies and their philosophical contribution to water conservation. It also discusses the practical implications of the major research findings for the interdisciplinary study of water conservation. Lastly, *Chapter 5* suggests areas for future research, recommendations and gives general conclusions.

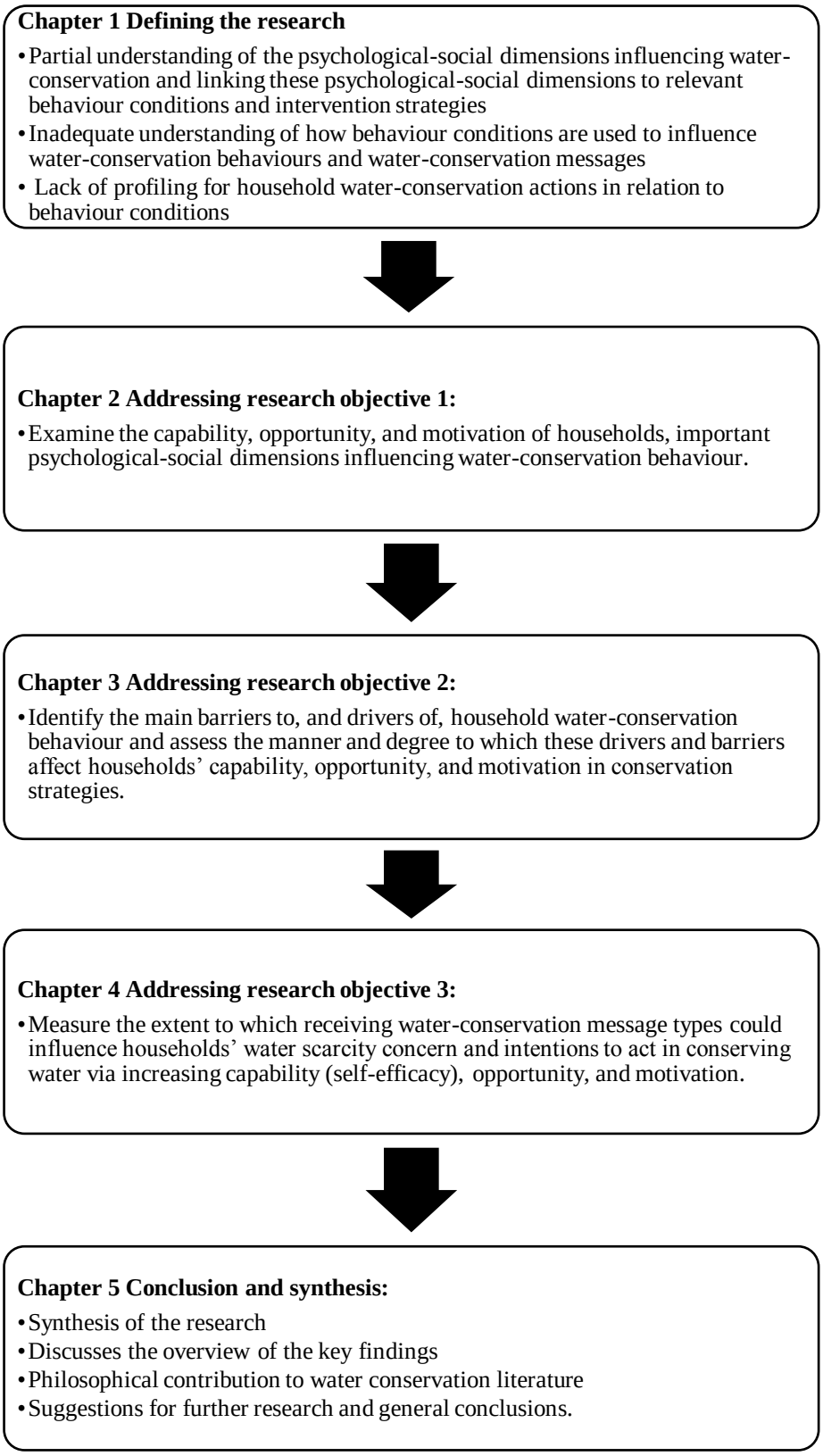

Figure 1.2. A conceptual overview of the thesis structure.

Chapter 2

HOUSEHOLD WATER USE AND CONSERVATION BEHAVIOUR: A META-ANALYSIS

Source: https://www.modestogov.com/ImageRepository/Document?documentID=6735

Abstract

Understanding the psychological-social drivers of water-use behaviour in households is essential for enhancing the effectiveness of water-conservation strategies and subsequent environmental benefits. This study used the Behaviour Change Wheel framework to review associations between capability, opportunity, and motivation (COM-B) dimensions and household water-use behaviours. A meta-analysis of 88 correlation coefficients from a combined sample of 15,656 participants showed positive relationships between water-use behaviour and COM-B dimensions. These three dimensions were statistically significant in predicting household water-use behaviour, with opportunity being the most moderate predictor of water-conservation behaviour ($r = 0.25$, $p < 0.001$), followed by motivation ($r = 0.24$, $p < 0.001$) and then capability ($r = 0.18$, $p < 0.001$). Collectively, these dimensions explained 37% of the variance in household water-conservation behaviour. Correlation coefficients also diverged as a function of COM-B dimension subtypes (i.e., psychological, physical, social, reflective, automatic), study location, study design and the gender of participants. Overall, the results are consistent with the Behaviour Change Wheel assertion that the integrative components of behaviour are important sources of psychological-social drivers of water-use behaviour. COM-B dimensions are useful for the identification of behaviours that influence water-use and how these may diverge depending on the water-use character of the region and environment.

2.1 Introduction

Water conservation by households commonly involves activities to reduce water consumption. These activities can be classified as 'curtailment' or 'efficiency' behaviours (Abrahamse and Steg, 2009; Fielding et al., 2012). Curtailment includes fixing leaking taps, reusing grey water, taking showers rather than baths, turning off taps while brushing teeth, and using dishwashers and washing machines with full loads (De Loe et al., 2001; Jorgensen et al., 2013). Efficiency requires greater personal involvement, financial investment and technical know-how. It involves the use of water-efficient services such as low-volume shower heads, front-loading washing machines, water-efficient dishwashers, dual-flush toilets and automatic reticulation systems (Richetin et al., 2016; Willis et al., 2011). Knowledge of the attitudes towards, and the uptake of, these activities is important for effective water conservation policy and planning. Household water-use activities are influenced by different opportunities, capacities and motivations (Fielding et al., 2012; Michie et al., 2011).

Models of human behaviour are commonly used as a basis to examine variable – effect relationships in conservation behaviour. The Theories of Planned Behaviour (Ajzen, 1985) and Reasoned Action (Ajzen and Fishbein, 1988) have been applied to behaviours of the use of natural resources. For example, Ajzen (1991) used the Theory of Planned Behaviour to propose that an individual's behaviour to conservation can be explained by their behavioural intentions and environmental factors, which can either limit or facilitate actual control over a behaviour. Intentions are conceived as a product of an individual's attitudes toward the behaviour, social norms, and the perception of the degree of control they have to enact the behaviour (Ajzen, 1991). The concepts of a reasoned action approach were employed by Fishbein and Ajzen (2010) to show that antecedent factors contribute to environmental attitudes. However, the

approach does not offer direct causal mechanisms on environmental behaviours, and therefore are insufficient in assisting with the development of strategies to change behaviours towards the environment and use of natural resources (Schwarz et al., 2012). Similarly, Dzewaltowski (1989) used the Theory of Reasoned Action to assess the motivation of choice and found that the factors used in variable – effect relationships did not demonstrate variance in behaviour. Whereas, the rational-choice model (e.g., expected utility models, consumer preference theory) which accentuates a consumer's possible income, the price of the goods, the consumer's tastes or inclinations, and the premise of utility maximisation is restrained because of an individual's choices (Begg et al 2003, Jackson, 2005). Many studies that have been based on a rational approach are limited to culturally isolated individuals operating in quest of their own interests (Darnton, 2008). Overall, application of human behaviour models in conservation efforts focus on examining relatively simple variable - effect relationships in order to understanding and effect change (Steg et al., 2012; Triandis, 1977; Kolmuss and Agyeman, 2002; Fishbein and Ajzen, 2010). Attempts to understand and examine direct causal mechanisms of behavioural change and conservation of natural resources are limited (Allison and Hobbs, 2006; Koontz and Thomas, 2006). Knowledge of the individual variable - effect relationships about natural resources and behaviours have reduced household consumption by up to 21% (Randolph and Troy, 2008; Winett et al., 1982) but they have not been effective in sustaining long-term behaviour change (World Health Organisation, 1996).

Household water-conservation behaviours are influenced by many psychological-social factors (Fielding et al., 2012). Communication is used to deliver water-conservation intervention strategies (Byrnes et al., 2010). Communication strategies attempt to persuade households to adopt constant, operative or intended actions to conserve water resources (Seyranian et al., 2015). Thus, communication can change behaviours by challenging the view that wasting water

is appropriate (Geller et al., 1983: Jorgensen et al., 2009). Cultural beliefs about water use can also influence the adoption of water conservation behaviours (Jorgensen et al., 2009). Cultural beliefs affect water use through awareness of the value of water and the benefits of conserving water. In similar environmental settings, diverse social groups may respond differently to the detrimental repercussions of water crises, in line with their prevailing belief systems and the values and norms of the group (Moser and Ekstrom, 2010, Jones and Boyd, 2011, Adger et al., 2012). Cultural traditions may also impede the implementation of adaptations that decrease susceptibility to drought and other external water threats (Nielsen and Reenberg, 2010). Understanding cultural beliefs about water wastage has been valuable for water utilities and individual in reducing water use (Gilli, 2004).

Age and education are also psychological-social drivers of water-conservation behaviour (Stern, 2000, Katherine, 2009). Clark and Finley (2007) claimed older people are more likely to conserve water, although Kantola et al. (1982) found that older people are less likely to account for conservation intentions. While older people (retirees) are greater water consumers (Lyman, 1992), teenage water consumption has been increasing since the 1980s (Mayer et al., 1999). Individuals with greater educational attainment have greater concern for the environment and are able to carry out informed and sustainable environmental practices (Fien et al., 2001; Katherine, 2009; Tilbury et al., 2002). Other psychological-social drivers of the adoption of water-conservation behaviour include household income (Gregory and Di Leo, 2003), type of home (Gilg and Barr, 2006), environmental beliefs and ecological worldview (Clark and Finley, 2007), and water pricing (Van Vugt, 2001).

A meta-analysis of the causal mechanisms of water-use behaviour is presented in this manuscript. The meta-analysis examines the capability, opportunity, and motivation of

households, important psychological – social dimensions, in influencing water conservation behaviours. The Behaviour Change Wheel framework of Michie et al. (2011) is used to organise psychological-social drivers and their effects on water-conservation. These drivers were categorised into a broad integrative model of system behaviour comprising capability, opportunity, and motivation-behaviour (COM-B). Looking at the causal mechanisms of behaviour from understanding water conservation in the lenses of the COM-B dimensions links drivers of and barriers to behavioural change with intervention strategies and policies which may result in effective and sustainable water conservation behaviour.

2.1.1 Theoretical framework

The Behaviour Change Wheel (BCW; Michie et al. 2011) provides a conceptual framework with which to research effective behaviour-change interventions for household water-use. The BCW is an integrative framework that recognises three conditions for behaviour change – the COM-B framework. Behaviour is conceptualised as a series of interactions that influences each individual condition; thus, behaviour becomes part of an interacting system involving all conditions (Michie et al. 2011). For example, motivation is influenced by opportunity and capability, whereas enacting behaviour can alter capability, motivation, and opportunity. Interventions designed to elicit behavioural change need to influence one or more of the individual conditions in order to enact the behaviour. The COM-B system provides a mechanism for merging different but related behaviour influences into a practical context that enables policy-makers to identify behaviours that are most relevant to household water-use and to design behaviour change interventions for water conservation.

The BCW allows for the identification of different causal mechanisms of behaviour and for these to be placed into broad categories of capability, opportunity and motivation. It does this

by identifying applicable types of intervention strategies for behavioural change, and the content and focus that an intervention requires. In particular, it allows the identification of a specific psychological-social mechanism or environmental condition that is linked to the specific behaviour of interest. Bundling together variables such as household size and water rates rebates into a single category (physical opportunity, for example), serves to conflate the effects of quite different variables. This conflation occurs in other COM-B dimensions. For example, where the behavioural dimension in the COM-B is concerned, capability – turning the tap off while brushing your teeth and watering the garden early in the morning and after sunset, for example, are different conservation behaviours (or habits as they are sometimes mistakenly referred to in the literature). These behaviours can differ in context, drivers and barriers. The COM-B system has advantages over other approaches to designing intervention strategies. Intervention Mapping (Bartholomew et al., 2011), for example seeks to relate behaviour to its theoretical cause(s). The BCW and COM-B system provides relevant intervention functions and policy categories to behaviour sources, thus, tools for linking behaviour interventions (Michie et al., 2011).

The capability dimension of the COM-B system refers to the individual's physical or psychological ability to enact the behaviour. It is characterised by two subtypes. Physical capability is the degree to which an individual can physically enact or participate in a behaviour and includes having the necessary physical skills, strength, or stamina to change behaviour (e.g., having the skills to repair minor water leakages). Psychological capability is an individual's knowledge and psychological skills to engage in the necessary mental processes to make an informed decision about a course of action (e.g. understanding the impact of water scarcity on the environment and reducing water wastage).

The opportunity dimension of the COM-B system is the external physical and social environment which enables the individual's behaviour. Opportunity factors are external to an individual and make the behaviour possible or prompt it. Opportunity is characterised by two subtypes. Physical opportunity afforded by the environment can include time, resources and location, but also economic enablers of water conservation (e.g., being able to conserve water because of financial incentives or rebates to promote water-conservation measures). Social opportunity includes, social cues and cultural norms that influence the way individuals think about making possible a behaviour (e.g., being able to conserve water in the house because of feeling under social pressure to install water-efficient appliances in the house and garden). Trust is also part of social opportunity. People conserve water if they trust that others are minimising their water use (i.e., inter-personal trust), and trust that water utilities and government are providing the necessary support for water conservation (i.e., institutional trust) (Graymore and Wallis, 2010; Jorgensen et al., 2009).

The motivation dimension comprises factors intrinsic and extrinsic to an individual that enact or direct behaviour. This dimension is characterised by two subtypes. Reflective motivation involves intentions and evaluations (beliefs about what is good and bad, conscious intentions, decisions, and plans) of the behaviour (e.g., a householder intending to take shorter showers). Automatic motivation involves emotional reactions, desires (wants/needs), inhibitions and reflex responses which activate or inhibit behaviour (e.g., feeling good by thinking about conserving water for the next generation). Motivation broadly involves evaluation mechanisms of water-conservation behaviour, general environmental attitudes, norms (personal and social), values, broad beliefs about the natural environment, water-peculiar beliefs and conventional practices pertaining to water use. The BCW is a framework for linking behavioural conditions to specific types of behaviour-change interventions and policies (Michie et al., 2011). Examples

include environmental/social planning, fiscal measures, guidelines, communication/marketing, legislation, service provision, and regulation. The use of the BCW model and the COM-B system to examine the psychological-social drivers for water conservation can enhance the engagement of respondents in innovative ways based on the householders' capability, opportunity, and motivation for conserving water.

2.2 Materials and methods

2.2.1 Literature search and screening

Two search approaches were adopted to find relevant studies for the meta-analysis of this study. First, we systematically searched the PsycINFO, ProQuest and JSTOR databases for studies written in English reporting behavioural drivers of influence on household water-use. The following key terms related to household water usage, COM-B system and water conservation were used: "water-efficient plumbing fixtures", "water-conservation measures", "purchase decision", "cultural beliefs", "environmental beliefs", "social norms", "perceived behavioural control", "educational background", "landscape choices", "home ownership", "type of house", "dwelling context", "moral persuasion", "normative beliefs", "awareness", "conservation campaign", "subjective norms", "water policy", "water pricing", "water restrictions", "commitment", "turning off tap", "perceived efficacy", "water-use habits", "financial incentives", "pro-environmental behaviour", "communication", and combinations of these truncated key terms. Second, water-conservation researchers were contacted directly to identify and obtain unpublished datasets and reports on behaviour change related to water-conservation activities.

Standard methods were used to record, screen and assess the eligibility of all identified articles and other information using the PRISMA protocol (Moher et al., 2009) (Figure 2.1). Screening was done using the PRISMA protocol and 'metagear' package for *R* which provides an abstract screener to filter through the abstracts and titles of multiple references (Lajeunesse, 2016). This screener sifted, flagged and removed all duplicate studies. To be included in the review, studies must have assessed the relationship between at least one COM-B dimension and at least one measure of water-behaviour outcome. The type of psychological-social predictors must have reported effect sizes or included enough information (e.g., means, standard deviations, variances, t tests, F tests, percentages, or chi-square) for effect sizes to be computed. The reference list of each retrieved article was further examined for relevant literature and the Google Scholar search engine was used to further search for articles by identified authorities in the discipline. Many community-based social marketing and behaviour-change studies driven by government initiatives have relevant information and these were included in the analysis. In total, 88 reported effect sizes (k = 88) were found that met the inclusion criteria (Table 2.1).

2.2.2 COM dimensions and data aggregation

To create variables representing the COM-B dimensions, we identified latent psychological-social drivers in the literature. The identified drivers were recorded and grouped to generate variables that represent the COM-B dimensions. Considering the psychological-social drivers into the COM-B dimensions, we collapsed the data in R-packages (Becker et al., 1988) using an aggregate function to group variables (psychological – social predictors) into relevant COM-B dimensions. The aggregate function (scalar function) calculated the summary statistics that made up the aggregated values. These values were further categorised under each COM-B dimension subtype to generate coding categories. Thus, each psychological-social predictor

with computed effect size was segregated under relevant categories of the COM-B dimensions for the meta-analysis.

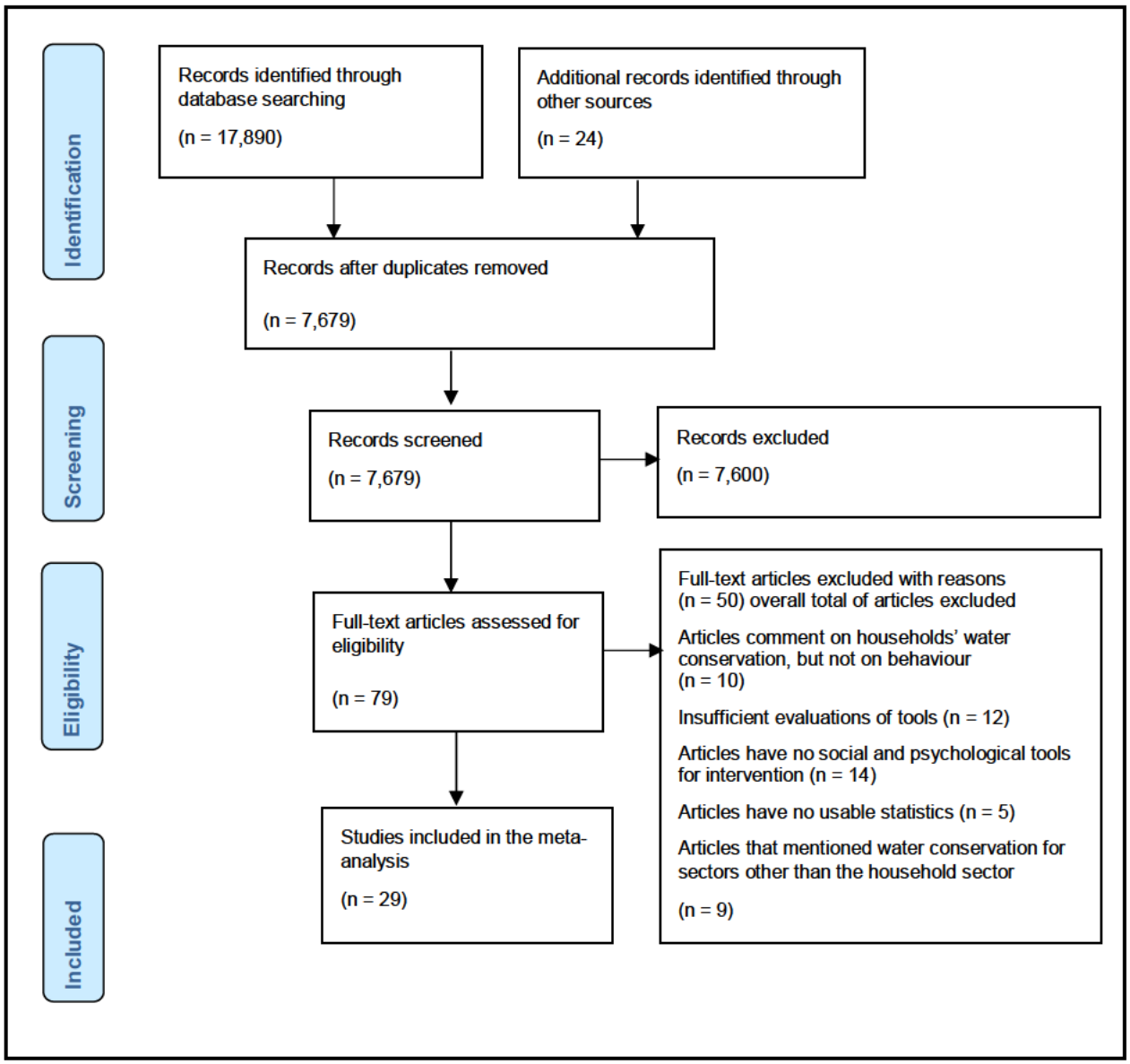

Figure 2.1. Flow of information used in the meta-analysis of household water-use. The flow included the identification, screening, eligibility and inclusion phases of the literature review, following the PRISMA method (Moher et al., 2009).

