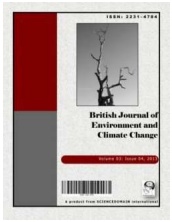

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Rainwater as a Domestic Water Supplement in Scotland: Attitudes and Perceptions

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Authors' contributions

This work is part of a PhD thesis. The research was carried out by author SNE and supervised by authors CB and SA. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Water resources in Scotland are under immense pressure despite the perception that Scotland enjoys abundant rainfall and water resources. The transport and treatment of water utilizes high amounts of energy is which contradicts the UK government's carbon neutral agenda. There is also the need to ensure reliable water supply to households whilst protecting the natural environment. The intent of this study therefore was aimed to explore the feasibility of rainwater harvesting (RWH) as a domestic water supplement in some selected peri-urban areas in Scotland by understanding people's perceptions, attitudes and behaviour towards RWH systems; and the preference for a community or individual system.
Methodology: Paper questionnaires were administered randomly to households using Private Water Supply (PWS) in three local areas: Highlands, Scottish Borders and Aberdeenshire over a period of 4 months.
Results: The response rates for Highlands, Scottish Borders and Aberdeenshire were 28%, 27% and 19% respectively, with the latter being marginally below target. The survey responses revealed that participants were unlikely to use RWH for domestic purposes including drinking, bathing, dishes and laundry but felt RWH would be acceptable for most uses except drinking. These included non-potable uses such as gardening, car washing and toilet flushing.
Conclusion: Most respondents were indifferent to implement RWH in their house if their neighbor used it or if it was a community set-up, but were willing to consider it if grant incentives were offered.

Keywords: Rainwater harvesting; private water supply; attitudes; behaviour; perceptions; community rainwater system.

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1. INTRODUCTION

1.1 Background

Water resources are essential for life and important not only to the society but also for the ecosystem [1]. An adequate supply of clean drinking water is important to sustain human life, but it is observed that millions of people throughout the world still do not have access to this basic necessity [2] and those who have access tend to take it for granted [3]. Over the years, there has been a global increase in demand for potable water due to a growing population and a change in users' behaviour. In the UK, population increase since 1964 has been over 10 million people (18.7%) and it has been projected to increase further in the coming decades [4]. This may lead to increase in pressure on fresh water resources and the infrastructure for managing mains water supply.

Households in the UK are the greatest users of water; approximately 55% of which 35% of the treated water for human consumption is flushed down the toilet [5].

Rainwater harvesting (RWH) can be used for this non potable usage of water. RWH is the immediate collection of rainwater running off surfaces upon which it has fallen directly and excludes run-off from land watersheds into streams, rivers, lakes [6]. This means controlling or utilizing rainwater close to the point rain reaches the earth and it has been known to control erosion and flood and also as an aquifer replenishment (Salem et al. [7]; Brhane et al. [8]; Fleskens et al. [9]). It can reduce the demand for mains water supply [10] therefore reducing the amount of energy used in pumping of mains water, along with the associated pollution and carbon dioxide emissions. RWH is very effective in mitigating the impacts of stormwater runoff pollution and enhancing water quality [11,12,13]. In improving water quality, runoff that generates impacts on water bodies in urban areas (automobile and asphalt contaminants) and rural areas (animal waste, fertilizer, herbicides and pesticides) can be reduced with harvesting rainwater [12,13]. Furthermore, examples of RWH systems can be found in all parts of the world and it has been observed to reduce water bills to meet the needs of remote communities or individual households in arid regions. Research by Basupi et al. [14], discovered RWH to be more cost effective, resilient and climate-change mitigating than conventional (re)design of water distribution systems (WDSs). Furthermore, there is reduction in sewerage disposal and treatment thereby reducing the amount of energy consumed [15]; Cook et al. [16]. Also the overall energy consumption associated with RWH systems is a very minor fraction of total building energy consumption [15].

Moreover, climate change has been reported to likely increase the variability of precipitation and the number of flood and drought episodes [17]. These predictions emphasize the need to adapt water management to new and challenging environmental and socio-economic conditions [18]. RWH may play a central role in widening water security and reducing impacts on the environment [19] by turning hazards like floods and polluted water into local resources (water for non-potable uses). Even though Scotland is known for abundant rainfall, the east coast tends to be much drier with some parts receiving only 550mm of rain (UK Meteorological Office) which puts it on par with Morocco, Sydney and Barcelona; therefore there is the need to conserve water through harvesting rainwater for non-potable uses like flushing the toilet, gardening and car washing.

