Social Science Perspectives on Dual Pipe / Water Reuse Systems

Response to WRC Dual Supply Pipe System – Call for Evidence: Social science perspectives on dual pipe / water reuse systems

Submission from Dr Claire Hoolohan[1], Prof Alison Browne[2], and Dr Ella Foggitt[1], University of Manchester, Enabling Water Smart Communities

[1] Tyndall Centre for Climate Change Research, School of Engineering.
[2] School of Environment, Education and Development (SEED).

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Summary:

- This response summarises work led by Hoolohan, Browne and Foggitt at the University of Manchester, as part of ongoing work within Enabling Water Smart Communities Project (www.EWSC.org.uk)
- It summarises a review of UK case studies of development-scale rain- and greywater reuse systems.
- It also summarises academic social science research relating to water reuse.
- This work is ongoing, and this response summarises work-in-progress findings.

Enabling Water Smart Communities (EWSC) is an Ofwat-funded innovation project exploring the interactions between communities and integrated water management in new housing developments. It is designed to unlock opportunities for cross-sector delivery and governance of new 'water smart communities.' As part of the project, Dr Claire Hoolohan, Professor Alison Browne and Dr Ella Foggitt at the University of Manchester are analysing how residents' interactions with new build 'water smart' developments affect social and environmental outcomes (for example, whether the presence of rainwater harvesting / greywater reuse systems affect sustainable consumption practices), to identify opportunities to enable sustainable everyday practices in water smart communities.

1. Review of UK case studies

The first part of this analysis involved a grey literature review, examining civil society, architects, and developer reports to identify how 'water smart communities' are envisioned in UK settings. Adopting a practice-based approach, this analysis of 72 documents shows that emphasis is placed on technical solutions without substantial consideration of how these developments will be lived in, and the interactions between residents and water systems. At the same time, open access documents do not consistently report on the technical features of such developments, the challenges in implementing reuse technologies, or how these have been overcome. These are important knowledge gaps. We propose that there are substantial opportunities for collating and sharing information on development scale water reuse (including planned/in-construction developments). There is also a need for further consideration of how people interact with water (both within homes and more broadly) in developments with water reuse.

As part of this review, a database of case studies has been collated, and is summarised here. Few examples of dual systems in operation were identified, though several developments planned/in construction are proposing implementing rain and greywater harvesting systems (see table 1).

Key points:

- Open-access information on rainwater harvesting and greywater systems is limited. Guidelines and a centralised system for collating and sharing this information would be beneficial (including technical details, cap/op costs, scale, installation and maintenance agreements).
- Rainwater harvesting for outdoor uses is more common than other options. Examples of water reuse primarily involved household scale rainwater harvesting for outdoor water use (e.g. garden watering), though several planned developments include greywater reuse (and dual pipe systems).

- Property-scale solutions are more common than development-scale solutions. Development-scale concerns cited include commercial issues & concerns over future maintenance of water reuse systems, and impact on secondary property sales.

Selected examples of rainwater and greywater harvesting in the UK

- One Planet Developments, Wales. Design guidance for these eco-communities encourages use of harvested rainwater as the primary water source, with greywater needing to be processed on-site. Many of these developments feature compost toilets, and therefore, do not use water (reused or otherwise for flushing), but reused water is widely used for irrigation.
- See also Hockerton Housing Project, Nottinghamshire. Rainwater harvesting, on-site filtration, and treatment. https://www.hockertonhousingproject.org.uk/water-systems/rainwater-harvesting/

Selected examples of where rainwater harvesting / greywater harvesting is proposed in new build developments (England):

- Hay Meadows, off London Road, Markfield, Leicestershire: Homes were fitted with water butts to enable rainwater harvesting for watering, but rainwater harvesting systems were not installed in the development due to concerns around maintenance, sales resistance and commercial challenges (Susdrain, no date).
- Welborne: Installation of grey water recycling systems were proposed in the planning phases of the development (Fareham Borough Council, 2016). The idea was that Albion Water could supply water through a dual-supply system with non-potable water provided for toilet flushing (Fareham Borough Council, 2015), but it is unclear what decision has been made around this.
- Hemel Garden Communities: The Hemel Garden Communities Charter (2018) states that alongside rainwater harvesting and surface water reuse, the possibility of non-potable water systems is being explored, but it is not clear whether a decision has been made about installation of non-potable water systems.

