Climate change, rainwater harvesting and private water systems: Perceptions, attitudes, and behaviours in Scotland

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ABSTRACT

Water resources in Scotland are under immense pressure despite the perception that it rains a lot and there are abundant water resources. High amount of energy is utilized for the transport and treatment of water for consumption which contradicts the UK government's carbon neutral agenda. Climate change is also expected to alter precipitation patterns in the UK especially Scotland despite the perception that it rains a lot and there are abundant water resources. There is the need to adapt to water-related changes by ensuring reliable water supply to households whilst protecting the natural environment.

This study explored the feasibility of rainwater harvesting (RWH) and climate change impacts on water supply in some selected peri-urban areas in Scotland. Other parameters of a water neutral development in Scotland were explored in the form of water consumption, water saving devices and water-related energy activities. Paper questionnaires were administered randomly to households using private water supply (PWS) in three local areas: Highland, Scottish Borders and Aberdeenshire and one household on the public mains water supply (MWS), Edinburgh over a period of 4 months. Overall, 378 residents' responses and 8 stakeholders were interviewed on the feasibility of RWH in Scotland.

Residents surveyed (98%) were aware of climate change in terms of the media, friends, and community. There were a lot of neutral outliers and negative responses from residents surveyed as to whether climate change was happening. When "wording" like the weather, floods, droughts, and water pollution were used, residents could relate to it happening and having a negative impact on their water resources.

Just over half (53%) of residents surveyed had "no water saving device" and the most water saving device was a dual-flush toilet (32.9%). A high percentage (66.3%) believed it was important to conserve water through alternatives like RWH.

For RWH to be acceptable, and implemented in Scotland, majority (66.7%) of residents felt having RWH would not be financially beneficial to them and their household but will implement it if given some form of grants. There was a distinct difference between PWS users MWS users; high proportion of PWS users perceived RWH not to be financially beneficial to them. More than half of the residents surveyed (55.6%) were willing to consider RWH if will ensure there was always constant water available and if it was easy to use (54.6%). Stakeholders felt, it will be difficult to implement RWH in Scotland, and sometimes confused RWH with greywater. Stakeholders perceived RWH as a climate change mitigation solution impossible.

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DECLARATION STATEMENT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PUBLICATIONS BY THE CANDIDATE

Egyir, S., Brown, C., Arthur, S., (2016). Rainwater as a Domestic Water Supplement in Scotland: Attitudes and Perceptions. Br. J. Environ. Clim. Change 6, 160–169. doi:10.9734/BJECC/2016/23723.

Egyir, S. N., C. Brown, C., Arthur, S., (2015). Public perceptions of climate change impact on Scottish private water resource**s**. Transactions of the Wessex Institute. PaperDOI:10.2495/WS150011.

Glossary

AWS- Alternate Water Systems

DWQR- Drinking Water Quality Regulator

GHG- Green House Gas

H_0- Null hypothesis

H_1- Alternative hypothesis

HL- Highland

Met- Meteorological

MWS- Main Water Supplies

OPA- Overall Performance Assessment

PWS- Private Water Supplies

RW- rainwater

RWH- rainwater harvesting

SEPA- Scottish Environmental Protection Agency

SWM- Sustainable Water Management

WC- water closet

WICS- Water Industry Commission Scotland

SW- Scottish Water

EHO- Environmental Health Information Officer

SEHO- Stornoway Environmental Health Officer

TOIS- Technical Officer Infrastructure Services

P- Participants

HN- Hydro Nation Manager

WID- Water Industry Division

CABS- Citizen Advice Bureau Scotland

CHAPTER 1- INTRODUCTION

1.1 INTRODUCTION

Water resources are essential for life and important not only to society but also for healthy ecosystems (Forslund *et al*., 2009). Adequate supply of clean drinking water is important to sustain human life, but millions of people throughout the world still do not have access to this necessity (World Health Organisation/United Nations Children's Emergency Fund, 2013) and those who have access tend to take it for granted (Pass, 2013). Despite the earth often being called the “Blue Planet,” warnings of increasing water scarcity in the world are common (Oki, 2006); nearly 80% of the world’s population are exposed to high levels of threat to water security (Vörösmarty *et al*., 2010). As early as in 1995, approximately 60% of European cities with more than 100,000 people were using their groundwater at a faster rate than it can be replenished (Stanners *et al*., 1995).

Furthermore, climate change and an increase in population are also pressuring water resources across the world (Ashley *et al*., 2003) which exacerbates the water scarcity issue globally. Even though climate change has been argued to affect future water supplies, the magnitude and severity of the impact is not properly understood (Chartres and Varma, 2010). However, water widely regarded as the most essential of natural resources and freshwater systems are directly threatened by human activities which are further affected by anthropogenic climate change (Meybeck, 2003; U.S. Global Change Research Program, 2009). Climate change has been reported to likely increase the variability of precipitation and the number of flood and drought episodes (Intergovernmental Panel on Climate Change (IPCC), 2007). Incidences of flooding increase year on year (Ward, 2010), which does not only affect people, but also affect the natural drainage system. With variations in the hydrologic regime due to global climatic, demographic, and economic changes have serious consequences for people and the environment. Extreme climate events such as aridity, drought, flood, cyclone, and stormy rainfall are predicted to leave an impact on human society (Pandey *et al*., 2003). These predictions emphasize the need to adapt water management to new and challenging environmental and socio-economic conditions (Domènech and Sauri, 2011).

1.2 BACKGROUND

Water is not distributed evenly over the globe and agriculture dominates world water use (World Business Council for Sustainable Development, 2005). There are however variations within countries on how water is used because of different incomes of nations. In many developing and or low income countries, irrigation accounts for over 90% of water which are withdrawn from available sources (World Business Council for Sustainable Development, 2005). Notwithstanding, in England where to some extent it is assumed that rain is abundant year round, water used for agriculture accounts for less than 1% of human usage (World Business Council for Sustainable Development, 2005). Yet even within Europe, water used for irrigation in Spain, Portugal and Greece exceeds 70% of total usage (World Business Council for Sustainable Development, 2005). Global use of water is further outlined in Figure 1.1.

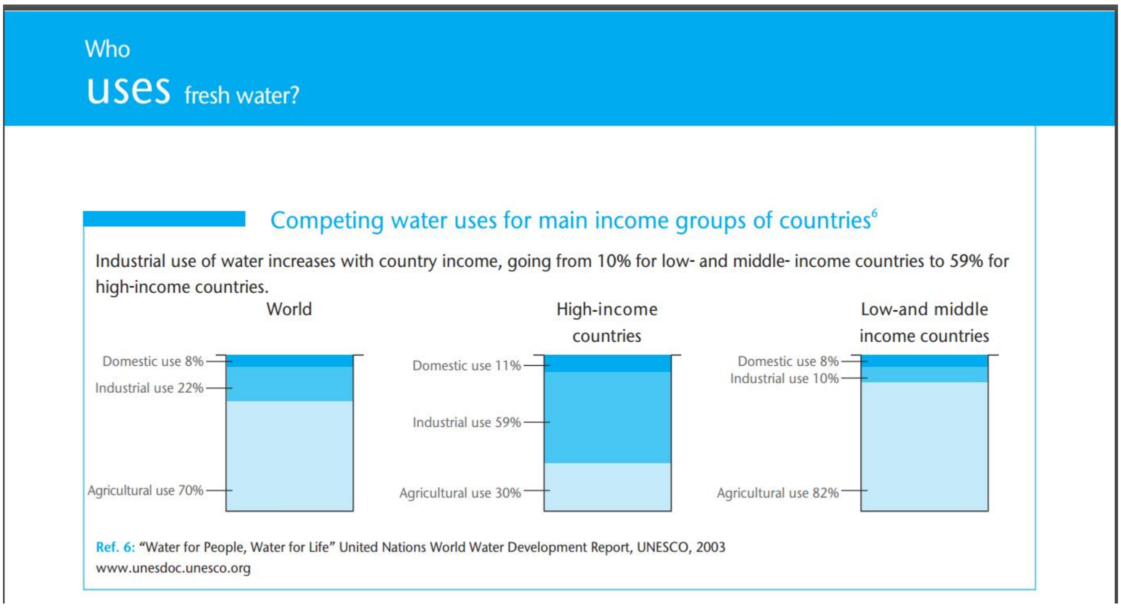


Figure 1.1: The World Business Council for Sustainable Development Water and Sustainable Development report on water uses per income of developing and developed countries in 2005 (Source: World Business Council for Sustainable Development, 2005)

There is a wide variation in average per capita water withdrawals for domestic use from different nations. Although UK has less available water per person than most other European countries (Waterwise, 2012), households in the UK are the biggest users of water. In the UK, approximately 55% of domestic supply of water for human consumption is flushed down the toilet (DEFRA, 2008). 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 (Oweis and Hachum, 2006). This means controlling or utilizing rainwater close to the point rain reaches the earth and it has been known to control erosion, flooding and as an aquifer replenishment (Salem *et al*., 2014; Brhane *et al*., 2006; Fleskens *et al*., 2005). It can reduce the demand for mains water supply (Ahmed *et al*., 2014) therefore reducing the amount of energy used in pumping of mains water, along with the associated pollution and carbon dioxide emissions. For every inch of rain that falls on a catchment area of $148.64m^2$, approximately $2.27m^3$ of rainwater is expected to be collected (University of California, n.d.). Considering a catchment area of $148.64m^2$ and with an average annual precipitation 61.8 inches in Scotland (Meteorological Office, n.d.), Scotland can collect $224.58m^3$/year. Considering the same catchment area of $148.64m^2$, the average yearly precipitation of Northern Scotland (67.8 inches), Western Scotland (70.4 inches) and Eastern Scotland (46.6 inches) will yield $246.38m^3$, $255.83m^3$ and $169.34m^3$ each year respectively. These are potential contribution that RWH can make to the water supply/demand and also reduce the kilo tonnes of carbon which is saved through less pumping of and treating water to good quality.

RWH is practised all over the world; both in developed and developing countries (Fewkes, 2012; Brown *et al*., 2005; EA, 2003). Apart from serving as alternative water supply (potable and non-potable); it is known to diminish flooding and the flow to storm water drain by reducing peak storm water runoff (Guo and Baetz, 2007; Pandey *et al*., 2003). RWH has also been observed to reduce water bills to meet the needs of remote communities or individual households in arid regions (Aladenola and Adeboye, 2010; Burns *et al*., 2015; Campisano and Modica, 2012). Research by Basupi *et al*., (2014), discovered RWH to be more cost effective, resilient, and climate-change mitigating than conventional (re)design of water distribution systems (WDSs). Also, the overall energy consumption associated with RWH systems is a very minor fraction of total building energy consumption (Ward *et al*., 2012). Furthermore, researchers have evaluated the multiple benefits of RWH systems to include reduction of pressure on existing potable water distribution systems (WDSs), provision of backup supplies in cities with insufficient water supply capacity, cost savings to customers and provision of wider water resource conservation benefits (Aladenola and Adeboye, 2010; Burns *et al*., 2015; Campisano and Modica, 2012; Ward *et al.*, 2012). In the UK, households in England are recognising the benefits of RWH through the reduction of their water bills (DEFRA, 2008).

Benefits of RWH is not only restricted to England, some countries in the Caribbean regions have taken initiatives in using rainwater by incorporating them into existing water infrastructures (Butler and Ward, 2009; Ward, 2010; Burns *et al*., 2015). As water resources come under increasing pressure, it will become imperative that water is used wisely and its waste is curtailed (Environment, Food, and Rural Affairs, 2012). However, sustainably managing water infrastructure is one of the biggest challenges facing the water sector; doing so is essential to protect human health and the environment. The concept of water neutrality using RWH is to offset potable water use and ensure managing water through a combination of conservation, catchment, and recycling (Pass, 2013). A way to achieve this goal is to consider the concept of climate change and water neutral development by harvesting rainwater even in a climate with abundant rainfall. This channels the water back into the system to replace potable water which is used for non-potable uses like flushing the toilet, gardening and car washing to save energy and improve environmental health.

However, complex socio-economic factors influencing RWH need to be understood at the household scale to enable the development of innovative ways to offset the water consumed. The concept has been noted not to be effective and can become productive only when clear definitions and guidelines are developed (Hoekstra, 2008). This includes policies and acceptability of new technologies by people. There will be a need for scientific cogency in developing methods, guidelines, and policies for water neutrality in terms of RWH well as behavioural adaptation to the technical system. This can be achieved by investing in projects that promote the sustainable and equitable use of water within the environment and community.

Aside climatic variability putting water resources under considerable pressure, 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. Yet, less attention has been given to how human society directly influences the state of the terrestrial water cycle despite the presence of the socioeconomic equivalent of the Mauna Loa curve, the rapid population growth and economic development (Vorosmarty, 2000). According to Oki, (2006), the global population will certainly grow and water demand will increase as a result. In the UK alone, the population has increased by more than 10 million since 1964 and continues to grow (Office for National Statistics, 2014). This may lead to increase in pressure on fresh water resources and the infrastructure for managing mains water supply because of economic growth. Not to mention, in recent years several water suppliers in the UK have reported a water shortage in the summer months, mainly due to reduced rainfall and population growth and the growing number of single person households (NHS, Scotland, 2013). Moreover, an increase in population further stresses the water resources through widespread land cover change, urbanization, industrialization and engineering schemes like reservoirs and irrigation to boost human access to water (Vörösmarty *et al*., 2010).

As well, some researchers and water watchdogs argue that water supply in areas that have abundant water resources through urbanization because of increase in population and climate variability can go from abundant to scarce water resource in a short amount of time (Chartres & Varma, 2010; Zetland, 2011; Mubako *et al*., 2013). However, another school of thought claims that although increase in population will have an impact on water resources, globally, the future adequacy of freshwater resources for domestic human use is difficult to assess due to a complex and rapidly changing geography of water supply and use (Vorosmarty, 2000). Nonetheless, around the world, there are now various signs that human water use exceeds sustainable levels (Postel, 2000). If population continues to increase and water use exceeds sustainable levels, UK might suffer from water scarcity in the future. Indeed, the population is projected to increase by 17% from 2008 to 2033 in UK (Huby and Bradshaw, 2012) and at the same time the cost of maintaining a steady supply of clean water is likely to rise within the context of an ageing infrastructure and habits of water use by people in UK. This calls for the need for a sustainable water management as an increase in population worldwide and urbanisation coupled with the recent evidence of climate change, may result in insufficient water being available to meet the population demand (Ruth *et al*., 2007) both worldwide and in the UK.

Sustainably managing our water infrastructure is one of the biggest challenges facing the water sector but it is essential to protect human health and the environment. To do this there is the need to introduce a concept of water neutrality that offsets the use of water and ensure its viable use through a combination of conservation, catchment, recycling, and desalinization (Pass, 2013).

The water-neutral concept was first conceived in 2002 at a Johannesburg World Summit for Sustainable Development (Water Neutral, 2002). The concept provides the scientific basis for estimating the volume and geospatial source of water consumed by communities (Stockholm International Water Institute (SIWI), 2008). The preposition for the water neutral concept was to see whether humans can somehow neutralise or offset their water footprint. It was regarded as distinct in the sense that it attracts a broad interest where it creates opportunities to translate water footprint impacts into action within both communities and businesses (Hoekstra, 2008). These actions can mitigate the occurring impacts for positive actions to offset environmental and social impacts of residual water footprints (Hoekstra, 2008). RWH is a technology that is part of the water neutral development scheme. In ensuring water neutrality, consumers can reduce their direct (domestic) water footprint and or water consumption by using water saving devices, harvesting and using rainwater and recycled grey water (Schuetze and Santiago-Fandiño, 2013).

1.3 SCOTTISH PERSPECTIVE

Despite the common perception that it rains a lot in Scotland; some areas receive about 3,000 mm per year (the western Highland) while other areas only 800 mm per year (the East coast) (Meteorological Office, n.d.). Water resources generally in United Kingdom (UK) are under pressure (Waterwise, 2007). A high volume of water is taken from the environment for human use. This requires high amount of energy to transport and treat for human consumption. Water Supply Companies (WSCs) in UK spend approximately £10 billion removing urban runoff from developments and importing treated water for consumption (Caffoor, 2008). It was projected to reach approximately £12 billion in 2015 (Ashley and Cashman, 2006). It was also modelled by the Environment Agency (E.A.) in 2011 that less water would be available in the UK in future for businesses, people, and the environment of which Scotland is part. If this should happen, it can lead to water scarcity and or poverty of water. Within the context of changing climate and reducing carbon footprints, this situation is not compatible with sustainable development. There is the need to plan carefully for the future to ensure reliable water supplies are available for everyone whilst protecting the natural environment (EA, 2010).

There is therefore the need to conserve water through harvesting rainwater for non-potable uses. However, literature is limited in Scotland with regards to RWH and the receptivity of households towards this technology. There has been a substantial research on RWH systems (feasibility, adaptation, benefits, and acceptance) in England (Ward, 2008; Parson *et al*., 2010). In England, RWH was perceived to be financially beneficial to households. Moreover, many countries are now embracing sustainable water management (SWM) practices which includes RWH and it is now at the top of many country's agendas (Ward, 2010). Although RWH is not a universal remedy, it forms a valuable part of the SWM approach; having dual benefits of water supply and storm water source control (Ward, 2010). However, in Scotland, compared to other nations in UK, there is scarce information on the feasibility, acceptability, and benefits of RWH in Scotland. The NHS, Scotland perceives that Scotland had identified a need for national research into the significance of using RWH as a means of water conservation and there is a compelling need to find a stasis between existing water supplies with growing water demand. Thus, Scotland adoption of RWH is important even though the country is perceived to have abundant water resources.

