UNDERSTANDING RAPID AND OPPORTUNISTIC SOCIO-TECHNICAL CHANGE IN THE CONTEXT OF URBAN WATER MANAGEMENT

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Abstract. The widespread installation of government subsidized household rainwater tanks (HRWTs) achieved during the Millennium Drought in south East Queensland (SEQ), Australia, demonstrates the potential for water communities to capitalize on rapid socio-technical change opportunities. However, recent research in the field of Sustainable Urban Water Management (SUWM) points to a lack of systematic approaches that water practitioners can draw on to understand and anticipate such changes. To address this gap, this paper uses the Realistic Evaluation approach to examine the system conditions and responses which led to an increase in HRWT ownership in SEQ from 4.8% in 2006 to approximately 40% in 2009. The study's findings are then discussed in their applicability to SUWM in Georgia.

INTRODUCTION

It is now widely accepted that more sustainable and integrated approaches to urban water management are required if cities and biological systems are to become resilient to the effects of growing urban populations and global warming (Bithas, 2008; Gleick, 2000; UNESCO, 2009). This is particularly relevant to the state of Georgia whose population is projected to increase substantially over the next 20 years (Couch & Miller Keyes, 2009) and, like much of the country, faces uncertainty regarding the impact that global climate change may have on the region's climatic conditions (Stooksbury, 2008). In addition, the 2009 Judge Magnuson decision, which calls into question Metro Atlanta's continuing use of Lake Lanier as a drinking water supply, also emphasizes the importance of exploring alternative solutions to meet Georgia's future water needs.

In spite of increasing worldwide interest in the area of Sustainable Urban Water Management (SUWM), however (see for example Wong & Brown, 2009), many experts argue that change is too slow (Brown & Farrelly, 2009; Pahl-Wostl, 2008). In particular, these authors cite socio-political and institutional barriers, rather than a lack of technical expertise as the principle impediments to more sustainable urban water conditions (Brown, Farrelly, & Keath, 2009; Brown & Farrelly, 2009; Brown, Sharp, & Ashley, 2006).

Research on socio-technical transitions suggests that extreme environmental events, like drought, may open up 'windows of opportunity' for the rapid adoption of alternative technologies and practices (Casagrande et al., 2007; Geels & Schot, 2007). Recent studies also show that extreme environmental events can serve to reinforce existing practices (Keath & Brown, 2009). Therefore, it is critical that relevant stakeholders (e.g. local governments and water service providers) develop the institutional capacity to enable them to proactively respond to extreme events and be a catalyst for SUWM when such opportunities for change arise (Keath & Brown, 2009).

One important aspect of being prepared for these opportunities is the ability to understand and anticipate socio-technical change. However, since the human dimension has been largely neglected in the design and implementation of traditional water infrastructure systems, there is a lack of systematic approaches that practitioners in this field can draw on to analyze conditions which support transitions towards more sustainable forms of urban water management (Panebianco & Pahl-Wostl, 2006).

To address this gap, this paper uses Realistic Evaluation (Pawson & Tilley, 1997), a methodological approach from the field of program evaluation, to examine factors which influenced the success of the government-funded household rainwater tank (HRWT) rebate schemes implemented in south east Queensland (SEQ) during the Millennium Drought. More specifically, this entails the development of a qualitative evidence-based model which describes:

i. Enabling and disabling contextual conditions which surrounded the schemes, e.g. the context of a "Most Severe Drought Ever Experienced in SEQ," (enabling context); and,
ii. Supporting and inhibiting social mechanisms which were triggered by the rebate schemes, e.g. the desire for residents to "Do-Their-Bit" for the community (supporting mechanism).

The study's findings are then discussed in their applicability to SUWM in Georgia.

Study Context. From 2001 to 2009, SEQ suffered its worst drought on record. Also referred to as the Millennium Drought (Whitaker, 2005, p. 220), this event brought the region's combined dam levels down to just over 20% of normal operating levels (see Figure 1).