1.2 Problem Statement

Despite the common perception that Scotland enjoys abundant rainfall, water resources there are under pressure. A high volume of water is taken from the environment for human use, which also requires a high amount of energy to transport and treat it for human consumption. Water Supply Companies (WSCs) in the United Kingdom (UK) spend approximately £10 billion removing urban runoff from developments and importing treated water for consumption [20]. In 2015, it is projected to reach approximately £12 billion [21]. Within the context of changing climate and reducing carbon footprints, this situation is not compatible with sustainable development. We need to plan carefully for the future to ensure reliable water supplies are available for everyone whilst protecting the natural environment [22].

As a water saving scheme, RWH can reduce dependence on the drinking water supply, flooding and the pressure on urban drainage infrastructure. Literature related to RWH in Scotland is limited with regards to RWH and receptivity of households towards this technology. Furthermore, in the context of a changing climate and reducing carbon

emissions, government agencies, private organizations, and individuals are or have faced a change in the climate over the years which might have affected water resources. To achieve carbon reduction targets and be water neutral at the same time, organizations need to find the most cost-effective ways of achieving these goals. One way to achieve such a goal is to consider a water saving scheme like RWH which reduces the amount of energy used to transport and treat water, thus reducing carbon emissions. The Scottish Environmental Protection Agency (SEPA) has shown concern about Scottish water resources given the uncertainties that climate change may bring; hence households need to conserve water by resorting to other alternatives as grey water and RWH [23].

There is the need to understand, and have a clear methodology which can define the different technologies and the risks (including financial) associated with RWH in Scotland with much focus on the policy context, socio-economic drivers and public perception. When these real-world problems are considered together, it will establish a clear need for a methodology which promotes RWH; in particular, it allows the drainage and water supply needs of different development types/scales to be assessed in a way which is sustainable and efficient. This methodology will limit environmental impacts whilst optimizing RWH and water consumption. According to Ward et al. [15], understanding the receptivity, of water-users such as householders to RWH, is vital in facilitating the promotion, appropriate installation, end-use and maintenance of these systems. There is therefore a need for a framework which bridges the gap between socio-economic acceptance, attitudes and perceptions towards RWH in Scotland.

1.3 Aims

The overall aim of this paper is to explore attitudes towards RWH among residents in Scotland. Questionnaire survey of households in rural areas with private water supplies were undertaken because it was assumed that users of PWS might be more inclined to save water because of the nature of their supply.

2. METHODOLOGY

To answer the research questions a postal questionnaire survey was conducted in three study areas: Aberdeenshire (AS), Highlands (HL) and Scottish Borders (SB). These areas were selected because they had the highest numbers of PWS users in Scotland. The questionnaire consisted of 40 questions in 4 sections: water supply and source of PWS (shared or not shared), measures of water consumption, water conservation and rainwater harvesting. This paper focuses on responses about RWH. The RWH question was based on: awareness and experience of RWH; willingness to implement RWH if incentives and or financial grants were given and technical adaptations of the system (maintenance, easy to use); likelihood of using and the acceptability of RWH for domestic purposes and the preference for a communal or individual RWH system. At the end of the questionnaires, participants were asked if they wanted to participate in focus group discussion to learn more about RWH and also to add comments.

Scottish Borders was used as a pilot study to test the response and distribution of the questionnaires. Over all a total of 1,000 questionnaires were distributed within the areas as follows (expected returns are shown in brackets): Aberdeenshire had the highest PWS users so a total of 400 questionnaires (80) were sent; Highlands the second highest; 350 questionnaires sent (70) and Scottish Borders which was the third highest was sent 250 questionnaires (50). The questionnaires were posted randomly to the selected study areas using the list of private water users provided by their council. A small number of returned/non-delivered surveys were voided, and replaced with additional mailings. An additional 34 questionnaires were added in this way.

3. RESULTS AND DISCUSSION

The expected response rate was 20% in all the study areas. Notwithstanding, the overall response rate received was approximately 24% and it was represented as follows: Scottish Borders (9.8%); Aberdeenshire (7.4%) and Highlands (6.5%). However, based on questionnaires sent to individual study areas, the actual response rate was 27% and 28% in Scottish Borders and Highlands respectively; but for Aberdeenshire it was 19% response rate which was marginally low. In the data analysis, the responses reported here were grouped into sections titled: socio-economic and technical adaptations (the willingness to implement if grant was given, how easy it was to implement and the financial benefits) and behaviour which

comprised of the attitudes and perceptions (awareness and experience of RWH; likelihood, acceptability of RWH). Generally, respondents were unwilling to use RWH but if incentives like grants were given, participants were willing to implement RWH. A greater part was not likely to finance RWH installation themselves since they believed RWH not to be financially beneficial to their households.