Table 2.1. Summary of articles included in the meta-analytic review and the variables coded in each article. *N* = sample size, *r* = point estimate of the effect size (Pearson's *r* correlation coefficient) using the summary correlation of outcomes reported, *SE* = standard error.

Author	*N*	Country	Sample type	Study design	Predictor type	COM subtype	COM dimensions	Water-use behaviour	% Females	*r*	*SE*
Adams et al. 2013	2226	USA	General population	Longitudinal	Information	Psychological	Capability	Water-use reduction	Unknown	0.42	0.02
Adams et al. 2013	2226	USA	General population	Longitudinal	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	0.07	0.02
Adams et al. 2013	2226	USA	General population	Longitudinal	Location	Physical	Opportunity	Water-use reduction	Unknown	0.02	0.02
Adams et al. 2013	2226	USA	General population	Longitudinal	Time	Physical	Opportunity	Water-use reduction	Unknown	0.16	0.02
Adams et al. 2013	2226	USA	General population	Longitudinal	Education	Psychological	Capability	Water-use reduction	Unknown	0.01	0.02
Adams et al. 2013	2226	USA	General population	Longitudinal	Knowledge	Psychological	Capability	Water-use reduction	Unknown	0.34	0.02
Aitken et al. 1994	321	Australia	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	0.30	0.05
Aitken et al. 1994	321	Australia	General population	Correlational	Habits	Automatic	Motivation	Water-use reduction	Unknown	0.24	0.05
Aitken et al. 1994	321	Australia	General population	Correlational	Values	Reflective	Motivation	Water-use reduction	Unknown	0.31	0.05
Bernedo et al. 2014	400	USA	General population	Experimental	Social norms	Social	Opportunity	Water-use reduction	Unknown	0.02	0.05
Chang 2013	900	China	General population	Correlational	Environmental concern	Psychological	Capability	Water-use reduction	44.60	0.11	0.03

Chang 2013	900	China	General population	Correlational	Normative beliefs	Social	Opportunity	Water-use reduction	44.60	0.05	0.03
Chang 2013	900	China	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	44.60	0.06	0.03
Chang 2013	900	China	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	44.60	0.12	0.03
Chang 2013	900	China	General population	Correlational	Information	Psychological	Capability	Water-use reduction	44.60	0.06	0.03
Clark and Finley 2007	750	Bulgaria	General population	Longitudinal	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	0.53	0.03
Clark and Finley 2007	750	Bulgaria	General population	Longitudinal	Environmental concern	Psychological	Capability	Water-use reduction	Unknown	0.21	0.04
Clark and Finley 2007	750	Bulgaria	General population	Longitudinal	Information	Psychological	Capability	Water-use reduction	Unknown	0.10	0.04
Corral-Verdugo et al. 2006	177	Mexico	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	44.60	-0.18	0.07
Corral-Verdugo et al. 2003	510	Mexico	General population	Longitudinal	Normative beliefs	Social	Opportunity	Water-use reduction	61.00	0.22	0.04
Dascher et al. 2014	273	USA	General population	Longitudinal	Information	Psychological	Capability	Water-use reduction	64.10	0.41	0.05
Dascher et al. 2014	273	USA	General population	Longitudinal	Water restrictions	Physical	Opportunity	Water-use reduction	64.10	0.32	0.06
Dascher et al. 2014	273	USA	General population	Longitudinal	Rebate	Physical	Opportunity	Water-use reduction	64.10	0.01	0.06
De Oliver 1999	203	USA	General population	Correlational	Income	Physical	Capability	Water-use reduction	Unknown	-0.07	0.07
De Oliver 1999	203	USA	General population	Correlational	Education	Psychological	Capability	Water-use reduction	Unknown	0.05	0.07

Dickerson et al. 1992	80	USA	Students	Experimental	Mindfulness	Reflective	Motivation	Water-use reduction	100.00	0.59	0.07
Dickerson et al. 1992	80	USA	Students	Experimental	Commitment	Reflective	Motivation	Water-use reduction	100.00	0.42	0.09
Dickerson et al. 1992	80	USA	Students	Experimental	Household size	Physical	Opportunity	Water-use reduction	100.00	0.09	0.11
Domene and Saurí 2006	532	Spain	General population	Correlational	Income	Physical	Capability	Water-use reduction	Unknown	0.01	0.04
Domene and Saurí 2006	532	Spain	General population	Correlational	Household size	Physical	Opportunity	Water-use reduction	Unknown	0.09	0.04
Fan et al. 2014	776	China	General population	Longitudinal	Perceptions of water-efficient devices	Psychological	Capability	Water-use reduction	Unknown	0.03	0.04
Fielding et al. 2012	1008	Australia	General population	Correlational	Intentions	Reflective	Motivation	Water-use reduction	56.60	0.52	0.02
Fielding et al. 2012	1008	Australia	General population	Correlational	Attitude toward conservation	Reflective	Motivation	Water-use reduction	56.60	0.42	0.03
Fielding et al. 2012	1008	Australia	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	56.60	0.36	0.03
Fielding et al. 2012	1008	Australia	General population	Correlational	Perceived behavioural control	Psychological	Capability	Water-use reduction	56.60	0.27	0.03
Geller et al. 1983	129	USA	General population	Correlational	Household size	Physical	Opportunity	Water-use reduction	Unknown	0.40	0.08
Geller et al. 1983	129	USA	General population	Correlational	Temperature	Physical	Opportunity	Water-use reduction	Unknown	0.30	0.08
Geller et al. 1983	129	USA	General population	Correlational	Humidity	Physical	Opportunity	Water-use reduction	Unknown	0.25	0.08
Gilg and Barr 2006	1600	UK	General population	Longitudinal	Education	Psychological	Capability	Water-use reduction	65.00	0.22	0.02

Gilg and Barr 2006	1600	UK	General population	Longitudinal	Purchase decisions	Reflective	Motivation	Water-use reduction	65.00	0.12	0.03
Gilg and Barr 2006	1600	UK	General population	Longitudinal	Habits	Automatic	Motivation	Water-use reduction	65.00	0.13	0.03
Gilg and Barr 2006	1600	UK	General population	Longitudinal	Income	Physical	Capability	Water-use reduction	65.00	0.26	0.03
Gilg and Barr 2006	1600	UK	General population	Longitudinal	House ownership	Physical	Opportunity	Water-use reduction	65.00	0.63	0.02
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Awareness	Psychological	Capability	Water-use reduction	Unknown	-0.05	0.05
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Involvement	Physical	Capability	Water-use reduction	Unknown	-0.17	0.05
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	0.03	0.06
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Habits	Automatic	Motivation	Water-use reduction	Unknown	-0.24	0.04
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Age	Physical	Capability	Water-use reduction	Unknown	-0.34	0.04
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Income	Physical	Capability	Water-use reduction	Unknown	0.42	0.04
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Education	Psychological	Capability	Water-use reduction	Unknown	0.17	0.05
Gregory and Di Leo 2003	471	Australia	General population	Correlational	Household size	Physical	Opportunity	Water-use reduction	Unknown	0.48	0.04
Hamilton 1983	431	USA	General population	Correlational	Income	Physical	Capability	Water-use reduction	Unknown	0.26	0.05
Hamilton 1983	431	USA	General population	Correlational	Education	Psychological	Capability	Water-use reduction	Unknown	0.11	0.05

Hamilton 1983	431	USA	General population	Correlational	Household size	Physical	Opportunity	Water-use reduction	Unknown	0.16	0.04
Kurz et al. 2005	166	Australia	General population	Experimental	Use of water-efficient devices	Physical	Capability	Water-use reduction	Unknown	0.23	0.07
Kurz et al. 2005	166	Australia	General population	Experimental	Attitude toward conservation	Reflective	Motivation	Water-use reduction	Unknown	0.18	0.08
Kurz et al. 2005	166	Australia	General population	Experimental	Information	Psychological	Capability	Water-use reduction	Unknown	0.67	0.04
Kurz et al. 2005	166	Australia	General population	Experimental	Feedback	Psychological	Capability	Water-use reduction	Unknown	0.47	0.06
Lam 2006	166	Taiwan	General population	Experimental	Attitude toward conservation	Reflective	Motivation	Water-use reduction	50.00	0.24	0.07
Lam 2006	166	Taiwan	General population	Experimental	Social norms	Social	Opportunity	Water-use reduction	50.00	0.26	0.07
Lam 2006	166	Taiwan	General population	Experimental	Perceived behavioural control	Psychological	Capability	Water-use reduction	50.00	0.20	0.08
Lapinski et al. 2007	72	USA	Students	Experimental	Social norms	Social	Opportunity	Water-use reduction	49.00	0.52	0.09
Lapinski et al. 2007	72	USA	Students	Experimental	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	49.00	0.25	0.11
Lapinski et al. 2007	72	USA	Students	Experimental	Intentions	Reflective	Motivation	Water-use reduction	49.00	0.28	0.11
Lowe et al. 2014	909	Australia	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	59.00	0.38	0.03
Lowe et al. 2014	909	Australia	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	59.00	0.24	0.03
Lowe et al. 2014	909	Australia	General population	Correlational	Perceived behavioural control	Psychological	Capability	Water-use reduction	59.00	-0.03	0.03

Lowe et al. 2014	909	Australia	General population	Correlational	Moral obligation	Reflective	Motivation	Water-use reduction	59.00	0.14	0.03
Lowe et al. 2014	909	Australia	General population	Correlational	Trust	Social	Opportunity	Water-use reduction	59.00	0.23	0.03
Marandu et al. 2010	462	Botswana	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	54.00	0.23	0.04
Marandu et al. 2010	462	Botswana	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	54.00	0.24	0.04
Newton and Meyer 2012	1250	Australia	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	-0.01	0.03
Newton and Meyer 2012	1250	Australia	General population	Correlational	Household type	Physical	Opportunity	Water-use reduction	Unknown	0.41	0.02
Newton and Meyer 2012	1250	Australia	General population	Correlational	Landscape choices	Physical	Opportunity	Water-use reduction	Unknown	0.44	0.02
Newton and Meyer 2012	1250	Australia	General population	Correlational	Location	Physical	Opportunity	Water-use reduction	Unknown	0.04	0.03
Richetin et al. 2016	41	UK	Students	Experimental	Descriptive norms	Social	Opportunity	Water-use reduction	46.00	0.38	0.14
Seyranian et al. 2015	374	USA	General population	Correlational	Social identity	Social	Opportunity	Water-use reduction	Unknown	0.06	0.05
Seyranian et al. 2015	374	USA	General population	Correlational	Personal identity	Social	Opportunity	Water-use reduction	Unknown	0.19	0.05
Seyranian et al. 2015	374	USA	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	Unknown	0.15	0.05
Stewart et al. 2013	151	Australia	General population	Longitudinal	Prompt	Reflective	Motivation	Water-use reduction	Unknown	0.27	0.08
Trumbo and O'Keefe 2005	868	USA	General population	Correlational	Values	Reflective	Motivation	Water-use reduction	Unknown	0.16	0.03

Trumbo and O'Keefe 2005	868	USA	General population	Correlational	Past actions	Physical	Capability	Water-use reduction	Unknown	0.11	0.03
Trumbo and O'Keefe 2005	868	USA	General population	Correlational	Social norms	Social	Opportunity	Water-use reduction	Unknown	0.44	0.02
Trumbo and O'Keefe 2005	868	USA	General population	Correlational	Attitude toward water conservation	Reflective	Motivation	Water-use reduction	Unknown	0.40	0.03
Trumbo and O'Keefe 2005	868	USA	General population	Correlational	Information	Psychological	Capability	Water-use reduction	Unknown	0.40	0.03
Van Vugt 2001.	278	UK	General population	Longitudinal	Household size	Physical	Opportunity	Water-use reduction	Unknown	0.33	0.05
Willis et al. 2011	132	Australia	General population	Longitudinal	Environmental concern	Psychological	Capability	Water-use reduction	Unknown	0.14	0.09
Willis et al. 2011	132	Australia	General population	Longitudinal	Perceptions of water-efficient devices	Psychological	Capability	Water-use reduction	Unknown	0.22	0.08

2.2.3 Coding and categorisation

We adopted standard meta-analysis procedures to find, code, and analyse the data from each article. The data were coded according to the information outlined in Table 2.1: (1) authors and year of publication, (2) outcome variables of water-use behaviour and COM-B dimensions and subtypes, (3) predictor variables which underscored the COM-B dimensions subtypes, (4) methodological moderators, and (5) the effect size (*r*) based on the Pearson's r statistic. The meta-analysis then computed the average effect sizes by the diverse types of coded variables (e.g., habits, water-efficient devices, norms, perceived behavioural control, and awareness). The three variables considered were:

1. Outcome variables. Each study was coded for a specific outcome variable for water-use behaviour – namely, water-use reduction (defined to include water efficiency, conservation and saving activities). Water-use reduction involves actions, programs, and procedures carried out to conserve water resources to support the environment, and to meet present and future use. It includes self-reports of past consumption behaviours (e.g. average number of showers per week), self-reports of efficiency and curtailment behaviours provided by a single household resident and using improved technology or devices to reduce water consumption (e.g., water-efficient washing machines and dishwashers). The studies were also coded for the COM-B dimensions (capability, opportunity, and motivation), and COM-B dimension subtypes (physical, psychological, social, reflective, and automatic).
2. Predictor variables. The studies in the meta-analysis measured various predictors in the context of COM-B influences on behaviour which included, for example, educational background, perceived behavioural control, water policy, cultural beliefs, subjective norms, and water-use habits (Table 2.1). Each of these predictors was

coded within the COM-B dimension subtypes to assess the associations between the COM-B dimension subtypes and the water-use reduction outcome measure.

3. Moderator variables. Methodological moderator variables were also coded to understand the modification of intensity or path of the correlational association among the predictor types and the water-use reduction outcome measures (Rose et al., 2004). These gender, study design, study location and COM-B dimension subtypes were used as the moderator variables to assess their influence on the effect sizes across the studies.

Coding reliability was determined using the method of Cooper (2010). The primary coder coded all studies, and the secondary coder re-coded an arbitrary collection of 45% of the initial article set. Inter-coder reliability for the included studies was 95% (Cohen's $k = 0.85$), indicating very high consistency. Disparities were determined through panel discussion between the coders and all the agreed documents were assessed further to establish consistency with any agreed changes. Data were analysed after reaching the final consensus. The relevant information from each article was entered into a data base in SPSS (Version 24, SPSS Inc., Chicago, IL, USA).

2.2.4 Data analysis

A random-effect model was used to capture variations in true effects existing between studies (cf. Quintana, 2015). The random-effect model provided both intra- and inter-study variability. In terms of study weighting, the random-effect model guided the study to assign larger weights to studies that involved a relatively smaller sample size whereas smaller weights were given to larger studies. Employing the random-effects model provides larger confidence intervals resulting in higher conventional values and conclusions (Lipsey and Wilson, 2001). Computationally, the inverse variance of each study was used to individually weight each study (Benos and Zotou, 2014; Stanley and Doucouliagos, 2012). The meta-

analysis functions in the Meta-Analysis Package for *R* ('metafor') (Viechtbauer, 2010) and Robust Variance Meta-Regression ('robumeta') were used. The 'metafor' package was used to perform the random-effect modelling whereas the 'robumeta' was used to perform uncertainty analysis and produce funnel plots of effect sizes (Hedges et al., 2010). In the random-effect modelling, the restricted maximum-likelihood (REML) method was used given that it is negatively biased and reported to have the best properties in estimating variance components (Viechtbauer et al., 2015). The Pearson's *r* correlation coefficient was employed as the index of effect size in all analyses. This correlation coefficient is not normally-distributed, so we converted the Pearson's *r* correlations to Fisher's *z* scores using Fisher's transformation and then converted Fisher's (*z*) back to Pearson's r for reporting the average correlation along with the 95% confidence interval, as recommended by Lipsey and Wilson (2001). Heterogeneity was assessed using the *Q* statistic (Hedges and Olkin, 1985), where a low p value is indicative of heterogeneity among the relevant effect sizes.

In those studies that presented multiple water-use behaviour outcome measures, more than one effect size was coded. To meet the key statistical assumption of effect size independence (Lipsey and Wilson, 2001) we computed an average effect size for each water-use behaviour outcome measure for each of these studies to obtain an overall correlation value. This ensured that an individual study presented a single effect size to each of the general analyses (k = 88) based on 15,656 participants.

2. 2.5 Issues of publication bias

A point of contention in many meta-analyses is the likelihood for information bias, where the research outcomes depend not just on the nature of the research but on the hypothesis experimented with and the magnitude and direction of effects observed in the published literature (Dickersin, 1990; Rothstein et al., 2005). To examine potential publication bias in our study, we produced funnel plots for effect sizes by standard error and used the Egger's

mixed-effects meta-regression model (Egger et al., 1997; Sterne and Egger, 2001) and a rank correlation test (Begg and Mazumdar, 1994) to quantify possible biases in the funnel plot using 'metafor' and 'robumeta'. The accuracy of each study (inversion of the standard error, y-axis) was mapped out against its correlation coefficient (x-axis). The funnel plot was a symmetrical inverted funnel, indicating no systematic publication bias (Figure 2.2). It also showed that the 88 effect sizes considered in this study were distributed symmetrically on both sides of the average effect sizes. To buttress for an improved evaluation accuracy, we further used Egger's regression intercept test in which the accuracy of each study was used to forecast standardised correlation coefficients (Egger et al., 1997). For Egger's intercept test, a statistically significant intercept is suggestive of bias. However, neither Egger's regression test ($p = 0.122$) nor the rank correlation test ($p = 0.196$) was statistically significant, substantiating the conclusion that there is substantial funnel plot inequality and consequently no indication of publication bias.