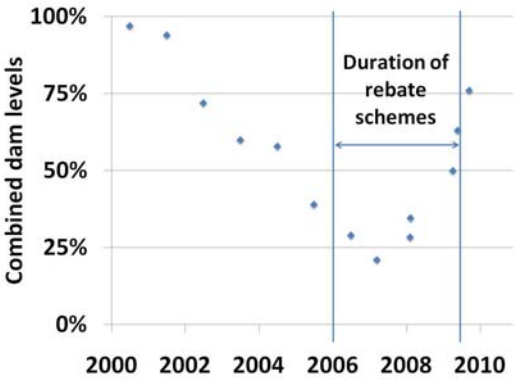

Figure 1. Impact of Millennium Drought on combined dam levels and duration of rebate schemes.

In response to the drought, policy-makers implemented a range of measures including: the provision of financial incentives to increase structural water efficiency, multi-level water restrictions, clearer billing and water consumption information, and community education campaigns (Queensland Water Commission, 2009). Together, these measures succeeded in reducing average levels of water consumption in SEQ from over 300 Liters (79 ga) per person per day (L/p/d) in 2005 to a record low of 115 L/p/d (30 ga) in July 2008 (QWC, 2008).[1] This paper investigates the first measure which contributed to these water demand reductions– the provision of financial incentives to increase structural water efficiency – with a specific focus on State and local Government rebates for the installation of householf rainwater tanks (HRWTs).

At a Queensland State level, HRWT rebates formed an integral part of the *Home and Garden WaterWise Rebate Scheme* which provided "a comprehensive package of incentives to help residential households in Queensland save water [...] [as] part of the government's plan to deal with the current drought affecting many parts of Queensland" (Queensland Government, 2006, p. 1). Beginning in July 2006, the *Home and Garden WaterWise Rebate Scheme* offered up to $1,000 per household for the installation of home rainwater storage systems.

In addition to the State Government rebate, residents in SEQ could also claim rebates from participating local governments. Unlike the State scheme, however, where rebates were not linked to the size of the tanks, local government rebates ranged from $500 to $750 depending on tank volume. For example, residents could apply for a $750 rebate in cases where the installed tank had a volume equal to or greater than 5,000 L (1,320 ga), whereas tank volumes equal to 3000 L (790 ga) but less then 4,999 L were only entitled to a $500 rebate.

Other local government areas impacted by the Millennium Drought offered similar schemes, such as the Gold Coast City Council's *Home Watersaver Rebate Scheme* and the Ipswich City Council's *Water Conservation Rebate Scheme*. Aside from the Gold Coast City Council's scheme, which began as a pilot scheme in April 2003 and concluded in June 2008, most schemes (both State and local Government) ran over the three year period from 2006 to 2009, coinciding with the height of the Millennium Drought, as illustrated in Figure 1.

On top of the rebate for purchasing a tank, some local government schemes also offered supplementary financial support of up to $200 (Brisbane City Council, 2006) to connect tanks to internal connections, such as the toilet or cold water laundry tap. However, as reported by Ironside et al. (2007), one year after the start of the State Government's rebate scheme only 2% of the 27,000 newly installed tanks in Brisbane were plumbed internally – the rest being mostly used to avoid negative impacts of water restrictions on gardening and other outdoor water amenities.

Figures such as these raised the question as to whether the State and local Government rebate schemes were actually fulfilling their intended purpose, that being, to "save water [...] [as] part of the government's plan to deal with the current drought affecting many parts of Queensland" (Queensland Government, 2006) by providing "a substitute source of water to the mains-water supply" (Brisbane City Council, 2006). According to the Brisbane City Council Lord Mayor at the time, Campbell Newman, the answer to this question was no, as illustrated in the following quote:

> *Water tanks are not saving water unless they are connected to a toilet or laundry* […] *There is absolutely no point in spending public funds* […] *to* [install] *tanks that only put water in the garden* […] *that will not take pressure off our water supplies* (Campbell Newman, reported by Chalmers & Thompson, 2007).