3.1 Socio-economic and Technical Adaptations of RWH in Scotland

The issue of how environmental technologies should be paid for is an important one in understanding attitudes to, and adoption of energy and water-saving technologies. Participants were initially asked if they were aware of RWH; approximately 28% were aware of RWH (Table 1). The survey further asked householders under what circumstances they were likely to adopt/implement RWH. The majority of the participants said that they would be likely to implement RWH if it was paid for by their Local Authority: HL (55%), SB (58%) and AS (59%), whereas only a minority of respondents would be willing to fund it themselves (Fig. 1). As the figure shows, there is a clear preference for some form of grant either by from a Local Authority or another organisation (Fig. 1). This result corresponds to research by Ward et al. [24]; Islam et al. [25] and Parson et al. [26], where participants were willing to implement and or consider RWH if the government provided some incentive in the form of subsidies. Further research in the UK shows financial and economic constraints have been a barrier to the installation of RWH in new UK houses and will remain until governmental incentives are introduced [26]. Therefore it was not surprising that respondents were willing to implement RWH if grants were given. New regulations and incentives that foster the use of rainwater are increasingly being developed worldwide by governments at both the local and regional levels [18] and this has been successful. Governments have been known to financially support and have approved regulations and policies for RWH implementation in countries like Brazil, Belgium, India, Jordan, Sri Lanka, some American states (Arizona and New Mexico) and some Caribbean Islands (Goonetilleke et al. [27]); Ministry of Urban Development and Water Supply Sri Lanka, [28]; Environmental Agency UK [29]; Domènech and Sauri [18].

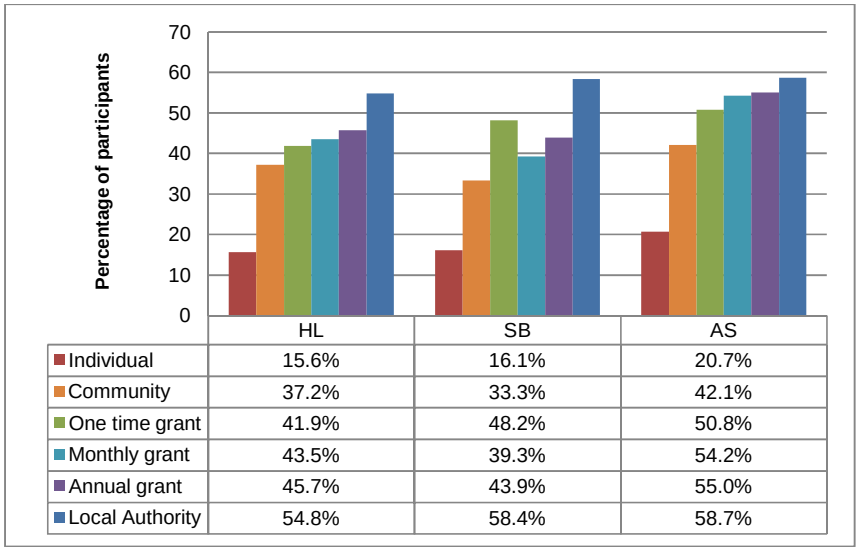
In addition to financial grants, some countries offer rebates and tax exemptions to inhabitants to promote RWH installation. Examples include Texas in the United States where rebates and tax exemptions are offered to champion RWH [Texas Water Development Board, [30]); Australia where several initiatives (rebates) at the national and regional level promote the use of alternative water sources such as RWH to all houses installing RWH [31] and in Germany where rainwater harvesters are exempt to pay storm water taxes [32] and also uses various RWH incentives and subsidies [33]. This is also the case in the UK, but the amount of the rebate is very small and almost no one takes it up. Therefore there is the need to look into the cost of RWH installation and the feasibility installation of RWH systems so that a policy for implementation of RWH systems in the homes may be designed in Scotland.

Comparing an individual setup to a community setup, most respondents preferred the idea of a community scheme (Fig. 1).

Although RWH is not necessarily a constant supply at all times, participants where asked if they will consider RWH as a water supplement if it will ensure constant water supply. Most respondents in Scottish Borders (57%) and Aberdeenshire (63%) said they were likely to consider RWH if it will ensure constant water supply. This was because it was observed some PWS supply dry up in summer or freezes up in winter. But in the Highland the level was marginally below 50% (Fig. 2), however, it should be noted the percentage willing to consider was more than the percentage not willing to consider (20%) and neutral (33%) (Fig. 2). Therefore it can be said from the three study areas most respondents were willing to consider RWH if it will ensure there was constant water available.

Table 1. Does your house have any form of rainwater harvesting such as a water butt or a storage tank that specifically collects rainwater?