As water resources come under increasing strain, it will become imperative that water is used wisely and its waste is minimised. It is therefore important to study the benefits of RWH in Scotland to reduce the pressure on the mains water supply and also as a water conservation measure. Concurrently the cost of maintaining a steady supply of clean water is likely to rise in the occurrence of climate change and extreme weather events (Huby and Bradshaw, 2012) even in Scotland. In the context of changing climate and reducing our carbon footprints, the government agencies, private organizations, and individuals are or have faced a change in the climate over the years which might have indirectly affected water resources and thence water supply. RWH may play a central role in widening water security and reducing impacts on the environment (El-Sayed *et al*., 2010) by turning hazards like floods (which happens in Scotland) and polluted water into a useable source of non-potable water. Dual-purpose RWH systems in Scotland can

provide storage within the catchment through detentions that have the capability of reducing urban flooding thereby minimizing storm water volumes and peak flow rates (Burns *et al*., 2015). In Japan, the impetus for implementing RWH was to minimize flooding and water supply and in Germany it was to reduce combined sewer overflow (CSO) releases (Butler and Ward, 2009; Ward, 2010).
To achieve carbon reduction targets as expected of the Scottish government and be water neutral as well, organizations within the Scottish government need to find the most cost-effective ways of achieving that. 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, and thus reduces carbon emissions. Research by Jackson *et al*., (2012), suggests that the Scottish' state control of economic and social matters approach to gas emissions gives a consistent policy framework. The framework allows for the focus on specific measures to reduce greenhouse gas emissions, while avoiding concerns about free-rider effects from non-participating councils. Thus, RWH when employed in Scotland can be one measure to reduce carbon emissions. Furthermore, the Scottish Environmental Protection Agency (SEPA) has shown concern on Scottish's water resources about the uncertainties that climate change may bring hence a need to develop alternatives like grey water and RWH (Scottish Water, 2012) thus echoing the need for research into the benefits of RWH in Scotland.

In 2013, Health Facilities Scotland identified a need for national research into the significance of using RWH for toilet flushing as a means of conserving water to balance existing water supplies with growing water demand in Scotland (NHS, Scotland, 2013). According to Water UK, (2007) this is the case all over the world even in countries that appear to have adequate water supplies like Scotland (Water UK position paper, March 2007). Even developed countries like Germany and Japan, who have embraced RWH, have their local governments addressing water crises by building greater water infrastructure around centralised recycled water treatment systems and are encouraging household-level installations of RWH (Nolde, 2007). However in so doing, since most researchers report that most communities are open to alternative water sources for domestic applications (Mankad and Tapsuwan, 2011), households on PWS in Scotland needs to identify and access the suitability of either a decentralised or a centralised water systems. Some countries have started legislating water conservation measures by incorporating the construction of decentralised systems into local development standards and building codes (Mankad and Tapsuwan, 2011). There is therefore the need for Scottish policy makers 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, public perception, and the preference for a communal or an individual system.

When these real problems are considered together, it will establish a clear need for a methodology which allows the drainage and water supply needs of different development types/scales to be assessed in a way which is sustainable and efficient. These will limit their impact on environment whilst optimizing RWH and water consumption. According to Ward *et al*., (2012), 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. This emphasizes the need for a framework which bridges the gap between socio-economic acceptance, attitudes, and perceptions towards RWH in Scotland.

1.4 RESEARCH AIM AND OBJECTIVES

The overall research aim of this thesis was to explore the feasibility of RWH in Scotland. By establishing the aim, this research is to contribute to the start of an implementation of a framework and or policy within which RWH is incorporated to reduce impact on the environment and mitigate against the impact of climate change on water resources by understanding people's attitudes, perceptions, and behaviours. This aim is thence achieved by meeting the following objectives:

1. Explore and understand the theories and practices of rainwater harvesting in the world;
2. To understand the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland;
3. To explore the factors affecting rainwater harvesting implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders' views; and
4. To explore the risk involved in using rainwater harvesting (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH.

These research objectives are further explained and summarized in the table below (Table 1.1). The justification of their selection is described in more detail in Chapter 3.

Table 1.1: Overview of the aim, objective and how the areas were explored to meet the objectives

AIM: To explore the feasibility of rainwater harvesting in Scotland	
Objectives	**Areas explored to answer and meet the objectives**
Explore and understand the theories and practices of rainwater harvesting in the world	• Looking at international examples of rainwater harvesting technology
To understand the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland	• Current information provision on climate change impacts on water resources globally • Assess the awareness of climate change, the perceived climate change and weather impacts on Scottish water resources and RWH as a potential mitigation towards climate change • Stakeholders' view
To explore the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders' views	• Current information provision of RWH in UK • Assess awareness of RWH, willingness, easiness to use/maintenance, financial incentives/benefits, and constant water availability • Assess households' preference for a community set-up or individual preference and willingness to implement RWH if it was a community set-up • Stakeholders' view
Explore the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH	• Current information provision • Assess the likelihood and acceptability for domestic purposes, perceived risks, positive environmental aspects through water conservation • Stakeholders' view

1.5 STRUCTURE

The thesis is divided into two parts. The first part discusses the perceptions of rainwater harvesting (RWH), climate change actions in the UK and the supply of water in Scotland. These chapters aim to acquaint the reader to understand the purpose of the study (aims); through exploring user perceptions of the of RWH around the world, the effect climate change may impact on Scottish water resources as compared to global impact and what householders think are sustainable acceptable solutions in relation to water conservation. Considering householders in Scotland think Scotland has abundant water resources, the appropriateness of the research method used for the study is explained in the methodology chapter. The second part discusses results of this study in a Scottish context through behaviour, beliefs, and attitudes towards RWH and climate change impact on Scottish water resources.

PART 1

The sections below feature a summary of the chapters in part one.

1.5.1 Chapter 1: Introduction

This includes a brief introduction, background and aims and objective of the research.

1.5.2 Chapter 2: Literature review

This chapter explores the feasibility and adaptation of RWH around the world and how countries have benefited from it. It further identifies gaps in RWH through the views, attitudes and perception of countries currently using it. The uncertainties that climate change may impact on Scottish water resources are discussed in conformity of water services resilience (water resource planning by understanding the sensitivity to climate change; water supply and quality) focusing on both Private Water Supply (PWS) and Mains Water Supply (MWS). The concept of water neutral is explored with a focus on what are socially acceptable and efficient design solutions for community water development to understand why participants might prefer an individual system or a community system.

1.5.3 Chapter 3: Research design and methods

This chapter explains the research design and philosophical foundations influencing the choice of methods and the research strategy. Based on the survey questionnaires and structured interviews, the research method is to identify the inclination towards RWH, the perceived impacts of climate change on Scottish water resources, frequency of water use in Scottish homes and water saving devices used in home to be water neutral. Using qualitative approach, results the survey are used in analysing the attitudes and perceptions of participants.

PART 2

The second part of the thesis is grouped into five chapters. The first chapter (Chapter 4) is on the demographics, statistics from the distribution of the questionnaires and the use of PWS. Prior to the statistics, it explores the selected study areas existing demographics and compares it to the demographics of the survey results. Then it explores the reasons for using PWS. The next three chapters (Chapters 5, 6, 7) present the findings of the research and discuss the results which are grouped into the objective of the research as themes. The first themed chapter (Chapter 5) focuses on climate change and Scotland's water resources. It explores the awareness of climate change and if climate change has an impact on Scottish water resources. Furthermore, it reviews if householders can distinguish between the weather and climate change and their willingness to reduce impact of climate change if it will influence their source of water supply. It also explores participants' desires and intentions (Figure 1.2) to reduce the impact of climate change through RWH.

The next two themed chapters on results and discussion (Chapter 6 and 7) are on RWH. Chapter 6 explores the socio-economic drivers: what makes RWH acceptable in Scotland, the financial incentives that drive it and the technical adaptations of RWH in Scotland; that is the ease of use, maintenance of the system and feasibility of adapting to the system by households. Chapter 7 on the other hand explores the attitudes and behaviour of RWH in Scotland through: beliefs, desires and intentions as shown below (Figure 1.2).

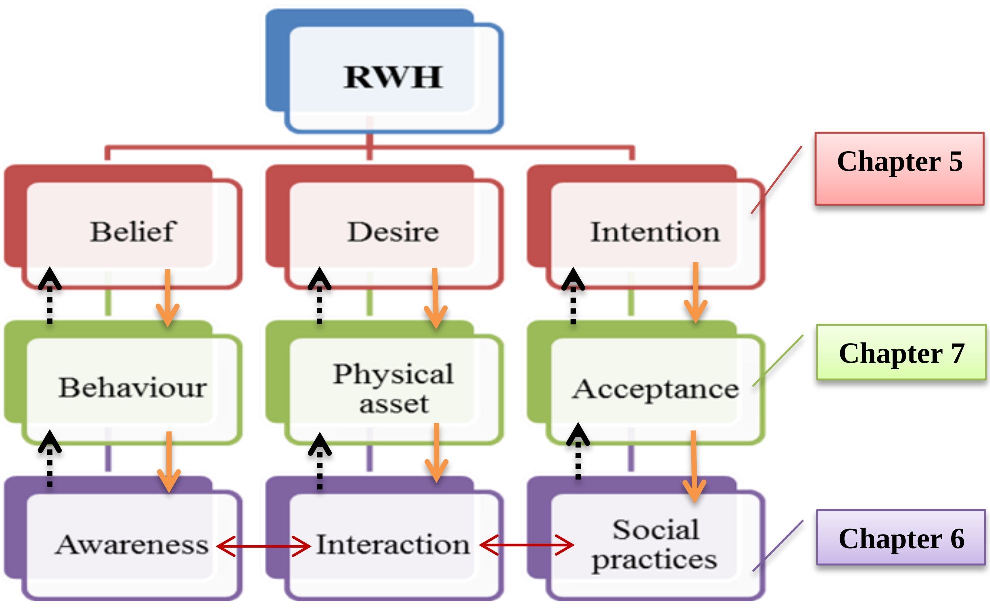


Figure 1.2: A diagram depicting how Chapters 6 and 7 were explored in this study

The beliefs, desire and intentions was an important part in this study and for the feasibility of a RWH in Scotland, these three keys translate into the assessment of the physical, social, and technical environments for it to be implemented. Figure 1.3 shows in detail how these three key factors with some interrelated are subsequently broken down for consideration.

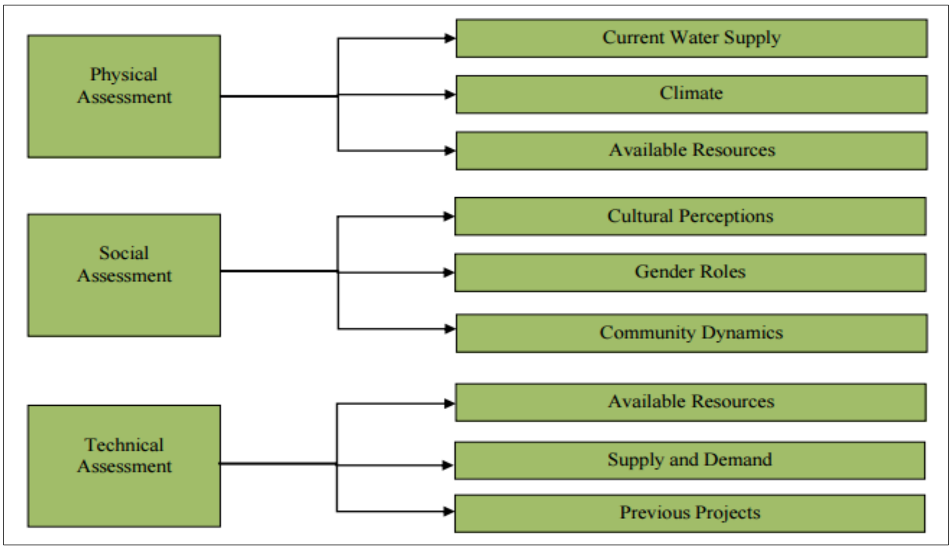


Figure 1.3: Areas to address when evaluating feasibility of a RWH system and exploring participants' desires and intentions to reduce the impact of climate change through RWH (Source: JeanCharles, 2007)

And the last chapter (Chapter 8) in the second part is on conclusions and recommendations from the overall study. The sections below feature a summary of the chapters in part two.

1.5.4 Chapter 4: Study areas and the use of private water supply (PWS)

This chapter summarises the responses from the questionnaires. The background of selected areas is explored in this chapter as well. Furthermore, households that answered the questionnaire are examined and compared with existing census data in Scotland. The use, source and reasons for using PWS and availability of MWS for people on PWS are also discussed in this chapter to understand the feasibility of RWH implementation. Additionally, shared PWS use is also explored to ascertain if community water development is acceptable to achieve part of Objective 3: "*exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance and ease of using the system) and stakeholders' views*".

1.5.5 *Chapter 5: Climate change and Scottish water resources*

The chapter analyses participants' perceptions on climate change and its effects on their source of water supply and Scotland's water supply. This was then compared to participants' perceived views on the weather as well to ascertain if they thought climate change and weather were two different phenomena. The parameters explored were energy, flooding, drought, water pollution (reduction in water supply and quality). After these parameters were used, participants' willingness to reduce the impact of climate change was further explored in this chapter to answer Objective 2: "*understanding the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland*". Stakeholders' interviews on climate change were also explored in this chapter to achieve Objective 2 and better understand the willingness to implement RWH.

1.5.6 *Chapter 6: Understanding the drivers for rainwater harvesting (RWH) in Scotland and acceptability of community RWH*

This chapter focuses on: water conservation through RWH, water energy relationship in domestic household, RWH implementation in terms of finance and incentives and the feasibility and easy adaptation of RWH. The measures of water consumption, water use and saving devices used in homes of households are additionally explored in this chapter. By understanding water consumption and the use of water saving devices used in the study areas, it helps in answering Objective 3: "*exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance and ease of using the system) and stakeholders' views*". Financial incentives, the ease, maintenance, and practicality of using RWH in Scotland are some of the drivers that are explored through the questionnaires. It further expands on previous international studies on RWH from Objective 1: "*explore and understand the theories and practices of rainwater harvesting in the world*". Furthermore, it tries to explore the acceptability of a water neutral concept through community adaptation of RWH in Scotland to achieve part of Objective 3 with references from Objective 1: "*explore and understand the theories and practices of rainwater harvesting in the world*".

1.5.7 Chapter 7: Attitudes to rainwater harvesting (RWH) in Scotland

This chapter explores from the questionnaire respondents' awareness, experience of RWH and unofficial collection rainwater. It was assumed some participants were already using rainwater but were not aware it was RWH, thus they were asked if they were willing to risk implementing RWH and the acceptability and likelihood of using it for domestic purposes to answer Objective 4: "*exploring the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH*". Considering RWH being identified as having dual benefits; as an alternative water supply, which helps reduce demand on potable supplies and as a storm water detention method to help allay urban flooding, understanding current user perceptions, including concerns and drivers, will help to facilitate a positive reaction to the promotion of such systems in Scotland.

1.5.8 Chapter 8: Conclusions and recommendations

The chapter, which is the final in the thesis, summarises the overall findings of this research and draws on a framework to allow for better policies that involves in public engagement. Furthermore, it advocates on public sensitization and recommends on innovative ways to make RWH appealing to the public in Scotland.

Chapter 2- UNDERSTANDING CLIMATE CHANGE AND WATER RESOURCES

2.1 INTRODUCTION

The previous chapter outlined the research aim and an overall outline of the thesis. This chapter explores climate change impacts on water resources, RWH (adaptations, attitudes, and perceptions) and community water development around the world and in UK. The purpose of this literature review was to expand on previous studies on climate change, RWH, policies and the acceptability of new technologies within a UK context and apply and or relate it to Scotland in terms of RWH and how it is feasible. Therefore, the overall research aim of this thesis was to explore the feasibility of RWH as a technology and technique part of the water neutral development scheme in Scotland. Thus, to reach there is the need for a review to understand participants' responses to the questionnaire survey. Therefore, to achieve the overall aim, this chapter covers 6 key topics:

1. Climate change
2. Water demand and supply in the UK
3. Water neutral development and attitudes to water saving in the UK
4. Rainwater harvesting
5. Community water development
6. Public acceptability to new technologies

2.2 THE ATTITUDES AND ADAPTATIONS TO CLIMATE CHANGE AND RAINWATER HARVESTING

The chapter begins with exploring climate change impact on water resources. This was to understand if RWH can be one of the climate change mitigation solution in terms of reducing floods, as a communal water neutral development and serving as water conservation measure for non-potable use. Therefore, climate change in the UK context is reviewed to understand and answer these questions below to meet Objective 2: "*understanding the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland*". In understanding and meeting Objective 2, these questions were asked and later compared to Scotland in the analysis:

- How do people perceive climate change?

- Does it have an impact on their water resources?
- Do households think climate change is happening in Scotland?
- What is the link between RWH and climate change? (The knowledge of climate change and its perceived effects on the source of water supply was also explored to observe if it is parallel to RWH implementation).
- Can RWH be one of the many climate change mitigation solution in Scotland?

Additionally, for RWH to be feasible in Scotland and also serve as a water neutral development scheme, water demand and supply in the UK has to be reviewed. This was to understand the Scottish context of RWH implementation. The structure of water supply and water consumption in Scotland is meant to give an idea on how participants' will perceive RWH. This was also further to understand their attitudes towards RWH, the willingness to implement RWH and to understand the drivers for RWH implementation, the acceptability of community RWH and water neutral development meeting Objective 3: "*exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders' views*". And understanding the risk involved in RWH through attitudes to and perception of RWH thus meeting Objective 4: "*exploring the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH*".

Thirdly, water neutral development was reviewed in conjunction with water saving devices. Harvesting rainwater is a technique that is part of the water neutral development scheme. The water neutrality concept was in relation to acceptability of a community water development in terms of RWH implementation. This was because literature shows that communities in the past have been known to work to neutralize the projected water demand of new development with water efficiency measures to create a neutral impact on overall water use (Alliance for Water Efficiency, 2015). Thus, the review on the water neutral development was to understand the feasibility of communal RWH implementation.

Finally, the history of RWH systems and their use in developing and developed countries are reviewed. This helps to contextualise the feasibility of implementation in

Scotland. The factors which influence the application and exploitation of RWH systems in the UK are discussed to review the Scottish perspective by looking at public acceptability to new technologies, community water development and energy conservation as a measure of water conservation. Therefore, the sub-topic areas were identified by taking an integrated view of RWH systems; its implementation, attitudes, and perceptions in both developing and developed countries. The purpose was to relate RWH implementation in Scotland to better understand and accomplish Objectives 3 and 4 by identifying the driving incentives for promoting RWH in Scotland by answering these questions:

- Is it feasible in Scotland?
- Are policies needed?
- Should we be concerned about public health?
- Is maintenance difficult?

Meeting Objective 1 of the research concludes the review which was done by exploring and understanding the theories and practices of rainwater harvesting in the world.