2. Review of social science evidence on dual water supply / reuse systems

Much of the social science literature are not directly related to 'dual pipe' supply or private water supply systems, nevertheless insights can be gained to inform decision making. In particular, the work around community perceptions and use of recycled and alternative water sources is relevant as the 'qualities' of water, and governance arrangements for that, will then flow through dual pipe, alternative and/or private water supply systems.

Key points:

1. There is good evidence of general public and industry support for water reuse, the degree of support varies by end-use (highest for outdoor water uses, WC flushing and laundry).
2. Public support for fit-for-purpose supply systems is closely related to their trust in water authorities, which in turn is related to wider public discourse on water governance (e.g. leakage, pollution, privatisation).
3. There are many different overlapping and interacting concerns about water reuse. These can be mitigated with sound legal and legislative frameworks that provide oversight and accountability.
4. Ongoing arrangements for funding and maintenance, particularly for development-scale water reuse systems, are not well researched.
5. There is some evidence that reuse (both greywater and rainwater) could enable sustainable lifestyles by deepening personal community connection with the environment and supporting different ways of living with water. The effect of this on water demand is uncertain, and there are very few evaluations of such systems in the UK that contribute to building the evidence base on the role of greywater harvesting/rainwater harvesting in fostering sustainable consumption practices.
6. The future of water demand is uncertain. Developments in other policy areas (e.g. active travel, work-from-home) have uncertain implications for demand, and fit-for-purpose supplies become more necessary in the future to balance other developments in consumption.

Trust in water governance

There is a lot of evidence within the social sciences and humanities that issues of governance and trust are essential for the public in the implementation of different water systems (See table 2). There are relevant studies from the UK, Australia and Chili that explore community perceptions of different fit-for-purpose water supply systems (mains supply, dual pipe, decentralised supply, managed aquifer recharge), and for a range of uses (drinking water, laundry, dishwashing, garden uses etc). There are several social studies around private supply systems such as water butts/tanks, particularly from Australia (e.g. Sofoulis), and the UK (e.g. MAGIC project).

Examples (citation details in Table 2)

- CSIRO (Commonwealth and Industrial Scientific Research Organisation) in Australia demonstrated how the 'yuck factor' for recycled water that is often cited as a barrier to implementing these systems is overstated. People generally do not hold a strong 'yuck factor' for recycled water (except for drinking) but instead focus on their (lack of) confidence in the governance of water safety. Trust in water authorities and water governance strongly affects public support for alternative supply systems, and mitigating perceptions of risk requires strong governance (to improve oversight and accountability) (Browne et al., 2008, in Table 2).
- Sefton et al., 2022, writing on SuDs but relevant here also, suggests that there are transformative advantages to a more community-oriented approach to flood resilience, particularly the potential to change the relationship between the public and flood authorities away from a traditional model that pictures the former as passive, towards a process of mutual learning and two-way communication.
- Tian et al, 2023 show customer satisfaction with water and wastewater services is fundamentally related to trust and communication with water utilities. The degree to which utilities are trusted relates to demographic factors (particularly age, older = more trusting). Information is important in building trust and credibility, but information comes through various channels, many of which a utility will have limited control over. This means the conduct of water authorities and wider public discourse, social media and general media coverage can have an important role in determining customer satisfaction.
- There is existing research from physical and social sciences around the 'public crises' in the UK around water pollution and quality (i.e., the government and the UK water companies not effectively regulating or preventing pollution to rivers and aquatic systems). Current concerns and lack of trust around the management of wastewater and water quality that is gathering a lot of public attention could overspill onto concerns for the governance of implementing dual pipe supply in a safe and efficient manner.