	Frequency	Percent	Valid percent	Cumulative percent
No	170	71.7	71.7	71.7
Yes	67	28.3	28.3	100.0
Total	237	100.0	100.0	



	HL	SB	AS
Individual	15.6%	16.1%	20.7%
Community	37.2%	33.3%	42.1%
One time grant	41.9%	48.2%	50.8%
Monthly grant	43.5%	39.3%	54.2%
Annual grant	45.7%	43.9%	55.0%
Local Authority	54.8%	58.4%	58.7%

Fig. 1. Socio-economic incentives to implementing RWH: HL (Highland); SB (Scottish Borders); AS (Aberdeenshire)

According to Barthwal et al. [34], people are now envisaging the implications that might be associated with the negligent management of water resources and given a choice, people would choose a strategy that would help them avoid a situation of scarcity of their water resources and may be inclined and be willing to participate in a program designed towards this cause (Sandakan Municipal Council 2008 [35]). In a RWH installation research in Brazil on subsidies, urban dwellers acknowledged the importance of diversifying the sources of water and becoming self-sufficient in terms of water supply [18]. This can be attributed to the response of participants willing to consider RWH if it will ensure there was constant water was available at all times. Furthermore, more than 50% of participants expressed in the comment box that they were willing to participate in focus group discussions to learn more about RWH. Some of the participants (approximately 28%) had some form of RWH in their house (Table 1) in the form of water butts which they used for gardening purposes but they did not realize they were harvesting rainwater. However, though they were considering RWH, they also perceived their buildings not to be appropriately designed for RWH.

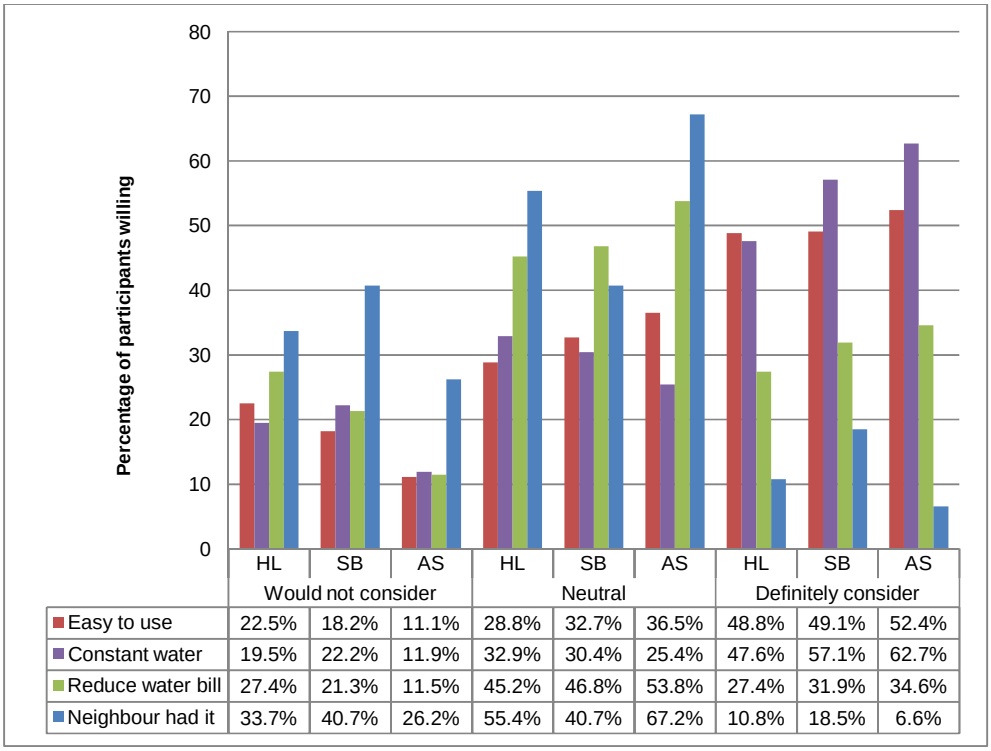
The survey explored the types of factors that would affect willingness to adopt RWH, including: a system that was easy to use; a system that improved/guaranteed water availability; that reduced bills; or was something the neighbours had.

Interestingly, among these PWS users, consistency of supply was more important to them than cost and this is seen in (Fig. 3) where they expressed RWH was not financially beneficial to them. This can be explained as a consequence of the low cost of water supply in Scotland, and the perception that water in Scotland is plentiful and free. This can be linked to the reason why participants were unlikely to implement RWH if it was to be paid by them but they were willing to consider it if it was easy to use (Figs. 1 and 2). However, with regards to a communal system or individual system, the results were slightly similar in all study areas where participants were not enthused to have it either way.