2.3 CLIMATE CHANGE IMPACTS ON WATER RESOURCES

Changes in climate pattern have been observed all over the world through rising global temperatures which are causing more extreme weather events, like flooding and heat waves (DEFRA, 2013). Climate change was perceived in the early 2000's to be the most persistent threat to global stability in the coming century (Adger *et al*., 2003). Moreover, current scientific evidence suggests that climate change is one of the greatest threats to social well-being and economic future (Kjellstrom and McMichael, 2013). It has been supposed by some researchers that climate change impacts will be most immediately felt through direct impacts on water resources with extreme events such as floods, droughts and a decline in the quality of water some years to come (Rockström *et al*., 2009; Millennium Ecosystem Assessment (MEA), 2005; Bates *et al*., 2008; DEFRA, 2013). Although the extent and timings of climate change altering annual and seasonal rainfall patterns is unknown, water companies in the UK estimate that without action to prepare nearly half of water resource could be at risk of deficit during a drought by the 2020s (Climate Change Adaptation Sub-Committee Progress Report, 2012). The deficit in water resources is attributed to the combined effect of climate change and population growth (Al-Bakri *et al*., 2013; Langsdale *et al*., 2007). This will ultimately affect the livelihood and well-being of societies since water is the primary medium through which climate change influences the Earth's ecosystem.

Over the years, researchers, governments, and policies have focused the debate on combatting climate change with its impact on water resources by focusing on mitigating greenhouse gas (GHG) emissions (Pittock, 2011). The mitigations are however dependent on technologies that consume a lot of water or have significant impact upon freshwater ecosystems, e.g., growing more crops for biofuels (Pittock, 2011). Due to that greenhouse warming continues to dominate the world's science and policy agenda on global change (Vorosmarty, 2000) since it is supposed to contribute to anthropogenic climate change (Weisser, 2007). Hence adaptation to climate change has increasingly become a focus of policy debates which is reflected in a number of articles in the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Adger *et al*., 2003). However although the Intergovernmental Panel on Climate Change (IPCC) acknowledges different forms of adaptation, they perceive that there is little evidence that efficient adaptations to climate change risks will be taken autonomously (Smit and Pilifosova, 2003). Nonetheless, it is widely assumed that increasing GHG will cause the global hydrological cycle to escalate with benefits for water availability (IPCC, 2001; Royer *et al*., 2002), although a possible exacerbation of hydrological extremes may counteract the benefits to some degree (Barnett *et al*., 2005). In many areas, climate change is likely to increase water demand while shrinking water supplies. Even though some areas may experience more rainfall which means more water resources, this might also likely increase the chance of flooding which can exacerbate the rate of coastal erosion and the loss of properties and sometimes death.

Furthermore, population growth alone without considering the challenges caused by climate change may threaten water and food security (Al-Bakri *et al*., 2013). This is because per IPCC, "*temperature and moisture regimes are among the key variables that determine the distribution, growth and productivity, and reproduction of plants and animals*" (IPCC, n.d). Moreover, increase in population results in increase in GHG emissions into the atmosphere. Generally it is assumed that human industrial activity has released vast quantities of about 900 billion tonnes of GHG of which 450 have stayed in the atmosphere (Stephenson *et al*., 2010). With the world population projected to reach 9.1 billion by 2050, water resources might be stressed due to human activities like urbanization because of climate change. Therefore, there is the need to address climate change impact on water resources with an estimated increasing of population growth.

2.3.1 Climate change impacts on water resources in the world

Climate change has been modelled to have several impacts on water resources and there have been some possible linkages between climate change and water services all around the world. Water is the primary medium through which climate change influences the earth's ecosystem and the most predominant climate drivers for water availability are precipitation, temperature, and evaporative demand (IPCC, 2007). The European Environment Agency further reiterate this; "*the main climate change consequences related to water resources are increases in temperature, shifts in precipitation patterns and snow cover, and a likely increase in the frequency of flooding and droughts*" (European Environment Agency, 2008). Yet evidence of actual observed changes related to regional climate changes specifically to water, is difficult to find. The fact that the global climate is changing is undeniable (Adger *et al*., 2003). Notwithstanding, a different global climate bring about different experiences based on the local weather, and climate change has been observed in different parts of the world (Adger *et al*., 2003). Examples are:

- Extreme summer heat, often combined with high humidity, have increased in most world regions and in 2003, the record-breaking heat wave increased mortality by around 35,000 heat-related deaths across Europe (Schär and Jendritzky, 2004; Vandentorren *et al*., 2004).
- The ElNiño/Southern Oscillation (ENSO) episodes over the last two decades (Adger *et al*., 2003).
- Severe hurricanes: Hurricane Mitch (1998), Hurricane Katrina (2005) and Hurricane Sandy (2012) (Opfer, 2013).
- The extensive riverine flooding in Mozambique led to the loss of lives and properties. In 2015, it was the worst flooding seen since 1971 (Davies, 2015).
- Coastal flooding in Orissa have led to many tens of thousands of premature deaths (Adger *et al*., 2003).

- The severe flood in Ethiopia in 2007 that resulted in 94 percent of respondents reporting that their crops were severely damaged or entirely destroyed (United Nations University, 2013).
- Hurricane Sandy which hit the New Jersey shoreline on 29 October 2012, killing more than 100 people (Neria and Shultz, 2012).
- Typhoon Haiyan in November 2013 in the islands of the central Philippines which left nearly 8000 people dead, missing or injured, and damaged or destroyed over 1.1 million houses (LeComte, 2014).

All these impacts of climate change directly and indirectly affect water resources. For example, warmer temperatures caused by extreme summer heat will increase the rate of evaporation of water into the atmosphere, in effect increasing the atmosphere's capacity to "hold" water (Karl *et al*., 2009). Additionally, as temperatures rise, the demand for water will increase as people and animals need water to maintain their health and thrive and for economic activities like producing energy at power plants, raising livestock, and growing food crops (Karl *et al*., 2009). Furthermore, when temperature rises, the amount of water available for these activities may be reduced as the earth warms leading to less water available on the earth for human consumption.

Hurricanes and flooding on the other hand can reduce the quality of water, can damage the infrastructure that are also used transport and supply water and the deterioration of health conditions owing to waterborne diseases. Not only does flooding affects water resources, the immediate impacts can lead to the loss of both human and animal life and damage to properties (Queensland Government, 2014). Moreover, managing the aftermath of flooding can be expensive both for individuals and the government. In Australia alone, the direct cost estimated over the period 1967-2005 was $377 million per year (calculated in 2008 Australian dollars) (Queensland Government, 2014).

Moreover, most climate change scenarios prediction for water resources will see an increase in annual average river flow and water availability whereas on the contrary average run-off in some rivers is projected to decrease thereby influencing water security through groundwater recharge (European Environment Agency, 2008). For poor countries that have always faced hydrologic instability, it is assumed that climate change will negatively impact on water security by making water more difficult and costly to achieve (World Bank, 2016). And for countries that for a hundred years have enjoyed reliable water supplies and few disturbances if any, climate change may bring water security challenges (World Bank, 2016). Due to that, the World Bank has projected water deficit in many parts of the world because of climate change impacts (Figure 2.1). The projection considered the water portfolio of 191 projects in 83 countries excluding the United States of America and Australia. This was because the regions that invested the most in water relative to their total regional investment like the Middle East and North Africa South Asian Region countries were mostly reviewed in the projection (World, Bank, 2016). Although results show rapid increases in water stress across the Mediterranean, the Middle East, the North American West, eastern Australia, western Asia, northern China, and Chile, the changes in water demand are driven by socioeconomic growth than driven by climate (Luck *et al.*, 2015).

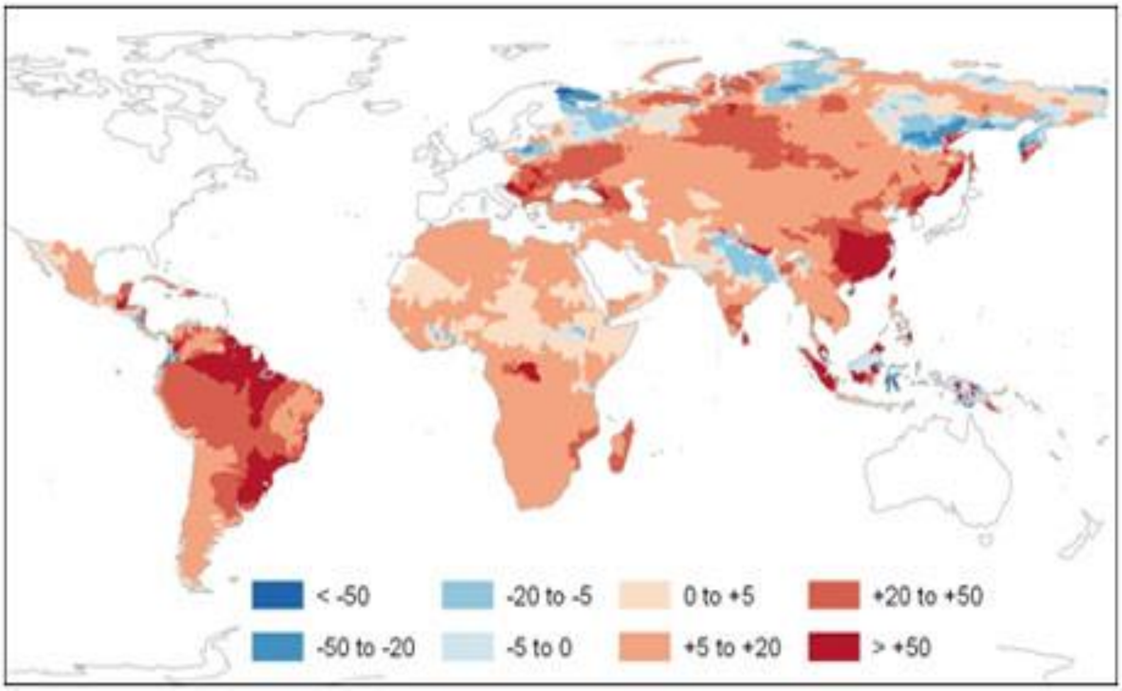


Figure 2.1: Projected percent change in water deficit index for 2030 (Source: World Bank 2016)

Thus, there is the need to conserve water and be water neutral as much as possible especially when considering climate change impacts on water resources even in water abundant regions. RWH can in some way mitigate the impacts of climate change as a water conservation tool and at the same time can reduce the impact of flooding in regions predicted to have abundant water resources.

2.3.2 Climate change: the water-energy nexus

Climate change has been supposed to affect availability and use of both water and energy since climate change acts as an amplifier of the already intense competition over water and energy resources (World Business Council for Sustainable Development, WBCSD, 2009). Energy is the most compelling sector to be adjusted in the pursuit to respond to climate change, and most energy generation technologies use blue water (Inhaber, 2004; Smart and Aspinall, 2009). For example, energy is needed to heat, treat, and move water, water heating in homes, water and wastewater treatment and distribution. Therefore, there have been debates centred on the water-energy nexus. In the water-energy nexus, the relationship between water and energy is discernible by considering the simple and straightforward fact that: water is used to create energy and energy is used for producing water; therefore, increasing supply of water may intensify GHG emissions (Figure 2.2).

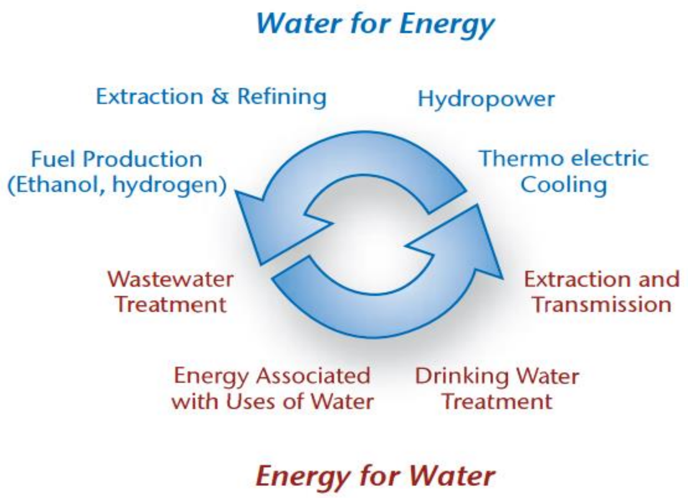


Figure 2.2: Water for energy, energy for water (Source: Paul Reiter/International Water Association)

But there is a different aspect to this water-energy nexus which is much complicated than it seems. Because of the energy needed to pump, clean and transport water or 'energy for water' (Smedley, 2013), it is assumed that climate change will increase the demand for water use; its use in cooling and most importantly in energy supply (Bates *et al.*, 2008; WWAP 2009). Linking the water-energy nexus to climate change there is a clear linkage between water supply and treatment, and demand for energy (Reffold *et al.*, 2008; Stillwell *et al.*, 2011). Therefore, water, energy and climate change are inseparable, hence to find a sustainable solution they must be linked. Even the World

Bank recognizes the importance of the water and energy nexus and thus it has scaled up its support for hydropower as the largest source of renewable energy and low-carbon energy (World Bank, 2016). The World Bank emphasizes the need for "demand management" and "energy efficiency" as ways to reduce energy consumption in the provision of vital water services.

The water-energy relationship is susceptible to several independent constraints. With too little water crops die, industries move away and or collapse, power plants fail, ecosystems suffer and people go thirsty (Webber and Sanders, 2013). With too much, floods ruin infrastructure and properties, destroy crops, spread waterborne diseases, and disrupt flows of clean water, wastewater, power, and transportation (Webber and Sanders, 2013). Energy on the other hand is constrained by lack of access to sufficient water. Power plant operators without access to water to build new power generation facilities use conventional designs which lead to environmental constraints like the temperature of cooling water being discharged into local streams (Webber and Sanders, 2013). Therefore failure to consider the interdependencies of energy and water (Figure 2.3) introduces vulnerabilities whereby constraints of one resource introduce constraints in the other (Stillwell *et al*., 2011).

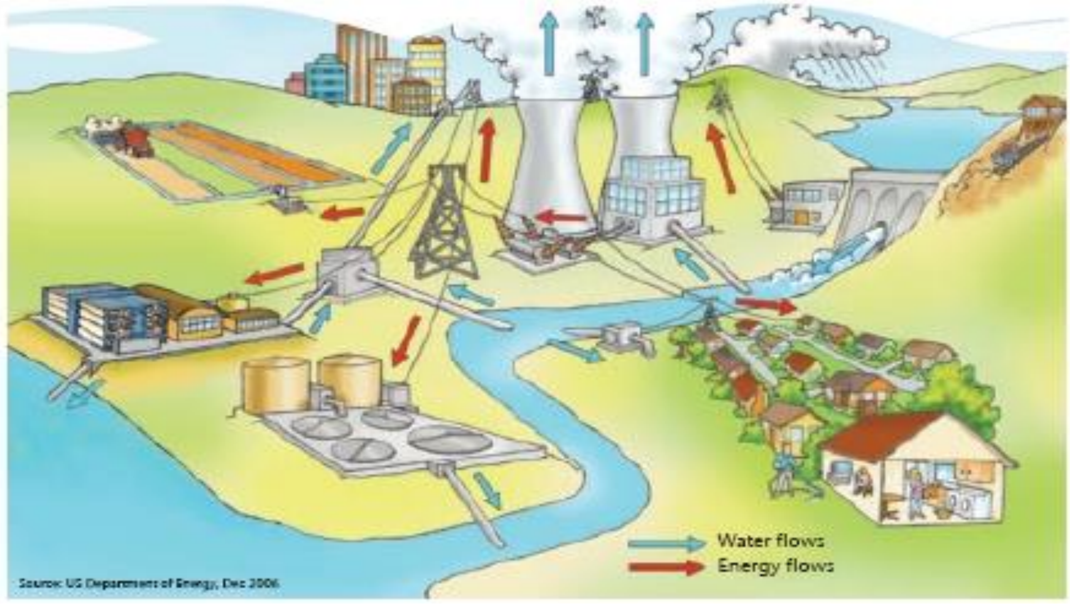


Figure 2.3: Examples of the interrelationships between water and energy (Source: US Department of Energy, Energy demands on water resources, 2009)

It is important to note that while there are reciprocal constraints, the negative consequences of their relationship are also true. This can initiate a range of options for policy makers since the water footprint of energy technologies varies considerably for managing the water-energy nexus (Pittock, 2011). Nuclear, solar, and wind energy can be produced with relatively limited water supplies, but water used in hydropower, geothermal, and bioenergy production is one to two orders of magnitude higher than this first group of technologies (Inhaber 2004; Gerbens-Leenes *et al*., 2009). Though the water-energy relationship is already under strain today, particularly in new urban sprawling cities, there is a tendency for the strain to be exacerbated unless an appropriate action is taken. This is because energy and water demands increase with income; at low income, energy and water are used for basic needs like drinking, cooking and heating. However, when income level increases, people use more energy and water to suit their lifestyles needs like the use of refrigerators, swimming pools, the mode of transport, watering gardens, and cooling (WBCSD, 2009).

It should be further noted that in managing the water-energy nexus in relation to climate change, what should be taken into consideration is whether water needs are met by increasing supply or reducing demand, which should include increased water use productivity (Butler and Memon, 2006; Pittock and Lankford, 2010). This is because the extraction, treatment, distribution, and use of water followed by the collection and treatment of wastewater require a lot of energy (US EPA, 2016). Therefore, saving energy saves water since reducing the amount of energy used reduces the amount of water evaporated in the production of that energy.

2.3.3 Climate change actions in the UK relating to water

In the UK, it is predicted that the impact of climate change will be felt first and most acutely on water (Water UK, 2008), thus it is most important to put the water industry at the forefront in adapting to a changing climate. The impact will be seen more in the quality and availability of water sources, the infrastructure vital to provide services, treatment that will be required to meet quality standards, flooding and or severe droughts. Natural disasters like flood and droughts have a tendency to increase in the UK with climate change which can worsen the impacts on water-dependent climate change response measures *(Bates et al*., 2008; Pittock 2009). Thus, issues in water use need to be considered when designing climate change policies for low-carbon energy generation, carbon sequestration, and adaptation (Pittock, 2011).