Public support for water reuse

- In Santiago (Chili), Amaris et al (2020, 2021) show that overall acceptance (in decreasing order of preference) for using high quality treated greywater for toilet flushing, laundry, garden irrigation, hand washing and, shower/bathtub use, but not for drinking.
- Aitken et al. (2014) evidence general public support for the idea of indirect potable reuse in the Thames Water region. The only demographic factor to show any significant difference from the whole sample was belief system, with Muslim respondents showing significantly less support than other groups. The study emphasises the need for meaningful public engagement and participation in decision making for the success of any particular proposal. Research by Snelling et al. (2019) supports this finding.
- Research by Dolnicar et al. (2010) shows that public support for alternative supplies can be increased with factual information. This does not imply that improvements to sustainable consumption, or willingness to adopt property-level / buy into development-level water reuse projects will be increased, further research would be needed.
- Goodwin et al. (2023) show the importance of methods in assessing and identifying strategies to navigate public concerns. Through multi-criteria judgements, results showed that stakeholders

prioritised health risk reductions and more conservative management interventions of adding water treatment processes.

Water reuse systems and demand

Much of the existing social science literature on water reuse focusses on public support and perceptions of risk. Less evaluates the relationship between water reuse and water demand, or other socio-environmental indicators.

- There is some research on the installation, use and maintenance around decentralised forms of supply (e.g., rainwater tanks), that shows these do not necessarily displace existing water demand (Sofoulis, 2015, Australia).
- Wolfle-Erskine (2015) emphasise that living with rainwater tanks (in California), learning to maintain them, and experiencing variation in water supplies increase residents' sense of interdependence with other human and nonhuman watershed residents. Compared to centralised supplies, living with these technologies and water supply systems gives rise to different understandings of water and different practices of water use and water management.
- The ongoing maintenance of water tanks is a key policy concern, and Walton and Gardner (2015) investigate how community acceptance of policy instruments that could be used to promote ongoing maintenance of domestic rainwater tank systems. They show how perceptions of policy fairness and effectiveness are important to acceptance. Policies that include enabling features associated with increased perceptions of effectiveness, and policies that use incentives are linked to increased perceptions of both fairness and effectiveness. Individual attitudes and motivations regarding tank maintenance were significant predictors of policy support.
- There is evidence, particularly from research in the global south, about the installation, use, maintenance, and governance challenges of managing dual water delivery systems (including off-grid options like Water ATMs). Learning about implementation, use and maintenance challenges within all global contexts could support implementation of a wider variety of water reuse options in the UK.

Building an Evidence Base around social and governance questions

There is presently limited evidence of regarding community perspectives (acceptance, use and impact) of water reuse systems. The evidence that does exist is localised, and focussed on public acceptability of different technologies, water quality, and use cases. Within the EWSC project we are working to address this gap, exploring these issues with publics and professionals to understand the potential for mains-limited developments in England. Greater attention and investment is needed into the social science and governance questions that underpin the implementation of these diverse forms of alternative supply.

Table 1: UK Case studies of development scale water reuse (of 16 cases)

Name	RWH				Greywater Reuse			
	Y/N	Description	Operational costs	Condition	Y/N	Description	Operational costs	Condition
Leeds Climate Innovation District	Y	Unspecified	-	-	N	-	-	-
The Steadings	Y	Water butts in private gardens.	TBD – under construction		?	Suggested, but unclear if approved.	TBD – under construction	
Oakfield	Y	Water butts to collect rainwater for gardening.	-	-	N	-	-	-
Riverside Sunderland	Y	Not specified.	TBD – under construction		N	-	-	-
Welborne	Y	Geocellular storage tanks.	TBD – under construction		?	Suggested, but unclear if approved.	-	-
Lammas One Planet Developments	Y	RWH for irrigation	-	-	Y	Households required to install and maintain a greywater reed-bed filtration system of at least 10m2, all household greywater must pass through this system.	-	-
Othello Way, Stratford-Upon-Avon	Y	Rainwater drained from roof is stored separately from space made for fluvial flooding. (Source: Baca)	-	-	N	-	-	-
Lamb Drove, Cambourne	Y	Water butts	-	-	N	-	-	-
Hay Meadows, off London Road, Markfield, Leicestershire	Y	Property-scale: 210l water butts provided for attenuation and water recycling. Development-scale: no RWH due to commercial issues & concerns over future maintenance and sales." (Source: Susdrain)	-	-	-	-	-	-
Winchfawr	Y	Source controlled attenuation systems managed flows from roofs. Combined with RWH for increase discharge	Not specified. Capital costs estimated "5000L	-	N	-	-	-