3.2 Behaviour, Attitudes and Perception of RWH in Scotland

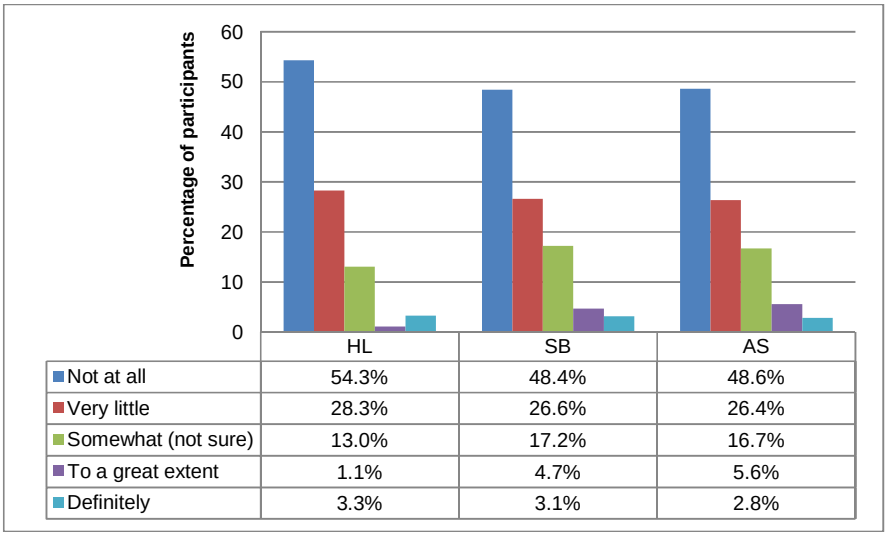
With regards to respondents' attitude and behaviour towards RWH implementation, majority of respondents said that they thought RWH perfectly acceptable for non-potable domestic purposes as dish washing, laundry, toilet flushing, gardening and car washing, but did not find it acceptable for drinking and bathing (Fig. 4). Additionally, participants perceived Scotland to have abundant and unlimited water resources; thus it was not important to use RWH for drinking and bathing. The observed acceptability for these purposes, according to Ward et al. [36,15], correlates to participants perceiving these uses to be less risky. Perceived

risk according to Ward et al. [36], is assumed when the type of use of rainwater becomes personal as in drinking and bathing therefore they do not find it acceptable. However for uses like gardening and toilet flushing where it is perceived not to be personal use they find it perfectly acceptable. And, a small number of respondents already use a water butt to collect rainwater for garden use [AS (35%); HL (26%); SB (25%)]. Similarly, studies by Hurlimann [37] identified that participants' perception of risk increased as the use became increasingly personal. Hence participants not finding RWH to be acceptable for drinking and bathing in this study can be attributed to the perceived risk of personal use of rainwater.



	HL	SB	AS	HL	SB	AS	HL	SB	AS
	Would not consider			Neutral			Definitely consider		
Easy to use	22.5%	18.2%	11.1%	28.8%	32.7%	36.5%	48.8%	49.1%	52.4%
Constant water	19.5%	22.2%	11.9%	32.9%	30.4%	25.4%	47.6%	57.1%	62.7%
Reduce water bill	27.4%	21.3%	11.5%	45.2%	46.8%	53.8%	27.4%	31.9%	34.6%
Neighbour had it	33.7%	40.7%	26.2%	55.4%	40.7%	67.2%	10.8%	18.5%	6.6%

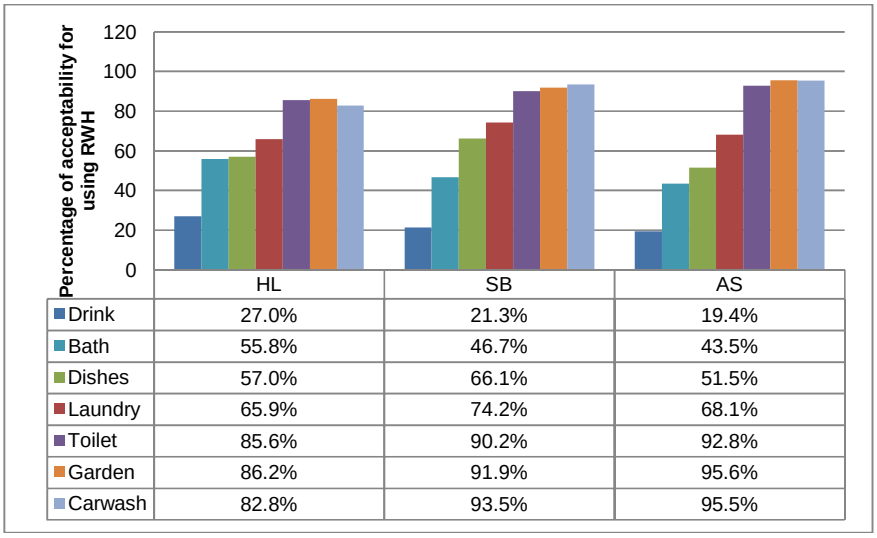
Fig. 2. Adaptations and inclinations to implement RWH