The organisation Water UK which represent all major statutory water and wastewater service supply organisations in England, Wales, Scotland, and Northern Ireland exists to identify, develop, and implement policies to bridge the gap in an era of climate change for a sustainable water industry (Water UK, 2008). Since climate change adaptation is a key part of Water UK, they have undertaken a range of activities to ensure the industry is well positioned to respond to the challenge of climate change. Per Callaghan (2012), water companies within the UK are under a general obligation to promote efficient use of water amongst their customers under the Water Industry Act 1991 but they have little genuine interest to do so due to lack of incentives. But these regulations seem to be restricted to England and Wales due to not enough water compared to Scotland which is perceived to have abundant water resources. Therefore, it is most important to put the water industry at the forefront in adapting to a changing climate all over UK since impact of climate change on water resources in one region might affect the whole UK. Though, the Water UK has covered enough ground on climate change impacts on water in the UK, much is seen on paper but the question to be asked is are Water UK really implementing these adaptations and mitigations? Per Water UK, (2008):

> *Water UK and its member companies have undertaken a range of activities to ensure the industry is well positioned to respond to the challenge of climate change. The industry has developed close working relationships with government, regulators and other stakeholders.*

According to their report, there has been some work relating to carbon accounting, mitigation and adaptation. But the Adaptation Sub Committee (ASC) latest assessment in 2012 stated that: "*four times as many properties are at risk of flooding in England without action on climate change*". And this is a recent report on UK's adaptation to climate change related with water. This does not just affect England alone but all of UK. One misleading factor in the report is although it states it as UK, it is only limited to England and Wales. The reports suggest that much concentration is on floods and droughts which are the largest risks in the English regions, thus it uses a set of national indicators to help assess adaptation progress on them by giving advice to the government for its upcoming adaptation programme. However, the whole UK context; Scotland, England, Wales, and Northern Ireland should be factored when adaptation plans are being drawn for the UK.

Additionally, it has been reported by Royal Geographical Society, (2012) that the water industry in the UK faces many challenges and a few mentioned include a changing climate. Other factors reported to face the water industry includes; population growth, rising demand for water and an uncertain economic future. Therefore, there is a need to look for alternatives way to curb the impacts climate change may impact on water resources in the UK, even in areas perceived to have abundant water resources. Even though water constraints can occur naturally, as in the case of droughts and heat waves, it can also be human-induced which can exacerbate the impacts of climate change on water resources. There is the need to consider alternatives like RWH.

2.3.4 Water service resilience and climate change adaptation and mitigation in UK

Water, sanitation, and drainage are critical to the way of life since they have direct implications for the health of the economy and society. According to Ofwat (a non-ministerial government department established in 1989 when the water and sewerage industry in England and Wales was privatised), climate change projections consistently show that the frequency of extreme weather events will increase in the future (Ofwat, n.d.). Recent research shows current climate change expectations in the UK climate in future have higher temperatures, altered precipitation patterns and increased frequency and severity of extreme weather events (Jenkins *et al*., 2010). Therefore, this will require the water industry sectors and services that they provide to adapt in new ways.

Recent studies on impacts of climate change on water resources around the world mostly highlight on the potential effects on urban water supply (Brekke *et al*., 2009; Buytaert and De Bièvre, 2012 ; Cha *et al*., 2012; Raje and Mujumdar, 2010; Vicuna *et al*., 2010) and it is silent on rural supplies. Furthermore, the absolute likelihoods of future climate change scenarios cannot be determined (Brekke *et al*., 2009). Maier *et al*., (2014) recognizes that uncertainty affects all aspects of water resources management and that the key sources of uncertainty need to be made discernible to present solutions that are not reckless. Hence, when looking for adaptations and mitigations in the UK both rural and urban water supplies need to be considered. The government has put in place the Climate Change Act 2008, a policy framework to promote adaptation action in the UK and this consists of the:

1. UK Climate Change Risk Assessment (CCRA): a five-yearly assessment of the major risks and opportunities from climate change to the UK.

2. National Adaptation Programme: The Government's long term strategy to address the main risks and opportunities identified in the risk assessment.
3. UK Adaptation Reporting Power: this grants the Secretary of State the power to require public service organisations to produce reports on what they are doing to adapt to climate change.
4. Other Government policies also affect the UK's capacity to adapt to climate change, such as the regulation of water companies or national planning policy.

However, in Scotland, there is the Climate Change (Scotland) Act 2009 which seeks to reduce greenhouse gas emissions and transition to a low carbon economy by ensuring that the net Scottish emissions account for the year 2050 is at least 80% lower than the baseline. This is similar to the Climate Change Act 2008. The 2008 Act was to limit UK's emissions of GHG through legally binding targets, both now and in the future UK to by reducing emissions by at least 80% in 2050 from 1990 levels (Committee on Climate Change, 2015). The national adaptation plan is mentioned in the Climate Change Act 2008 but it requires governments to assess the risks from climate change and prepare a strategy to address them.

In England, The Adaptation Sub-Committee (ASC) latest assessment on how well the UK is preparing for climate change reports that many properties in England are as four times at risk of flooding without action on climate change (ASC, 2012). It uses a set of national indicators to help assess adaptation progress on flooding and droughts which are two of the largest risks to the English regions in terms of resilience. In Scotland, the report by the government states that climate change might impact on rainfall patterns which may increase the competition for water between households, agriculture, industry and the needs of the natural environment (Scotland and Scottish Government, 2014). Furthermore, the report states that as summer droughts become more frequent and more severe it might cause a decline in water quality and supply (Scotland and Scottish Government, 2014). According to them, they have a solid evidence base for understanding the impacts of climate change on water supply in Scotland and acknowledge the need to continue to build the evidence base. This they hope is to improve their understanding of the impacts of climate change, and how best to adapt and to deal with threats and seize opportunities. One way of dealing with this is for Scottish Water to prepare a plan which promotes water conservation and water-use efficiency. Since this is being implemented for those on MWS, it leaves behind people on PWS, thus defeating the purpose. There is the need to incorporate both rural and urban areas in terms of climate change adaptation and resilience policies.

2.3.5 Climate change and Scottish water resources

In the Scottish Climate Change Act 2009, Scotland has targeted to reduce their GHG emissions by at least 80% by 2050 (Climate Change (Scotland) Act 2009). This target is something that the Scottish Water also as a public body must meet. In reducing their carbon foot print in producing water, Scottish Water is currently developing an updated Carbon Management Plan to quantify some of their carbon savings from their previous Carbon Plan (SEPA, 2012). Currently what is available is the carbon plan for 2010. Data collected from household and research by Scottish Water (Figure 6) depicts the treatment and distribution of water and the collection and treatment of waste water as the most energy intensive activities (Scottish Water, 2011; Scottish Water Sustainability report, 2012). Electricity consumption represents the major source of carbon emissions for Scottish Water (Scottish Water, 2014) and GHG emissions associated with providing water and waste water services to a household is 125kg (Scottish Water Sustainability report, 2012). Per SEPA, though they have improved in their understanding of climate change and how it may impact on water resources over the last two decades, there remain uncertainties (Scottish Water, 2012). However, in a recent survey, customers of Scottish Water were willing to understand the link between hot water and energy costs to be able to make better choices in terms of being more water efficient and saving money on energy bills (Accent Scotland, 2010).

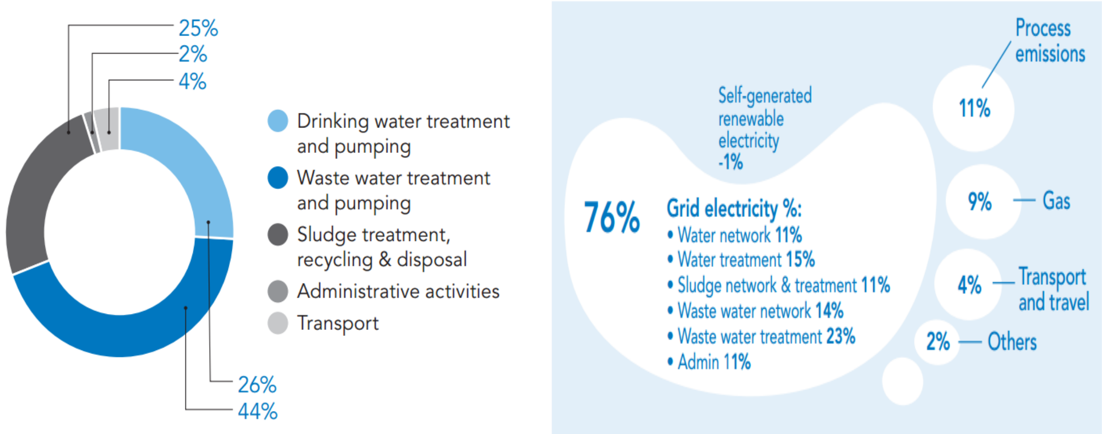


Figure 2.4: Greenhouse gas emissions by activity 2014/15 and greenhouse gas emissions by source 2014/15 (Source: Scottish Water, 2015)

People assume Scotland to be a water-rich country considering that there might be unlimited water available for treatment and supply (Scottish Water, 2011). Therefore, it is assumed that people in Scotland take water for granted. But according to Scottish Water, there are significant regional variations in asset capability to cope with such pressures as a changing climate, demographic movement and increasing demand for water as part of people's daily routine. This therefore contradicts people's perception on abundant water resources since it is different from asset capability of Scottish Water to supply water. Therefore, to reduce the GHG emissions and hence decarbonize water, there is the need ensure water use efficiently through alternate technology and water conservation methods. When there is less need to treat, and distribute water, it will lower the carbon footprint since the capture, treatment, transfer, heating, cooling and use of water requires large amounts of energy. Since electricity consumption represents the major source of carbon emissions for Scottish Water, there is the need for alternative measures as in RWH and grey water. These alternative sources can reduce the volume of water used and the energy embedded into treating and distributing water. Hence, there is the need to understand the willingness of people to use this service and helping the government to achieve cutting their carbon emissions by 80% as targeted.

However, with regards to reducing energy and carbon emission, a recent study in Scotland on public perceptions of climate change and low-carbon energy technologies, show that the participants were broadly supportive of efforts to reduce carbon dioxide emissions (Howell *et al*., 2014). Participants expressed a preference to use these low-carbon energy technologies to reduce their carbon footprint and energy consumption if renewable energy technologies are to be employed to achieve this. Though participants were willing to use it, they were cautious about implementation due to factors such as the perceived costs and benefits of the technology. Furthermore people's personal values and trust in such technologies also impacted upon participants' attitudes towards the technology (Howell *et al*., 2014). Though there is research on low-carbon energy technologies, there is no research concerning water use and water conservation as a climate change mitigation solution to reduce energy and carbon emission. Since RWH can be part of climate change mitigation, there is the need to understand participants' attitudes towards its use in Scotland.

2.4 WATER DEMAND IN THE UNITED KINGDOM

Households and industry, including the food and beverage industry, are the major users of water in the UK (IGD, 2008). The average water usage in a UK home is approximately 150 litres per person per day although this varies with affluence or socioeconomic group (Fewkes, 2012). In households, water used in toilet cisterns represents around an average of 30% of water consumption for a household (Fewkes, 2012). This is followed by: the bath, shower and the usage of washing machine (Butler, 2010). In the UK, Waterwise reports that only 4% of the perfectly drinkable water used every day is for drinking (Waterwise, 2008) as depicted in Figure 2.5. Waterwise, an independent, not-for-profit and a leading authority on water efficiency, estimate levels of water usage in the UK to have risen by 1% every year since 1930 (Waterwise 2012). This is corroborated by research in 2012 which observes that there has been an increase in per capita consumption of domestic water in the UK over the last two decades (Fewkes, 2012). These changes in the water consumption have been attributed to demographic changes, socioeconomic factors, climatic variation, and an increase or decrease in population results in a subsequent change in water usage (Fewkes, 2012).

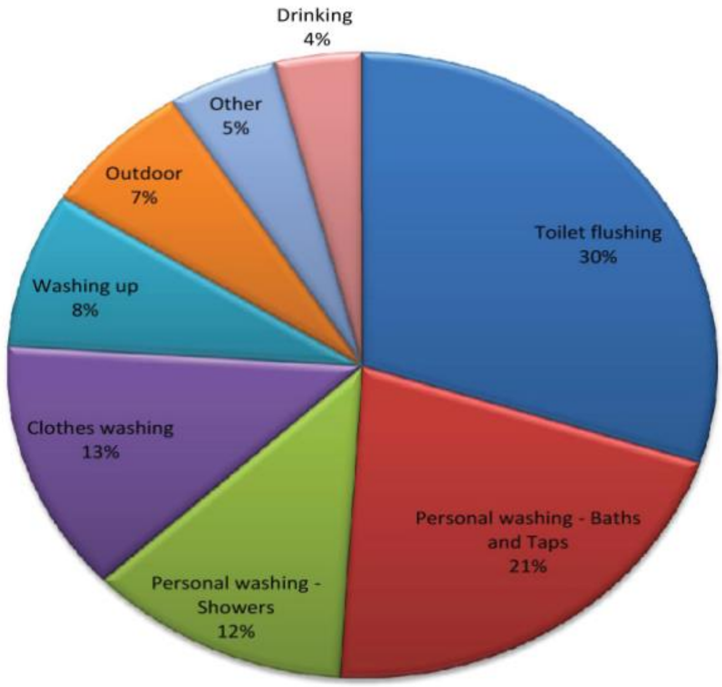
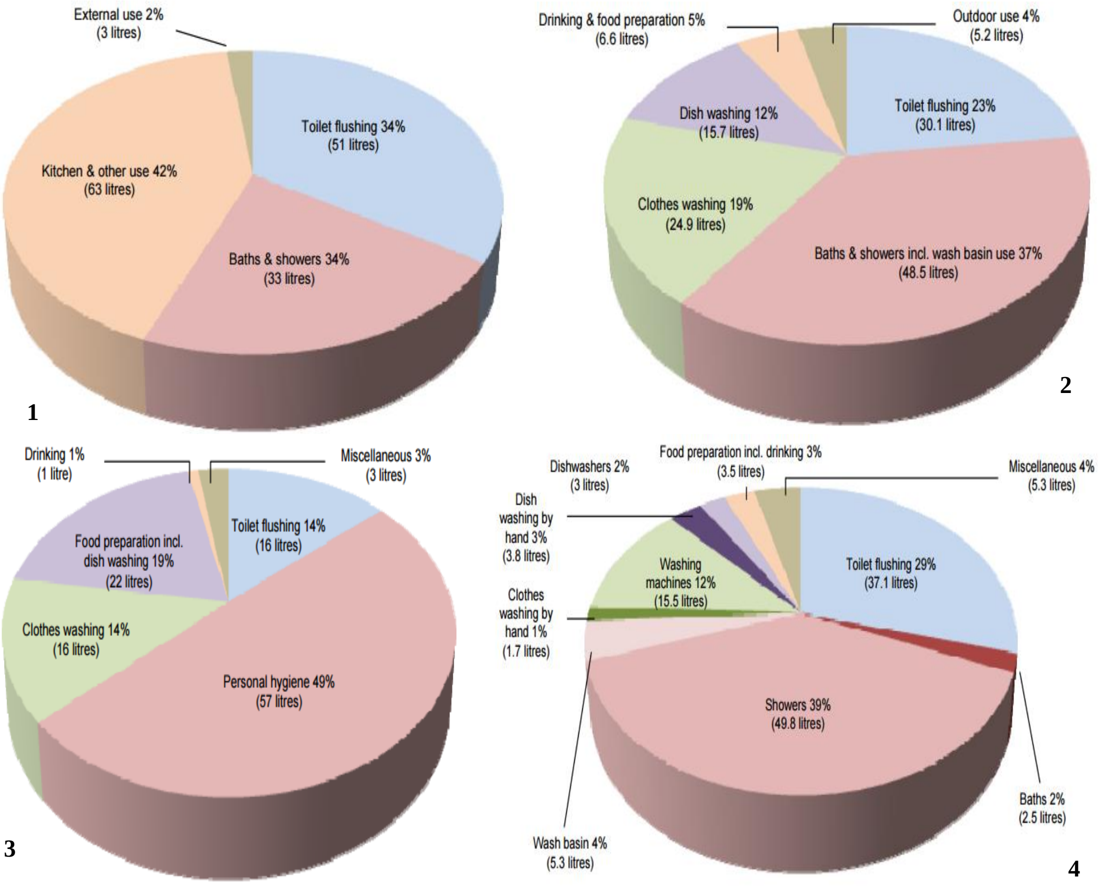


Figure 2.5: How water is used in UK homes (Source: Waterwise UK, 2008)

Over the past 100 years the UK has lost 75% of its natural water supplies (ponds and floodplain grasslands) and majority UK's residents' water footprints come from overseas (IGD, 2008). In a 2008 report by the Guardian newspapers, it stated that

British has become the sixth largest net importer of water in the world with only 38% of the UK's total water use coming from its own resources; the rest depends on the water systems of other countries, some of which are already facing serious shortages (Lawrence, 2008). Waterwise corroborates this by saying about 70% of the UK's water footprint is now generated overseas (Waterwise, 2008). This rate is not sustainable in the long-term and if an action is not taken to ensure efficient water use in the UK, it will face increased water stress in the future.

Furthermore, research by the UK Environment Agency (EA) in 2008 which commissioned Aquaterra UK Ltd to carry out a review of per capita consumption (PCC) in selected countries in Europe revealed that less portable water is used for flushing toilets in other European countries (Figure 2.6). For example, the domestic per capita consumption (PCC) in Finland for flushing the toilet is 14% (Figure 2.6). The downward trend of PCC in Finland was because of higher water prices, better technology in households and utilities, increased consumer awareness and better utility management (Katko *et al*., 1998).