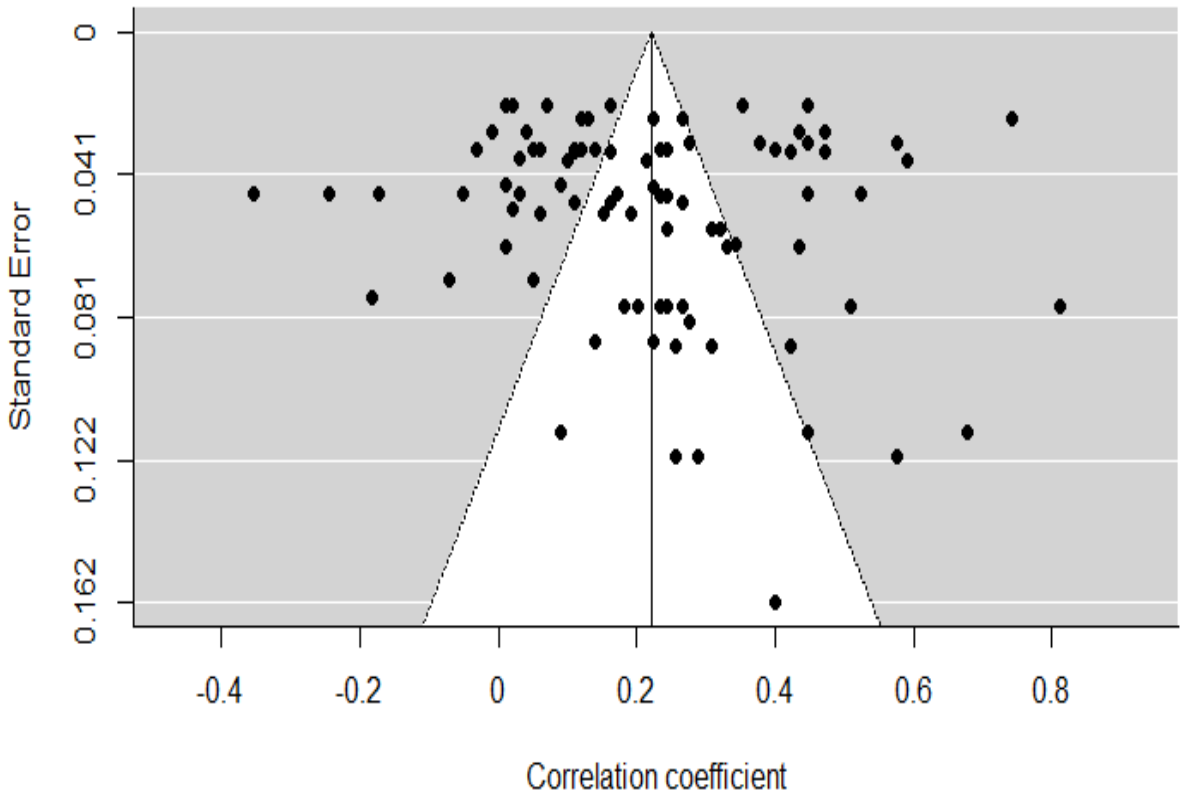

Figure 2.2. Funnel plot to illustrate potential publication bias and the effect sizes of the correlation between COM-B dimensions and household water-use behaviour. Egger's regression test (p = .122), and the rank correlation test (p = .196) were not statistically significant.

2.3 Results

The studies included in this meta-analysis vary in overall character (Table 2.1). In terms of household water-use behaviour outcomes, the studies measured household water-use reduction (e.g., efficiency, conservation, and saving activities). Samples were largely taken from the general population (92.0%), but also included students (8.0%). The sample size of studies varied from 41 to 2,226, with a mean of 539.8 (SD = 93.6). Most studies were conducted in Australia (36.4%), followed by the USA (35.2%), UK (8.0%) and China (6.8%). In terms of study design, 56.8% of studies employed a correlational design, 26.1% used a

longitudinal design, and 17.1% adopted an experimental design. The studies also yielded a range of predictor types which underscored capability, opportunity, and motivation within each COM-B dimension.

2.3.1 Overall effect sizes for COM-B dimensions

There were significantly weak linear associations with the COM-B dimensions and water-use reduction (Table 2.2). The overall weighted effect size (r = 0.25) for opportunity and household water-use reduction activities indicates that households who scored higher on the opportunity dimension perceived that the physical or social environment enables water-conservation behaviour. The effect size for motivation (r = 0.24) indicates that reflective or automatic mechanisms activate and/or inhibit water-conservation behaviour, while the effect size for capability (r = 0.18) indicates that participants who scored higher on the capability dimension perceived a psychological or physical ability to enact water behaviour.

Table 2.2. Effect sizes for COM-B dimensions. k = number of effect sizes. r = point estimate of the effect size (Pearson's r correlation coefficient), using the summary correlation of outcomes reported, CI = confidence interval; the 95% lower and upper limits, Z = Fisher's transformation of the effect size, p <.001.

COM-B dimensions	*k*	*r*	95% CI		*z*	*p*
			Lower	Upper		
Capability	31	0.18	0.09	0.26	4.42	<.001
Opportunity	32	0.25	0.18	0.33	6.92	<.001
Motivation	25	0.24	0.17	0.31	5.97	<.001

Heterogeneity statistics provide evidence of a significant and large Q statistic (Q (87) = 2495.29, p < 0.001) based on a measure of weighted squared deviations. The I^2 index (I^2 = 96.57%, p < 0.001) indicated that almost 97% of the observed variance was explained by

systematic effect-size differences across the studies. The effect sizes for each COM-B dimension showed substantial heterogeneity across the studies (capability $Q = 836.04$, $p < 0.001$; opportunity $Q = 948.13$, $p < 0.001$; motivation $Q = 667.36$, $p < 0.001$). Thus, the high observed heterogeneity indicates the need to explore moderators (Lipsey and Wilson, 2001) such as COM-B dimension subtypes; study location, study design and gender of participants.

2.3.2 Moderator variables

We explored the influence of four moderator variables: COM-B dimension subtypes (capability: physical and psychological; opportunity: physical and social; and motivation: reflective and automatic), as well as study location, study design and gender of participants.

2.3.3 COM-B dimension subtypes

The results of the categorical moderator analyses comparing the effect sizes between the COM-B dimension subtypes and water-use behaviour are presented in Table 2.3. Average effect sizes varied significantly by the outcome variable within each of the COM-B dimension subtypes and between group *Q*-tests. Studies assessing physical capability and psychological capability showed weak association based on non-overlapping 95% confidence intervals, but only psychological capability expressed significant association with water-use reduction. The individual psychological-social drivers of physical and psychological capability revealed a varied association with water-conservation behaviour (Table 2.4). For physical capability, income ($r = 0.53$, 95% CI [0.16, 0.89]) correlated significantly with water-use reduction. Variations in income levels of people revealed that wealthier people have the money to buy water-saving devices, if only they wanted to, but they do not want to, hence they could do more in greater intentions to purchase water-efficient devices in reducing water consumption. Lower income earners performed poorly in water-use reduction activities

presumably because they cannot afford to undertake these activities and they have low intentions of buying water-efficient devices.

Water-use reduction increased where people could use water-efficient devices whereas water-use reduction was low when people failed to use these water-efficient devices. Although use of water-efficient devices was significantly associated with water-use reduction, the strength of this association was moderate (r = 0.59, 95% CI [0.09, 1.09]). Psychological capability was measured in diverse ways, but for 'awareness' all measures significantly moderated water-use reduction (Table 2.4). Psychological capability measures such as 'feedback' (r = 0.86, 95% CI [0.36, 1.36]), 'information' (r = 0.78, 95% CI [0.40, 1.15]) and 'knowledge' (r = 0.71, 95% CI [0.23, 1.19]) strongly moderated water-use reduction whereas 'education' (r = 0.47, 95% CI [0.09, 0.84]), 'environmental concern' (r = 0.51, 95% CI [0.11, 0.91), 'perceived behavioural control' (r = 0.50, 95% CI [0.11, 0.89) and 'perceptions of water-efficient devices' (r = 0.47, 95% CI [0.05, 0.89) revealed a strong association with water-conservation behaviour.

The moderator analysis of the opportunity subtypes (i.e., physical and social) also showed a significantly weak association with water-use reduction. Physical opportunity was the only moderator that accounted for this significant association with water-use reduction (Table 2.3).

Table 2.3. Moderator analysis of effect sizes for the COM-B subtypes. Capability Q (1) =794.99, p < .001. Opportunity Q (1) = 930.61, p < .001. Motivation Q (1) = 620.80, p < 001, k = number of effect sizes.

COM-B dimension and subtype	*k*	*r*	95% CI		*z*	*p*
			Lower	Upper		
Capability						
Physical	10	0.08	-0.05	0.22	1.23	.220
Psychological	21	0.14	-0.03	0.30	1.65	<.001

Opportunity						
Physical	16	0.28	0.18	0.37	5.62	<.001
Social	16	-0.07	-0.21	0.07	-0.99	.320
Motivation						
Reflective	21	-0.15	-0.08	0.37	1.29	.197
Automatic	4	0.13	-0.08	0.33	1.23	<.001

Among the various 'physical opportunity' measures, only 'house ownership' revealed a mild association with activities that promote water-use reduction. Although the average correlation of social opportunity (r = -0.07, 95% CI [-0.21, 0.07]) shows a correlation that is weak and not statistically significant, 'trust' (r = 0.22, 95% CI [0.68, 1.01]) was the only significant social opportunity measure in driving water-use reduction in a weak but positive linear direction (Table 2. 4).

In terms of motivation, studies that focused on reflective and automatic subtypes also produced a significantly weak linear association with water-use reduction activities. Although 21 and 4 effect sizes were observed for reflective motivation and automatic motivation respectively, it was automatic motivation measures that revealed a statistically significant association with water-use reduction (r = 0.13, 95% CI [-0.08, 0.33]). The correlational link between automatic motivation and water-use reduction was, however, weak. It is worth noting that the interaction between measures of automatic motivation (and not the individual measures on their own) accounted for the reduction in water consumption. Attitude toward water conservation was the only statistically significant measure of reflective motivation (r = 0.25, 95% CI [0.14, 0.36]), this measure showed a weak positive association with water-use reduction (Table 2.4).

Table 2.4. Moderator analysis of effect sizes for the COM-B dimension predictor variables. Capability Q (2) = 312.60, p < .001. Opportunity Q (2) = 207.48, p < .001. Motivation Q (2) = 451.66, p < 001, k = number of effect sizes.

COM-B dimension and subtype	Predictor type	*k*	*r*	95% CI		*z*	*p*
				Lower	Upper		
Capability							
Physical	Age	1	-0.35	-0.69	-0.01	-2.03	.042
	Income	6	0.53	0.16	0.89	2.79	<.001
	Involvement	1	0.18	-0.30	0.67	0.74	.460
	Past actions	1	0.47	-0.02	0.95	1.89	.058
	Use of water-efficient devices	1	0.59	0.09	1.09	2.31	.021
Capability							
Psychological	Awareness	1	0.30	-0.18	0.79	1.23	.218
	Education	5	0.47	0.09	0.84	2.45	<.001
	Environmental concern	3	0.51	0.11	0.91	2.52	<.001
	Feedback	1	0.86	0.36	1.36	3.39	<.001
	Information	5	0.78	0.40	1.15	4.06	<.001
	Knowledge	1	0.71	0.23	1.19	2.91	<.001
	Perceived behavioural control	3	0.50	0.11	0.89	2.48	.013
	Perception of water-efficient devices	2	0.47	0.05	0.89	2.18	.029
Opportunity							
Physical	House ownership	1	0.51	0.01	1.01	1.99	.045
	Household size	6	0.04	-0.34	0.43	0.21	.835
	Household type	1	0.20	-0.29	0.70	0.79	.429
	Humidity	1	0.02	-0.50	0.55	0.08	.937
	Landscape choices	1	0.24	-0.26	0.74	0.94	.349
	Location	2	-0.20	-0.64	0.23	-0.93	.354
	Rebate	1	-0.22	-0.55	0.46	-0.86	.389
	Restriction	1	0.10	-0.41	0.61	0.38	.708
	Temperature	1	0.08	-0.45	0.60	0.28	.779
	Time	1	0.25	-0.57	0.43	-0.29	.774
Opportunity							

Social	Normative beliefs	2	0.23	-0.12	0.59	1.29	.194
	Descriptive norms	1	0.17	-0.42	0.76	0.55	.581
	Personal identity	1	-0.04	-0.55	0.46	-0.16	.871
	Social identity	1	-0.17	-0.68	0.33	-0.68	.500
	Social norms	10	-0.09	-0.38	0.36	-0.05	.959
	Trust	1	0.22	-0.22	0.68	1.01	<.001
Motivation							
Automatic	commitment	1	0.20	-0.25	0.64	0.87	.383
	Habits	3	-0.21	-0.45	0.04	-1.65	.098
Motivation	Attitudes toward water conservation	12	0.25	0.14	0.36	4.57	<.001
Reflective							
	Intentions	3	0.21	-0.01	0.87	1.32	.059
	Mindfulness	1	0.43	-0.01	0.87	1.88	.059
	Moral obligation	1	-0.11	-0.49	0.28	-0.54	.588
	Prompt	1	0.03	-0.39	0.45	0.13	.897
	Purchase decisions	1	-0.13	-0.52	0.26	-0.65	.517
	Values	2	-0.01	-0.30	0.28	-0.07	.944

2.3.4 Study location

For the majority of studies, study location did not significantly moderate the effect sizes (Table 2.5). However, Australia was the exception. We compared studies conducted in Australia with those in Bulgaria, Botswana, China, Mexico, Spain, Taiwan, UK, and USA. Group Q-tests revealed significant differences between studies in these countries for all the COM dimensions. Studies pertaining to Australia (e.g., $r_{capability}$ = 0.18, 95% CI [0.04, 0.32]) revealed a significantly weak linear association with effect size. However, Australia and Mexico made use of both the physical and social opportunity dimensions to achieve water-use reduction. Studies from Australia ($r_{opportunity}$ = 0.33, 95% CI [0.21, 0.46]) showed that opportunity measures and water-use reduction were weakly associated in the same direction, whereas in Mexico the association was inversely correlated ($r_{opportunity}$ = -0.30, 95% CI [-0.58, -0.02]).

Table 2.5. Moderator analysis of effect sizes for study location. Capability $Q(3) = 594.32$, $p < .001$, Opportunity $Q(3) = 420.23$, $p < .001$, Motivation $Q(3) = 502.29$, $p < 001$, k = number of effect sizes.

Study location	*k*	*r*	95% CI		*z*	*p*
			Lower	Upper		
Capability						
Australia	12	0.18	0.04	0.32	2.53	<.001
Bulgaria	2	-0.02	-0.38	0.34	-0.12	.905
China	3	-0.11	-0.42	0.19	-0.72	.472
Spain	1	-0.17	-0.66	0.32	-0.67	.502
Taiwan	1	0.02	-0.48	0.53	0.09	.925
UK	2	0.07	-0.29	0.43	0.36	.716
USA	10	0.04	-0.17	0.24	0.36	.718
Opportunity						
Australia	8	0.33	0.21	0.46	5.13	<.001
Botswana	1	-0.09	-0.45	0.28	-0.47	.641

China	2	-0.25	-0.52	0.02	-1.79	.073
Mexico	2	-0.30	-0.58	-0.02	-2.11	.035
Spain	1	-0.24	-0.60	0.12	-1.30	.192
Taiwan	1	-0.07	-0.45	0.32	-0.33	.739
UK	3	0.19	-0.06	0.44	1.48	.138
USA	14	-0.12	-0.28	0.03	-1.56	.118
Motivation						
Australia	12	0.22	0.10	0.34	3.67	<.001
Botswana	1	0.01	-0.42	0.44	0.05	.959
Bulgaria	1	0.37	-0.06	0.79	1.69	.090
China	1	-0.16	-0.59	0.26	-0.76	.450
Taiwan	1	0.02	-0.42	0.48	0.10	.924
UK	2	-0.10	-0.41	0.21	-0.62	.573
USA	7	0.10	-0.11	0.30	0.93	.352

2.3.5 Study design

Group *Q*-tests showed variance in results across study design subtypes (i.e., correlational, experimental and longitudinal) for all the COM-B dimensions (Table 2.6). Experimental and correlational approach studies weakly influence effect sizes in a positive direction whereas non-significant influence was observed for longitudinal approach studies. Correlation studies proved to have a significant but a weak influence on effect sizes. Studies involving correlational design was the only measure that significantly associated with study effect sizes in a positive linear direction for example, motivation ($r_{correlational}$ = 0.22, 95% CI [0.11, 0.33]), indicating that studies conducted using a correlational approach were related to an increase or decrease in household water-use.

Table 2.6. Moderator analysis of effect sizes for study design. Capability $Q(5) = 705.04$, $p < .001$. Opportunity $Q(5) = 940.35$, $p < .001$. Motivation $Q(5) = 641.92$, $p < 001$, k = number of effect Sizes.

Study design	*k*	*r*	95% CI		*z*	*p*
			Lower	Upper		
Capability						
Correlational	16	0.19	0.13	0.24	6.35	<.001
Experimental	4	0.16	0.13	0.58	2.47	<.001
Longitudinal	11	0.05	-0.05	0.16	1.06	.290
Opportunity						
Correlational	20	0.23	0.15	0.32	5.18	<.001
Experimental	5	0.02	-0.20	0.23	0.15	.879
Longitudinal	7	0.03	-0.15	0.20	0.32	.749
Motivation						
Correlational	14	0.22	0.11	0.33	3.98	<.001
Experimental	6	0.12	-0.09	0.34	1.12	.262
Longitudinal	5	0.01	-0.20	0.23	0.13	.898

2.3.6 Gender of participants

Most studies included in the meta-analysis did not report gender, thereby reducing effect sizes to $k = 36$. However, group *Q*-tests showed significant heterogeneity ($p < 0.001$) across gender for all the COM-B dimensions and the water-use behaviour subtypes (Table 2.7). Studies with more females had stronger water-behaviour measure effect sizes than those with more males. The capability of people to promote water-conservation behaviour was gender insensitive as weak linear association was observed for both sexes: male ($r_{male} = 0.23$, 95% CI [-0.20, 0.36]) and female ($r_{female} = 0.41$, 95% CI [0.04, 0.48]) respectively. For opportunity, male study participants ($r_{male} = -0.25$, 95% CI [-0.36, 0.32]) showed a significant but weak negative

influence on effect sizes whereas female participants (r_{female} = 0.25, 95% CI [0.14, 0.35]) revealed a positive influence. There was no difference between splitting studies by gender as both male and female participants showed that effect sizes for motivation measures were significantly associated with water-use reduction in a positive linear direction for male (r_{male} = 0.26, 95% CI [0.14, 0.39]) and female (r_{female} = 0.30, 95% CI [0.19, 0.42]) respectively.

Table 2.7. Moderator analysis of effect sizes for the gender of participants. Capability Q (6) = 835.41, p <.001. Opportunity Q (6) = 902.98, p < .001. Motivation Q (6) = 632.91, p < 001, k = number of effect sizes.

Gender	k	r	95% CI		z	p
			Lower	Upper		
Capability						
Male	8	0.23	-0.20	0.36	3.28	<.001
Female	8	0.41	0.04	0.48	3.06	<.001
Opportunity						
Male	14	-0.25	-0.36	0.32	4.64	<.001
Female	14	0.25	0.14	0.35	4.64	<.001
Motivation						
Male	13	0.26	0.14	0.39	4.11	<.001
Female	14	0.30	0.19	0.42	5.20	<.001

2.4 Discussion

The meta-analysis examined associations between scores on COM-B dimensions and household water-use reduction by incorporating the outcomes of studies that have both these psychological-social predictors of water-use reduction. Higher scores on the COM-B dimensions were associated with higher levels of perceived household water-use behaviour. Moderation analyses showed that correlation coefficients varied significantly as a function of COM-B dimension subtypes, study location, study design, and the gender of participants. Positive correlation between the COM-B dimensions and water-use behaviour shows that when an increase in opportunity dimension measures occurs (e.g., water-use restrictions), for example, households should expect a corresponding increased tendency for water-use reduction. Correlations were negative when the variables move in an inverse or opposite direction, for example, an increase in one variable results in a decrease in the other variable. Thus, negative correlation between the opportunity dimension measures (e.g., rebate) and water-use behaviour means when a rebate increases, a possibility of reducing water consumption is achievable as households will have greater incentives to buy water-efficient appliances. This correlational strength or direction applies to the individual measures (predictor variables) of the COM-B dimensions.

2.4.1 COM-B dimensions for understanding household water-use behaviour

Moderate effect sizes for all the COM-B dimensions suggest the results of this meta-analysis on water-use activities are consistent with the BCW model and that COM-B dimensions influence water-conservation behaviour. The results showed that psychological-social predictors (e.g., environmental concern, education, income, feedback, house ownership, perceived behavioural control, trust, information, positive attitudes toward conservation, etc.) had modest effects on relevant, defined water outcome measures (e.g., water-use reduction) which may include garden watering, showering times; metered household consumption; self-

reported water use, curtailment and efficiency behaviours. All three dimensions hypothesised by the BCW framework are set out to be significantly correlated with household water-use reduction in our meta-analysis. The BCW framework suggested that respondents who scored high on the COM-B dimensions were inclined to change behaviour. According to the BCW framework, behaviour is part of an interacting system relating to these behaviour conditions to provide targets for intervention (Michie et al., 2011). The effectiveness or strength of the correlational association between the COM-B dimensions and the household water-use reduction varied significantly as a function of the moderator variables of each COM-B dimension.