Within six months, this position was echoed by State members of parliament such as the then Natural Resources and Water Minister, Craig Wallace, who commented that "connected tanks were eight times more efficient [than free standing tanks]" (Lion, 2008a). In the context of these discussions, the Brisbane City Council changed their rebate scheme in July 2007 requiring that rainwater tanks be connected to an internal fitting (Brisbane City Council, 2009). The Queensland Government followed suit just over half a year later.

To assist homeowners with the extra costs of connecting their tanks, the State Government rebate was increased

[1] Current levels fluctuate between 140 and 180 L/p/d (37 to 48 ga) (for daily updates see http://www.qwc.qld.gov.au/).

from $1,000 to $1,500 (Queensland Government, 2008) and the Brisbane City Council rebate for a 5,000L tank increased from $750 to $900 (Brisbane City Council, 2009).

These changes to the State and local Government schemes had an immediate impact on the number of applications submitted for rainwater tank rebates. Days prior to when the Brisbane City Council's changes were due to take effect, Chalmers (2007a) reported that "… while rebate requests had already doubled in the past two months, applications have skyrocketed from 330 a day to 800 a day since the announcement [that the schemes would change requiring internal connections]". One month later Thompson (2007) reported that "… only one rebate application was received under the new scheme during the first two weeks of July, compared with 150 to 250 a day before Cr Newman's proposal". This reaction on the part of the public was repeated when the State Government changed their rebate scheme in February 2008, as noted by Lion (2008a) "… in the first three months of the new system only 507 rebates have been received. The previous system attracted 5000 applications a month late last year".

Although it is possible that the reductions in rebate applications may have been, in part, due to a saturated HRWT market, as indeed was suggested by the Minister Wallace three months after the State Government changed their scheme (Lion, 2008b), the stark contrast before and after the scheme changes, in terms of uptake, suggests that other factors were also at play, such as, for example, the level of uncertainty regarding internal connection costs and doubts as to whether the additional rebates would cover these costs (Chalmers, 2007b).

The above description of the effectiveness of the HRWT rebate schemes in SEQ during the Millennium Drought points to the need for the investigation of socio-technical factors surrounding the implementation of these schemes; in particular if water practitioners in other implementation contexts, like Georgia, are to benefit from the lessons learnt in SEQ.

Methodology. This study employed the Realistic Evaluation approach as a methodological framework for investigating factors which influenced the effectiveness of the rainwater tank rebate schemes in SEQ, with a particular focus on before and after the above-described scheme changes. This section describes the theoretical framework underpinning the Realistic Evaluation approach and the specific data collection and analysis methods used in the study.

Theoretical Framework. Realistic Evaluation is a methodological approach that was developed in the late 1990s as a means to build theory relating to how policy-driven interventions 'work' in social contexts. The theory-building process within a Realistic Evaluation study rests on the notion of generative causation (Pawson & Tilley, 1997). In other words, socio-technical interventions, like the HRWT rebate schemes offered SEQ residents during the Millennium Drought, are said to 'work' ('generate' successful "outcomes"), only insofar as they introduce the appropriate ideas and opportunities ("mechanisms") to groups in the appropriate social and cultural conditions ("contexts"). I.e, Context + Mechanism = Outcome. These three concepts form the theoretical basis of Realistic Evaluation studies and are defined in more detail in the following paragraphs.

The key point in seeking to understand mechanisms is that it is not the socio-technical intervention, or 'measure' which is the basic unit of analysis for causation but the mechanisms that the intervention stimulates. As Pawson and Tilley note "a measure may work in different ways, or in realist parlance, they may trigger different mechanisms (M_1,… , M_n)" (2004, p. 7).