		rates and site sustainability. Specifics: - 8X 5m^3 rainwater harvesting units, calibrated to 0.1l/s discharge rate. - 8X Domestic RWH (Source: Susdrain).	RWH dual gravity feed systems RRP £3450+VAT Considerable, discount applied due to scale. (Source: Susdrain).					
Albion Close	Y	Roof run-off collected in tank buried under private driveways. (Source: Susdrain).	-	-	N	-	-	-

Table 2: Social science citations

Citation	Summary
Browne, A.L., Leviston, Z., Green, M.J., and Nancarrow, B.E. 2008. Technical and Community Perspectives of Risks associated with Purified Recycled Water in South East Queensland: A Q-Study. Urban Water Security Research Alliance Technical Report No. 4	This research focuses on community perceptions of risk associated with the implementation of purified rainwater schemes (PRW). Most participants are supportive of the PRW scheme but are generally cautious. The report highlights trust, risk, fairness, and emotion are important in determining public support for PRW. Conversations about risk need to reflect the connections between different types of risk (technical, environmental, and personal health risks), a high degree of complexity and heterogeneity exists in public attitudes towards PRW. Those accepting of PRW schemes felt that there needed to be sound legal and legislative frameworks to offer oversight and accountability. Those not accepting of the scheme were often concerned about health risks, and these were frequently the result of perceived system risks. See also: Leviston, Z., Browne, A.L. and Greenhill, M. (2013), Domain-based perceptions of risk. J Appl Soc Psychol, 43: 1159-1176. https://doi.org/10.1111/jasp.12079

Tian K.; Goodwin D.; Gallagher E.; Smith H. 2023 An Exploration of Customers' Satisfaction with Water and Wastewater Services in the UK Water Economics and Policy	Customer satisfaction with water and wastewater services is fundamentally related to trust and communication with water utilities. The degree to which utilities are trusted relates to demographic factors (particularly age, older = more trusting). Information is important in building trust, and credibility is built through multiple channels, many of which a utility will have limited control over. This means wider public discourse, social media and general media coverage can have an important role in trust.
Goodwin D.; Raffin M.; Jeffrey P.; Smith H.M. 2019 Collaboration on risk management: The governance of a non-potable water reuse scheme in London Journal of Hydrology	This study presents a case study of the London 2012 Olympic Park, an operational sewer mining scheme in London, where reclaimed non-potable water is used for irrigation and toilet flushing. The findings indicate that formal and informal engagement activities centred on risk management can support the development of common understandings, build important inter-stakeholder relationships and help maintain trust. Non-potable reuse can contribute to the resilience of megacities through infrastructure diversification, but its feasibility will depend on the willingness of stakeholders to participate and continually negotiate new risk management practices.
Aitken, Bell, Hills, Rees; Public acceptability of indirect potable water reuse in the south-east of England. *Water Supply* 1 October 2014; 14 (5): 875–885.	Public controversy over planned indirect potable reuse of wastewater has been a significant obstacle to implementing proposed schemes in the United States and Australia. Surveys of public attitudes to water reuse show lower acceptance of wastewater for potable use compared with other uses, such as irrigation. In this study, 2,000 Thames Water customers participated in an on-line survey of their attitudes to indirect potable reuse. The survey showed overall support for the idea of indirect potable reuse. The only demographic factor to show any significant difference from the whole sample was belief system, with Muslim respondents showing significantly less support than other groups. The survey results indicate that indirect potable reuse may be socially acceptable in the south-east of England, but that public engagement and participation in decision making will be important for the success of any particular proposal.
Dolnicar, S., Hurlimann, A. & Nghiem, L. D. 2010. The effect of information on public acceptance - The case of water from alternative sources. Journal of Environmental Management, 91 (6), 1288-1293.	This study shows that factual information (as opposed to persuasive campaigns) about water from alternative sources increases public acceptance. 1000 Australian respondents were asked about their acceptance of recycled and desalinated water for a range of purposes under two conditions: 1) no information provided and 2) information about the production process provided. Results indicate that the stated likelihood of use increases if people are provided with factual information about the production process.