2.4.2 Impacts of moderator analyses for each COM-B dimension on water-use reduction

The effectiveness or direction of the correlational association between the COM-B dimensions and household water-use outcome measures varied significantly as a function of the moderators (e.g., feedback, information, environmental concern, and knowledge) of COM-B dimension subtypes, study location, and gender participants.

The moderator analyses revealed the capability dimension subtype of psychological capability had the strongest effects on household water-use reduction associated with feedback, information, environmental concern, and knowledge. This highlights households' logical reasoning and understanding to engage in the necessary mental processes that occurred sufficiently or partly attached to water-conservation activities. For example, understanding the impact of greenhouse emissions on the environment was more important than having the physical skills, strength or stamina to engage in water-use reduction activities (e.g., check and repair minor water leakages). The significant effect size for psychological capability may indicate that personal experience with water shortages can facilitate conservation activities. For example, having experienced a water crisis will equip households to with the ability and knowledge to adapt to water shortages. In semi-arid areas of China, for

example, educated farmers (i.e., having the psychological capability) were more likely to use rainwater harvesting and supplementary irrigation technology to alleviate water shortages (He et al., 2007).

Participants who scored higher on the capability dimension perceived vital information for strategic conservation activities by highlighting which activities require critical psychological skills to engage in conservation measures. This insight aids respondents to strive to improve upon their skills to reduce the risk of water shortages by ensuring that their selected skills are made based on the capabilities needed to be successful in conservation behaviours. Consistent with the findings of Russell and Fielding (2010), households with psychological knowledge may exhibit high awareness of water conservation intentions and install water-efficient appliances to reduce water consumption. Our findings support the proposition that water-conservation programs should relate to behaviour conditions to strengthen and promote extensive water-conservation practices within localities. For example, government water agencies working in areas prone to water scarcity may understand that water-conservation behaviours can differ in context, drivers, and barriers and provide proactive interventions that improve coping responses and increase resilience within their communities. This could involve providing the community with capability-focused strategies that focus on individuals' physical and psychological abilities to enact the desired behaviour (e.g., feedback, information related to water-efficient devices, and skills support).

The social opportunity dimension displayed an inverse correlation that was not statistically significant in our meta-analysis (Table 2.3). This is based on social opportunity measures in driving water-use reduction, where only trust had a significant effect. The significant correlation between trust and water-use reduction for households is consistent with the assertions of the BCW that households are committed to conserving water when interpersonal influences (social opportunity), such as, trust, social cues and cultural norms affect the way

they think about water resources. Richter (2014) argues that water-conservation practices should be encouraged through cultural beliefs and interpersonal trust. This provides an avenue for water authorities and governments to establish trust in delivering quality services to water users (Jorgensen et al., 2009). In addition, awareness campaigns and water-conservation programs should be tailored to the beliefs of the community. Tailoring awareness campaigns and water-conservation programs to beliefs of the community have turned out to be striking, constructive, and cost effective in various spheres of water crises (Gilli, 2004).

Motivation subtypes observed higher intentions and emotional reactions with water-use reduction than those who obtained lower scores on motivation subtypes. This result supports a more general conclusion from this meta-analysis; that motivation tends to be moderately related to water-conservation behaviour. The significant correlation between automatic motivation measures (e.g., habits) and water-use reduction may imply an individual's ethical drive to reduce consumption. Automatic habits or routines (Steg and Vlek, 2009) are behavioural tendencies practised generating a belief among householders that water crises create a possible hazard to society by increasing socio-economic uncertainty, poor productivity, health issues, and social injustice (Richter, 2014; Butler and Memon, 2006). This association is partly due to the relationship between an individual's high voluntary water-conservation habits and perceived future water crises that may make households susceptible to more bouts of water shortages. In contrast, many repercussions of water crises, such as warfare, sanitation issues, hunger, reduced economic activities, and poverty are more noticeable, and that need to discourage the occurrence of water shortages. Therefore, motivated householders may habitually respond to water-conservation practices because they can voluntarily conserve water without complying with any restrictions and rely on the available information related to water crises and conservation behaviour.

The results of the moderator analyses for study location show that most of the studies assessing the associations between COM-B dimensions and water-use behaviour have been conducted in Australia, UK, and the USA. Australian studies, on average, produce larger effect sizes. These results suggest that the more susceptible a country is to a water crisis, the larger the effect size, which in turn encourage and strengthen efforts to sustain water resources. Most of the studies included in our meta-analysis were conducted in Australia, reflecting the water issues that are prevalent in this arid country (Australian Bureau of Statistics, 2014). The Australian government and water industries are gradually improving in the implementation and enforcement of water-demand management strategies and environmental policy such as water metering, water restrictions, pricing structure and retrofitting to make household water-behaviour possible or to prompt it. These factors proved to be less reliable and presented smaller and weaker assenting strength in non-Australian cases. Thus, it is not unexpected that the COM-B dimensions employed in this study generated significantly greater correlation coefficients in the Australian context.

Moderate effect sizes were found in capability, opportunity and motivation, indicating the gender of participants is, in general, highly associated with water-use reduction. For opportunity, both men and women associated with water-use reduction but in opposite directions. Women habitually conserve water and have a strong concern with the efficiency and sustainability of water interventions and the management of water resources. Studies on gender differences in pro-environmental behaviour validate that women intuitively report engaging in more pro-environmental behaviours than their male counterparts (Lam and Cheng, 2002; Zelezny et al., 2000). Women show greater positive attitudes towards water conservation. They value conservation practices, express interest in collaborating with water authorities, and rely on information about conservation more than men (Druschke and Secchi, 2014); hence, all their household activities channel to water reduction.

2.4.3 COM-B dimensions: implications for household water-use

The accuracy of using the COM-B dimensions as sources of behaviour change is important if they are used as the principal variables in intervention development. It is most appropriately perceived as a novel behaviour-change model providing interventions whose effects are more answerable, transparent, mediated and moderated by other behavioural factors. This suggests that the COM-B dimensions, when linking with the targeted household water-conservation behaviours, can provide specific conservation intervention strategies of which individuals will be able to recognise to adopt and promote worthwhile household water-conservation practices. The BCW framework assumes that behavioural change is determined by three factors: capability (determined by physical and psychological skills), opportunity (characterised by physical and social factors), and motivation (perceived by reflective and automatic reactions) towards the behaviour for predicting behaviour change. The COM-B dimensions provide excellent and precise predictions of household water behavioural feedbacks within an applied frame of reference. It shows whether individual households will be capable of being actively involved in water conservation in the face of climate variations such as drought. Water conservation practitioners and householders can apply these findings to modify outreach applications that will further enhance the community's water-conservation programs.

2.4.4 Research limitations

There were various constraints associated with the interpretation of the results of this meta-analysis. Distinct categories covered in the moderator analyses comprised comparatively small effect sizes. Most significantly, average effect sizes from studies that were conducted in Botswana, Bulgaria, Taiwan, UK, and USA should be treated with caution. One possible explanation for this was that insufficient information was available for the moderation analyses and the sample sizes were not large enough because not every study generated the

data necessary for moderation analyses. Additionally, the rigid inclusion criteria to establish precision of the analyses and significance of the outcomes, suggested that some valuable information (e.g., data in conference proceedings, seminal and unpublished studies) was inappropriate for inclusion in the analysis. In a similar vein, the current investigation focused on household water use as opposed to other water users, for example, in agricultural, industrial, and other sectors. Although many of the studies deliberated about these water uses, measures that were provided in the literature were limited to household water use. Given the high inverse associations between diverse predictor types and conservation approaches, it gives the impression that multiple conservation behaviours may not concurrently influence households' consumption behaviour, the expression of which may be environment-specific. If this is accurate, it may be practical to conduct empirical studies based on different predictors and water-use behaviours. Scientists may benefit from investigating the divergent practices in which water-use behaviours are related.

Our research has raised questions in need of further investigation. First, future research might strive to classify the location contexts under which COM-B dimensions have the strongest and least effectiveness, which would suggest to researchers when these sources of behaviour may be most reliable and applicable. Our investigation revealed the need for rigorous studies in multiple settings to determine the extent to which COM-B dimensions could be applied in well-defined pro-environmental behaviours in all sectors. Studies have found evidence that daily environmental actions change gradually over time, but the effect of pro-environmental behaviours in conserving resources demands activities be considered to accelerate conservation measures (Dascher et al., 2014; Goldsmith and Goldsmith, 2011; Wahlen, 2011). Finally, using mixed method approaches may help identify the most appropriate sources of behaviour worthwhile for promoting specific conservation strategies among all users. Anticipating this research, policy-makers, practitioners, and water authorities should

note that there are many influences on water-conservation behaviour and a ‘homogenous’ approach to promoting water conservation may be less successful.

2.5 Conclusions

The results of our meta-analysis on water-use behaviours suggest that household water-use behaviour is associated with three necessary conditions: capability, opportunity, and motivation. As hypothesised by the BCW framework, we found that households may adopt water conserving behaviours when they have a higher perception of being capable and when having all the necessary opportunities at their disposal, and when motivated to conserve water. Moderator analyses showed that correlation coefficients differed significantly because of COM-B dimension subtypes, study location, study design, and gender of participants. The results of our study are generally aligned with the BCW framework’s assertion that the integrative components of behaviour can be important sources of psychological-social predictors of household water-use reduction. These highlight the importance of viewing the COM-B dimensions as hypothetical sources of psychological-social predictors differently such that water utilities, practitioners, governments and stakeholders might consider adopting these sources of behaviour to promote water-conservation behaviours. However, while the COM-B dimensions are useful, the specific results may diverge considerably based on the water-use characteristics of the region and the environment.

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Chapter 3

BARRIERS AND DRIVERS OF HOUSEHOLD WATER CONSERVATION BEHAVIOUR: A PROFILING APPROACH

Source: https://www.moneycontrol.com/news/technology/auto/piaggio-lines-up-new-investments-to-launch-electric-three-wheeler-before-2020-2798371.html

Abstract

Factors that influence behavioural response (barriers and drivers) are important for household water-conservation practices. These factors can either support or inhibit sustainable behaviour. In this research, a latent profile analysis (LPA) was used within the capability-, opportunity-, and motivation-behaviour (COM-B) framework to identify key barriers and drivers of household water-conservation behaviours. Participants (N = 510, mean age = 56.08 years, SD = 14.71) completed measures of psycho-social constructs related to barriers and drivers of water-conservation behaviour. A latent profile analysis yielded a 3-profile solution: capability (35.8%), opportunity (23.2%), and motivation (41.0%) conceptualising levels of barriers and drivers of water-conservation behaviour. Major identified barriers and drivers associated with these profile groupings were time constraints, acuity of water-efficient devices, lack of skills to adopt conservation practices, and availability of incentives/disincentives for water-saving devices. Validation analyses showed that the three COM-B groups diverged considerably based on socio-demographic status and actual water-conservation behaviour. Results are pertinent to water authorities in identifying interventions to reduce barriers and promote drivers of positive household water-conservation behaviours by altering and directing appropriate COM-B dimensions to individual water consumers.

3.1 Introduction

Behaviours that may influence water conservation can be constrained by barriers or facilitated by drivers (McKenzie-Mohr, 2011; Steg and Vlek, 2009; Stern, 2000). The literature on barriers and facilitators to water conservation is spare, but many studies have investigated barriers and facilitators to behaviour change when considering environmental behaviour more generally. Barriers to water-conservation behaviour prevent people from conserving water regardless of their attitudes or intentions (Kollmuss and Agyeman, 2002; Lane et al., 2007). Constraints undermine the enthusiasm or readiness of people to engage in water-conservation behaviours and these include distrust, time constraints, poverty, and scarcity of suitable information (Stokes et al., 2012). In contrast, drivers are factors that promote a desired activity such as reduced water-use or use of recycled water (Graymore et al. 2010; Corral-Verdugo and Frias-Armenta, 2006). Factors that facilitate pro-environmental behaviours include climate/seasonal variability, incentives, regulations and ordinances, environmental values and socio-economic factors (Berk et al., 1980; Fernandino et al., 2003). Water conservation activities are more likely to occur when individuals believe that water is scarce and when they perceive that other consumers are likewise conserving water (cf. Corral-Verdugo et al., 2002).

Barriers and drivers of water-conservation behaviour are influenced by many factors, including psychological factors such as values, beliefs, trust, affective (emotional) reactions and attitudes (Corral-Verdugo et al., 2002; Smith et al., 2018), socio-economic factors such as income, water pricing and policies, environmental factors such as seasonal variations and demographic factors such as age and household size (Berk et al., 1980). Moreover, water-conservation is influenced by the management of local water resources and household attitudes and behaviour-change challenges (Hoque, 2014). Water-price mechanisms (e.g., estimated under-pricing of water), ageing infrastructure and poor institutional and financial

capacity are also factors influencing water-conservation behaviour. Concerns about the installation and functionality of water-efficient devices and the inconvenience resulting from practising water-saving behaviour are major problems for everyday water-conservation behaviour (Fielding et al., 2010). Lack of free water-audits and personalised advice, rebates and help in purchasing and retrofitting existing appliances has prevented many people conserving diminishing water resources (Hoque, 2014). Water-conservation behaviour may be improved if behaviour conditions are profiled to identify barriers and drivers of water-conservation activities.

Profiling in behavioural studies attempts to understand a person or group based on personal characteristics or behaviour (Dwyer, 2009). Profiling comprises transforming data into knowledge (Hildebrandt, 2006). Profiles are useful for many corporations in customising their services to suit their customers and to increase revenues. Customising results from profiling are likewise helpful to the users to get information relevant to their interest (Castelluccia, 2012). The obvious intent of behavioural profiling is to trail users over time and build knowledge of their interests, characteristics, behaviours and activities. Although behavioural studies (e.g., Corral-Verdugo et al., 2003; Syme et al., 2004) have considered the relationship between psycho-social factors (barriers and drivers) and household water-use behaviour, a few of these have used a profiling approach to understand the barriers and drivers of household water-conservation in relation to behaviour change theory - the BCW model and COM-B framework.

The BCW model (Michie et al., 2011) is based on behaviour change theory and involves three interactive but distinct domains of behavioural conditions: capability, opportunity and motivation-behaviour (COM-B dimensions). Capability is defined as acquiring psychological and physical ability/self-efficacy to work out specific behaviours or actions, including having suitable insight, knowledge and skills (Michie et al., 2011). Opportunity explains external

factors to the individual that make the behaviour conceivable or prompt it, such as a social surrounding or physical environment that permits or prohibits a behaviour. Motivation describes the cognitive processes that vitalise and guide behaviour, such as habitual responses, emotional responses, and rational decision-making. These cognitive processes involve reflective motivation, such as making-good intentions or doing appraisals, and automatic motivation, involving emotional and impulse responses. Pro-environmental behaviour such as water conservation can be sustained when intervention activity targets one or more conditions within this behaviour system (Michie et al., 2011).

Applying the COM-B framework with profiling and water-conservation behaviour can highlight specific intervention strategies. Profiling is a potential solution because it groups and classifies several barriers and drivers of water-conservation behaviours into specific behaviour conditions (COM-B dimensions). This relates behaviour conditions to the relevant intervention strategies of interest to target more effective measures and solutions that promote sustainable water-conservation behaviour. The COM-B provides distinct behavioural conditions with relevant intervention strategies and linking with profiling may show how a group of people respond to their environment within a specific domain of water-conservation behaviour. The matter and focus of that intervention helps with the individual's behavioural change, choice of conservation measures and best fit within the environment. Providing a profile acts as a compass to determine how best to understand water-conservation behaviours (environmental conditions) that constrain a particular behaviour of interest (Bartholomew et al., 2011). The benefits ensuing from this approach may include raising the interest of an individual's sustainability initiatives, providing solutions to sustainability problems, building trust among household water users and providing meaningful opportunities for water-conservation actions. Although these psycho-social benefits influence the way people act environmentally, there are barriers and drivers to water-conservation behaviours.

This study seeks to adopt a profiling approach to understand barriers and drivers influencing sustainable household water-conservation behaviour based on the BCW model and the COM-B framework. Individual behavioural conditions – COM-B dimensions – have been found to influence sustainable behaviour (Moore et al., 2014). The aim of this study is to classify barriers to and drivers of household water conservation using a profiling approach and link these barriers and drivers to appropriate behaviour conditions for effective water-conservation intervention strategies based on the COM-B dimensions.

3.2 Materials and methods

3.2.1 Recruitment processes

Study participants were recruited through a social research panel (Qualtrics^{TM}) in March and April 2017 and asked to undertake an online survey. Participants received a reward commensurate with the time commitment involved in completing the survey. Participants had to be at least 18 years of age, have responsibility for paying utility bills (including bills for their household's water-use), have access to a garden as part of their property, and reside in New South Wales (NSW), Australia. The research was approved by the University of New England Human Research Ethics Committee.

3.2.2 Study participants and characteristics

The sample comprised 510 NSW residents. Participants were aged from 18 to 84 years (mean age = 56.08, *SD* = 14.71), with equal numbers of males and females. Most participants (35%) had completed technical/vocational/TAFE education, 28% had completed high school, 19% had achieved a bachelor's degree and 18% completed a higher degree. Sixty-eight percent described their residential situations as either solely or jointly owned property, 28% reported residence in a rented property, and 4% indicated that they resided in a property owned or rented by family or friends. In terms of access to a garden as part of their property, 91%

declared access to a garden. Regarding responsibility for paying utility bills, 60% of the sample was solely responsible, and 40% shared the responsibility with other household members.

3.2.3 Measures of water-conservation behaviour

Two surveys were administered to participants (Figure 3.1). The first measured attitudes, barriers and drivers of water conservation, and the second measured actual water-conservation behaviour. For the first survey, participants indicated agreement with five items about physical capability (skill, strength, stamina) for conserving water (Appendix A). The physical capability scale had good internal consistency (Chronbach's alpha = 0.75). Ten items (Appendix A) assessed psychological capability to engage in water-conservation activities (Chronbach's alpha = 0.89). Physical opportunity to influence water conservation was shown by levels of agreement with 12 items (Appendix A). The scale exhibited good internal consistency (Chronbach's alpha = 0.73). Six items assessed respondents' social opportunity afforded by interpersonal influences, social cues, and cultural norms that influence water conservation (Appendix A). The social opportunity scale had adequate internal consistency (Chronbach's alpha = 0.65). Six items assessed respondents' reflective motivation which involves intentions and evaluations (beliefs about what is good or bad) (Appendix A). The scale displayed good internal consistency (Chronbach's alpha = 0.86). The automatic motivation items assessed respondents' emotional reactions towards water conservation. Respondents showed their emotional reactions, desires (wants/needs), inhibitions, and reflex responses to 12 water-conservation measures. Automatic motivation toward water conservation had good internal consistency (Chronbach's alpha = 0.72). All responses were answered using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

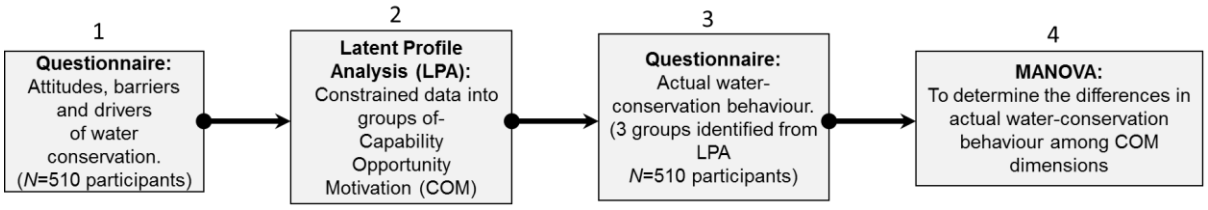

Figure 3.1. Flow diagram of data collection and processes

3.2.4 Analysis

A latent profile analysis (Lanza et al., 2003) was conducted in the Mplus software package (Muthén and Muthén, 2004) to extract profile groups based on households' attitudes, barriers and drivers of water-conservation (Figure 3.1). Three goodness-of-fit indices were used to determine the optimal number of classes for the profile: Bayesian information criterion (BIC) (Schwarz, 1978; Sclove, 1987); the Akaike information criterion (AIC) (Akaike, 1987); and the Lo-Mendel-Rubin likelihood ratio test (LMRT) (Lo, Mendell, & Rubin, 2001). The best fitting model is when a dataset shows the smallest BIC and AIC values generated between competing models. A significant p-value for LMRT measures the fit of a target model to a comparison model. The p-value produced for the LMRT shows whether the solution with more groups or fewer groups fits better. To buttress model assessment, entropy was also used as an index of model performance, with acceptable values close to one deemed perfect (Ostrander et al., 2008).