	HL	SB	AS
Not at all	54.3%	48.4%	48.6%
Very little	28.3%	26.6%	26.4%
Somewhat (not sure)	13.0%	17.2%	16.7%
To a great extent	1.1%	4.7%	5.6%
Definitely	3.3%	3.1%	2.8%

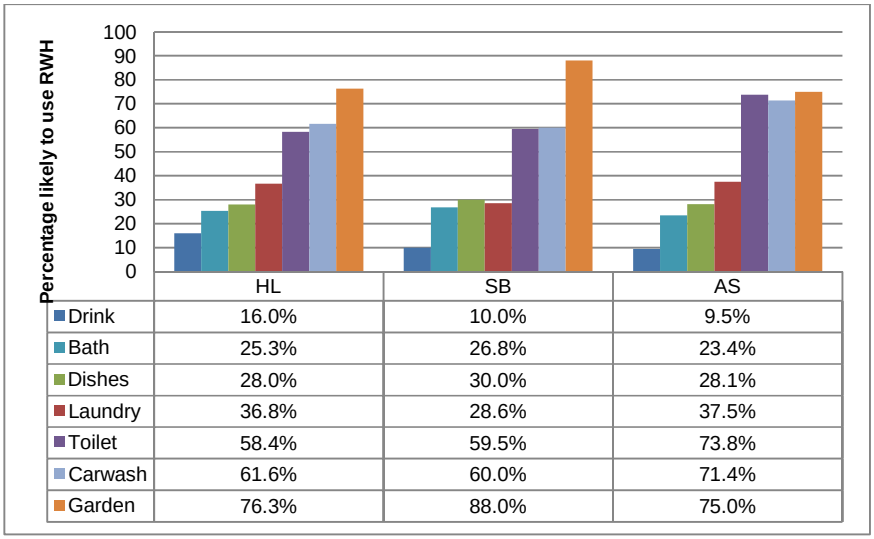
Fig. 3. Participants response to RWH being financially beneficial

Though they found RWH to be acceptable for most domestic purposes, they were only extremely likely to only use it for toilet flushing, car washing and gardening (Fig. 5) which further corroborates Ward et al. [36] and Hurlimann [37], where the perceived risk increases as the type of use becomes increasingly personal. Furthermore, some respondents said they would not use RWH for drinking because there was the possibility of the water being infested with crow droppings. According to Sadhu et al. [38], rainwater collected and stored in domestic tanks may contain a range of microorganisms from one or more sources which might or might not be harmless but further stresses that the safety of rainwater will depend on excluding or minimizing the presence of enteric pathogens. Even though there is some health risks associated with RWH, according to Sadhu et al. [38], the chemical and physical quality of rainwater may not directly cause health risk but can influence water disinfection methods and promote bacterial growth. However, they state that "*the physical and chemical quality of drinking water directly affects its acceptability to consumers*"; this may be the reason why some participants found it unacceptable for drinking purposes.



	HL	SB	AS
Drink	27.0%	21.3%	19.4%
Bath	55.8%	46.7%	43.5%
Dishes	57.0%	66.1%	51.5%
Laundry	65.9%	74.2%	68.1%
Toilet	85.6%	90.2%	92.8%
Garden	86.2%	91.9%	95.6%
Carwash	82.8%	93.5%	95.5%

Fig. 4. The level of acceptance of using RWH for domestic purposes



	HL	SB	AS
Drink	16.0%	10.0%	9.5%
Bath	25.3%	26.8%	23.4%
Dishes	28.0%	30.0%	28.1%
Laundry	36.8%	28.6%	37.5%
Toilet	58.4%	59.5%	73.8%
Carwash	61.6%	60.0%	71.4%
Garden	76.3%	88.0%	75.0%

Fig. 5. The likelihood of using RWH for domestic purposes

4. CONCLUSION AND RECOMMENDATION

Overall, this research revealed that Scottish respondents have a low level of awareness about RWH, with little technical knowledge or understanding of the implementation of RWH. However, respondents showed varied awareness and acceptability of installing RWH systems. Therefore the main findings of this paper are:

1. Participants were willing to use RWH if grant funded by local authority but not by self.
2. There was indifference of preference between individual or communal systems.
3. Participants would be willing to consider if RWH was easy to use and had a constant supply.
4. Participants found RWH to be acceptable for non-potable applications such as toilet flushing, gardening and car washing.