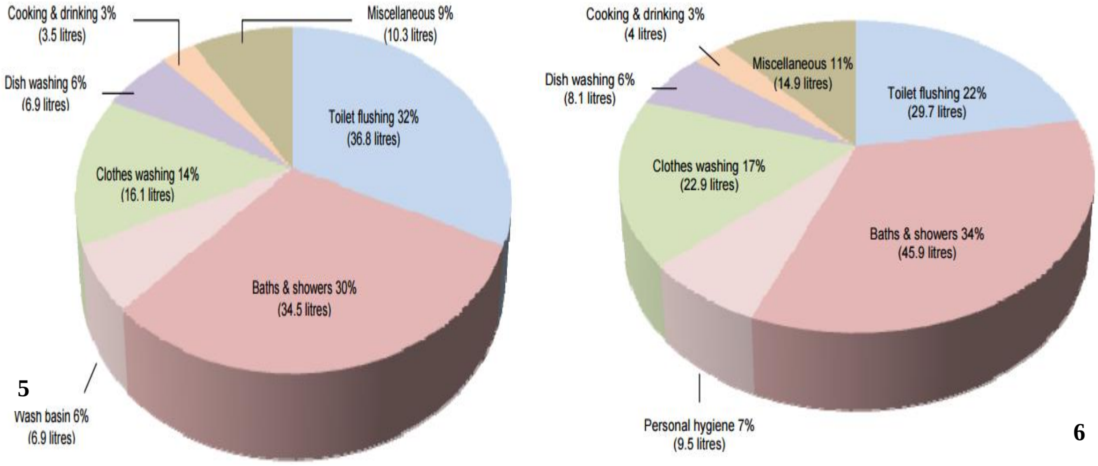


Figure 2.6: The breakdown of PCC in selected European Countries: 1- England and Wales; 2- Denmark; 3- Finland; 4- Netherlands; 5- Germany; 6- Austria (Source: EA, 2008)

Finland has a population of about 5.27 million (Internationaler Währungsfonds, 2008) which is similar to that of Scotland, however comparing PCC, there has been a decline in Finland since the mid-1970s (Katko *et al*., 1998). Prior to the early 1970s, PCC was very high in largest cities and up to 420 l/h/d in Helsinki (Katko *et al*., 1998). This means that Scotland is behind in terms of water use efficiency. As stated above, this is not sustainable and other alternatives like RWH can be substituted for non-potable uses like flushing the toilet.

2.4.1 Water supply in Scotland

There are two types of water supply: private and public mains water supply in Scotland. Most people living in Scotland are on the mains water supply with only 3% on PWS (Citizens Advice Scotland, 2015; Scotland and Drinking Water Quality Regulator for Scotland, 2014). In Scotland, drinking water standards are set down by law in The Public Water Supplies (Scotland) Regulations 2014, which are in line with European Community (EC) requirements. They are grouped into seven main bodies:

1. The Scottish Government: this group is made up of Scottish Ministers and their officials. Their role is to manage the relationship with Scottish Water and its regulators within the statutory framework established by the Scottish Parliament. Also, they have set up an Outputs Monitoring Group (OMG) to ensure that Ministers' Objectives are delivered.
2. Scottish Water: A public corporation accountable to Scottish Ministers and through them to the Scottish Parliament. It is the main source of public water supply in Scotland.

3. Water Industry Commission for Scotland (WICS): WICS determines the price limits for mains water supply based on the lowest reasonable cost of achieving the Ministers' Objectives for the water industry.
4. Drinking Water Quality Regulator for Scotland (DWQR): DWQR is responsible for monitoring and confirming that the drinking water supplied by Scottish Water meets the requirements of the drinking water quality regulations and is safe to drink. DWQR also advises Ministers on the delivery of and the need for future investment in drinking water quality.
5. Scottish Environment Protection Agency (SEPA): Their responsibility is to monitor discharges from Scottish Water's to ensure they meet environmental requirements.
6. Citizens Advice Scotland (CAS): It is the statutory organisation which campaigns for a fair deal for consumers in Scotland through information, research, and representation.
7. Scottish Public Services Ombudsman (SPSO): They are responsible for handling complaints about most public services in Scotland.

2.4.1.1 Private water supply (PWS)

The source of water for public supply in Scotland is from ground water sources, but majority of private supply is from surface water sources (Scottish Water, 2013). According to the Scottish Government, "*around 150,000 people in Scotland rely on a private water supply - any water supply not provided by Scottish Water - for their drinking water*" (Scottish Government, 2013). The source of private water supply (PWS) varies ranging from surface water such as streams and rivers, private impoundment reservoirs, and groundwater such as wells and boreholes or springs where groundwater issues naturally at the surface from an aquifer. The owner or person who uses the supply is responsible for its maintenance. Sometimes the quality of water from private supplies can be poor and can cause significant health problems (Nemec, 2013; Scotland and Drinking Water Quality Regulator for Scotland, 2014). There have been guidelines which have been put in place for private companies wishing to set up water distribution in Scotland called The Private Water Supplies (Scotland) Regulations 2006. Supplies vary in size from those that serve one household to those that serve hundreds of people. Tens of thousands of people also use them occasionally each year, typically when they are on holiday. The 2006 Regulations defines supplies as either: Type A where supplies providing 10 m^3 of water a day or serving 50 or more persons; and supplies to commercial or public activities irrespective of their size and Type B where supplies serving only domestic premises with less than 50 persons supplied. Overall Type B supplies are more (17,482) than Type A supplies (2,434) (DWQR, 2012). Type A supplies fall within the provisions of the E.C. Drinking Water Directive (98/83/EC) which requires each supply to be sampled and analysed for a wide range of parameters at least once a year. But the Type B supplies are required to comply with a limited range of parameters that are defined in the regulations and do not form part of a statutory sampling programme.

Furthermore, in ensuring that PWS is safe to drink in Scotland, the DWQR:

1. Reports on the quality of private water supplies.
2. Checks that local authorities are regulating private water supplies in their area.
3. Provides guidance and clarification to local authorities.

The Scottish Government further has introduced a grant scheme to assist users improve their private supplies. Grants of up to £800 are available from their local authorities if individuals meet certain conditions to set up their own private water supply. The Private Water Supplies (Scotland) Regulations 2006's overriding objective is to ensure the provision of clean and wholesome drinking water and deliver significant health benefits to those using such supplies. The 2006 Regulations, which came into force on 3 July 2006, incorporate the latest advances to improve drinking water quality including the use of risk assessments from 'source to tap' as part of an effective drinking water surveillance programme. The primary legislation pertaining to water supplies in Scotland is the Water (Scotland) Act 1980. Under the Act, each dwelling requires to be supplied by an adequate and wholesome water supply. If an unsatisfactory supply is identified, the local authority has powers to serve a notice requiring improvements to be carried out.

According to the Citizen Advice Bureau, "*a private water supply has to be registered with the local authority environmental health department*". After registration, the quality of water must be tested regularly by the environmental health department. However, a PWS is unlikely to be treated for public consumption in the same way as water provided by Scottish Water. There are some individual private companies that also provide water in Scotland. Highwater is one of those companies in Scotland that operates throughout the Scottish Highland, Perthshire, Moray, and Aberdeenshire supplying them with water. But there is not enough information on other private water companies; instead figures are given for the communities being supplied water by private companies. In 2013, there were 20,193 private supplies registered in Scotland (Scotland and Drinking Water Quality Regulator for Scotland, 2014). The highest users of PWS in Scotland are Aberdeenshire (7,676), Highland (2,338), Argyll and Bute (1,848), Perth and Kinross (1,476), Scottish Borders (1,420) and Dundee City (1,367) (DWQR, 2012). However, the percentage of population on PWS is not related to the number of supplies available. For instance, 25.85% of the Argyll and Bute population was served by PWS as compared to 14.15% of Aberdeenshire population which had the highest PWS users (Scotland and Drinking Water Quality Regulator for Scotland, 2015). The rest of the Local Councils have PWS but were below 1,000. The geography of Scotland is diverse, from rural lowlands to barren uplands, and from large cities to uninhabited islands (Scottish Government, 2006). Therefore, it should be noted that PWS are mostly found in semi-rural to rural areas in Scotland. Although Scotland is a highly-urbanised country, there are areas like Highland which are sparsely populated and the population is scattered in villages, small towns and isolated farmsteads or crofts (Scottish Government, 2006). This can be attributed to the differences in supply in different Local Councils.

2.4.1.2 Public water supply

In Scotland, the public water supply (water and sewerage services) is provided by a single public company, Scottish Water, supplying 97% of the Scottish population. Water supplies are taken from several sources and they are all treated to good quality before it reaches consumers. Though DWQR ensures that drinking water in Scotland is safe to drink, the environmental regulator is SEPA. SEPA’s standards and wastewater discharge standards are determined by the EU. Aside all these regulators, the economic water industry regulator, the WICs for Scotland also promotes the interests of water and sewerage customers making sure that householders and businesses receive a high-quality service and value for money by setting prices, monitoring Scottish Water’s performance, and facilitating competition in the water industry. The overall performance assessment (OPA) index by the Water Commission is used to measure the service quality of Scottish Water. This is normally done considering: unplanned supply interruptions, pressure, drinking water quality, responses to written complaints, ease of telephone contact, sewer flooding, sewage treatment works compliance and leakage (Scottish Water Performance, 2014). Scottish Water's OPA score improved from 162 in 2003-2004 to 397 in 2013-2014 (Scottish Water Performance, 2014).

On a yearly basis, Scottish Water tries to improve its water quality by taking water samples about 350,000 tests every year from water treatment works, storage points and consumers' homes. This is to ensure that the water quality meets good standards and to improve it (DWQR, 2011). The DWQR further:

1. Monitors the quality of water samples taken by Scottish Water.
2. Enforces serious breaches of the regulations.
3. Checks Scottish Water are taking and analysing samples correctly.
4. Inspects Scottish Water's assets and activities.
5. Oversees the quality-driven investment programme.
6. Assists consumers where Scottish Water has failed to adequately resolve a complaint about water quality.

Scottish Water operates and maintains over 47,000 kilometres of water pipes, 50,000 kilometres of sewer pipes, 1,837 waste water treatment works (including 1206 septic tanks) and 297 water treatment works plus pumping stations, sludge treatment centres, reservoirs (Scottish Water, 2012). Therefore, in contrast to PWS in Scotland, it is assumed that mains water is of good quality compared to PWS.

In Scotland, public water costs are based on council tax band and compared to PWS, the cost is negligible for PWS users. To pay the water bill, the water charges are added to the council tax bill and paid through the council for those without a water meter. The charge normally depends on which council tax band homes are located therefore most Scots do not pay per litre but pays a flat charge. As a result, most people in Scotland do not have a water meter installed in their homes. This is because where there is a water meter fitted, Scottish Water sends such households a monthly or a quarterly bill which normally consists of a fixed charge, plus a charge for water used, measured by the meter, and an estimated charge for waste water. Installation of a water meter normally starts around £93.10 (Shelter Scotland, 2015) and the minimum cost of any pipework alterations is around £230.00 excluding VAT (Scottish Water, 2012). Per Ferguson, (2014), a minimum of around £300 is expected to be paid for a water meter because

Scottish Water hasn't been allocated any funding to install meters. The meter though paid by households interested in installation remains the property of Scottish Water but households can revert to unmetered charges if so desired. Comparing the use of water meters in Scotland to England and Wales, more people in England and Wales prefers to use water meters as compared to Scotland because if you live in England and Wales, the water company provides and installs a meter completely free of charge. And per Ofwat 46% of customers in England and Wales who now have a water meter paid on average, £100- £400 less for water and sewage services than customers without a meter in 2013 (Ferguson, 2014) whereas in Scotland, people pay a flat rate for water.

2.4.2 Water demand in Scotland

The main component of demand for water in Scotland is use by households (Figure 2.7) and on average each household uses about 154 litres per day which is like the average unmetered household consumption in England and Wales (Scottish Water, Water Efficiency Plan, n.d.). The components of demand for water use in Scotland is depicted in Figure 2.7 where the demand is the measured distribution input leaving the water treatment works.

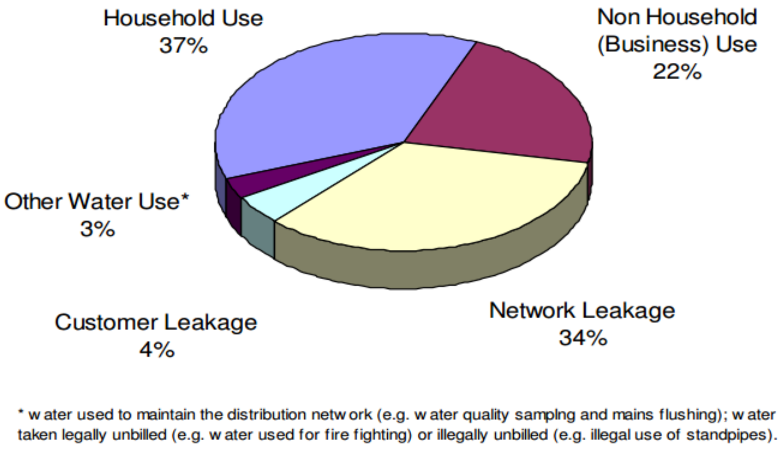


Figure 2.7: The Components of Demand 2009/10 in Scotland (Source: Scottish Water, Water Efficiency Plan, 2011-2015, n.d.)

In meeting demand to the various uses of water in Scotland, network leakage is a major problem with Scottish Water thus it has been part of their major focus in recent years to reduce leakage from their network. Leakage is therefore part of their demand component. Researched data shows that they have been successful over the years to reduce leakage. It was reduced in 2005 from 1104 Ml/d to 704 Ml/d in 2010 (Scottish Water, Water Efficiency, n.d).

2.5 WATER NEUTRAL DEVELOPMENT

The water-neutral concept was first conceived in 2002 at a Johannesburg World Summit for Sustainable Development (Water Neutral, 2002) and it is also known as the water-offset concept (Hoekstra, 2008). The concept provides the scientific basis for estimating the volume and geospatial source of water consumed by communities (Stockholm International Water Institute (SIWI), 2008). The preposition for the water neutral concept was to see whether humans can somehow neutralise or offset their water footprint. It was regarded as distinct in the sense that it attracts a broad interest where it creates opportunities to translate water footprint impacts into action within both communities and businesses (Hoekstra, 2008). Albeit water neutral concept take a variety of forms, the key and basic principle is that new water uses offset their impact to water supplies through an on-site water-saving choices and or an off-site actions that will increase supply or reduce existing water demand (Harder, 2014). These actions can mitigate the occurring impacts for positive actions to offset environmental and social impacts of residual water footprints (Hoekstra, 2008). In ensuring water neutrality, consumers can reduce their direct (domestic) water footprint and or water consumption by using water saving devices, harvesting, and using rainwater and recycled grey water (Thorsten & Vicente, 2013). Further examples of water neutral concept include:

a. Indoor measures: highly efficient fixtures, dual-flush toilets, front-loading washing machines, or hot water on-demand systems.
b. Outdoor water saving choices: sub-metering for common area irrigation and multi-family/senior housing, xeriscaping and drip irrigation, self-adjusting irrigation controllers in all landscaped areas, and use of recycled water in common areas, parks, and other community outdoor facilities.
c. Sophisticated measures: rainwater cisterns, greywater systems and stormwater capture.

By employing on-site choices and offsite actions, it is perceived that communities can find a better balance between finite water resources and the boundless desire to grow their businesses in a growing population where demand for water increases with increasing income with the water neutral concept (Dickinson, 2015). Growing populations and certain economic growth will place even more pressure in the future on already declining water supplies (American Planning Association, 2016). This is because as population continues to grow and urbanize, it becomes challenging for planners and decision makers to accommodating new water customers with existing and possibly limited water supplies (Alliance for Water Efficiency (AWE), 2015). Because of this, many countries are adopting the water neutral concept including developed countries like the USA, Netherlands and England in the UK. (Harder, 2014).

In the USA research by the government shows that closely 40 out of 50 states in the USA are experiencing or anticipating water shortages in the next decade. This anticipation will in turn create potential challenges for growing communities and industrial centres in both arid and traditionally water-rich regions in the USA (U.S. Government Accountability Office, 2014). Therefore, in the midst of growing demands on water resources in the USA, water-neutral growth programs have been shown as an effective way for communities to support sustainable growth, (AWE, 2015). Between 2007 and 2009, the Environment Agency in England issued a series of reports exploring the potential for the use of new development offsets as movement toward water efficiency by using community conditions to support the use of offsets (Harder, 2014).

The water-neutral concept has been known to show similarity to the carbon-neutral concept in response to the challenge of taking the climate change countermeasures although the idea of 'water neutral' is different from 'carbon neutral'(Gerbens-Leenes *et al*., 2009). This is because according to Gerbens-Leenes *et al*., (2009), "*it is theoretically possible to generate enough energy without emitting carbon. Alternative names to 'water neutral' that have been suggested include water offset, water stewardship, and water use reduction and reuse*". However, as discussed above in Section 2.2 on climate change, RWH also part of the water neutral agenda can be used as a part of climate change mitigation solution. This is because the use of RWH has the potential to reduce GHG emissions from water storage reservoirs and water treatment processes which can contribute to climate change impacts (IPCC 2007; Flower *et al.*, 2007). Therefore, there is the need to consider RWH in details with respect to Scotland to reduce flood risk and improve its environment since water resources is predicted to be affected by climate change.

2.6 WATER SAVING IN UK

Water in UK is relatively cheap compared to other European countries like Germany, Switzerland, Denmark, and Netherlands (O'Brien, 2014). This means the same economic drivers for conservation are missing. It has been observed from literature reviewed that metering, low-flush toilets, low-water or waterless urinals, water conservation fittings, SUDS, grey water recycling and RWH are some water management systems that have been proposed can be employed in homes within England (Waterwise 2012; Great Britain and Office of Water Services, 2000; Khastagir and Jayasuriya, 2010; Penn *et al*., 2013; Ward, 2010). Water security supply is almost taken for granted in Scotland. There seems to be no known information on 'water-saving devices use' in homes in Scotland. What seems to be information available on water saving devices used in home is a report submitted to the Westminster Parliament known as "Future Water-The Government's water strategy for England" (DEFRA, 2008). This report which was presented to Westminster Parliament by the Secretary of State for Environment, Food and Rural Affairs in February 2008 sets out the UK Government's plans for water in the future and the practical steps that we will take to ensure that good clean water is available for people, businesses, and nature in South-east England after it experienced droughts in 2004-2006 and floods in 2007.

Although most water utility companies are investing in their infrastructure to reduce leakages through distribution network, the relatively low cost of water in the UK, capped capital investment and the absence of compulsory metering (especially in Scotland) mean there is little incentive for individual developers or occupiers to reduce water consumption (Rawlinson & Langdon, 2007). There is a substantial savings that can be achieved using simple measures such as metering and low-flush toilets; more than 30% of domestic water is used for flushing the toilet. However, the motivation to invest in high-impact measures such as rainwater capture or greywater recycling must come from non-financial factors (Rawlinson & Langdon, 2007). Chief among these are planning requirements to incorporate RWH in buildings, which are often driven by local constraints on water supply or the cost of upgrading the local infrastructure which seems. In Scotland, this motivation does not exist and will be deemed expensive.