3.2.5 Evaluating actual water-conservation behaviour

The second questionnaire assessed actual water-conservation behaviour (Appendix B). Respondents indicated whether they were presently taking action to reduce their water consumption in 15 ways (e.g., using front-loading washing machine, using dual-flush toilet). A score of 1 indicated installation of water-efficient appliances and a score of 0 indicated no water-efficient appliances. The reliability estimates for water-efficient devices had good internal consistency (Chronbach's alpha = 0.85). Seven items assessed respondents'

perceptions about water-efficient appliances (Appendix B) in conserving water (e.g., "Water-efficient appliances are a promising idea", "I would consider purchasing a water-efficient appliance."). All responses were answered using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale displayed adequate internal consistency for this measure (Chronbach's alpha = 0.96). Nineteen items assessed respondents' indoor behaviours aimed at reducing water consumption. Respondents indicated how often they engaged in a range of indoor behaviours associated with reduced water consumption (e.g., "I connect a rain tank to bathroom", "I make sure that taps do not drip", and "I fix leaks when they occur"). The scale showed good internal consistency (Chronbach's alpha = 0.76). Twenty items were used to assess outdoor water-conservation practices. Respondents showed whether they engaged in a range of outdoor behaviours associated with water conservation (e.g., "I allow my lawn to go brown if there is insufficient rain", "I strictly adhere to water restrictions", and "I connect a rain tank to the garden"). All responses were answered using a five-point Likert scale ranging from 1 (never) to 5 (always). The internal reliability was good (Chronbach's alpha = 0.85). A single item assessed how respondents compared the rate of current water shortages with the situation in the next five years in their locality. All responses were answered using a four-point Likert scale ranging from 1 (less severe) to 4 (more severe). Thus, higher scores indicated higher expectancy of future water shortages.

To validate the significant differences in actual water conservation among profile groups, we examined access to a garden, indoor and outdoor water behaviours, ownership of water-efficient devices and perceptions and future expectancy of water crises between memberships in the profile groups. Multivariate analysis of variance (MANOVA) in the statistical package SPSS version 24 was used to test the differences in dependent variables (demographic, actual behaviour scores) among the profile groups.

3.3 Results

3.3.1 Derivation of profile groups

The 2- and 4-profile solutions produced the least BIC and AIC values, a significant LMRT value ($p < 0.001$), and acceptable entropy values demonstrating that a 4-profile solution provided a better fit for the data than a two-profile solution (Table 3.1).

Table 3.1. Model fit indices for the 2- through 4-profile solutions. The best fitting solution indicates lower BIC and AIC values and a significant LMRT value. All entropy values showed an ideal fit. ***$p < 0.001$

No. of profiles	BIC	AIC	LMRT	Entropy
2	2768	2528	-1228.34***	0.79
3	3692	5469	-1243.17	0.77
4	2350	2050	-1130.98***	0.81

The LMRT showed that the 2-profile solution offered a significant improvement in fit over the 3-profile solution. The 2- and 4-profile solutions both produced similar BIC and AIC values, significant LMRT values, and acceptable entropy values. Coupled with a significant LMRT and greater weight on the entropy value, the 4-profile solution presented better profile uniformity and the best-fitting model for the data. The 4-profile solution was therefore the most interpretable profile solution. The profiles show unique characteristics which each indicate distinct attitudes, barriers and drivers of behaviour conditions for household water-conservation behaviour (Figure 3.2).

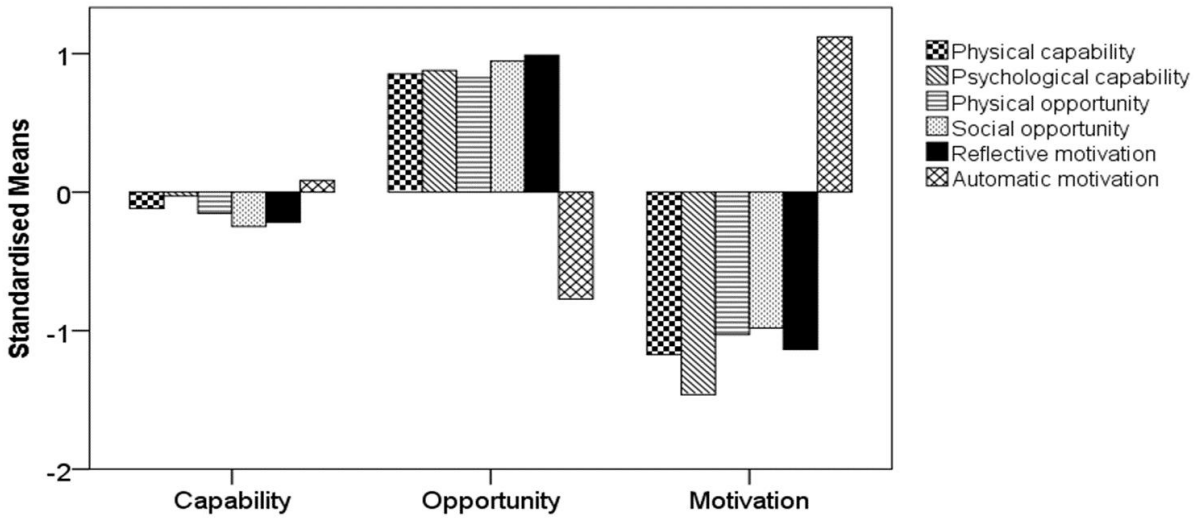

Figure 3.2. Profile characteristics explaining the 3 profile groups by their attitudes, barriers and drivers of water-conservation behaviour (N = 510). Sample average = 0.

3.3.2 Profile groups and their characteristics

The 2- through 4-profile solutions that emerged corresponded with the COM-B dimensions (Figure 3.2). The profiles showed a unique behaviour condition for household water-conservation behaviour. Profile 1 comprised 35.8% of respondents (n = 189) who were labelled as being capable (capability) about water-conservation behaviour (Figure 3.2). On average, the capability group reported moderate social opportunity barriers to water-conservation behaviour, very low levels of physical and psychological capabilities, and low levels of reflective motivation regarding water conservation and considered its impacts to be significant. Except for automatic motivation toward water-conservation behaviour (which was the most positive across the profiles), mean scores on all psycho-social mechanisms were below the sample average.

Profile 2 comprised 23.2% of the total sample (n = 119) and was labelled opportunity. This profile was characterised by mean scores on all psycho-social mechanisms that were above the sample average. Opportunity respondents tended to report high reflective motivation

barriers to water-conservation behaviour and the social and psychological effects, and strong physical capability regarding water conservation. They exhibited moderately high levels of physical opportunity toward water conservation. Their mean scores were much higher than the average sample mean, however, automatic motivation toward water conservation was moderately lower in this profile group.

The third profile comprised 41.0% of the sample (n = 202) and was labelled as the motivation group. This group was similar in many respects to the capability group. Mean scores on most of the profiling variables were below the sample average. The capability group was characterised by positive moderate automatic motivation to water conservation, whereas motivation respondents tended to report high levels of automatic motivation that were just above the sample mean. This suggests a possible high lack of commitment, disincentives and negative water-conservation attitudes toward water-conservation practices. This profile also reported the lowest levels of psychological capability and reflective motivation to water-conservation behaviour.

3.3.3 Profile differences in actual water-conservation behaviour among the COM-B dimensions

Each of the profile groups differed in their social demographic variables and actual water-conservation behaviours (Table 3.2). The effect for profile differences accounted for 32% of the profile differences and their related error variance. On average, members of the capability group were significantly older and more educated than those in the opportunity and motivation groups, however, all the groups showed greater desire and interest in water conservation when they have access to a relevant conservation information. Additionally, capability group members reported less residential status than opportunity and motivation group members. The MANOVA revealed that the overall respondents in the capability group showed more actual water-conservation behaviour (Table 3.2). The capability group reported

installing and having ownership of water-efficient devices, and stronger tendency to reduce water consumption and support water-conservation policies than respondents from the other two profiles. Additionally, opportunity and motivation respondents had positive perceptions about water-efficient devices and reported greater concern for future expectancy of water crises. They were of the view that supporting water-conservation actions is their priority if they were given the necessary opportunities and also motivated to act. Although the outcome variables were significantly different across the three different profiles (Table 3.2), each outcome variable accounted for less than 5% of the profile differences and their associated variance.

Table 3.2. Key demographic and outcome variables: means, standard deviation, and group differences

Outcome variables	Profile 1: Capability (n = 189)		Profile 2: Opportunity (n = 119)		Profile 3: Motivation (n = 202)		Group differences	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	Partial η^2
Mean age (years)	57.08[a]	1.97	54.22[a]	1.89	53.87[a]	1.68	31.43**	0.04
Education level	3.48[a]	0.17	3.79[b]	0.18	3.45[b]	0.16	8.69***	0.01
Residential status	1.29[a]	0·06	1.43[b]	0.08	1.41[b]	0.07	5.78**	0.02
Access to a garden	1.13[a]	0.03	1.16[a]	0.04	1.14[a]	0.03	7.43***	0.01
Indoor behaviour	4.46[a]	0.14	4.21[a]	0.16	4.29[a]	0.15	6.89*	0.01
Outdoor behaviour	4.39[a]	0.09	4.16[a]	0.10	4.25[c]	0.09	4.56***	0.03
Ownership of water-efficient devices	1.83[a]	0.06	1.76[b]	0.04	1.85[a]	0.05	3.21*	0.02
Perceptions of water-efficient devices	3.58[a]	0.07	3.60[b]	0.09	3.89[a]	0.10	2.34**	0.01
Future expectancy of water crises	2.28[a]	0.09	2.32[a]	0.11	2.39[c]	0.12	4.22***	0.01

Notes: N = 510. Wilks' lambda (Λ) = .06, F (13, 507) = 10.98, $p < .001$, $\eta^2 = .32$. Means with different superscripts (in rows) vary significantly at $p < .05$. Possible score ranges: education level, residential status, indoor behaviour, outdoor behaviour, ownership, perceptions, future expectancy variables from 1 to 5; access to a garden from 1 to 2. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $\eta^{2\,=}$ Partial Eta squared.

3.4 Discussion

Three behavioural conditions influencing water-conservation behaviour were identified in this study. Those with the motivation profile had several sets of barriers involved in water-conservation behaviour. These were physical and psychological capabilities, reflective motivation, social and physical opportunities. Expressions such as indifference/laissez-faire attitudes toward water conservation, disincentives, lack of environmental values, discomfort in using water-efficient devices, and absent-mindedness emerged as perceived barriers to water conservation behaviour from the viewpoint of participants in the motivation group. For example, most members from this group showed low intentions (i.e., motivation/plan) to engage in conservation behaviour and articulated that social support (rebates, incentives) was difficult to get from important bodies, such as government water agencies, in their efforts to take part in conservation behaviour. As a result, this affected their intention to undertake conservation actions because most of the water-efficient devices are costly and they lacked money (i.e., opportunity barrier) to buy these appliances. This result is similar to the study of Stokes et al. (2012) who established that attitudinal barriers inhibit behavioural changes. Moreover, intrinsic or extrinsic motivational factors such as incentives and rebate programs influence behaviour (Herzberg et al., 2011). Motivated households may promote water-conservation actions and decrease water consumption despite environmental stressors such as climate change and population growth. These households report being more susceptible to water-conservation behaviours. Herzberg et al. (2011) suggested that basic needs, such as emotional needs and fringe benefits motivate individuals for greater change of behaviour (e.g., output of work). A household with motivation profile may be ready to conserve more

water if they believe they will receive a desired reward for reaching an achievable target of water conservation.

The capability group had barriers associated with understanding conservation behaviours and actual water-conservation actions. Most barriers identified in this group related to personal capabilities such as lack of knowledge and education about the need for water conservation, inadequate conservation information, paucity of theory-based research-driven programs and evaluation, and poor feedback on water consumption (i.e., psychological capability barriers) (Figure 3.2). It also included perceived lack of skills to participate in conservation activities (i.e., physical capability barriers). Moderate levels of barriers were displayed for social opportunity (socio-demographic variables, obsolete values, beliefs and customs) in the capability group. Participants reported that insufficient information and a shortage of theory-based research-driven programs and evaluation, and inoperative campaigns, weakened their knowledge of water conservation resulting in an elusive behavioural change. Poor feedback and lack of clarity regarding conservation programs inhibit conservation actions. Personal inclinations such as discomfort in using water-efficient devices (reflective motivation barriers) negate attitudes toward water-conservation practices.

A considerable number of households showed they would take part in water conservation actions if they had relevant information about water-conversation strategies and the environmental and socio-economic effects of their actions. Household members who attain a higher education level and income may have stronger appreciation of the call for water conservation and higher readiness to install water-efficient devices that can cut household water consumption (Russell and Fielding, 2010). In addition, the capability group faced, inflexibility of water infrastructure and lack of resources for initiatives (i.e., physical opportunity barriers) as perceived impediments to water-conservation behaviour. Households with a capability profile agreed that lack of community support, scarcity of funds, and paucity

of resources or time to start conservation activities influenced their conservation capabilities. Jackson (2005) claimed community-based initiatives appear to have a significant role in influencing sustainable behavioural change. Thus, it is plausible that the perceived lack of support, trust, funds, and resources (physical and social opportunity barriers) from government water agencies to start conservation activities can negate the likelihood of individuals with this profile in taking part in water-conservation actions.

Members of the opportunity group were identified with barriers in relation to demand-side strategies for water conservation. This group were agitated about water policies such as pricing schemes, excessive cost of water-efficient devices, and housing status. The opportunity group reported a high mean score on psycho-social barriers which include time constraints, prohibitive cost of water-efficient devices, and lack of funds for monetary support and rebates. Household members showed high discomfort with paucity of rebates and monetary support for water users. They revealed that failure to offer rebates and monetary support discourage the act of replacing outmoded fixtures which then slow retrofitting programs and repel sustainable water-conservation behaviour. On the contrary, the opportunity group showed lower levels of automatic motivation (e.g., sense of personal obligations/voluntary action), in conserving water because group members reported being influenced by demand-side strategies which restrict their behavioural change tendencies. Prohibitive costs of water-efficient devices (i.e., physical opportunity barriers) restrict low-income household members from purchasing and installing water-efficient appliances. Thus, the use of water-efficient devices among this group may not be possible. However, combinations of increased rebate programs and public education on the performance of water-efficient devices could increase the effectiveness of conservation intentions (reflective motivation). Subsidy programmes for household water-saving devices could encourage the installation of these devices in the household to reduce water consumption (Nauges, 2014; Steg and Vlek, 2009). This will encourage households to build physical infrastructure and

mechanical facilities needed in the household to reduce water consumption and invest in quality water-efficient products.

Other prevalent and predictive barriers for the opportunity group included psychological capability barriers. This includes little to no knowledge of water-conservation techniques, lack of environmental concern and inadequate conservation information. This is consistent with the study of Trumbo and O'Keefe (2005), where information about water shortages and behaviour actions was shown to be a significant intervening variable between households' attitudes towards conservation and behavioural intentions. Individuals receptive to information are knowledgeable, and knowledge about drought conditions and water scarcity has a significant effect on intentions to conserve water (Dziegielewski, 1991). For example, people who understand the environmental and socio-economic benefits of water conservation are more likely to practise water- conservation behaviour (Cameron and Wright, 1990; Middlestadt et al., 2001; Dolnicar et al., 2012). Households with relevant conservation information are likely to exhibit higher conservation intentions (Gilg and Barr 2006). In contrast, information deficiency makes interventions rarely evaluated or findings disseminated (Lehmann and Geller, 2004; Revell, 2012). Resistance to implementation may be linked to a lack of information and skills or an indifference towards water-conservation activities (Grol and Grimshaw, 1999). To overcome the barriers described above, intervention activities need to persuade households to become involved in conservation activities by receiving adequate information. One example of such an intervention is awareness creation through an effective community-based conservation campaign that sets out practical ways to conserve water that eliminate or work around the barriers to conserving water resources.

Barriers in the opportunity group are also related to social opportunity. This includes distrust (inter-personal and institutional distrusts) and demographics. Household water-conservation activities incorporate the influence of distrust, peer influences, and utilitarian water beliefs on

conservation behaviour. In this study, households in the opportunity profile believed water as a natural resource is infinite, should not be restricted and that they should be allowed to use water as much as they want. People who considered water as a renewable resource or unlimited exhibited less water conservation behaviour and had lower intentions to install water-efficient appliances (Corral-Verdugo et al., 2003; Lam, 1999). Thus, households should be encouraged to believe in their vulnerability to drought and in the benefits of water conservation for the environment. Furthermore, it was reported that personal and institutional distrust obstructs conservation behaviour. Households perceived that management and social networks responsible for water services were reluctant to support conservation initiatives. Individuals are more likely to endorse an intervention if key personalities and individuals in their social networks will support the actions (Greenhalgh et al., 2004). Intervention activities involving committed staff members, individuals who serve as role models or guides, testing, encouraging, carrying out, and promoting conservation activities must be the champions for conservation programs.

3.4.1 Effects of socio-demographic variables associated with profile solutions

The highest mean age of participants was associated with the capability group. In the capability group age was a barrier to water-conservation behaviour (i.e., physical capability barriers) and these respondents were also less likely to undertake water-conservation activities. Socio-demographic characteristics such as age and gender influence conservation intentions and water-consumption styles. Differentials in age, for example, older household members (retirees) are high water consumers, teenagers in a household increase water consumption, and full-time working adults reduce water usage (Lam, 2006; Kantola et al., 1982; Lyman, 1992; Mayer et al., 2004). In contrast, older people stay at home more regularly than when they were working full time and are high water users (Makki et al., 2013). Although older household occupants are expected to be water conservers (Clark and

Finley, 2007), Lam (2006) claimed there is no significant relation between age and water conservation intentions. Age underscores intricacies in the relation between age and water-conservation behaviour should be context-specific as a function of the demands related with specific life stages (Russell and Fielding, 2010).

3.5 Conclusions

Identifying barriers and drivers of water-conservation activities remain one of the most important aspects of safeguarding sustainable local water resources. Profiling the barriers and drivers of water-conservation behaviour can make an important contribution to understanding and constructing successful water conservation strategies. The profiling approach, as used in this study, expressed different barriers and drivers of water-conservation into relevant behaviour conditions. The profiling approach advances the understanding of these barriers and drivers of water-conservation behaviour in relation to the COM-B conditions. The findings suggest that these barriers and drivers can be linked to the relevant intervention activities based on the COM-B framework. Government water agencies and stakeholders could use profiling to uncover possible implementation strategies that will abate and break down local conservation barriers and intensify drivers of water- conservation behaviour to inform policy-making decisions.

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Chapter 4

REDUCING HOUSEHOLD WATER-USE: THE INFLUENCE OF WATER-CONSERVATION MESSAGES ON INTENTIONS TO ACT

Source: https://pngtree.com/freebackground/water-conservation-shock-poster-background_315605.html.

Abstract

As water crises become severe, the desire to explore alternative strategies to prevailing demand-side water-conservation approaches increase. Changing behaviour through persuasion (message framing) may be an integral part of the mix of solutions. In this study we examined the effectiveness of messages related to household water-use on water scarcity concern and intentions to act and tested whether this relationship was mediated via increasing capability, opportunity, and motivation-behaviour (COM-B dimensions). We applied two message types related to concern about severe water scarcity and conservation strategies to the behaviour change conditions in two combinations: (1) severe water scarcity and water-saving tips/strategies, and (2) severe water scarcity and no water-saving tips/strategies. There was broad support for the hypothesis that COM-B dimensions would mediate the effect of message type on water scarcity concern and intentions to act in conservation activities. Households that received the message framed in terms of water-saving tips/strategies expressed greater water scarcity concern and higher intention to act than those that received the no water-saving tips/strategies message. Mediation analyses showed that the message framed in terms of specific water-saving tips/strategies was mediated by increasing households' capacity (self-efficacy), opportunity and/or motivation in water-conservation actions. Thus, specific water-conservation strategies made available to households have a stronger impact on water-conservation behaviour because these messages appeal to behavioural change conditions.