Another way to think about mechanisms is to reflect on the ways in which socio-technical interventions "engage in trying to change the balance of choices open to their subjects" (Pawson & Tilley, 1997, p. 122). Taking HRWT rebate schemes as an example, such schemes may motivate residents to install a rainwater tank 'now' at an subsidized price, rather than risk deciding to install a tank at some time in the future after the rebates have finished; whereby the mechanism is the decision to install the tank now at an subsidized price, i.e. **Forward Planning (M_x)**, rather than the tank itself, or the rebate scheme. Alternatively, the schemes may make rainwater tanks more affordable to residents who have previously wanted to install a tank but who did not have the means to do so, whereby the mechanism could be surmised as **Affordability (M_y)**. Then again, the rebate schemes might be perceived by some residents as **Free Money (M_z)** which they would like to take advantage of, regardless of how they intend to use the tank once it is installed.

Identifying the underlying program mechanisms, however, is only one part of a Realistic Evaluation study. Next it is necessary to determine the conditions, or 'contexts' which "enable or disable" (Pawson & Tilley, 1997, p. 70) the intended (and unintended) mechanisms for change. Context, in this sense, refers to pre-existing structures, that is, "the prior set of social rules, norms, values and interrelationships gathered in these places which sets limits on the efficacy of program mechanisms" (Pawson & Tilley, 1997, p. 70).

Drawing once again on the example of the current study, various responses to the rainwater tank rebate schemes may be conditioned by circumstances and structures such as the perception of a **Water Crisis (C_x)**, **Water Restrictions (C_y)** and/or a desire to **Maintain Current Gardening Practices (C_z).**

Finally, outcomes are the "social 'regularities', 'rates', 'associations'… [and] 'patterns'" (Pawson & Tilley, 1997,

p. 71) that realist inquiries seek to explain. In the case of this study, the outcomes of interest were:

O_1 The initial rapid and widespread installation of freestanding HRWTs, i.e. without internal connections; and,

O_2 The dramatic reduction in rebate applications following changes to the schemes requiring that tanks be connected to an internal fitting.

Data Collection. Using the overarching theoretical framework outlined above, this study employed a document analysis of newspaper reports published in SEQ during the Millennium Drought to investigate the following two research questions:

i. What mechanisms for change were triggered by the provision of rebates in SEQ for the installation of HRWTs, both before and after the scheme changes, and how did they impact on existing social processes? And,

ii. What social and cultural conditions (contexts) were necessary for these change mechanisms to operate?

According to O'Donnell & Rice (2008), media reporting of drought, climate change and other environmental issues reflects and shapes public understanding about water and energy systems and their connections to society and the natural environment. Moreover, Bell (2009), who analyzed press reports to compare the onset of drought in Sydney in 2002 and in London in 2006, argues that newspaper reports provide "a useful record of public discussion and debate which reflects wider social and cultural considerations that may be overlooked in expert-led management of water systems" (p. 582-583).

Given the severity of the Millennium Drought in SEQ, this issue received a high level of press coverage, including for example, regular updates of dam levels, changes to water restrictions, stories concerning what 'regular' people were doing to "Save Water [and] Beat the Drought" (Collins, 2007), information relating to new water infrastructures, as well as numerous advertisements for various kinds of water saving devices. This high level of attention and diverse range of topics reported on made a document analysis of newspaper articles published during the Millennium Drought an accessible source of data for this study.

Using the interpretive lens of generative causation (i.e. context + mechanism = outcome), the document analysis thus aimed to provide an account of how the public perceived and reacted to the provision of rebates for HRWTs in the context of the Millennium Drought. It is emphasized that the purpose of the document analysis was not, therefore, to determine whether or not the newspaper articles reported the 'facts' of these events accurately.

Articles for the document analysis were sourced from SEQ's two most highly circulated newspapers – The Courier Mail (n=105) and The Sunday Mail (n=43) – and a local newspaper from an adjoining local government area, Ipswich – The Queensland Times (n=16). Table 1 presents a summary of the newspaper articles included in the document analysis. It is noted that more Courier Mail articles were examined as part of this study. This is because the Courier Mail was the first newspaper to be searched and its articles analyzed, thus informing early theoretically saturated categories. In other words, articles in later searches were reviewed and excluded from the analysis if they were found to contain the same theoretical properties of saturated categories, as coding them would "only add […] bulk to the coded data and nothing to the theory" (Glaser & Strauss, 1967, p. 111).