In England, there is the Water Saving Group (WSG) which was established in October 2005 to reduce per capita water consumption in households. Aside the formation of this group, there has not been any known studies on acceptability by the public in domestic water saving devices although they have been raising customer awareness. Hence there is the need for practical measures to manage water consumption. But the readily availability of low-cost, high-quality water, management of water consumption especially in Scotland has not demanded the same attention as other sustainability initiatives (Rawlinson & Langdon, 2007). Therefore, this will make it difficult to achieve the aim of water saving in homes in Scotland.

In Scotland, Scottish Water has a relatively low cost of water than the average in England and Wales (in 2012/13 the average household charge in Scotland was £52 lower per annum than the average household charge in England and Wales (Scottish Water 2012). Scottish Water is the largest single consumer of electricity in Scotland (Table 2.1) thus there is large cost when divided among consumers in terms of the energy consumed to produce the water (Scottish Water, 2014). The Scottish Water reports that over the past six years there have been several genuine increases and decreases in their operational emissions of carbon with electricity being the highest and main contributor (Figure 2.4). Emissions associated with providing drinking water saw a genuine fall of about 10% in 2011/12 but on the wastewater side, reductions observed in emissions from electricity and natural gas use were attributed to the milder winter experienced in 2011/12 compared with 2010/11 (Scottish Water, 2014).

Table 2.1: Emissions by Scope (Source: Scottish Water Sustainability Report, 2012)

Net Emissions	tCO_2e
Scope 1 Direct emissions: on-site combustion of fossil fuels; process emissions; and emissions from vehicles owned or leased by Scottish Water	31,082
Scope 2 Indirect emissions: use of grid electricity	232,534
Scope 3 Indirect emissions: business travel by public transport and private vehicles used for company business; outsourced activities (includes sites run by PFI companies on our behalf); and chemicals purchased	464,990

Thus, it cannot be concluded if the emissions were attributed to new technologies. Their overall carbon footprint for 2011/12 was measured at 464,990 tCO_2e (Table 2.1, Scottish Water Sustainability Report, 2012). Therefore, there is the need to think of the carbon cost, new sustainable technologies to provide water and not just the low cost of the water to aid in reducing the carbon emissions.

2.7 RAINWATER HARVESTING (RWH)

The demand for water worldwide is increasing and has resulted in growing concerns to secure global water resources for future generations (Fewkes, 2012). Rainwater harvesting (RWH) is an old practice adopted by many nations as a viable decentralized water source to secure water (Julius *et al*., 2013). RWH is the collection of rainfall from the roof of a building and can reduce the demand on the public water supply (Fewkes, 2012; Julius *et al*., 2013; Roebuck and Ashley, 2007; Ward, 2010). This involves collecting, storing, and using rainwater as a primary or supplementary water source for non-potable application. Infiltration of rainwater for groundwater recharge is another aspect of RWH and helps with storm water management, the replenishment of the groundwater levels and reduce peak runoff rates (Coombes *et al*., 2002; Hamdan, 2009; Xichang, 2015). For over 4,000 years, RWH has been practised throughout the world and has provided drinking water, domestic water and water for livestock and small irrigation (Fewkes, 2012; Gould and Nissen-Petersen, 1999). Due to that, different techniques have been developed and used for millennia in many parts of the world (Julius *et al*., 2013). The systems used for harvesting the water are often easy to construct and maintain with the ability to operate independently of central water supply systems (Fewkes, 2012).

However, in the twentieth century the use of RWH was abandoned or slowed in many parts of the world due to cost and the development of more advanced technologies (Julius *et al*., 2013; Roebuck and Ashley, 2007; Shaffer and Leggett, 2002; Heggen, 2000). The concept is now receiving increased recognition as a source of water supply in many parts of the world due to climate change impacts on water resources (as an adaptation or mitigation solution) (Mwenge Kahinda *et al*., 2010; Pandey *et al*., 2003; Vohland and Barry, 2009). Furthermore, RWH has received attention globally as a result of water shortages from droughts, pollution and population growth (Meera and Ahammed, 2006; Nolde, 2007). Now new regulations and incentives that foster the use of RWH are increasingly being developed in countries both in developing and developed countries that are both water rich and water scarce (Domènech and Saurí, 2011). Additionally, research shows that RWH has been beneficial around the world (Fricano and Grass, 2014) (Table 2.2).

Table 2.2: Costs and benefits of rainwater harvesting systems (Source: adapted and modified from Fricano and Grass, 2014)

COSTS	
Cost	**Source**
Capital Costs	U.S. EPA (2013), Roebuck, Oltean-Dumbrava & Tait (2011), Leidl, Farahbakhsh & FitzGibbon (2010)
Energy Consumed	Cook, Sharma. & Chong (2013), Ward *et al.*, (2012) Farreny, Gabarrel & Rieradevall (2011) Roebuck *et al.*, (2011)
Maintenance & Equipment Replacement	U.S. EPA (2013) Ferenny *et al.*, (2011)
Metered Mains	Roebuck *et al.*, (2011)
Overflow	Imteaz *et al.*, (2010)
BENEFITS	
Benefits	**Source**
Water Conservation	U.S. EPA (2013), Ward, Memon. & Butler (2012), Rahmen, Keane, & Imteaz (2012)
Reduction in Sewerage	Liedel *et al.*, (2010)
Reduction in Water Treatment*	Cook *et al.*, (2013)
Economies of Scale*	Cook *et al.*, (2013)
Reduced Footprint*	Cook *et al.*, (2013)

*Applicable to communal systems

2.7.1 The use of rainwater harvesting around the world

2.7.1.1 The use of RWH in developing countries

There has been a growing interest in RWH as an alternative source of drinking water in developing countries (Meera and Ahammed, 2006). Due to water scarcity in most African countries, the use of rainwater for almost all domestic and irrigation purposes is very popular (Sturm *et al.*, 2009). Successful examples of developing countries using RWH are: Uganda, Southern Zimbabwe (Hartung, 2006), Kenya (Hartung, 2007), Bangladesh (Karim *et al.*, 2013), Palestine (Al-Salaymeh *et al.*, 2011), Indonesia, Thailand, China, Philippines (UNEP, n.d.) and India (Glendenning *et al.*, 2012). Not to mention, amid the second half of the 20th century, RWH has been catering water supply needs to a growing and urbanizing populations in Africa, Asia, and South America (Lee *et al.*, 2000). In Jordan for instance it was estimated that there was a considerable amount of water savings from RWH implemented in residential areas (Abdulla and Al-Shareef, 2009).

RWH has been feasible in most developing countries due to inadequate piped water supplies and the introduction of policies and incentives have further boosted the use of

RWH in most regions (Domènech and Saurí, 2011; UNEP, n.d.). Jordan, Sri Lanka, China and Brazil have all approved RWH policies at the national level (Zhu *et al*., 2004; Goonetilleke *et al*., 2005; Ghisi *et al*., 2006; Ministry of Urban Development and Water Supply Sri Lanka, 2005). Not to mention, in New Delhi and Chennai, India, it is mandatory to have a RWH system for a building plan to secure building approval from the local authority (UN-HABITAT 2005). Although in some parts of Africa there is a rapid development of RWH, progress has been slower compared to Southeast Asia (UNEP, n.d).

Households in these regions normally store their rainwater in cisterns, tanks, oil drums and jars (UNEP, n.d.; Al-Salaymeh *et al*., 2011; Domènech and Saurí, 2011; Handia *et al*., 2003; Zhu *et al*., 2004). This is inexpensive and in terms of public health and water quality, rainwater from rooftop stored in jars is known to be an appropriate and inexpensive means of obtaining high quality drinking water (UNEP, n.d.; Al-Salaymeh *et al*., 2011; Handia *et al*., 2003; Zhu et al., 2004). And households mostly use RWH for domestic consumption in developing countries since it is known that pure rainwater is mostly low polluted depending on the quality of the atmosphere (Helmreich and Horn, 2009) and also sometimes harvested rainwater is the only known source of water supply.

To conclude, in most developing countries, using RWH has been feasible, and in some instances policies were needed to ensure its successful implementation. Maintenance was relatively easy since the use of RWH systems were in storage tanks and cistern and with public health most of the water quality has been on par with the WHO standard.

2.7.1.2 The use of RWH in developed countries

In some developed countries the adoption of RWH systems to supply non-potable water to buildings in urban areas has become popular during the last two to three decades (Fewkes, 2012). There has been success and large scale use of RWH in countries like Australia, Japan, Singapore, Japan, USA, New Zealand and in Millennium dome in London (Brown *et al*., 2005; EA, 2003; UNEP, n.d.; Chilton *et al*., 1999; Hills *et al*., 2001; Zaizen *et al*., 2000). In Singapore, collected and treated rainwater accounts for 28 to 33% of the total water used, resulting in savings of approximately S$ 390,000 per annum (UNEP, n.d.). Australia encourages the widespread use of RWH both in rural and urban areas and has demonstrated the benefits of these systems as a vital role in substituting and/or supplementing reticulated urban water supply from centralised water supply facilities (Mitchell, 2004). Furthermore, RWH is the major source of untreated drinking and domestic water supply in New Zealand and other countries (Heyworth, 2006; Simmons *et al*., 2001). More than 10% of rural communities in New Zealand not supplied by centralised systems use RWH as their drinking water (Abbott *et al*., 2007). In the USA, it is estimated that over 100,000 RWH systems are used in at least a dozen US states and territories (Fewkes, 2012). Texas alone has 15,000 RWH systems now in operation as a result of extreme climatic conditions and continuing population growth (Krishna, 2007).

What all these developed countries have in common is that they are mostly water stressed areas. In Germany which is on par with Scotland and not considered a water-poor country, RWH has been used by households since the 1980s and about 50,000 professional RW plants are installed yearly in new one-family houses (Nolde, 2007). It has been observed that RWH in developed countries in terms of feasibility has been feasible even in water which is not considered as a water poor country. There have been policies similar to those of developing country that has also increased the wide spread of RWH in some regions. For example in Flanders, Belgium, new buildings with a roof area more than 100 m^2 are required to install RWH attenuation systems (Environmental Agency UK, 2008) and in the USA, RWH is mandatory in new buildings of Tucson (Arizona) and Santa Fe County (New Mexico) (Domènech and Saurí, 2011). And for instance, in Germany households harvesting rainwater are exempt to pay stormwater taxes (Hermann and Schmida, 1999). This shows that with policies and incentives in place, there has been a high uptake of RWH in some developed countries even perceived to have abundant water resources like Scotland. Therefore, it will be interesting to see if it is feasible in Scotland since RWH has been known to have a lot of benefits. There it is important to explore the acceptability of RWH in some of these countries.

2.7.2 Acceptability and users' perceptions of rainwater harvesting

To understand the acceptability and or behaviour and attitudes towards RWH, countries in developed, developing, water scarce and water abundant regions should be reviewed to see if there will be different attitudes to understand a Scottish perspective. Public consultation is considered to be key factor in boosting the receptivity and acceptance of water demand management approaches (Sharp, 2006). But, this on the other hand has been known to result in difficulties in curtailing usage or introducing water conservation activities; and at most times, public perception is regarded as a primary barrier to conservation and reuse projects (Jeffrey & Geary, 2006).

Most previous research has examined public's perceptions, and attitudes toward recycled water use in terms of greywater, but there is limited research about RWH (Hurlimann, 2006; Ward *et al*., 2008; Dolnicar *et al*., 2011; Hurlimann & Dolnicar, 2011; Dolnicar *et al*., 2010). Information with regards to the public attitudes, behaviours and receptivity towards RWH whether in the private homes, for residential purposes and or commercial setting is limited (Ward *et al*., 2008). There is a need for an elucidation of issues that makes private individuals in households or in a commercial setting be motivated to use RWH technologies (White, 2007). This clarification will help improve access to information for an understanding of the targeted promotion of such systems. This, if it is to be achieved will contribute to the reduce water resources problems faced worldwide.

Though research on acceptability and user perceptions of RWH is limited in scope, earlier studies have centred on the technical specifications of the systems, their general acceptability and characterization of the factors motivating householders to install them (Leggett *et al*., 2001; White, 2007). For instance, research shows in Italy RWH systems are not well developed and or accepted due to lack of consumer knowledge and perceptions coupled with lack of design guidance as the significant setbacks of RWH (Paciarotti *et al*., 2007). With 550 firms working in the hydraulic installation when consulted over RWH installation, 92.4% of them had never installed RWH systems. The 7.6% that had installed started only eight years ago, and they attributed low installation as a result of lack of data and reference source and or point on the system sizing and the planning stage was mainly based on the installer's experience (Paciarotti *et al*., 2007).

According to Ward *et al*., (2008), there have been few studies to assess the perceptions in relation to the risks associated with the type of use, awareness of system maintenance requirements and factors likely to encourage installation of such systems by users. Perhaps, this limited scoop of information on behavioural attitudes towards RWH can be attributed to the lack of relevant regulation and public acceptance (Angelakis *et al*., 2003). In other parts of the world like India, USA, and Australia, though there is no validated research, it can be observed that RWH have been adopted. But it is good to note those parts of the world accepting RWH are facing water problems. The same cannot be said for the UK where adoption is slow even though RWH was included in the now defunct documents like the Code for Sustainable Homes, the BREEA, Future Water and water service provider Strategic Direction Statements (Ward *et al*., 2008).

Managing the demand for water and ensuring sustainability requires knowledge of how people use water and the relationships between social and technical aspects of water use (Seidl *et al*., 2010). This can help understand attitudes and perception towards recycled water. For instance, in areas with persistent water issues and limited natural water resources as in Spain, Australia, Israel, Bangladesh, Malaysia, water reuse RWH is beginning to become an accepted and normal part of everyday life (Friedler *et al*., 2006; Mohad. Shawahid *et al*., 2007; Friedler, 2008). This contrasts to the UK, where persistent water issues are only now being recognised as an ongoing challenge (Ward *et al*., 2013). The use of RWH systems to supply non-potable water to buildings in urban areas of some developed countries has become popular as well with people accepting it for non-potable uses (Berndtsson, 2004). In Australia, research by Hurlimann (2006; 2007) shows that a survey in two office buildings in Australian cities (Melbourne and Bendigo) and in the community of Mawson Lakes and Adelaide, 35% and 64% participants respectively in the studies were 'happy' to use recycled water for drinking and watering gardens and street vegetation due to prior experience of recycled water systems. However, it was observed from these studies from different parts of the world on the use and acceptability of RWH that these communities were water stressed and RWH seems a viable option and solution for them.

Despite the office workers in Australia surveyed were enthused to adopt the use of recycled water and even on a community level as well it is observed that they did not want to be in direct contact with the recycled water (Hurlimann, 2006; 2007). This was on the contrary in the coastal parts of Bangladesh where groundwater was only the source of drinking water due to arsenic affected areas thus RWH was the only alternative water supply source. They did not mind being in direct or getting a personal contact with harvested RWH. What's more, households in some part of Bangladesh perceive rainwater harvested on a community scale to be the most preferable source of water for drinking and cooking purposes with most users expressing high satisfaction (Karim *et al*., 2005). They were not worried and completely comfortable to be in direct contact with harvested rainwater. The research shows that aside from them being pleased; they were also directly involved in operation and maintenance of the systems in their community. Comparing the two countries, although they found the use of RWH acceptable, acceptance and attitudes towards RWH changes when one comes into direct contact with the water.

Additionally, research on RWH involves the technicalities, feasibility, and the cost of the systems and quality of the water being discussed. There is also little or no information on the ease of use and maintenance of the system. Bruvold *et al*., (1981), perceives that projects deemed fit by engineers and other technical personnel, may not be similarly accepted by a community. For that Stenekes *et al*., (2006), acknowledges that values (trust, credibility, stability, familiarity, transparency, accountability and legitimacy) of organisations rather than facts underpin people's receptivity perspectives, as responsibility for a resource such as water. It was also observed that most governmental agencies, NGO's, and environmentalist are pushing for RWH but there are gaps in information for understanding the users' perception towards being in direct contact with RWH.

2.7.3 Rainwater harvesting in the United Kingdom

In 2003, the UK government established the Sustainable Buildings Task Group to identify how government and industry could improve the quality and sustainability of new and renovated buildings with concentration on four areas which included energy and water conservation in England (Fewkes, 2012). This led to the government outlining their current water strategy to reduce domestic water consumption to 130 litres per person per day by 2030 in England and Wales (DEFRA, 2008). To achieve this, there was the need to introduce alternate water systems (AWS). AWS is the technical, social, financial and institutional aspects associated with decentralized AWS systems like greywater recycling, rainwater harvesting and recovery of water through condensation and sewer mining (Memon, 2015). Therefore, the motivation for RWH in the UK stemmed from the large amount of water use per day by homes; the average water usage is approximately 150 litres per person per day with significant variability linked broadly to affluence or socioeconomic group (Butler *et al*., 2010). It was also observed that domestic water use increased over the last two decades (it has increased from 110 litres per person per day to 157 litres per person per day), due to assumed factors such as demographic changes, socioeconomic factors and climatic variation and the population was predicted to increase in the UK over the period 1997-2025 by 3.3 million (EA, 2001). Thus, it was realized that the collection and use of rainwater for WC flushing could result in approximately a one-third reduction in the public water supply to the average household without necessarily considering other non-potable uses like washing machine usage, and outdoor uses such as garden watering and vehicle washing.

Even though RWH could have a significant future role in reducing domestic water consumption in the UK (Fewkes, 2012), over the last decade, reports suggest a lack of interest in installing the systems, and that the technology is being ignored and too readily disregarded (Heggen, 2000; Shaffer and Leggett, 2002). This was first perceived by Mustow *et al*., (1997), since RWH systems in the UK were not new, and a lack of use was highlighted in 2001 where only 75 successful and operational domestic systems were identified (Diaper *et al*., 2001). Though it has been stated that the situation is improving, most places with RWH are in England and Wales but there is very little research in Scotland and Ireland in terms of receptivity to RWH. Perhaps the receptivity to RWH in England and Wales could be attributed to the fact that meters were introduced in homes to reduce water consumption whereas in Scotland there are no meters. Nonetheless the last and recent market intelligence suggests RWH was becoming more widely adopted (Fewkes, 2012). According to Nash, (2012), in 2011 approximately 7,500 RWH systems were installed in UK domestic and commercial properties as compared to 75 successful and operational domestic systems installed in 2001 (Parsons, 2001). However, this cannot be considered as a conventional adoption when compared to the most current researches by (Ward *et al*., 2013) in South-West of England.