4.1 Introduction

Water security is important in highly variable, unpredictable environments where demand for water is increasing. Water security is one of the 31 leading interconnected overall risks to competitiveness (World Economic Forum 2014). Factors contributing to the risk of water security for households include population growth, industrial growth, and the unpredictability of water supply. Climate change has also exacerbated water crises globally, reducing river flows and dam storage volumes (Postel et al., 1996; Wilbanks and Kates 2010). The possible consequences of water anxiety and crisis include acute water deficits, reduced food security, degradation of riparian ecosystems, extinction of species, and difficulties in maintaining a variety of sources of water supply (Postel et al., 1996). In addition, water crises threaten efforts to reduce the carbon footprint and maintain the affordability and constancy of municipal water supply and treatment systems (Hoekstra and Chapagain, 2007; Richter 2014).

The overwhelming water crises globally demonstrate the importance of strategies that address water demand (demand-side) in water management and water planning (Gober et al., 2010; Fielding et al., 2012). Demand-side strategies for water management are measures or initiatives that result in a reduction in the expected water-use or water demand by the resource provider (e.g. a utility) as part of its corporate-planning and capital-investment process (Stiles, 1996). Most demand-side strategies adopted by water utilities focus on water-use efficiency, water supply restrictions, and regulations with consequences as a means of controlling water use (Bemelmans-Videc et al., 2011; Kathleen and Bremer, 2017). Although demand-side strategies dominate water-conservation approaches (McGranahan, 2002), they are restrictive because they do not encourage voluntary individual behavioural change. Instead, they are a command-and-control approach to household water usage. More effective

water-conservation outcomes may be achieved through persuasion (message framing) for behavioural and attitudinal change among water consumers.

The communication of conservation messages encourages behavioural changes that result in sustainable water conservation. Communication includes the framing and content of messages for household water-conservation behaviour. Households may receive information about water scarcity and specific water-saving strategies (e.g. use of dual-flush toilets) to conserve water (Seyranian et al., 2015). Such information can transform behaviours impacting water quality and supply (Jorgensen et al., 2009) and challenges the belief that wasting water is acceptable. However, research emphasising communication about resources has not included the wider psycho-social dimensions for developing and testing theories of attitudinal change and conviction (Crano and Prislin, 2006). Agencies implementing water conservation strategies and interventions remain ineffective in achieving behavioural outcomes, thus raising the issue of how best to convey and set conservation messages for behavioural outcomes (Hine et al., 2013). Continuity in sustainability-related water-conservation intervention has not resulted in the desired behavioural change, due to targeting of the wrong behaviours, poor communication (e.g. framing of messages) and respondents' ability to comprehend the conservation message for behavioural change across diverse water-consuming audiences, cultural settings and environments (McKenzie-Mohr, 2008; Russell and Green, 2009). Most households have constructive dispositions towards water conservation, but these are not always transformed into specific conservation actions (Dolnicar et al., 2012) because of poor communication or failure to change water-use behaviour.

To achieve greater success in water-conservation behaviour, messaging may be improved by understanding the psycho-social mechanisms of behaviour change. The Behaviour Change Wheel (BCW) model (Michie et al., 2011), based on behaviour change theory, contains three

distinct behaviour conditions: capability, opportunity and motivation (COM-B dimensions) which can influence conservation messages presented to a receptive audience (Michie et al., 2011; Hine et al., 2013). Capability is defined as acquiring psychological and physical ability/self-efficacy to adopt specific behaviours or actions, including having suitable insight, knowledge and skills (Michie et al., 2011). Opportunity explains external factors to the individual that make the behaviour conceivable or prompt it, such as a social surrounding or physical environment that permits or prohibits a behaviour. Motivation describes the cognitive processes that vitalise and guide behaviour, such as habitual responses, emotional responses, and rational decision-making. These cognitive processes involve reflective motivation, such as making-good intentions or doing appraisals, and automatic motivation, involving emotional and impulse responses. Pro-environmental behaviour can be sustained when intervention activity (e.g. conservation messages) targets one or more conditions within this behaviour system (Michie et al., 2011). The aim of this study is to examine whether the COM-B conditions mediate the effect of the type of water-conservation message on water scarcity concern and households' intentions to engage in water-conservation behaviour.

4.2 Methods

4.2.1 Recruitment of study participants

Study participants were recruited through a social research panel (Qualtrics^{TM}) in March and April 2017 and asked to undertake an online survey. Participants received a reward commensurate with the time commitment involved in completing the survey. Participants had to be at least 18 years of age, have responsibility for paying utility bills (including bills for their household's water-use), have access to a garden as part of their property, and reside in New South Wales (NSW), Australia. The research was approved by the University of New England Human Research Ethics Committee.

4.2.2 Characteristics of study participants

The sample comprised 510 NSW residents. Participants were aged from 18 to 84 years (Mean age = 56.08, *SD* = 14.71), with equal numbers of males and females. Most participants (35 percent) had completed technical/vocational/TAFE education, 28 percent had completed year 12 at high school, 19 percent had achieved a bachelor's degree and 18 percent completed a higher degree. Sixty-eight percent described their residential situations as either solely or jointly owned property, 28 percent reported residence in a rented property, and four percent indicated that they resided in a property owned or rented by family or friends. In terms of access to a garden as part of their property, 91 percent declared access to a garden. Regarding responsibility for paying utility bills, 60 percent of the sample was solely responsible, and 40 percent shared the responsibility with other household members.

4.2.3 Experimental procedure

Following questions on demographic data, we assessed the effect of water-conservation messages on water scarcity concern and intentions to act in conservation activities. Participants completed a questionnaire assessing the extent to which receiving the water-conservation message types could influence their water scarcity concern and intentions to act in conserving water. Videos containing the water-conservation message types were then shown to participants. We then assessed the effect of water-conservation message videos using the COM-B dimensions as mediating variables on water scarcity concern and intentions to act in conserving water.

4.2.4 Measures evaluating the effects of messages on water scarcity concern and intentions to act

Water scarcity concern was assessed using 15 items appraising the degree to which participants understood the need for water-conservation message and the degree to which it

inspired them to adopt conservation measures by installing water-saving devices (Appendix C). For example, participants indicated whether they had installed water-efficient devices (e.g. "I have installed a dual-flush toilet in my house") by selecting 1 (no) or 2 (yes). The internal consistency of the water scarcity concern scale was good (Chronbach's $\alpha = 0.78$). Intention to act was assessed using 23 items (Appendix C) that gauged participants' opinions about how the framing and content of the water-conservation message videos when watched could alter their behaviour and put water-conservation measures into action (e.g., "I allow my lawn to go brown if there is insufficient rain", "I use drought-resistant grass") by selecting 1 (no) or 2 (yes). The internal consistency of the intentions to act scale was high (Chronbach's $\alpha = 0.89$).

4.2.5 Analysis

A Chi-square test was conducted in the statistical package SPSS version 24 to determine whether the message types have an effect on water scarcity concern and intentions to act. Water-conservation message types were coded as 1 for "water-saving tips/strategies" and 2 for "no water-saving tips/strategies". Water scarcity concern and intentions to act scales were regressed against conservation message types. The effects of messages on water scarcity concern and intentions to act scales were assessed by using the "yes" or "no" responses which show the effects of message types on water scarcity concern and intentions to act.

4.2.6 Allocation of water-conservation message videos

Participants were randomly assigned to view one of two household water-conservation messages, differing in their treatment of conservation strategies and information about options for conserving water: 1) severe water scarcity with water-saving tips/strategies; and, 2) severe water scarcity with no water-saving tips/strategies. Participants in the water-saving tips/strategies group viewed a video selected from YouTube

(https://www.youtube.com/watch?v=4MDLpVHY8LE&t=6s). This message outlined the negative impacts of water crises on the environment and highlighted water crisis and water shortage as a serious global concern needing to be addressed. The water-saving tips/strategies message also described water-conservation strategies that households could adopt. These strategies were described as providing holistic approaches to secure water supply and ensuring environmental benefits by reducing the quantity of water wasted by households. It likewise encouraged and required active involvement in and commitment to conservation actions, providing step-by-step water-conservation measures. Participants in the no water-saving tips/strategies group also viewed a video selected from YouTube (https://www.youtube.com/watch?v=fLMn2P5q1ho). The no water-saving tips/strategies message outlined the same negative impacts of water crises on the environment but did not describe water-conservation strategies that households could adopt. Thus, the only distinction between the water-saving tips and no water-saving tips conservation messages was the inclusion of strategies that households could adopt to conserve water.

Immediately after viewing the water-conservation message videos, participants in both groups answered questions evaluating the degree to which the water-conservation message type influenced their water scarcity concern and intentions to act in reducing water consumption. Participants' responses to the water-conservation messages were assessed using 39 items using COM-B dimensions (capability, opportunity and motivation-behaviour) as a taxonomy to evaluate water scarcity concern and intentions to act (Appendix D).

The capability dimension was measured by 17 items, comprising two psycho-social dimensions of physical capability and psychological capability, which measure a participant's capacity to engage in water-conservation practices. Physical capability was assessed with eight items describing physical skills, strength or stamina in conserving water (Appendix D). Participants indicated their levels of engagement with each statement using a Likert scale

ranging from 1 (never) to 5 (always). The physical capability scale had high internal consistency (Chronbach's $\alpha = 0.86$). Psychological capability was assessed using nine items (Appendix D). These items determine the extent to which participants' relevant knowledge, reasoning and psychological skills related to the perception that the household water-use communications were relevant and worthwhile. The capability dimensions also encouraged household members to engage in water-conservation activities and seek more information about water-conservation practices. The Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree) and the psychological capability scale also had high internal consistency (Chronbach's $\alpha = 0.95$).

The opportunity dimension was measured with five items addressing a range of physical and social water-conservation conditions in the external environment that activate or inhibit water-conservation behaviour. Physical opportunity was assessed using three items (Appendix D), indicating factors external to participants which activate or inhibit a water-conservation behaviour. The Likert scale ranged from 1 (strongly oppose) to 5 (strongly support). The physical capability scale had high-quality internal consistency (Chronbach's $\alpha = 0.89$). Social opportunity was measured with two items (Appendix D), indicating social cues or community values and norms that persuade or inhibit water-conservation behaviour. The Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree) and the internal consistency for the social opportunity scale was high (Chronbach's $\alpha = 0.95$).

The motivation dimension was assessed using 17 items measuring reflective and automatic mechanisms that activate or inhibit water-conservation behaviour. Reflective motivation was assessed by 10 items (Appendix D), evaluating the extent to which respondents' objectives and evaluations perceived the household water-use messages to be convincing about water-conservation actions. The Likert scale ranged from 1 (does not describe me) to 5 (describes me extremely well). The reflective motivation scale displayed high internal consistency

(Chronbach's α = 0.84). Automatic motivation was assessed with seven items (Appendix D), weighing the extent to which respondents' emotional reactions, desires (wants/needs), inhibitions, and reflex responses perceived the household water-use messages to be credible about water-conservation practices. The Likert scale ranged from 1 (does not describe me) to 5 (describes me extremely well). The automatic motivation scale had high internal consistency (Chronbach's α = 0.93).

4.2.7 Analysis

Path analysis (Arbuckle 2006) was conducted using the Analysis Moments of Structures software package (SPSS/AMOS, Version 24) to test the strength of behaviour conditions (COM-B dimensions) in mediating the effects of the water-conservation message types on water scarcity concern and households' intentions to engage in conservation behaviour. The performance of the model was assessed using relative chi-square (CMIN/DF), goodness-of-fit index (GFI), comparative fit index (CFI), root mean square error of approximation (RMSEA) and the standardised root mean square residual (SRMR). To assess good model fit, data must fit: $\chi^2/df < 3.0$, GFI > 0.90, CFI > 0.90, RMSEA < 0.05 (90% CIs [0.05, 0.10]), and SRMR < 0.08. The pathway analysis was conducted with maximum likelihood estimation (MLE). Bootstrapping was used for calculating the significance of the indirect pathways to generate confidence intervals.

4.3 Results

There was a significant effect of the two messages on intentions to act χ^2 (1, N = 510), 88.46, $p < 0.001$ and water scarcity concern χ^2 (1, N = 510), 8.51, $p < 0.001$. The influence of message types on water scarcity concern and intentions to act were 75 percent for participants who perceived that water-saving tips/strategies could impact conservation actions and 25

percent for participants who perceived that no water-saving tips/strategies message type responses could influence water conservation actions (Figure 4.1).

The model presented a significant fit to the data: χ^2 (4, N = 510) = 6.80, p =.15; χ^2/df = 1.70, GFI = 0.94, CFI = 1.00; RMSEA= 0.04, 90 % CIs [.00, 0.09], SRMR= 0.02. All testing of indirect effects was calculated through decomposition tests grounded upon 1,000 bias-corrected bootstrapped samples in AMOS. Given the acceptable model fit, the pathway coefficients between water-conservation messages and water scarcity concern and intentions to act were significant in the hypothesised directions. There was a significant effect of message type on water scarcity concern (Figure 4.2). For the interaction involving message types and the COM-B dimensions, providing information about water-saving strategies produced significant increases in water scarcity concern.

Message type was mediated by participants' views about capability and motivation behaviour. The significant path coefficients showed that capability appeared to be particularly important in mediating the impact of the water-conservation message type on water scarcity concern (0.42, $p < 0.01$) (Figure 4.2). Participants who scored higher capability reported greater levels of psychological perception of water scarcity concern. Motivation elicited a lower but significantly positive score (0.24, $p < 0.01$). A lower score on motivation predicted lower levels of water scarcity concern. Opportunity had a significant moderate positive effect (0.15, $p < 0.01$) on water scarcity concern, however, it mediated both message types. As expected, participants in the water-saving tips/strategies message condition, relative to those in the no water-tips/strategies message condition expressed greater levels of water scarcity concern. Providing explicit information about how to conserve water and avoid wastage increased water scarcity concern and intentions to act in many participants compared to household members who received a message containing no water-saving tips/strategies. In examining the overall variance, the model explained 43 percent of the variance in water

scarcity concern. The indirect effect of the message types by COM-B interactions was significant for water scarcity concern responses ($\beta_{indirect}$ = 0.19, *SE* = 0.07, $p < 0.01$).

Participants' perceived capability increased when provided with specific message about how to conserve water. This was associated with higher psychological and physical skills which in turn increased participants' intentions to act (Figure 4.1). Results confirmed increased capability (0.74, $p < 0.01$) and motivation (0.38, $p < 0.01$) to be correlated with greater water-conservation intentions when provided with a specific, pragmatic message about how to reduce water consumption. Opportunity also mediated the impact of message type on intentions to act but weakly (0.13, $p < 0.01$). In examining the overall variance, the model explained 75 percent of the variance in intentions to act. The indirect effect of the message types by COM-B interactions was significant for intentions to act responses ($\beta_{indirect}$ = 0.15, *SE* = 0.05, $p < 0.01$).

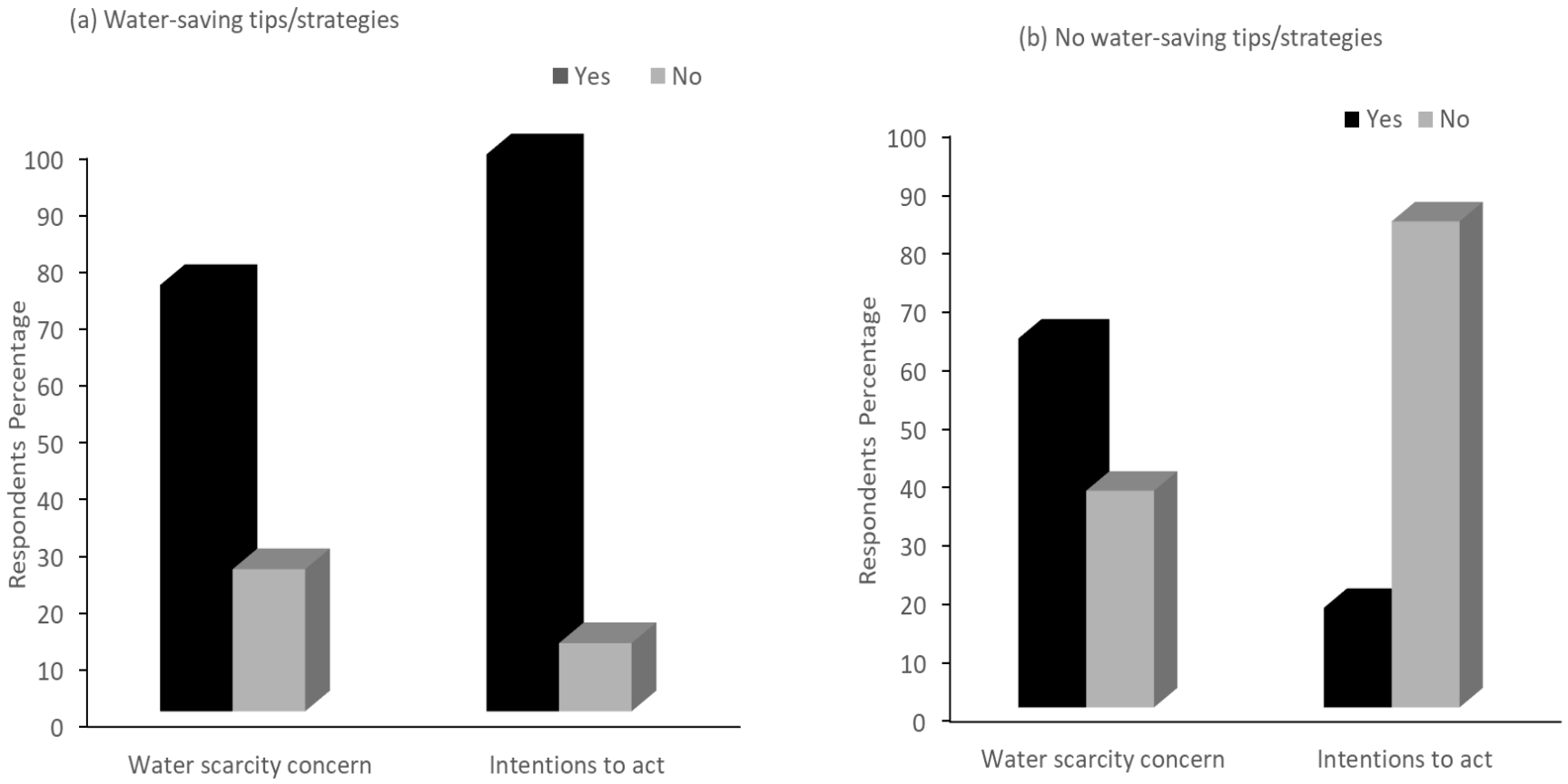

Figure 4.1. Effects of (a) water-saving tips/strategies and (b) no water-saving tips/strategies message types on water scarcity concern and intentions to act. Yes and No indicate whether message types influence water scarcity concern and intentions to act.

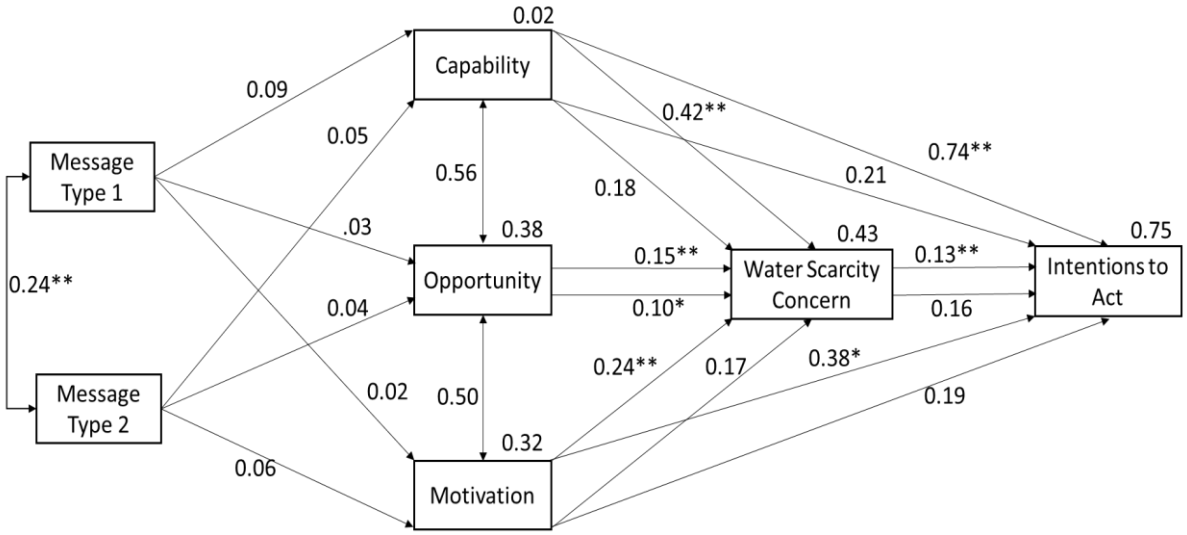

Figure 4.2. Path model testing the hypothesis that capability, opportunity, and motivation dimensions mediating the effects of water conservation message types (1 = severe water scarcity – water-saving tips/strategies and 2 = severe water scarcity – no water-saving tips/strategies) and water scarcity concern and intentions to act. Values on pathways represent standardised weights. Model fit indices: χ^2 (4, N = 510) = 6.80, P = 0.15, GFI = 0.99, CFI = 1.00, RMSEA = 0.04, SRMR = 0.02. *p < 0.05, **p < 0.01.