Table 1. Summary of Data for the Document Analysis.

Year of publication	The Courier Mail	The Sunday Mail	The Queensland Times	Total per year
2006	37	12	1	50
2007	33	27	7	67
2008	18	3	2	23
2009	17	1	6	24
TOTALS	105	43	16	**164**

Data Analysis. The newspaper articles were qualitatively analyzed for contexts, mechanisms and outcomes using the constant comparative method (Glaser & Strauss, 1967) supported by the qualitative software package NVivo8.

Qualitative coding in the study was initially descriptive, often employing *in vivo* category names (Richards, 2005). The following excerpt, for example, was coded for the **Dinner Table Discussion** context.

> *The Mitchells are spending $7000 to install two tanks for household use and one for the garden.* [...] *While the family will not be dependent on the town water supply, they have discussed water issues around the dinner table as the region's dam levels have fallen.*

As the coding progressed, it became apparent that categories with similar properties could be grouped together as clusters, thus refining the theoretical constructs developed in the study. For example, the **Do-Your-Bit** category was grouped alongside the mechanism categories **Take Individual Control** and **Teach the Value of Water** in the **Actions Driven by a Sense of Responsibility** cluster. Two additional mechanism clusters were developed in this way, as well as three context clusters. These six clusters and their respective subcategories are illustrated in Figure 2.

Finally, findings were validated against interviews with policy-makers involved with the Millennium Drought response (n=3), water practitioners (n=6), and local residents (n=17).