Goodwin D.; Raffin M.; Jeffrey P.; Smith H.M. 2019 Stakeholder evaluations of risk interventions for non-potable recycled water schemes: A case study Science of the Total Environment	This study highlights how the feasibility of water reuse schemes can be diminished by high capital and operating costs which can be elevated by perceptions of health risks and subsequently overly cautious risk reduction measures. The study also highlights how different methods elicit different results; the use of recycled water for flushing toilets and washing clothes in a residential development was ranked favourably through the multi-criteria method, in contrast with low support for this alternative elicited through attitudinal survey questions. Through multi-criteria judgements, results showed that stakeholders prioritised health risk reductions and more conservative management intervention of adding water treatment processes. In contrast, responses to the attitudinal survey indicated that the stakeholders favoured maintaining the existing levels of risk control but increasing stakeholder engagement.
Snelling A.M.; Lamond J.; Everett G.; O'Donnell E.C.; Ahilan S.; Thorne C. 2024 Public perceptions of rainwater harvesting (RWH): comparing users and non-users of RWH systems Urban Water Journal	This study examines public preferences for rainwater harvesting, showing that RWH is perceived positively by most respondents indicating an openness and acceptance of this technology (and/or lack of strong negative attitudes). Implicit attitudes are generally more positive than explicit, especially in respondents with RWH systems, implying that the positivity is deep-seated in their subconsciousness. We also reveal differences between subconscious (implicit) beliefs and practical difficulties (explicit opinions). Outdoor uses of rainwater are preferred, hence, more work in promoting indoor uses is needed to maximise the resource potential of UK rainfall and uptake of RWH systems.
Goodwin D.; Raffin M.; Jeffrey P.; Smith H.M. 2018 Informing public attitudes to non-potable water reuse – The impact of message framing Water Research	This study assesses whether providing information on water reuse increases public support. The findings suggest that reinforcing compliance with water quality requirements has a positive impact, but a focus on safety message framed in terms of the selection of water treatment technology to remove contaminants nor in terms of non-potable water risks relative to other every-day risks does not result in increased public support. These findings could be used to frame messaging and inform the debate on whether an increased understanding of risk positively or negatively influences willingness to support water reuse schemes.
Williams J. 2022 Challenges to implementing circular development–lessons from London International Journal of Urban Sustainable Development	This study highlights the importance of accountability and transparency in the process of implementing and maintaining circular developments (not limited to water reuse). It also discusses the tensions between the reliance on civil society to engage with circular actions versus public resistance, highlighting the multiple roles the public play in planning and implementation of circular solutions.
Fam & Sofoulis 2015	This special issue is dedicated to research on small-scale infrastructures in the global North.

Walton & Gardner. 2015. Community acceptance of policy options for managing the maintenance of rainwater tanks, Local Environment, 20:5, 565-580	Abstract: This research examined community acceptance of policy instruments that could be used to promote ongoing maintenance of domestic rainwater tank systems. Using an online survey of 533 tank owners in South East Queensland, Australia, the research investigated four sets of factors that influence policy acceptance: features of the policy, judgements of policy fairness and effectiveness, contextual framing, and individual attitudes and motivations towards tank maintenance. Results demonstrated that perceptions of policy fairness and effectiveness are important to acceptance. Policies that include enabling features associate with increased perceptions of effectiveness, and policies that use incentives are linked to increased perceptions of both fairness and effectiveness. Individual attitudes and motivations regarding tank maintenance were significant predictors of policy support. Perceptions of a person's own ability to undertake tank maintenance tasks were negative predictors of policy intervention, suggesting that people who believe they can carry out maintenance themselves may not see the need for a policy that encourages tank maintenance to exist.
Wolfle-Erskine. 2015. Thinking with salmon about rain tanks: commons as intra-actions, Local Environment, 20:5, 581-599, DOI: 10.1080/13549839.2014.969212	This study, in California, shows how living with rainwater tanks, learning to maintain them, and experiencing variation in water supplies increase residents' sense of interdependence with other human and nonhuman watershed residents. Compared to centralised supplies, living with these technologies and water supply systems gives rise to different understandings of water and different practices of water use and water management.