4.5 Discussion

The COM-B dimensions significantly mediated the effect of each conservation message type on water scarcity concern and intentions to act. In this experimental study, it emerged that households need to be given specific conservation strategies of what to do and how to change otherwise they are less likely to have concern for water scarcity or intent to act. Households that received the no water-saving tips/strategies message showed relatively moderate water scarcity concern but less intention to take water conservation actions than households that received the water-saving tips/strategies message. This finding is congruent with earlier research that showed that providing relevant water conservation strategies influenced conservation behaviour (Bohner and Dickel, 2011). Consistent with earlier research, our results showed that care for water conservation increased after individuals received the

relevant conservation strategy information (Simpson and Stratton 2011; Fielding and Roiko, 2014).

Mediation pathways provided behavioural insights about how the COM-B dimensions changed recipients' level of concern about water scarcity and intentions to engage in conservation actions. It enabled us to determine which output variables (water scarcity concern and intentions to act) remained influenced by our water conservation message, and which dimensions most predicted water scarcity concern, and intentions to act in water-conservation activities. Pathway analysis showed that water-conservation message types were significantly associated with capability, opportunity, and motivation for water-conservation intentions. This showed that a water-conservation message type can help to reduce water scarcity and increase households' intentions to engage in conservation activities when households can understand conservation messages, have available opportunities, and are motivated. In this respect, our results are consistent with earlier studies that have shown the effectiveness of messages for increasing conservation awareness and activities (Simpson and Stratton, 2011; Dolnicar et al., 2012).

Our findings further showed a significant effect of households' capability to perceive water scarcity concern and higher intentions to conserve water. High household capability for water scarcity concern and intentions to act determined households' responsiveness to water-conservation messages. Household members reported more water scarcity concern and greater intentions to act after receiving specific water-conservation messages. The mediating effects of capability on water scarcity concern and intentions to act means that household capability manifests higher levels of water scarcity concern and intentions to act in conserving water. Households that received specific conservation messages become well informed and tuned-in to water-conservation actions. This encourages households to acknowledge or receive constructive information about how to decrease their water

consumption. Households that received specific conservation-strategies as part of their message were more comfortable with taking action to conserve water. They also felt it was important to be alerted to fixing and repairing minor leakages compared to households that did not receive the specific conservation-strategy message. Thus, if households are aware of issues related to water shortages and can find conservation strategies, they are more likely to engage in water-conservation actions and exhibit a reduced tendency to waste water. Intensifying water-conservation programs and campaigns (Strang, 2001; Letcher et al., 2002) targeted at individuals and communities and offering detailed and holistic views of diminishing water resources may make individuals capable of adopting conservation measures.

Conservation messages can influence households' capability if they are tailored to target the factors underlying this behaviour dimension. Household members exhibiting high capability may pay attention to water-conservation messages if those messages are understood and contain relevant conservation strategies. Household capability intensified after they received water-saving tips/strategies message type and likewise, resulted in increased water scarcity concern and intentions to engage in conservation actions, likely because participants respond to communications that are within their domain and coherent with their preferences and prevailing concepts (Sarabia-Sánchez et al., 2014). Overall, increase in water scarcity concern and intentions for water-conservation behaviour was higher when the water-saving tips/strategies communication message given was within the households' capability. Households' higher water scarcity concern and intentions to engage in water conservation behaviour may be occurring because water crises have been a risk for a prolonged period and many households may have once experienced severe droughts and listened to debates for and against water wastage (Fielding and Roiko, 2014).

Opportunity explained significant variation in household water scarcity concern and intentions to act in conservation behaviour in households receiving either conservation message. This is consistent with other research which has shown that communicating water policies (e.g., water governance and retrofitting programs) involving water metering, billing, network repair, and non-pricing strategies (Kenney et al., 2008) impacts water-conservation behaviour. This suggests that households having the opportunity to receive conservation messages are more likely to decrease their volume of water consumption or demand and have a prominent role to play in water management and pro-environmental behaviours. Although households assenting to messages about social opportunity (e.g., social cues, cultural norms, interpersonal influences, and values) are less likely to engage in water-conservation activities (Jorgensen et al., 2009; Graymore and, 2010), those consenting to messages about physical opportunity such as water restrictions, pricing scheme, and locations (Kenney et al., 2008) are more likely to conserve water.

Opportunity not only mediated significantly the effect of message content on households' observed water scarcity concern and intentions to act in conserving water, but, likewise, compelled household tendency to receive or deny water-conservation messages. A significant part of the opportunity dimension on water-conservation messages is water restrictions, providing discounts, rebates, lower rates and free materials or labour for installing water-efficient devices. When households are provided with financial incentives on retrofit programs, there is a high tendency for water reductions (Berry, 1984; Inman and Jeffrey, 2006). Countries such as Australia, the United States, and the United Kingdom have used financial incentives or retrofit programs that installed new and replaced old appliances such as toilet dams, faucet aerators, and low-flow shower-heads and have achieved remarkable water reductions (Hoque, 2014; Richter, 2014). In contrast, spending money on water-efficient appliances, high tariffs, and thrifty policies on financial incentive programs may discourage conservation investments and household's participation in conservation activities.

The pathway results for motivation responses showed that support was moderate on water scarcity concern when households were provided with the severe water scarcity and water-saving tips/strategies message. However, augmenting conservation messages with messages about incentives for good conservation behaviour yielded high intentions to act. Households that received information about strategies and how to use them in tackling water crises were prompted to use certified water-efficient appliances and agreed to reduce their water consumption. Specific messages on conservation strategies influence households' cognitive, affective, and behavioural responses to water-conservation behaviour, perceived water scarcity concern, and intentions to act.

One plausible explanation for this finding is that messages about conservation strategies encouraged households to activate and voluntarily recognise their involvement in water-conservation actions and the benefits of these actions to the environment. Positive attitudes, emotions, and reactions to water crises play a significant role in conservation-related issues when households show concern or intent to act, and support for water-conservation regulations (Renwick and Archibald, 1998; Lam, 2006; Kenney et al., 2008; Bohner and Dickel, 2011). It is worthwhile noting that households may do well to engage with water-conservation behaviour when given motivational messages and consider that information as proposing something tangible over and beyond what they perceive. Another prospect is that motivated households are concerned about environmental issues and they try to do all it takes to contest the negative perceptions of pro-environmental behaviours. Messages framed to be pro-conservation can help to reduce domestic water consumption when information underlying conservation activities is well understood (Seyranian et al., 2015). Individuals will respond better to conservation message contents when they are capable, have the opportunity, and are motivated to engage in pro-environmental behaviour (Vining and Ebreo, 1992; Michie et al., 2011). These results give further support for use of the Behaviour Change Wheel model in the field of water-conservation communication.

As water security has become important in ensuring sustainable local water sources, providing specific water-conservation messages may be important for behavioural change. Conservation messages may be improved by understanding the psycho-social mechanisms of behaviour change. In this study we have shown that COM-B dimensions mediate the effects of water-conservation messages on water scarcity concern and intentions to act. Conservation messages related to the COM-B dimensions all have a role to play in determining household water-conservation behaviour. The results confirm that providing messages that are specific to the COM-B characteristics about water-conservation strategies can improve households' involvement in and commitment to water-conservation behaviour. The present investigation affirms that for a conservation message to be successful it must move people through changing their behavioural conditions towards maintaining resources at their disposal. The results indicated that specific conservation strategies made available to households had a stronger impact on conservation behaviour when messages appeal to the behavioural change conditions. For example, in localities where water-efficient labelling schemes are in operation, evidence of strenuous message and education programs directing households to their usage and installation are worthwhile (Petty and Cacioppo, 1986; Makki et al., 2015). Water- conservation communication efforts do not function in a void and the importance of policy-makers and government water agencies can likewise alter the conversation around water scarcity concern and intentions to act. The COM-B behaviour information can improve water-conservation activities by linking existing strategies to support water-conservation behaviour conditions to reduce vulnerability to environmental risks – including water crises. The COM-B dimensions not only increase behavioural propensity and resilience but enable individuals and households to promote and sustain behavioural and attitudinal change towards pro-environmental behaviour. Specific information is important to inform proper policy responses at the household levels but messages that build on the COM-B dimensions are among the most likely to change conservation behaviour. Future research can identify

perceived barriers to and drivers of effective communication that can boost dissemination of information and diffuse resistance to water scarcity concern and intentions to act in decreasing water consumption.

Journal-Article Format for PhD Theses at the University of New England

STATEMENT OF AUTHORS' CONTRIBUTION

(To appear at the end of each thesis chapter submitted as an article/paper)

We, the PhD candidate and the candidate's Principal Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated in the *Statement of Originality*.

	Author's Name (please print clearly)	**% of contribution**
Candidate	Isaac Bright Addo	80
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Type of work	Page number/s
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Chapter 5

THESIS SYNTHESIS

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This synthesis chapter provides a summary of the research undertaken and the key findings of the thesis. It is structured into three sections. The first section reviews and details the main findings of the three research manuscripts. For each, the technical and philosophical contributions to water conservation are highlighted. The second section discusses the philosophical contribution of the thesis, and how the findings of the research presented in this thesis collectively contributes to the field of water conservation. Finally, the third section provides suggestions for future research that have emerged from this thesis. The summary of thesis objectives, the chapter in which each was addressed; the key findings emerging from each manuscript and implications is presented in Table 5.1

5.1 Summary of major findings

The aim of this thesis was to investigate the mechanisms of water-conservation behaviour through the lenses of capability, opportunity, and motivation-behaviour (COM-B system). It was anticipated that this aim would be achieved by analysing psychological-social factors of household water-conservation behaviour, profiling barriers and drivers of water conservation and relationships between the type of conservation message and intentions to conserve water, and the influence of capability, opportunity, and motivation on these relationships. Three questions were put forward to address this aim:

1. What are the key psychological-social predictors of household water-conservation behaviour, and how do these predictive relationships vary with a household's capability, opportunity, and motivation in water conservation?
2. What are the barriers to, and drivers of, water conservation in terms of capability, opportunity, and motivation, and what is the manner and degree to which these barriers and drivers can strengthen and inhibit effective water-conservation behaviours?

3. What is the effectiveness of conservation messages on the intentions to act and engage in water conservation, and do the relationships of these messages change with capability, opportunity, and motivation in terms conserving water?

Understanding mechanisms of behavioural change is important in order to achieve sustainable water-conservation behaviour. When behaviour mechanisms can be identified, the potential for improvement in water conservation increases. Household water consumption behaviours were linked to behaviour mechanisms that influence attitudes and behaviour. This signifies that while many people may have the capability (self-efficacy), opportunity and motivation for water conservation behavioural mechanisms must be directly linked to attitudes and behaviours to conservation itself. This is important when designing intervention strategies for water conservation. Given that information is understood differently by a diverse range of consumers, profiling conservation messages based on behaviour mechanisms may improve household water conservation. Significant differences in communicating water-conservation messages were recorded for diverse groups of households when behaviour mechanisms are examined. The results of this research underline the potential use of interdisciplinary approaches to water conservation study.

Table 5.1. A summary of thesis objectives, findings and implications.

Thesis objectives	Manuscript	Key findings	Implications for water conservation
1. Examine the capability, opportunity, and motivation of households, important psychological-social dimensions, in influencing water-conservation behaviour	**Chapter 2** Objective 1	▪ New dimensions for understanding and directing psychological-social predictors of water-use behaviours of households ▪ Household water-use behaviour is associated with three necessary conditions: capability, opportunity, and motivation. ▪ Opportunity is the most important dimension influencing water conservation ▪ These behaviour conditions are useful for the identification of behaviours that influence water use and how these may diverge depending on the water-use character of the region and environment	▪ Women are more capable of conserving water ▪ Households with greater income are more open to water-saving opportunities ▪ People with more advanced educational attainment are more likely to interpret and implement water conservation measures
2. Identify the main drivers and barriers to household water-conservation behaviour and assess the manner and degree to which these drivers and barriers affect households' capability, opportunity, and motivation in conservation strategies	**Chapter 3** Objective 2	▪ Barriers and drivers of household water-conservation behaviour were classified into three water conservation groups based upon households' capability, opportunity and motivation viewpoints of conserving water ▪ Five barriers and drivers associated with these profile groupings were identified ▪ These were time constraints, acuity of water-efficient devices, lack of skills to adopt conservation practices, and availability of incentives/disincentives for water-saving devices ▪ Household water-conservation groups diverge considerably based on socio-	▪ Increased water tariffs are the most effective driver promoting water-saving behaviours ▪ Financial incentives motivate households to adopt water conservation practices ▪ Collaboration between government water agencies and households is needed to ensure support for physical and psychological capability in making a behavioural plan with conservation activities ▪ Such collaborations could also be used to identify opportunities for

		demographic status and actual water-conservation behaviour ▪ Understanding the profile of individuals may be used to better influence water-conservation behaviour.	households to seek sustainable water conservation behaviour ▪ Water conservation strategies must consider the heterogeneity of water conservation behaviours that occur among individuals. A one size fits all approach is unlikely to be effective
3. Measure the extent to which receiving water-conservation message types could influence households' water scarcity concern and intentions to act in conserving water via increasing capability (self-efficacy), opportunity, and motivation	**Chapter 4** Objective 3	▪ The impact of the message type on households' intentions to act in water conservation is moderated by households' capability, opportunity, and motivation mechanisms ▪ Households presented with a specific water-conservation strategy message reported higher levels of perceived conservation behaviour than households without a specific water-conservation strategy message ▪ Households with higher perceived capability, opportunity, and motivation were more likely to take water-conservation actions ▪ The psychological-social dimensions to water conservation and communication are best summarised as a simple paradigm involving three behaviour mechanisms: capability, opportunity and motivation.	▪ Effective communication for water conservation will require multifaceted strategies that consider interacting effects of individual capability, opportunity, and motivation ▪ Water conservation policies and programmes should prioritise outreach and education programs to understand mechanisms of behavioural change. This increases household level of knowledge on water conservation in changing mind-sets and attitudes to water supply.

Chapter 2 (Manuscript one), '*Household water use and conservation behaviour: A meta-analysis*', addressed objective 1. Understanding psychological-social dimensions of behaviour is important because these dimensions are the direct causal mechanisms of water-conservation behaviour. A formal empirical meta-analysis of 88 correlation coefficients from a combined sample of 15,656 was used to examine the direct causal relationships between water-conservation behaviours and the psychological-social dimensions of capability, opportunity, and motivation-behaviour (COM-B system).

The main finding of the meta-analysis was that capability, opportunity, and motivation were all highly correlated with household water use. Opportunity was the most important dimension (r = 0.25, 95% CI [0.18, 0.33]) to predict household water-conservation behaviour. The study also found that within the dimensions of capability, opportunity, and motivation, correlations to water-conservation behaviour differ with household socio-demographic status and actual water-conservation behaviour. It was apparent from the meta-analysis that household water conservation behavioural change and understanding the mechanisms of behavioural change can lead to long-term sustainable household water conservation. A focus on the direct causal mechanisms of sustainable long-term water conservation in households is an alternative approach to the traditional or command-and-control approaches to water conservation. This contrasts to the command-and-control approaches that have tended to dominate water conservation practices.

This is the first meta-analysis to your knowledge that focuses on causal mechanisms of water-conservation behaviour. Organising psychological-social drivers and their effects on water-conservation behaviour into a broad integrative model of behaviour comprising capability, opportunity and motivation dimensions allowed for the identification of interventions relevant to sustain water resources such as fiscal measures, guidelines, environmental/social planning, communication/marketing, legislation, service provision and regulation. Thus, effective water

conservation strategies must relate water-conservation behaviour to its causal mechanisms and interventions. If this is not done the link between variable and effect fails, because interventions target the wrong behaviours (Bartholomew et al., 2011; McKenzie-Mohr, 2008). Bandura and Watt (1996) noted that a lack of linking appropriate household water-conservation behaviour to relevant intervention strategies such as fiscal measures, guidelines, environmental/social planning, communication/marketing, legislation, service provision and regulation and causal mechanisms for example, capability, opportunity and motivation affected the success of these strategies. Addressing the issue of the causal mechanisms of psychological-social drivers of water conservation using the mechanisms of capability, opportunity, and motivation is a prerequisite to understanding and changing attitudes and behaviours to water conservation.

The implications of these findings for water conservation (Table 5.1) are women are more capable of conserving water. Households with greater income are likely to adopt water saving measures. In addition, people with higher levels of education are more likely to implement water conservation measures. Thus, knowing something about these characteristics of communities will enable more efficient targeting and therefore better outcomes of water conservation strategies

Chapter 3 (Manuscript two), '*Barriers and drivers of household water conservation behaviour: A profiling approach*', addressed objective 2. Understanding the profile of individuals may be used to better influence water-conservation behaviour. A latent profile analysis was used within the capability-, opportunity-, and motivation-behaviour (COM-B system) framework to identify key barriers and drivers of household water-conservation behaviours. Participants (N = 510, mean age = 56.08 years, SD = 14.71) completed measures of psychological-social constructs related to barriers and drivers of water-conservation behaviour. The latent profile analysis yielded a 3-profile solution in which capability (35.8%),

opportunity (23.2%), and motivation (41.0%) conceptualised barriers and drivers of water-conservation behaviour.

The main finding from the profiling groups demonstrated reoccurring barriers and drivers inhibiting and promoting water conservation. Major barriers and drivers identified were time constraints, acuity of water-efficient devices such as front-loading washing machine, lack of skills to adopt conservation practices such as checking and repairing minor water leakages, and availability of incentives such as rebates or subsidy on water-efficient devices and disincentives for water-saving devices. The study also found that barriers and drivers of household's water-conservation behaviour can be viewed in terms of the behavioural conditions of capability, opportunity, and motivation. When viewed in terms of capability, opportunity and motivation, different factorial levels can help deliver behaviourally effective strategies to reduce household water use. This research identified the factors associated with psychological capability, physical capability, social opportunity, physical opportunity, reflective motivation, and automatic motivation have a major influence on water conservation. This finding has not previously been demonstrated. Coordinating barriers and drivers of water conservation with associated behaviour condition(s) may guide intervention strategies to strengthen drivers of effective water conservation and policy decisions. These profiling groups, link interventions to reduce barriers such as time constraints and promote drivers such as social support of positive household water-conservation behaviours by altering and directing appropriate behaviour conditions to individual water consumers and provide relevant interventions such as environmental/social planning, service provision and regulation. The profiling approach was used in this thesis to understand the barriers and drivers of household water conservation, in relation to behaviour change theory. It demonstrated that capability, opportunity and motivation can influence component parts of an intervention or strategy for effective conservation. Behaviour has a series of underpinning factors that, either support or inhibit sustainable water conservation.

Profiling and identifying barriers and drivers to water conservation, and how this relates to human behaviour, remains a critical area for long-term sustainable management of water resources. The profiling approach used in this thesis expressed different barriers and drivers of water conservation into relevant causal mechanisms of behaviour. The findings suggest that these barriers and drivers can be linked to the relevant intervention activities based on the BCW and the COM-B framework for behavioural action. Latent profile analysis can enhance understanding of the barriers and drivers of water-conservation behaviour. It also aids in implementing successful water conservation strategies. The implications of this study on the identified barriers and drivers to water conservation suggests water conservation strategies must consider the heterogeneity of water conservation behaviours that occur among individuals. A one size fits all approach is unlikely to be effective (Table 5.1).