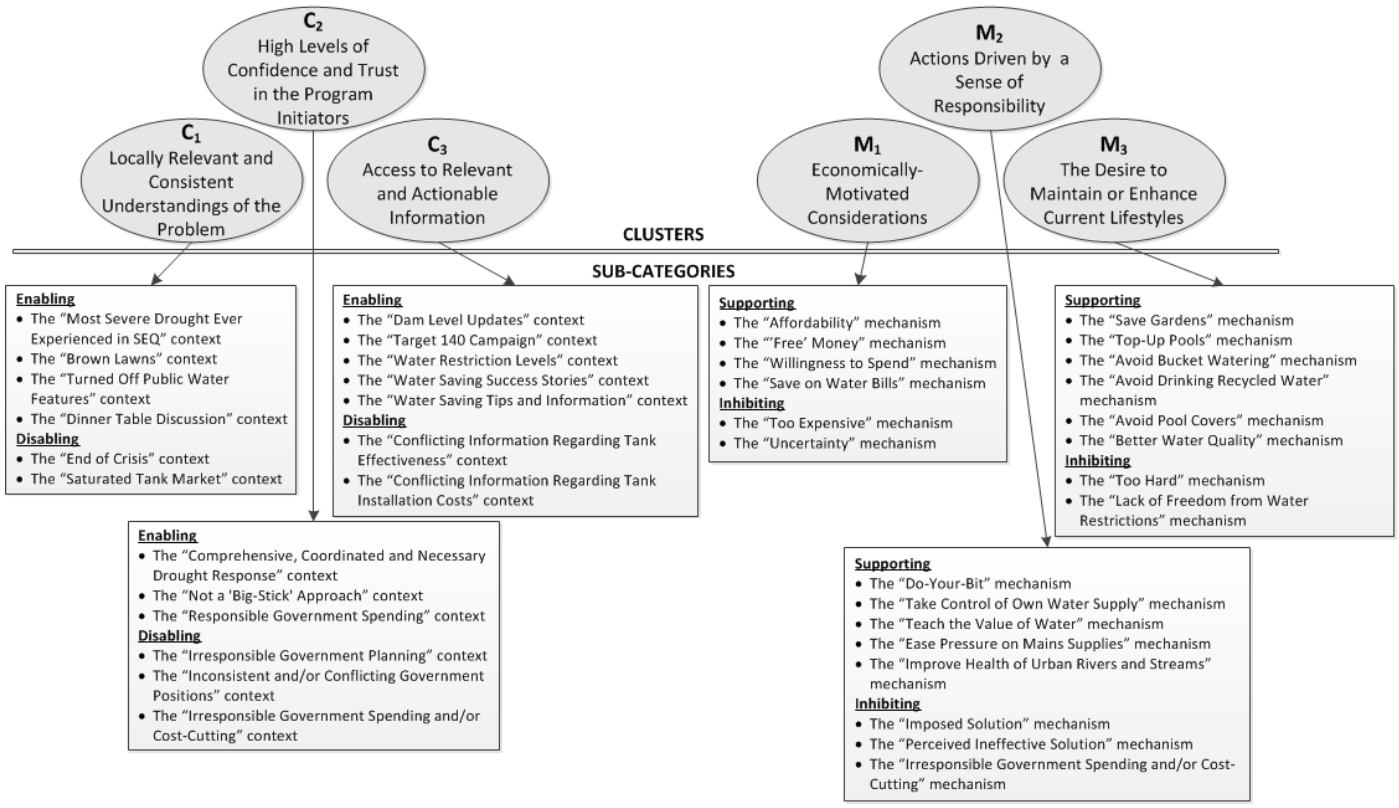

Figure 2: Empirical Model of Factors which Influenced the Effectiveness of the HRWT Rebate Schemes in SEQ

Results and Discussion. Qualitative analysis of the newspaper articles resulted in the development of an evidence-based model detailing the system conditions (con--texts) and responses (mechanisms) which surrounded i) the initial rapid and widespread implementation of freestanding HRWTs (O_1), and ii) the subsequent dramatic reduction in rebate applications following changes to the schemes requiring that tanks be connected to an internal fitting (O_2). Broadly, contexts and mechanisms associated with O_1were interpreted as 'enabling' and 'supporting', respectively, whereas contexts and mechanisms identified to explain O_2 were coded as 'disabling' and 'inhibiting', respectively (bolded in Figure 2).

The evidence-based model presented in Figure 2 performs two important functions. First, it shows how Realistic Evaluation can be used as a systematic methodological framework to develop a systems understanding of socio-technical change scenarios. More specifically, the approach does this by shifting the focus from the intervention itself to the contingent relationship between the context of implementation, the mechanisms that the intervention triggers and the outcomes produced.

Following on from this first function, the model illustrates the specific and theoretically abstracted contextual conditions and mechanisms, i.e. subcategories and clusters, which were found in the document analysis to influence the effectiveness of the HRWT rebate schemes offered in SEQ. Of particular interest to the this study is the apparent mismatch between the arguably more technologically beneficial solution, i.e. internally connected tanks, and the inhibiting mechanisms that this solution appeared to trigger, e.g. the **Too Expensive**, **Imposed Solution** and the **Lack of Freedom from Water Restrictions** mechanisms, combined with a number of corresponding disabling contextual conditions, e.g. the **End of Crisis** and **Inconsistent and/or Conflicting Government Positions** contexts.

These two main functions of the model point to the importance of *contextual conditioning* (Pawson & Tilley, 1997, p. 69, 216) and *mechanism focusing* when implementing socio-technical interventions in the context of urban water management. Arguably the most obvious form of contextual conditioning present in the study setting was the context of the **Most Severe Drought Ever Experienced in SEQ,** coded under the **Locally Relevant and Consistent Understandings of the Problem** cluster. As reported by Sharp (2006), however, the context of a drought does not guarantee a cooperative public response. This is illustrated by the case of the Yorkshire drought in the United Kingdom in 1995 when there was very little public response to appeals for public water savings (see also Bakker, 2000). Also found to be important in SEQ was **High Levels of Confidence and Trust in the Program Initiators** and **Access to Relevant and Actionable Information**. It is proposed that both these forms of contextual conditioning could be developed in implementa-

tion settings outside of drought periods; thereby improving the likelihood of rapid socio-technical change should a drought occur and be accompanied by efforts to more sustainably manage urban water resources.