In some developed countries the adoption of RWH systems to supply non-potable water to buildings in urban areas has become popular (Fewkes, 2012) but UK is falling behind other countries who are now embracing domestic RWH on a large scale (Berndtsson, 2004). For instance, in October 1998 in Berlin, Germany, RWH systems were introduced as part of a large scale urban re-development to control urban flooding, save city water, and create a better micro climate and in Tokyo to mitigate water shortages, control floods, and secure water for emergencies (UNEP, n.d.). In UK, what is common is the use of water butts found in domestic gardens to collect rainwater, which is then used to water the garden. Research by Fewkes, (2012), states that RWH could have a significant future role in reducing domestic water consumption in the UK, and consequently in reducing the demand for potable water. Although England and Wales have embraced RWH, Scotland is far behind due to the perceived belief that Scotland has abundant water resources. Thus, it will be good for Scotland to strive to encourage a similar uptake in the future.

2.7.3.1 Barriers to rainwater harvesting implementation in United Kingdom

According Ward *et al*., (2013), little research has been done on RWH in UK and their most recent studies on RWH systems were in South-West of England. Even though in 2007 the UK introduced the now defunct Code for Sustainable Homes (CfSH; DCLG 2010) in England and aimed at reducing the average consumption of potable water from 150 l/p/d to 120 l/p/d and to reduce the impact of drainage on site to reduce the risk of flooding; the question is: "*How far have these polices been implemented?*" This is because the CfSH encourages greater consideration of RWH system implementation, but then housing developers have been demonstrated by Ward *et al*., (2013) to exhibit resistant to include RWH in development plans in England and Wales. Furthermore, the code has been scraped and research in England shows that perceived barriers of RWH were as a result of gaps in regulations, institutional, economic and financial constraints, and absence of incentives, lack of information, technical knowledge and attitudes of the house builder (Fewkes, 2012; Ward *et al*., 2013a).

As of 2010 in England, the government was not offering any financial incentives to householders or developers to install RWH systems, but recent studies showed that 87% of the residential developers surveyed would increase RWH in UK (England) if incentives were available (Parsons *et al*., 2010). The cost as in 2010 to install RWH system in UK in a new building was between £1,500 and £3,000 with most respondents, indicating a grant of £750-£1,000 would be sufficient to use RWH in their dwellings. It should be noted that in direct contrast, the government is supporting RWH in the commercial sector through tax incentives for enhanced capital allowances for companies investing in environmental friendly technologies (Parsons *et al*., 2010).

Benefits of RWH for example like flood reduction is unproven and the financial benefits are not well explained to consumers. Contrary to the UK, in other countries, incentives that foster the use of rainwater are increasingly being developed (Domènech and Saurí, 2011). Example, in Brazil, the government is supporting the installation of one million cisterns in the semi-arid areas (Domènech and Saurí, 2011), in Texas there are rebates and tax exemptions to foster the use of RWH (Texas Water Development Board, 2005) and in Australia the government gives a $500 rebate to all houses installing RWH systems (Australian Government, 2009).

Another perceived barrier is of public health concern. Many guidelines have been proposed in the UK for RW recycling but there has been lack of water quality standards (Brewer *et al*., 2001; Leggett *et al*., 2001; Woods-Ballard *et al*., 2007) and this has resulted in public health concerns as a perceived barrier to people using RWH. These concerns can be attributed to the fact that most people in the UK use the mains water which has high quality since it is heavily regulated. This makes their concern for quality and public health concerns valid since they are used to good water quality which they don't have to regulate themselves. Nonetheless, Ward *et al*., (2013) suggested further research on RWH in UK based on the following:

- Product development (enhancing the technical relevant).
- Capacity building (enhancing social receptivity).
- Support services (enhancing institutional commitment): the cost of installing or implementing AWS can be substituted in blanket cost or charges in the rent without people necessarily realizing it (water, energy and housing developing agencies).

Moreover, there is limited information with regards to the public attitudes, behaviours, and receptivity towards RWH whether in the private homes, for residential purposes and or commercial setting particularly in the UK as stated by Ward *et al*., (2008). The first of such studies to be undertaken was by Jeffrey, (2002) who conducted a survey of public attitudes to in-house recycling with 300 participants in England and Wales. But this research was focused on grey water reuse from the shower and bath where there was a general willingness to recycle water, provided the organisation setting standards for reuse were to be trusted. In this study, it was observed that metered participants were more willing to recycle water than unmetered participants. Those interested in recycling wanted it to be from their own residence and for less personal end uses. Another study in the UK was a pilot study where the perceived risk increased when the type of use became personal as in physical contact with the water (Ward *et al.*, 2008). This result was also similar to Jeffrey's UK-based study in 2002 who also found the perception of risk of recycled water, (including rainwater); to increase as the use became increasingly personal.

The acceptability of RWH systems is very important as it requires an understanding of the social environment in which they are to be applied. Without the necessary information and knowledge relating to RWH systems, the listed perceived barriers may diffuse through all the categories identified. There is the need to consider the perceptions of Scotland since most research has been done in England and Wales. However there exist some differences between these two regions; in England, there are metered systems and in Scotland there are none. Results in England showed that metered participants were more willing to implement RWH and without the existence of meters in Scotland attitudes, perceptions, and behaviour towards RWH implementation might differ from England. Along these lines, it is important to understand households' willingness to implement RWH in a Scottish context.

2.8 COMMUNITY WATER DEVELOPMENT

Providing the world's population with clean, potable water is one of the greatest challenges facing both remote rural and urban areas. In cities, there must be a reliable structured management of water where industries, municipalities and residents depend on this precious resource. In rural areas, there lacks such structures since water management are mostly reliant on management by the community. Community management is known to be the leading model for implementing rural water supply systems but at most times, many communities struggle with their management tasks and many water systems break down after some years (Schouten, 2006). According to Schouten, (2006), the scaling up approach which advocates continuous support to communities in their water services can be used to strengthen community management. It also explores supplying water from very remote areas; that is from the current "islands of community success" to larger areas, reaching the entire populations.

To be sustainable and socially acceptable, it is dependent on the use, needs and purpose for the water. Reusing grey water and harvesting rainwater are also known to be sustainable ways of providing water on a community scale and conserving water resources in buildings. However, the UK has variable weather that changes from day to day and or seasons to seasons between different regions and within different regions (Meteorological Office, 2016). Notwithstanding, in England, Environment Agency, (2007), has stated that for UK homes, it is more cost effective to save water than to reuse rainwater or grey water because grey water and rainwater systems often increase the total amount of energy used and carbon dioxide emissions (Crettaz *et al*., 1999). Although for a larger communal domestic or commercial development the economics may be better as compared to individual use. According to Cook *et al*., (2013) communal RWH systems can serve as an alternative potable water services to developments that are not connected to municipal supplies. However this comes with an energy cost which can be improved by using smaller sized-pumps (Cook *et al*., 2013).

Globally, the limitations of a community water supply include community dynamics, political or social conflict, failure to generate sufficient tariff income, failure to account transparently for funds generated, lack of preventive maintenance, lack of community cohesion and lack of capacity (Schouten, 2006). Sometimes these constraints maybe external to the community and might include poor design of water systems, poor construction, political interference in planning and resource allocation, lack of spare parts, lack of supportive policies and legislation and, very importantly, failure to support communities who are attempting to deal with major repairs, conflicts and other problems with extension and upgrading (Thematic Group, 2005). However, the UK does not have community based water supply. Hence it will be difficult to access and know socially acceptable and truly sustainable design solutions for community water development in the UK since there has not been much research in the area.

There has not been any known socially acceptable and truly sustainable development for community water development in the world. What might come close to being socially acceptable is going green and developing eco-towns. Sustainability has become a hot word with people, products and institutions promoting their company products as "green" practices with labels that read "environmentally-friendly" or "low impact." It is difficult to grasp or identify something sustainable just because it is eco-friendly; there is much more to it than that. For it to be sustainable, it is important to create a system that will really be used and maintained, thus if it is not used then it is not sustainable. This should consider of economic, social and environmental factors to produce projects and programmes which will have results which are not dependent on finite resources. To do this you need to understand the culture and the values of the end user.

In 2009, research by Stockholm Environment Institute and United Nations Environment Programme, (2009) advocated for RWH as a way to support ecosystem services and human well-being. In Australia, household water heating consumes approximately 25% of their total household energy use, which is equivalent to the same in household greenhouse gas emissions (AGATC, 2010), but RWH is widely practised and encouraged in Australia both privately and on a community level. RWH has played a vital role over the years in quenching Australia's thirst (Chanan *et al*., 2007). Because of that there is an association called the Rainwater Harvesting Association of Australia (RHAA), formerly Australian Rainwater Industry Development group (ARID), which assists manufacturers and other plumbing industry stakeholders in promoting the benefits of rainwater and reuse water, whilst also providing a sometimes different perspective on water sustainability issues to stakeholder groups and Governments (RHAA, 2013). Likewise, in other parts of the world, it has been observed the use of RWH has been more cost effective and being encouraged by the government. In Singapore RWH accounts for accounts for 28 to 33% of the total water used, resulting in savings of approximately S$ 390,000 per annum; in Thailand, it has been realized that storing rainwater from rooftop run-off in jars is an appropriate and inexpensive means of obtaining high quality drinking water; in Bangladesh, rainwater collection is a viable alternative for providing safe drinking water in arsenic affected areas (UNEP, 2013).

2.9 PUBLIC ACCEPTABILITY TO NEW TECHNOLOGIES: ENERGY CONSUMPTION IN UK HOMES

There is a close connection between energy and water, as such it is important to understand UK households' perceptions and attitudes to energy consumption in UK homes to better relate it to RWH implementation in Scotland. Moreover, there has been more research on energy efficiency as compared to water efficiency in the UK. As a result, it is important to link the two; water and energy since a constraint on one affects the other. Of all the CO_2 emissions in the UK, 6% are from water use in homes and 89% of this comes from heating water in homes (Environment Agency, 2008b). In UK homes, it is estimated that hot water use contributes £228 to the average annual combined energy bill and emits 875kg of CO_2 per household per year (Energy saving trust, n.d.).

Domestic energy use in the UK accounts for 26.5% of total final energy consumption which is similar to the proportion of the country's carbon emissions (DECC, 2012; DECC, 2013). Recently, there have been many concerns about energy security and climate change which are driving significant changes in how energy and electricity specifically, is generated, transmitted, and consumed in the UK (Devine-Wright, 2007). Energy conservation has become one of the first sustainability issues to be addressed through a combination of national and local government policies (Brandon and Lewis, 1999). Conservation research in the past has been focused on energy crisis, global warming, and threats to biodiversity (Gardner and Stern, 2002). According to Devine-Wright, (2007), studies have been attempted to identify levels of public understanding and awareness of different forms of energy technology and their impacts. Findings produced were not concrete; there was a mixed set of findings due to the varied nature of questions that were asked.

Different households in the UK have different levels of knowledge, attitudes and different energy-using/saving practices (Wood and Newborough, 2003). Global environmental problems and individual behaviour according to Brandon and Lewis, (1999), can be associated to domestic energy consumption even if consumers do not immediately recognize the connection. However research shows that environmental attitudes and behaviour have a minimal influence on the total percentage difference of energy consumed (Cook and Berrenberg, 1981; Hutton *et al*., 1986; Brandon and Lewis, 1999). Nonetheless, in the UK, in response to increasing energy prices as well as economic crisis, consumers were conscious of their energy bills and how much they were paying and thus reported some change in their behaviour (Balta-Ozkan *et al*., 2014). In terms of saving money on energy, it is has been observed that some householders in the UK will switch to energy-efficient appliances and will further go to the extent of acquiring digital meters to monitor their energy usage (Balta-Ozkan *et al*., 2014). Not only that, a research in south-east of England shows that householders were interested in receiving information concerning household energy use and the associated environmental impact, and were also willing to modify their behaviour in order to reduce household energy consumption and environmental damage *(*Mansouri *et al*., 1996).

2.9.1 The importance of considering water and energy saving together

According to the energy saving trust, "*the UK public does not often relate to news stories on water shortages. It seems to rain much of the time. When we turn on the tap there is plenty of water. What is there to worry about? The dangers – shortages of supply, expensive utility bills and harmful carbon emissions – lurk out of sight and out of mind*". But what people tend not to realize is that every time the tap is turned on to take a shower, wash dishes and or run a bath or any appliances that uses water money is spent, carbon emissions are emitted and water is taken out of the reserves (Energy Saving Trust, n.d.). Furthermore, water has a significant, hidden impact on costly fuel bills as a result of heating water which is the second largest source of energy use in the home (Department of Energy and Climate Change, 2012). It is estimated that 8% are aware that heating water impact on their energy bills in the UK (Environment Agency, 2008b). Annual energy used in homes thus is heating water in UK homes is detailed in Figure 2.8.

Figure 2.8: Annual energy bills from heating water in the kitchen and bathroom in UK homes (Source: Energy Saving Trust, n.d.)

Improving heat and water use efficiency in the home could significantly reduce carbon emissions (Energy Saving Trust, n.d.). The energy used to heat water in UK homes emits an average of 875kg of CO_2 per household and the bathroom uses the hottest water in the home, and so responsible for the most water-related carbon emissions (Figure 2.9).

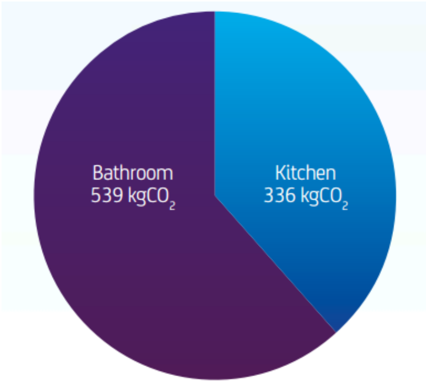


Figure 2.9: Carbon emissions from water heating and water-using electrical devices in the home (Source: Energy Saving Trust, n.d.)

Water is used in three main areas of the home: the bathroom, the kitchen, and the garden. In the bathroom, which is the highest emission of carbon, RWH can be used for non-portable uses like toilet flushing etc. which thereby reduces one's water/carbon footprints. In as much, understanding of attitudes to energy consumption in UK homes can help understand Scottish households' perception to RWH implementation.

2.10 CONCLUSION

This chapter has provided an extensive review of literature regarding RWH at both UK and some international countries and has shown the existing gap in implementation in Scotland. It has also provided discussion on climate change in the UK, several theories on community water development and the existing frameworks and guidelines on community water development. Due to the emerging links between energy and water, the acceptability of new technologies to the public and energy consumption awareness which is applicable to the study of RWH in Scotland was also reviewed. However, it was observed that there were gaps in the implementation of policies relating to water regulation, climate change and the perceptions of people towards the use of recycled

water in the UK, especially RWH in Scotland. There is an extensive research on RWH in the UK by a lot of researchers but it is focused mainly on England and Wales.
In meeting the third objective: "*to explore the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance and ease of using the system) and stakeholders' views*"; it was realized in England research shows RWH has a place in England as an alternative technology to increasing water demand, reducing water and effluent charges and a perceived adaptability and resilience to flooding in the face of climate change and population growth. Households in England were willing to implement RWH if it will reduce their water bills, free from contaminants, some form of financial incentives and the system was easy to use. Internationally, there have been tax rebates, financial assistance giving to households that use RWH and a policy framework to guide builders and planners. Further, there have been wider benefits of RWH as an alternative water supply during droughts, reducing water usage in homes (conservation), a storm water source control, firefighting and reducing the heat island effect.

With regards to Scotland however, it was observed from literature that most Scots perceived that water was free in Scotland and was in abundant supply. In most international countries that had adopted RWH, capital outlay (who finances; financial incentives) was very influential in RWH implementation. Not only that, but operational and maintenance difficulties (who is responsible for maintenance and if owner is responsible how do they go about maintaining the system) was also a factor and or barrier to RWH implementation worldwide. Furthermore, potentially long payback periods (depending on the efficiency of the system design), a shortage of specialists and health and safety fears also played an important role in the socio-economic and technical adaptations of RWH which has yet to be explored in Scotland thus Objective 3. Additionally, in exploring socio-economic acceptance of RWH in Scotland, it is important to explore financial incentives since literature suggests that providing financial incentives in other countries has been significant in achieving a widespread adoption and implementation of RWH reinstating the reason for Objective 3: "e*xploring the factors affecting RWH implementation*".

Literature review further suggests that in England, the Code for Sustainable Homes that was aimed to support and promote RWH and now defunct; their actions were limited to encouragement rather than enabling the implementation of systems. Furthermore, the literature review did not identify any studies in the UK concerning stakeholders' perceptions of risk from RWH. This represents a significant knowledge gap and studies are required to analyse behaviour, attitudes and perception of RWH in Scotland to achieve Objective 4: "*to explore the risk involved in using RWH (attitudes towards risk which influences the perception of RWH)*" and not just stakeholders but households. Accordingly, it is important to look at the barriers that inhibit from people accepting RWH in Scotland since the review suggests that little has been done in the UK on RWH concerning public awareness of RWH. There is the need to understand their perception, attitudes, risk involved and familiarity with RWH systems and an adaption to climate change thus Objectives 4.

It was revealed that some of the countries using RWH were on par with Scotland it terms of water abundance or richness. In comparing Scotland with the other countries considered (Japan, Germany, USA, Australia, Spain, and some African countries), literature is limited and this is another knowledge gap in Scotland with regards to the use of RWH in terms of adaptations to climate change and reducing the carbon footprints of people. There is a non-existent in initiative which focus on adaptation to climate change thereby revealing gaps which is yet to be explored the benefits of RWH in Scotland and therefore achieving Objective 2: "*to understand the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland*". There is the need to understand climate change and have a clear methodology which can define the different technologies and the risks (including financial) associated with water conservation and the use of RWH in Scotland with much focus on the policy context, socio-economic drivers, and public perception (particularly with regard to public health). Moreover, to do this, it is important to understand and explore a community water development scheme in Scotland since literature suggests communal water development is the leading model for implementing rural water supply systems. However, there is paucity of data concerning guidelines on community owned private water supply in Scotland thus as part of Objective 3: "*to explore the factors affecting RWH implementation*".