Chapter 4 (Manuscript three), '*Reducing household water-use: The influence of water-conservation messages on intentions to act*' addressed objective 3. Communicating water-conservation messages based on the BCW and the COM-B system is important because it provides a model and a common language to communicate about water conservation more effectively to bring about sustained behavioural change. The study examined relationships between the type of conservation message and intentions to conserve water and the influence of capability, opportunity, and motivation on these relationships. Participants completed a questionnaire related to water-conservation message types. Videos containing the water-conservation message types were then shown to participants. A structural modelling analysis was employed for this study. A pathway analysis was used to determine the effect of framing messages in terms of households' capacity (self-efficacy), opportunity, and/or motivation in water-conservation actions. The results of this study showed the impact of message type on households' intentions to act in water conservation was moderated by households' capability, opportunity, and motivation mechanisms. Households when presented with a specific water-conservation strategy message reported higher levels of perceived conservation behaviour

than households without a specific water-conservation strategy message. The results also indicated that households with higher perceived capability, opportunity, and motivation are more likely to take water-conservation actions. This study shows that effective communication is important for effective water conservation. Water conservation policies and programmes should prioritise and design education measures that are cognisant of the mechanisms of behavioural change (Table 5.1).

Specific information is important to inform policy responses and conservation messages. Targeting sustainable behaviours that build on the BCW and the COM-B system are more likely to have a longer-term change in conservation behaviour. Thus, water conservation communication messages can best be summarised as a simple paradigm involving three behaviour mechanisms: capability, opportunity and motivation. This paradigm shift in communicating conservation messages across water users targets the hearts and the minds of individuals because the message framing appeals to their psychological perspectives.

5.2 Philosophical contributions to water conservation

Behavioural change within the context of water conservation has been the focus of this thesis. The research undertaken has made a philosophical contribution to the body of knowledge on water conservation. This has occurred in four areas: 1) understanding mechanisms of behavioural change; 2) linking behaviour mechanisms to strategies of change in water conservation; 3) interdisciplinary approaches to water conservation; and, 4) communicating water-conservation messages based on behaviour mechanisms. Each is discussed in the following sub-sections.

5.2.1 Understanding mechanisms of behavioural change

This thesis argues that a deeper understanding of the causal mechanisms of behaviour is required for sustained water conservation (Section 1.6). Traditional approaches to the study

and application of conserving water have been primarily focused on command-and-control strategies (Section 1.2). Command-and-control approaches do not result in long-term sustainable water conservation because they are, by nature, restrictive. Command-and-control management approaches to conservation assume that issues of water conservation are generally simple to conceptualise, with clear boundaries and linear cause to effect relationships (Holling and Meffe 1996). Understanding of the causal mechanisms of behaviour, and attitudes to water provides an alternative approach for effective and long-term conservation of water.

The use of the BCW as an integrative approach provides an evidence-based framework (the COM-B system) with which to understand behavioural change. Three key factors to understanding behavioural change are capability, opportunity, and motivation. These key factors can help government water agencies, stakeholders and individuals to understand the causes of behaviours, and identify relevant intervention strategies and policies for changing and promoting water-conservation behaviours. In this study, the use of the integrative BCW framework showed that the capability, opportunity and motivation dimensions of behaviour are causal mechanisms that bring about behavioural change in water conservation. Understanding behavioural change and the use of the BCW framework is an alternative to command-and-control approaches to achieving sustained water conservation. This is a key contribution of the thesis.

5.2.2 Linking behaviour mechanisms to strategies of change in water conservation

Behavioural mechanisms have been shown to be important drivers influencing human activities related to the environment (Fielding et al., 2012). The identification of different psychological-social drivers such as social supports of behaviour, placed within the categories of capability, opportunity and motivation (i.e. causal mechanisms of behaviour) helps to identify the most appropriate intervention strategies such as environmental/social planning,

service provision and policy tools such as fiscal measures for changing behaviour. Quantitative evidence provided in this thesis supported this effect for example, households which are opened to various water conservation opportunities such as rebates, retrofitting programs and financial incentives are more likely to conserve water – opportunity ($r = 0.25$, $p < 0.001$). The meta-analysis demonstrated strong significant correlations between capability, opportunity, and motivation and water conservation behaviour.

Overall, opportunity was shown to have the strongest influence on water conservation, followed by capability and then motivation. Opportunity correlated significantly with water conservation – facilitating external conditions from the environment that prompt or enable the target behaviour to occur. In considering the opportunity dimension in water conservation, cultural or community values, cues, and norms that encourage or inhibit the target behaviour were shown to be important. Linking the opportunity dimension to appropriate intervention strategies for changing behaviours in water conservation go beyond the traditional command-and-control approach. Water conservation must endorse motivation drivers, individual capability and triggers of opportunity as they influence the likelihood that a specific behaviour will occur. This approach of understanding behaviour is an alternative to command-and-control to achieving sustained water conservation.

5.2.3 Interdisciplinary approaches to water conservation

Applying paradigms, theories and models derived from different contexts is an interdisciplinary endeavour. Interdisciplinary approaches to solving current environmental issues facilitate new understandings of water conservation by bridging dominant paradigms from many individual disciplines. In this thesis, paradigms, theories and models from the discipline of psychology were applied to the context of water conservation. This has resulted in an alternative approach for water conservation. Changing paradigms and perspectives towards water use provides a very different format for developing policies and interventions to discuss behavioural constraints to water conservation (Batchelor et al., 1998). Bridging psychology into water conservation gives a deeper understanding of how behaviour occurs and the best way for changing complex water use behaviours. Underpinning factors for sustaining water conservation are individual attitudes and behaviours towards water usage.

5.2.4 Communicating water-conservation messages based on behaviour mechanisms

This thesis has shown that there are strong relationships between conservation messages and the behavioural dimensions of capability, opportunity, and motivation. Results suggest that individual profiling can identify appropriate communication intervention strategies that directly relate to the understanding and domain of orientation for water conservation. For example, individuals in the motivation group may wish to hear conservation messages coupled with incentive packages, rewards, or motivational drivers to trigger their action. The research findings from this thesis contribute to an understanding of communicating water-conservation messages influencing behavioural mechanisms. Linking behavioural mechanisms to relevant intervention functions and policy categories is an important application of the results of this thesis (section 1.5). The BCW and COM-B system information can improve water-conservation activities by influencing behaviour mechanisms to reduce vulnerability to environmental risks – including water crises. Information is

important to inform policy responses at the local, regional, and national levels but messages that build on the BCW and COM-B framework are more likely to change conservation behaviour and bring about sustainability. For example, conservation messages about physical capability in terms of making a behavioural plan with conservation activities – activities that require physical skills, strength, and stamina – must be specific to the recipient's audience in achieving behavioural outcomes. Households must be provided with the necessary information pertaining to specific skills needed to conserve water. Moreover, when considering psychological capability messages relating to conservation activities, it is important for the recipient to understand and know why making a behavioural plan for water conservation is important now and for the next generation. Households must have the opportunity to obtain relevant information in relation to water conservation in shaping their conservation prowess.

Information relating to physical opportunity – areas where individuals can be enlightened and knowledgeable – should be free from constraints and social opportunity messages. Importantly, individuals should take active roles in discussing and encouraging conservation actions. Motivation messages – both reflective and automatic can play a vital role in determining the likelihood of carrying out behavioural planning and conserving water, when individuals believe that the behaviour (water conservation) is a good thing to do. This motivation message is mediated by individuals' psychological capability in understanding and knowing the effects of their behaviour. Applying behavioural mechanisms in communicating water conservation messages contributes to water conservation for sustainability.

5.3 Suggestions for further research

Notwithstanding the theoretical and practical contributions of the thesis, this study also indicates critical areas for future research. First, the investigation used a quantitative method, particularly in the self-reporting surveys used in Manuscript 2 and 3. Although this method

has many advantages such as providing significant forecasts, simplicity of data collection and the ability to measure various constructs, the outcomes are general and lacking the specific contextual assumptions that qualitative inquiry grants (Cooksey and McDonald, 2011). Therefore, both qualitative and quantitative investigations to examine synergies among household water conservation and behaviour conditions is an essential early step in reaching this outcome (Walton et al., 2013).

Second, future research could use longitudinal studies and/or empirical methods to review the psychological-social drivers and barriers in line with the COM-B system impacting other behaviours such as energy consumption and travel behaviours. For example, longitudinal studies are required to help clarify the precise nature of how the association between the COM-B system and conservation behaviour develops over time, and the primary direction of interconnectivity.

Third, the present project concentrated on "curtailment" and "efficiency" of water use and their relationships to water-conservation behaviours. Thus, it is not obvious how the COM-B system might fit into specific behaviours such as energy consumption, recycling, and traveling. In terms of the potential impact of the COM-B system on household water conservation behaviour, future research should aim to set up specific COM-B system studies on either indoor or outdoor water consumptions and check their "curtailment" and "efficiency" development and progress. This move could contribute to developing new "wise integrated interventions" needed to curb persistent water stressors and again offer water conservation communicators proper insights to create more resilient and effective messaging tailored and directed to each behaviour dimension.

Finally, in Manuscript 3 I found evidence that water conservation messages directed at stimulating household commitment to conservation behaviour may not be compelling for audience members who do not share the same behaviour sources of influence. Further

research needs to determine which specific message components and frames are best for each conservation audience. Likewise, the experimental manipulation of messages relating to the potential conservation intentions to act, will help in identifying the connection and directionality between household water use and conservation behaviour.

5.4 General conclusions

This investigation has established that behavioural approaches provide an alternative to command-and-control strategies to water conservation. The BCW and the COM-B dimensions (i.e., capability, opportunity, and motivation-behaviour) all have a part to play in shaping household water-conservation behaviour. By recognising barriers such as time constraints, acuity of water-efficient devices, perceived lack of conservation skills, cultural values, prohibitive cost of water-efficient devices and disincentives that obstruct household water-conservation behaviour, the findings identify the need for decision-makers to support a practice of water conservation that could prevail even when the environmental stressors occur. This is achievable through providing the public with capability, opportunity and motivation focused strategies to encourage appropriate water-conservation behaviours and household commitment to acquire and build in water-efficient devices. Giving constant capability, opportunity and motivation focused strategies such as feedback, incentives and rebate programs and community-based campaigns that emphasise the susceptibility of water resources, are techniques that could encourage households in the conservation process. Like most behavioural change strategies, household water-conservation behaviour involves a complex and a major challenge for government water agencies and stakeholders.

The thesis extends the literature on capability, opportunity, and motivation responses which can effectively influence household water consumption. We bundled together different psychological-social factors such as household size and rebates into a single physical opportunity dimension to help households engage in conservation processes. The use of the

BCW and the COM-B framework in water-conservation actions will provide an insight for government water agencies about specific strategies and interventions such as environmental/social planning, service provision and regulations to tackle water scarcity in relation to behavioural conditions such as capability (fixing and repairing minor leakages), opportunity and motivation. These results can offer policy makers with an insight into some of the impacts of pro-environmental behaviour such as water and energy-saving actions, allowing them to consider some of the interventions such as environmental/social planning, service provision and regulations aimed at remedying specific psychological-social processes such as lack of commitment, poverty, distrust, forgetfulness and discomfort that contribute to a problem or that prevent people from taking active conservation behaviour.

This thesis acknowledged that the BCW and the COM-B framework may intensify the effect of water-conservation messages by focusing on household behaviour conditions and water consumer audience responses. This shows that the BCW and COM-B framework may impact household water-consumption behaviour and is useful for government water agencies when planning and expressing water-conservation messages. This thesis further highlighted the need for future longitudinal studies and/or empirical research to review the psychological-social factors underscoring the COM-B framework and to offer a better fit with other behaviours such as energy, recycling, and travel behaviours.

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Appendix A. Items used in Survey 1 assessing household water-conservation behaviour, attitudes, barriers and drivers.

Dimensions	Sub-dimension	Items
Capability	Physical capability	It is important to check and repair minor water leakages
		I consider collecting rainwater for watering my garden
		It is important to collect water from shower/sink/bath for use elsewhere
		Water-efficient devices too costly
		Lack of skills to participate in conservation activities
	Psychological capability	It is important to understand the impacts of water shortages on the environment
		It is good to have a knowledge about water crisis; it increases your conservation awareness
		Lack of knowledge about the importance of water conservation
		Little to no knowledge of water conservation techniques
		Inadequate conservation information
		Paucity of theory-based research-driven programs and evaluation
		Acuity of water-efficient devices
		Lack of information on water-efficient devices
		Poor feedback on water consumption
		Lack of environmental concern
Opportunity	Physical opportunity	I think financial incentives or rebates are likely to promote water-conservation measures
		Some people use communal appliances; they don't buy their own appliances
		It is worthy to take an extra time to save water
		Time constraints and availability; time-consuming
		Lack of clarity regarding conservation programs
		Lack of incentives and rebates
		Inflexibility of water infrastructure
		Lack of resources for initiatives

		Prohibitive cost of water-efficient devices
		Climate change/seasonal variability
		Landscapes choices
		Lack of funds for monetary support; disincentives or no rebates
	Social opportunity	Socio-economic factors (e.g., age, gender)
		Inter-personal and institutional distrust
		People conserve water because of their cultural beliefs
		Social pressure is a key influential to water conservation
		Obsolete values, beliefs and customs (social and cultural cues)
		Housing status influence water conservation behaviour (e.g., unit, detached, storey, age)
Motivation	Reflective motivation	It is everyone's responsibility to conserve water for the future
		It pays to save water around the house and garden
		It is good to be conscious of the amount of water-use in each day
		It is an offense for not installing water-efficient appliances in the house and garden
		It is advisable to use quality water-efficient appliances
		Discomfort in using water-efficient devices
	Automatic motivation	I always forget to turn off the tap when washing face or brushing teeth
		It is inconvenient for me to use water-efficient devices
		Lack of motivation affects my water-conservation behaviour
		I am not concerned at all with water conservation
		I am not committed to water-conservation actions
		Water conservation is not my sole responsibility
		I conserve water whenever and wherever I can
		Disincentives on water-efficient devices reduce water conservation
		Lack of environmental values and conservation attitudes

	Laziness/lackadaisical attitudes toward water conservation
	It is impractical for me to conserve water
	It is inconvenient for me to conserve water

Appendix B. Items used in Survey 2 assessing households' actual water-conservation behaviour.

Scale	Items
Actual ownership of water-efficient devices	Front-loading washing machine
	Water-efficient dishwashers
	Water-efficient taps
	Tap aerators
	Dual flush toilet
	Low-volume showerheads
	Baths and indoor spa
	Automatic electronic reticulation systems
	Sprinklers (drippers/pop-ups)
	Hand held hose for garden
	Watering can for garden
	Low-volume tap
	Hot water insulation
	Water collection system for sink/washing machine/shower
	Manual automated reticulation system
Perceptions about water-efficient devices	Water-efficient appliances are a promising idea
	Water-efficient appliances do not save enough water to be worth the cost
	Water-efficient appliances are costly
	I look for a good water usage rating when buying appliances
	I think water-efficient appliances are good if they are cost effective
	Water-efficient appliances can be a hassle to use
	Water-efficient appliances should be mandatory
Indoor water conservation practices	I connect a rain tank to bathroom
	I make sure that taps do not drip

	I use minimal water for cleaning
	I take shorter showers
	I flush the toilet less often
	I only use the washing machine when it is full
	I do not hose my driveway
	I use a broom, not a hose for cleaning
	I only use the dishwasher when it is full
	I fix leaks when they occur
	I do not use an in-sink disposal unit
	I use water-efficient taps
	I have a dual flush toilet
	I do not use running water for rinsing
	I turn off taps when brushing my teeth
	I use water-efficient showerheads
	I use a water-efficient/front loading washing machine
	I hand wash clothes
	I do not conserve water
Outdoor water conservation practices	I allow my lawn to go brown if there is insufficient rain
	I strictly adhere to water restrictions
	I rarely water my garden
	I reduce lawn area
	I do not wash my car with water
	I use drought-resistant grass
	I connect a rain tank to the garden
	I use a watering-can, not a hose
	I install and use efficient irrigation
	I wash the car less often
	I collect water from shower/sink/bath for use elsewhere
	I recycle grey water from the washing machine for garden
	I recycle grey water from the shower for garden

	I have a drought-tolerant plants/low-water consumption garden
	I mulch the garden regularly
	I group plants with similar needs
	I collect water when it rains (not in a rainwater tank)
	I water the garden according to conditions
	I irrigate in the morning or evening
	I have a rain water tank

Appendix C. Items comprising the water scarcity concern and intentions to act scales.

Scale	Items
Water scarcity concern	Front-loading washing machine
	Water-efficient dishwashers
	Water-efficient taps
	Tap aerators
	Low dual-flush toilet
	Low-volume showerhead
	Baths and indoor spa
	Automatic electronic reticulation system
	Sprinklers (drippers/ pop-ups)
	Hand held hose for garden
	Watering-can for garden
	Hot water insulation
	Water collection system for sink/washing machine/shower
	Not automated reticulation system
	I install and use pool cover
Intentions to act	I strictly adhere to water restrictions
	I rarely water my garden
	I reduce lawn area
	I do not wash my car with water
	I use drought-resistant grass
	I connect rain tank to garden
	I use a watering can, not hose
	I install and use efficient irrigation
	I wash car less often
	I collect water from shower/sink/bath for use elsewhere
	I recycle grey water from the washing machine for garden

I recycle grey water from the shower for garden
I have a drought-tolerant plants/low water consumption garden
I mulch garden regularly
I group plants with similar needs
I collect water when it rains (not in a rainwater tank)
I water garden according to conditions
I irrigate in the morning or evening
I have a rain water tank
I allow my lawn to go brown if there is insufficient rain
Stopping what I am doing to turn off a dripping tap
Conserving water is my responsibility
Checking for regular plumbing leaks

Appendix D. Items comprising the COM-B scales**.**

Dimension	Items	Sub-dimensions
Capability	Looking out for news and facts on water shortages and crises areas	Psychological capability
	Knowing the effective methods of watering garden to save water	Psychological capability
	Understanding the negative impacts of water scarcity on sustainable livelihood	Psychological capability
	Providing information about water conservation to householders	Psychological capability
	Taking feedback about the level of water consumption seriously to check my water usage	Psychological capability
	Prioritising ecological issues such as water scarcity and pollution	Psychological capability
	Understanding the impacts of water shortages and conservation processes	Psychological capability
	Communicating the severity of water scarcity to neighbours/families	Psychological capability
	Learning about water crises and their consequences on the environment	Psychological capability
	Harvesting rainwater for the garden	Physical capability
	Using a bucket instead of a hose to water the garden	Physical capability
	Using water-efficient appliances in my house	Physical capability
	Checking and fixing leaking water-efficient plumbing fixtures	Physical capability
	Planting hardy plants/drought-resistant xeriscape gardening	Physical capability
	Having power spray attached to a hose	Physical capability
	Owning water-efficient electrical appliances	Physical capability
	Minimising the flushing of toilets and bath times	Physical capability
Opportunity	People conserve water because of their cultural beliefs	Social opportunity
	Social pressure is a key factor for water conservation	Social opportunity
	I think financial incentives or rebates are likely to promote water-conservation measures	Physical opportunity
	I strictly adhere to water restrictions	Physical opportunity

	It is advisable/mandatory to use quality water-efficient appliances	Physical opportunity
Motivation	Informing myself about flow regulators	Reflective motivation
	Supporting environmental pressure groups to protect the natural resources	Reflective motivation
	Informing myself about certified water-efficient appliances	Reflective motivation
	Feeling upset when I see someone using water to wash the footpath/sidewalk or driveway	Reflective motivation
	Feeling indignant at the lack of awareness of some people regarding water conservation	Reflective motivation
	Feeling frustrated when I see a toilet/tap running without anyone doing anything about it	Reflective motivation
	Feeling guilty when I leave a tap running	Reflective motivation
	Feeling good when I can save water	Reflective motivation
	Feeling happy to see someone who is trying to save water	Reflective motivation
	Feeling upset by the waste of water in public places	Reflective motivation
	Rinsing vegetables under running water	Automatic motivation
	Showering for less than 3 minutes	Automatic motivation
	Wanting to complain when I see someone wasting water	Automatic motivation
	Washing vegetables in a bucket or sink instead of running water	Automatic motivation
	Stopping what I am doing to turn off a dripping tap	Automatic motivation
	Conserving water is my responsibility	Automatic motivation
	Checking for regular plumbing leaks	Automatic motivation