Furthermore, participants asked questions and were interested in RWH systems. Coupled with the lack of knowledge and technical expertise relating to the design and installation of RWH and willingness of some participants to install RWH, the following recommendations have been determined:

1. Government can start by implementing educational programs in conventional school-system instruction and curriculum, educational symposiums / workshops, outreach, and accessible informative literature for the public on RWH since respondents showed a low level of awareness about RWH. They can take a cue from certain municipalities in the United States that have implemented educational programs.
2. Since there is no existing policy of RWH implementation in Scotland, Government in Scotland should consider the introduction of new regulations and incentives that foster the use of rainwater by looking into the cost of RWH installation and the feasibility installation of RWH systems so that a policy for implementation of RWH systems in the homes may be designed.
3. Local Authorities can also create incentives and encourage RWH as most participants have been shown to be interested if grants are given at the local level.
4. Most participants felt their building design could not accommodate RWH therefore it will be good to have buildings designed in a way that supports RWH.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Forslund A, Renöfält BM, Barchiesi S, Cross K, Davidson S, Farrell T, Meijer K, Krchnak K, Smith M, McClain M. Securing water for ecosystems and human well-being: The importance of environmental flows. Swedish Water House Report 24. SIWI; 2009.
(Accessed 25 April 2013)
Available:http://www.siwi.org/documents/Resources/Reports/Report24_E-Flows-low-res.pdf.
2. UNICEF & World Health Organization. Progress on Sanitation and Drinking-Water, 2013 Update.
(Accessed on 22 January 2014)
Available:http://apps.who.int/iris/bitstream/10665/81245/1/9789241505390_eng.pdf
3. Pass G. Many people still take water for granted reports water and health researcher Sharon Kleyne. Reported speech from Sharon Kleyne as she predicts increasing global water wars and shortages; 2014.
(Accessed 22 January 2014)
Available:http://www.prweb.com/releases/2013/8/prweb10999739.htm
4. Office for National Statistics. Changes in UK population over the last 50 years: Part of Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2013 Release; 2014.
(Accessed 1 May 2014)
Available:http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/2013/index.html
5. Department for Environment Food and Rural Affairs (DEFRA). Future Water: The Government's water strategy for England.
(Accessed 1 May 2015)
Available:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69346/pb13562-future-water-080204.pdf
6. Oweis T, Hachum A. Water harvesting and supplemental irrigation for improved water

productivity of dry farming systems in West Asia and North Africa Agric. Water Manage. 2006;80:57–73.

7. Salem HM, Valero C, Muñoz MT, Gil-Rodríguez M. Effect of integrated reservoir tillage for in-situ rainwater harvesting and other tillage practices on soil physical properties. Soil and Tillage Research. 2015;151:50-60.
8. Brhane G, Wortmann CS, Mamo M, Gebrekidan H, Belay A. Micro basin tillage for grain sorghum production in semiarid areas of northern Ethiopia Agron. J. 2006; 98:124–128.
9. Fleskens L, Stroosnijder L, Ouessar M, De Graaff J. Evaluation of the on-site impact of water harvesting in southern Tunisia J. Arid. Environ. 2005;62:613–630.
10. Ahmed A, Smithson E, McGough D. The potential of rain water harvesting for increasing building and urban resilience: A case study of Coventry University and Coventry City Centre. Smyth B, Jenkins J. (Eds.), in Proceedings of the Water Efficiency Conference 2014, 9-11 September. Brighton, UK: WATEF Network / University of Brighton. 2014;83-92.
11. Coombes PJ, Kuczera G, Kalma JD, Argue JR. An evaluation of the benefits of source control measures at the regional scale. Urban Water. 2002;4:307–320.
DOI: 10.1016/S1462-0758(02)00028-6
12. Hamdan SM. A literature based study of stormwater harvesting as a new water resource. Water Sci. Technol. 2009;60: 1327.
DOI: 10.2166/wst.2009.396
13. Xichang W. An applied research in the rural landscape of rainwater collection system based on the concept of LID. IEEE. 2015;72–75.
DOI: 10.1109/ICITBS.2015.24
14. Basupi I, Kapelan Z, Butler D. Reducing life-cycle carbon footprint in the (re)design of water distribution systems using water demand management interventions. Urban Water Journal. 2014;11(2):91-107.
15. Ward SL, Barr S, Memon FA, Butler D. Rainwater harvesting in the UK: Exploring water-user perceptions, Urban Water Journal. 2012;10(2):112-126.
DOI: 10.1080/1573062X.2012.709256
16. Cook S, Sharma A, Chong M. Performance analysis of a communal residential rainwater system for potable supply: A case study in Brisbane, Australia. Water Resour. Manag. 2013;27: 4865–4876.
DOI: 10.1007/s11269-013-0443-8
17. IPCC: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, et al (Eds.). Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; 2007.
18. Sauría D, Domènecha L. A comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the Metropolitan Area of Barcelona (Spain): social experience, drinking water savings and economic costs. Journal of Cleaner Production. 2011;19(6–7):598–608.
19. El-Sayed M, Mahgoub M, van der Steen NP, Abu-Zeid K, Vairavamoorthy K. Towards sustainability in urban water: A life cycle analysis of the urban water system of Alexandria City Egipt. J. Clean Prod. 2010;18(10–11):1100–1106.
20. Caffoor I. Energy efficient water and wastewater treatment. Priority Technology Area 3. Energy Efficient Environmental Knowledge Transfer Networks. Energy Efficient Water & Wastewater Treatment (EEWWWT) Business Case PDF File; 2008.
21. Ashley and Cashman. The impacts of change on the long-term future demand for water sector infrastructure, in infrastructure to 2030: Telecom, Land Transport, Water and Electricity, OECD, Paris. 2009;289. (Access 23 January 2014)
Available:http://www.oecd.org/futures/infrastructureto2030/40953164.pdf
22. Environment Agency (EA). A scenario approach to water demand forecasting, National Water Demand Management Centre, Worthing. PDF File; 2010.
23. Scottish Water. Shaping the future of your water and waste water services; raft Strategic Projections; 2012.
(Accessed 24 January 2014)
Available:http://www.scottishwater.co.uk/assets/consultation%20site/consultation_guide_2012.pdf
24. Ward S, Butler D, Memon FA. Benchmarking energy consumption and CO_2 emissions from rainwater harvesting