In terms of mechanism focusing, the study points to the need to look beyond a technological understanding of the intervention in question to *what it is* about the intervention that appeals to the program targets. An understanding of these mechanisms, for example the **Save Gardens** as opposed to simply a broader plea to "take pressure off our water supplies" (Campbell Newman, reported by Chalmers & Thompson, 2007), could, in turn, inform more effective education and advertising campaigns. An understanding of the mechanisms that interventions trigger could also lead to further technological refinements.

Applicability to Georgia Context. From 2006 to 2007, Georgia suffered its worst drought in more than a century. In response, State-wide water restrictions were imposed to curb water consumption. After the drought broke in late 2007, however, the restrictions were relaxed and water consumption rebounded to normal levels. In terms of rainwater harvesting, rain barrels for outdoor watering purposes were promoted by some counties and university extension programs. More extensive use of harvested rain and gray water, however, was not permitted until January 1, 2009 when amendments to the 2006 International Plumbing Code took effect (see Georgia Department of Community Affairs, 2009).

Looking towards the future, in May 2009, the Georgia Department of Natural Resources Environmental Protection Division published a report entitled "Georgia's Water Conservation Implementation Plan" which outlines a strategy to more efficiently and sustainably manage the region's water resources (Couch & Miller Keyes, 2009). Efforts to conserve water in Georgia have also taken on particular importance since the 2009 Judge Magnuson decision, as briefly discussed in the introduction section of this paper.

So, what contributions does this study make to SUWM in Georgia? First and foremost, the study demonstrates the very real potential for communities to achieve rapid and socio-technical change, provided that a) the contextual conditions are favorable and, b) the proposed changes trigger supportive responses among residents. It is noted, however, that these responses may not always align with the original, technologically-motivated intentions of the intervention, e.g. the perspective that internally connected tanks are more effective in reducing pressure on the mains water supply.

Second, this study shows how social methods of inquiry, like Realistic Evaluation, can provide structured ways in which to understand and anticipate socio-technical change; thus allowing for the more effective utilization of environmental, social and economic 'windows of opportunity' for change, like extreme periods of drought.

Third, the model developed in this study provides an empirical basis which could be used to inform the planning of future socio-technical interventions in Georgia. While certain parts of the model have been identified in previous studies, Pahl-Wostl (2008), for example, discusses the importance of trust between water companies and their customers, the model presented in Figure 2 emphasizes the transient nature of these system conditions and responses; thus providing a greater awareness of the need for contextual conditioning and mechanism focusing.

Taking a step back, this study provides further evidence to support the argument that current barriers to SUWM are "largely socio-institutional, rather than technical reflecting issues related to community, resources, responsibility, knowledge, vision, commitment and coordination" (Brown & Farrelly, 2009, p. 839). On this basis, it is hoped that the study will stimulate further debate on the emerging role of socio-technical, interdisciplinary research in informing and supporting transitions to more sustainable urban water conditions.

Conclusion. This paper used a document analysis within an overarching realist methodological framework to examine the rapid and widespread implementation of government subsidized household rainwater tanks in south east Queensland during the recent Millennium Drought. The analysis highlighted a range of contextual conditions and system responses (mechanisms) which were likely to have influenced the initial success and later slower uptake of the government rebate schemes. Elements of the model, in particular the theoretically abstracted clusters, e.g. the need for **Locally Relevant and Consistent Understandings of the Problem**, are tentatively transferable to other implementation settings, like Georgia. More broadly, the study demonstrates the value of using systematic social methods of inquiry to further our understanding of socio-technical transitions in the context of urban water management.

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