Amaris G.; Gironás J.; Hess S.; Ortúzar J.D.D. 2021 Capturing and analysing heterogeneity in residential greywater reuse preferences using a latent class model Journal of Environmental Management	In this case study of Santiago (Chile), where greywater is not yet widely applied, the authors find varying degree of support for greywater - identifying four key clusters in the urban population (greywater enthusiasts, greywater sceptics, appearance conscious and water expenditure conscious). These clusters are characterised and explain peoples' varied preferences for indoor greywater reuse, and tolerance to different visual appearance of treated greywater. The clusters show differences between socio-economic characteristics and experience of greywater systems, as well as household characteristics (e.g. responsibility/care for others aged under 15 or over 75, number of sanitary devices, location and condition/type of garden). There is not an equivalent study in the UK.
Amaris G.; Dawson R.; Gironás J.; Hess S.; Ortúzar J.D.D. 2020 Understanding the preferences for different types of urban greywater uses and the impact of qualitative attributes Water Research	This study shows overall acceptance (in decreasing order of preference) for using high quality treated greywater for toilet flushing, laundry, garden irrigation, hand washing and, shower/bathtub use, but not for drinking. When the quality of appearance in terms of colour and odour gets worse, monetary incentives could be needed even for those uses that do not involve human contact. Gender, age, educational level, water expenditure level, and in particular previous knowledge about greywater reuse, are important determinants of acceptability and thus willingness to pay for greywater use; however, their importance varies according to the type of use.
Amaris G.; Hess S.; Gironás J.; Ortúzar J.D.D. 2021 Using hybrid choice models to capture the impact of attitudes on residential greywater reuse preferences Resources, Conservation and Recycling	This study, in Chile, shows people have varying degrees of support for different uses of treated greywater, and about the heterogeneity of choices among individuals and uses. The model suggests that heterogeneity in the acceptance of greywater reuse can be linked back mainly to underlying attitudes, for all uses except drinking. This knowledge can be used as an input to evaluate diffusion strategies to increase greywater reuse acceptability focused on messages about its direct (ff) and indirect benefits (environmental benefit, water security).

Hargreaves A.J.; Farmani R.; Ward S.; Butler D. 2019 Modelling the future impacts of urban spatial planning on the viability of alternative water supply Water Research	This paper looks at how housing density and other urban planning trends affect the costs and water savings of different water reuse systems. The water-savings of rainwater harvesting would vary greatly at a regional scale depending on residential densities and rainfall. Greywater recycling would be less affected by spatial planning but would have a finer balance between system costs and water-savings and its feasibility would vary locally depending on household sizes and water efficiency. The sensitivity of the water savings to differences in rainfall and water prices would vary with residential density.
Bunney S.; Melville-Shreeve P.; Chisholm A.; Cotterill S. 2023 Perspectives on multi-benefit water reuse systems: A confluence of water and wastewater management planning Water and Environment Journal	This paper reports on a workshop organized by the Chartered Institution for Water and Environmental Management (CIWEM) with 25 participants from England's Water Service Providers (WSPs), regulators (Ofwat and the Environment Agency) and consultants working within the UK water sector. The participants acknowledged that water reuse is relevant to both water resource and drainage and wastewater management planning, but that current regulatory and funding frameworks are constraining effective engagement between water resource and drainage and wastewater management planners by encouraging the development of separate plans. A general consensus of the participants was that it would be beneficial to include water reuse technology within current and future Water Resource Management Plans (WRMPs) and Drainage and Wastewater Management Plans (DWMPs). Participants suggested this could be developed through collaborative working partnerships and support from regulatory and funding frameworks that allow for the growth and development of innovative technologies and nature-based solutions. Participants also highlighted a stronger economic case could be made for water reuse technologies if the approach seeks to capture the wider benefits and not only the 'best value' solution. Societal acceptance and the availability of good quality data will be key to the successful adoption of any incentivized water reuse schemes.

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