systems: An improved method of proxy. Water and Environment Journal. 2011; 26(2):184–190.
25. Islam MM, Chou FNF, Kabir MR. Feasibility and acceptability study of rainwater use to the acute water shortage areas in Dhaka City, Bangladesh. Natural Hazards. 2011;56:93–111.
26. Parsons D, Goodhew S, Fewkes A, and De Wilde P. The perceived barriers to the inclusion of rainwater harvesting systems by UK house building companies. Urban Water Journal. 2010;7(4):257–265.
27. Goonetilleke A, Thomas E, Ginn S, Gilbert D. Understanding the role of land use in urban stormwater quality management J. Environ. Manage. 2005;74:31–42.
28. Ministry of Urban Development and Water Supply Sri Lanka, 2005. Ministry of Urban Development and Water Supply Sri Lanka National Rainwater Policy and Strategies; 2005.
(Accessed 10 November 2012)
Available:
http://www.lankarainwater.org/rwhsl/nrwpolicy_2005.pdf
29. Environmental Agency UK. Harvesting Rainwater for Domestic Uses: An Information Guide; 2008.
(Accessed 19 November 2011)
Available:http://publications.environment-agency.gov.uk/pdf/GEHO0108BNPN-E-E.pdf
30. Texas Water Development Board. The Texas Guide on Rainwater Harvesting. Austin, Texas (third ed.); 2005.
(Accessed 10 March 2010)
Available:http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf
31. Australian Government. Water for the Future. National Rainwater and Greywater Initiative; 2009.
(Accessed 10 November 2010)
Available:http://www.environment.gov.au/water/publications/action/pubs/nrgi.pdf
32. Herman T, Schmida U. Rainwater utilisation in Germany: Efficiency, dimensioning, hydraulic and environmental aspects. Urban Water. 1999;307–316.
33. Partzsch L. Smart regulation for water innovation – the case of decentralized rainwater technology. J. Clean. Prod. 2009;17:985–991.
DOI: 10.1016/j.jclepro.2009.01.009
34. Barthwala S, Chandola-Barthwalb S, Goyala H, Nirmania B, Awasthia B. Socio-economic acceptance of rooftop rainwater harvesting – a case study, Urban Water Journal. 2013;11(3):231-239.
DOI: 10.1080/1573062X.2013.765489
35. Sandakan Municipal Council. Briefing on rainwater harvesting system application for buildings in Sandakan by Yap Siew Hen. Rainwater Harvesting Briefing Presentation for UKM delegation on 19th - 21st of March in "Rain Water Harvesting and Ground Water Recharging in North Western Himalayan Region for Sustainable Agricultural Productivity" (Authors: Kumar R, Thaman S, Agrawal G and Poonam S. Universal Journal of Environmental Research and Technology. 2011;1(4):539-544.
36. Ward S, Butler D, Memon FA. A pilot study into attitudes towards and perceptions of rainwater harvesting in the UK. 10th British Hydrological Society National Hydrology Symposium, Exeter, UK. 2008;366-372.
37. Hurlimann A. Is recycled water risky? An Urban Australian community's perspective. The Environmentalist. 2007;27(1):83–94.
38. Sadhu G, Chaudhary M, Chakravarty N. Health risk assessment of domestic roof water harvesting using failure mode and effects analysis: Evidence from Nagaur, Rajasthan, India. Human & Ecological Risk Assessment. 2014;20(3):668.