Chapter 3– RESEARCH DESIGN AND METHOD

3.1 INTRODUCTION

The overall research aim of this thesis was to explore the feasibility of RWH as a component of water neutral development scheme in Scotland. The approach used in this study was a mixed methods approach using qualitative and quantitative research. To meet the four objectives:

1. To explore and understand the theories and practices of rainwater harvesting in the world.
2. To understand the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland.
3. To explore the factors affecting RWH implementation and stakeholders' views.
4. To explore the risk involved in using RWH.

The study employs a social science approach; however, the author's background is not in social sciences. Nonetheless, three main methods: literature review, residents' survey and stakeholder interview as a mixed method approach was used in this study. The study did not focus on all of Scotland but rather selected different areas and reason for selection are further explained in Section 3.3.

3.2 OVERVIEW: GENERAL APPROACH

As the world is interpreted through the classification conceptions of the mind (Williams and May, 1996: 19, cited in Gray, 2013, p23), the diverse views of respondents are valuable in detailing the behaviour, perception, attitudes, and inclination towards RWH in this study; thus, the reason for using a mixed method approach. Simultaneous data collection and analysis from the surveys using Statistical Package for the Social Sciences (SPSS) and interviews were explored to understand attitudes to RWH and climate change. Mixed methods research refers to studies in which researchers utilize qualitative (interviews in this research) and quantitative techniques (surveys in this research), to integrate findings and draw inferences from both the qualitative and quantitative components (Leech, 2013). Research methodology is a structured set of guidelines or procedures to facilitate in achieving a valid and reliable research results (Mingers, 2001). The methodology used in studies should be able to answer specific questions, solve different scientific and practical problems (Bryman, 2012). However, each subject or area being analysed is subjected to its own research methods. Hence for this study the mixed method approach in the form of literature review, resident/user surveys and stakeholder interviews were used to answer specific questions in Objectives 1-4 (Table 3.1).

Table 3.1: Overview of the objective and its corresponding chapter

Objectives	Method	Chapter
Explore and understand the theories and practices of rainwater harvesting in the world	➢ Literature review	Chapter 2
Understanding the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland	➢ Literature review ➢ Resident/user survey results ➢ Stakeholder interviews	Chapter 5
Exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders' views	➢ Literature review ➢ Resident/user survey results ➢ Stakeholder interviews	Chapter 4 Chapter 6
Exploring the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH	➢ Literature review ➢ Resident/user survey results ➢ Stakeholder interviews	Chapter 7

The literature review was used to explore RWH implementation in Scotland, climate change impact on waters and a communal water development. Emphasis was placed on understanding the perceptions and behaviour of Scots in relation to RWH. This was to develop public acceptability to an alternate source of water supply if climate change will impact on their water resources to answer Objectives 2-4 (Table 1.1; Chapter 1). A structured questionnaire was used to investigate associations between residents' perspectives on RWH, climate change and water supply and the type of respondent (e.g. age, gender, etc.) was employed in this study. The quantitative approach was further used in exploring the relationships between gender, age, and willingness to conserve water, implement RWH and awareness of climate change. Age and gender were explored because there have been several constructions of theories of general propositions representing regular causal relationships between gender and age as a factor in showing concerns for the health of the environment. The qualitative approach on the other hand was employed through stakeholders' view (policy/framework) and feasibility of RWH in Scotland (Table 1.1; Chapter 1) through interviews to meet Objectives 2-4 (Table 1; Chapter 1).

In obtaining potable and or drinking water, the most common technology used are related to the development of technologies that uses surface water from rivers, streams and lakes, and groundwater from wells and boreholes. But these sources of potable water according to Water-Aid, (2013), account for only 40% of total precipitation. Alongside, in the UK, approximately 107m^3 of rainfall falls on each domestic roof top per year and water companies spend comparatively £10 billion disposing of it in a manner which manages the risk to the public, the economy and the natural environment (Caffoor, 2008). To such a degree, it will be cheaper to catch some of this falling rain and use it for some domestic purposes like flushing the toilet and gardening. This overall will also reduce the pressure on mains water supply thereby reducing the amount of energy needed to pump and treat water thus reducing carbon emissions. But to use harvested rain, it is important to understand how people perceive rainwater as a source either as an alternative or as a water supplement.

Falling rain is known to be a source of clean naturally occurring water as a result of its natural distillation process that is at risk only from airborne particles and from man-made pollution caused by the smoke, ash of fires and industrial processes (Water-Aid, 2013) and some people have been using it for domestic purposes. However, the definition of RWH is a subjective topic because it might be practised within communities where people might not have the wording and meaning right. There are different terminologies people around the globe use to describe RWH; in the UK, most people refer it as the use of water butts. Some might not have an idea that by using rainwater for domestic purposes like gardening and washing cars they are harvesting rainwater. Therefore, it is important to explore how people perceive RWH and if they are aware they are doing it. Furthermore, to promote the use of RWH in households, three key areas: beliefs, desires and intentions are explored in this study to understand the attitudes and external factors that might encourage the uptake of RWH in Scotland. This is further detailed in the Figure 3.1.

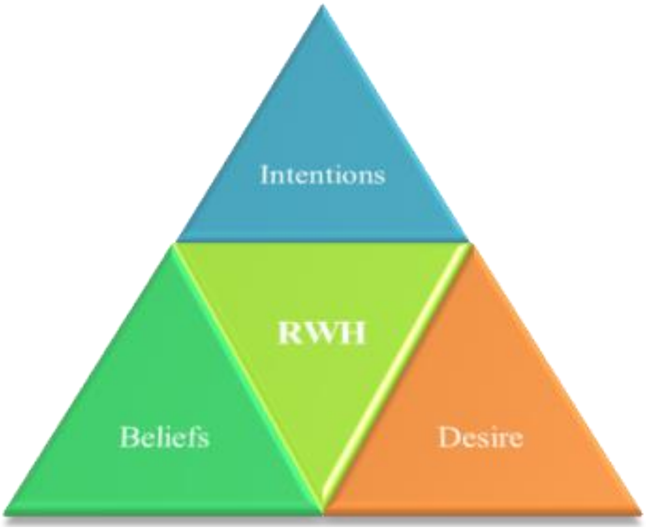


Figure 3.1: The 3 keys areas explored in this research: beliefs, desires and intentions which are influenced by attitudes and external factors

Accordingly, as this study tried to understand the intentions to implement RWH in Scotland, it explored through the objectives as specified above by: exploring social and technical adaptations of RWH in Scotland; analysing behaviour, attitudes, and perception; understanding people's perceptions on climate change and its effects on their source of water supply and exploring the feasibility of a community water development scheme (Figure 1.3). Furthermore, this study on exploring the beliefs seeks to explore the behaviour and awareness of RWH and if householders are implementing it in their homes. Additionally, it looks at stakeholders involved in the water industry in Scotland and looks at their view on RWH and climate change. Hence the wording is very critical in what people think of RWH as well as the purpose for storing rainwater. How a person views and understand RWH might affect their behaviour and attitude towards the use of rainwater. The human mind as researched by Blumer, (1962) involves an interconnectedness of objectivity and subjectivity which leads to individuals' perceptions and experiences in shaping their realities. It is believed by Mertens, (1998) that reality is socially constructed. This means that meaning is not discovered, but constructed since in the understanding of knowledge, different people may construct meaning in different ways to the same phenomenon. Shah and Velleman, (2005), contend that "*conceiving of an attitude as a belief that P entails conceiving of it as governed by a norm of truth, that is, as an attitude that is correct if and only if P is true*". As in the case of RWH, people may not be aware rainwater can be treated to a good standard for personal contact in use. Thus, in using 'belief'', one aim of this study was to explore awareness, behaviour and attitudes towards RWH.

According to Crotty, (1998) , subject and object emerge as partners in the generation of meaning. Therefore, for someone to desire something they must understand how it functions and if it is beneficial to them. Desires are outcomes the individual seeks and the states of affairs that people would wish to be brought about. It can be a physical asset or through interaction since one of the most fascinating things about humans is conversation (Pettit and Smith, 1996). Conversation is known to stimulate people to change their minds from what is heard from others and if not satisfied, then they usually feel obliged to make clear why they are not and why indeed the others should alter their views instead (Pettit and Smith, 1996). Desires are further expressed as an individual which is normally referred to as "an agent" in models, motivation, or objectives that they wish to accomplish. Therefore, in exploring desire in this study, it is to test the financial benefits of RWH in householders and what will make householders willing to implement RWH. Is their desire to implement based on: RWH myths, a financial incentive, like it being financially beneficial to them or getting grants for it, to be green (environmental friendly), as climate change mitigation solution and because of a neighbour having it or an individual preference.

The beliefs and desires factors lead to intentions; it is formulated that people will follow a course of action whereby their behaviours are guided by underlying principles (Schank & Asbelson, 1977). When all three; belief, desire and intention (Figure 3.1) are all present in the mind, it is assumed that then a person would "*rationally*" lead to a given action (Barsalou, 1985). Thus, the study adopts the epistemological approach of anti-positivism (interpretivist/subjective) and also the positivist (objective) side where emphasis is placed on understanding the perceptions and behaviour of people in relation to RWH.

In interpreting attitudes towards different sorts of water systems in this study (PWSs and MWSs) to understand inclinations towards RWH, the positivism and the interpretivist approach used a methodology of survey in the form of questionnaires, followed by interviews and then statistical analysis, observations, and reference to documents and later discussion. The choice of methodology was to answer specific questions, solve different scientific and practical problems as suggested by Bruman (2012) and have an insight into management of RWH if it was to be implemented in Scotland. In choosing the mixed method approach, other methods were analysed before settling for a mixed method approach. There was the option of using either qualitative method or quantitative method. However, within the environmental psychology it is common to analyse environmental behaviours from the point of view of 'values, beliefs and norms' (VBN) (Stern, 2000). This theory assumes that "*pro-environmental actions occur in response to personal moral norms about such actions and that these are activated in individuals who believe that environmental conditions pose threats to other people, other species, or the biosphere (awareness of consequences, or AC)*" (Stern, 2000) (Figure 3.2). With the keys areas beliefs, desires, and intentions being explored in this study, it was necessary to use a method that capture social perceptions as well as give an insight into the feasibility of RWH in a Scottish climatic context. According to Staddon and Genchev (2013), "*while VBN models have been found to explain behaviour more completely than other factors such as socio-demographics, contextual factors are likely to be at least as important, not least because any given attitude may have multiple underlying drivers, social, cultural, political, economic, which only approximately triangulate onto the measured value or attitude*". As a result, socio-economic features of the respondents although may certainly influence the perception and attitudes towards RWH implementation in Scotland; this influence could not be analysed in this study as other contextual factors like financing was used instead.

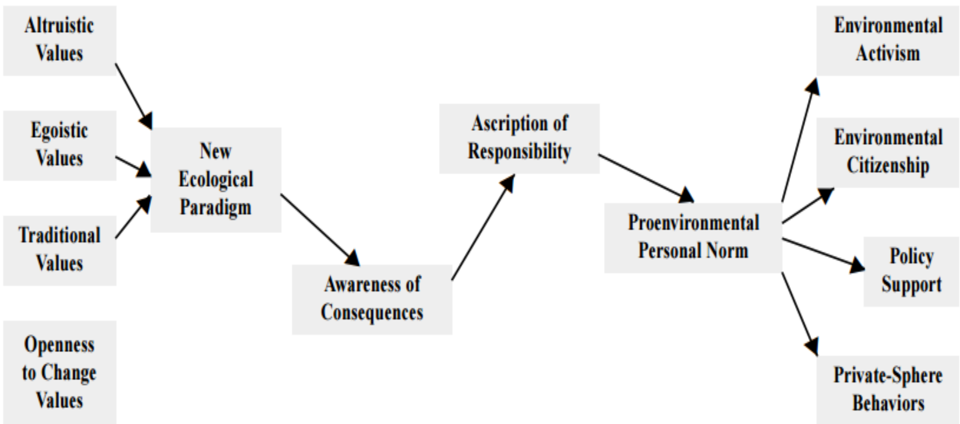


Figure 3.2: Schematic model of variables in the Value-Belief-Norm theory as applied to environmentalism, showing direct causal relationships between pairs of variables at adjacent causal levels (Source: Stern, 2000)

Researchers for investigating similar studies have used either qualitative or quantitative research methods or both (Domènech and Saurí, 2011; Hurlinmann (2006, 2007);

Özdemir *et al*., 2011; Parsons *et al*., 2010; Ward *et al*., 2008; Ward *et al*., 2013). These methods were in the form of questionnaire surveys, interviews, or both. However, other researchers also used logistic regression techniques (Baguma and Loiskandl, 2010) and binary logistic regression model *(He et al*., 2007) to evaluate attitude or risk preference for adoption of RWH. Comparing results of these studies and the aim of this study, a mixed method approach in the form of questionnaire survey and stakeholders interview was deemed appropriate for this study. This was because to capture social perceptions and to provide insights into the role of residents and or stakeholders in the management of existing rainwater harvesting systems, interviews were known to be effective from the other studies. Also, multi-method research approach per Staddon and Genchev, (2013), can yield a wealth of information on social and cultural aspects of attachments things.

The study thus employed a similar methodology to other researchers by using a mixed method approach to explore why participants who were on PWS were using PWS and whether they had MWS in their neighbourhood through questionnaires surveys of households and interviews of stakeholders. This was intended to interpret and understand responses from participants on their inclinations towards RWH, impact of climate change on Scotland's water resources and relating it to policies through their beliefs, desires and intentions as depicted in Figure 1.3 (Chapter 1, page 14). The physical assessment, social assessment, and technical assessment (Figure 1.3) were interconnected with beliefs, desires, and intentions (Figure 1.3) since it comprised of:

1. Physical assessment: current water supply in Scotland (PWS and MWS), climate and available water resources which was assumed to be plentiful in Scotland (beliefs).
2. Social assessment: cultural perceptions, gender roles and community dynamics (which can influence the desires of participants concerning RWH through interaction since one of the most fascinating things about humans is conversation (Pettit and Smith, 1996).
3. Technical assessment: available resources, supply and demand and previous projects (availability of financial resources and the demand for water will lead to the intention of both PWS and MWS users to be inclined towards RWH).

Thence the use of the three key areas beliefs, desires, and intentions.

3.2.1 Ethical Considerations

Prior to sending out the questionnaires, an ethics form was filled and after it was approved by the university's ethics committee, the questionnaires were then sent out. Participants were appropriately informed of the aim of the study, and how their contacts were known was also explained. They were further informed that their responses would be anonymised and analysed for this study. They were also given the opportunity to verify the authenticity of the research by contacting the school, my supervisor or myself. This was made available in the form of email address and a telephone number.

Prior to meeting stakeholders for the interviews an information sheet with a summary for the interview (appendix I), summary of results (appendix II) and a consent form (appendix III) were sent to participants. The consent form ensured stakeholders were informed their participation was voluntary and they were free to withdraw at any time, without giving reason.

3.3 DATA COLLECTION

3.3.1 Choice of study area

Four study areas: Aberdeenshire, Highland, Scottish Borders and Edinburgh were chosen to answer the questionnaires. Four study areas were chosen due to time constraints and flexibility in analysing the data. Aberdeenshire, Scottish Borders, and Highland were on PWS and the city of Edinburgh which was on the mains water supply (MWS). The criteria for selecting the study areas on PWS was due to the fact they had the highest PWS users in Scotland as of 2012 and data was readily available from their councils. Prior to selecting the 4 councils, the list of PWS by Local Authority Area from Scottish Governments' 2012 report was accessed to identify the council with the most PWS. It should be noted that at the beginning of this research it was only the 2012 report which was available. A freedom of information (FOI) per the Scotland Act (2002) was used to request Local Councils with PWS users for the number of properties/households on PWS, the postcodes of those properties, use for the PWS, the source of PWS and the type of PWS. The councils that responded were Orkney, Argyll and Bute, Fife, the city of Edinburgh, Dundee, and Falkirk. Based on the councils that replied, the three Local Authorities with the highest PWS use was selected. The highest number of supplies was Aberdeenshire (7,676) followed by Highland (2,338) and Scottish Borders (1,420). In Edinburgh, it was based on proximity and easy access to households if the need be. Majority of the PWS type was type B in all the 3 areas on PWS.

PWS users were selected because it was assumed that they will be more concerned with impacts of climate change on their water resources and will be more willing to practice water conservation measures like RWH. This is because PWS users are responsible for maintenance their water supply. However, one MWS was added to the three PWS to observe if there will be differences between responses from MWS users to PWS users. The study areas are further described in Chapter 4.

3.3.2 Setting: Resident survey

To meet the research objectives, a postal questionnaire survey on attitudes towards RWH and climate change impact on Scottish water resources was conducted in Aberdeenshire (AS), Highland (HL), Scottish Borders (SB) which was on PWS and compared to the city of Edinburgh (ED) which was on MWS. The themes in the questionnaire were derived from Ward *et al*., (2013) and were later modified to fit a Scottish setting.

3.3.3 Participants

400 houses in AS, 350 houses in HL, 250 houses in SB and 1000 houses in ED were sent questionnaires to participate in this study. The houses selected were given an introduction on the purpose of the study and what it aimed to achieve. They were given the opportunity to verify the authenticity of the survey. Only 20% of households in each study area were expected to respond to the survey. The expected total number of households expected to participate in the study was 400 (200 from PWS and 200 from MWS). Therefore, based on the councils that were selected, the total number of questionnaires sent and expected back (in brackets) was in this format: AS had the highest PWS users so a total of 400 questionnaires (80); HL the second highest was sent 350 questionnaires (70) and SB which was the third highest was sent 250 questionnaires sent (50). The city of Edinburgh was sent 1000 questionnaires and a total of 200 were expected back.

3.3.4 Survey design

A postal questionnaire survey was sent randomly to postcodes obtained from the councils of PWS users and MWS users in Edinburgh. Addresses were randomly selected to eliminate bias by giving all individuals an equal chance to be chosen. To ensure that each element in the population had an 'equal and independent' chance of being selected, the address was randomly selected from the list of addresses that were obtained from the council for those on PWS. However, it should be noted that there was the possibility of bias in the questionnaire survey design and the responses received since questionnaires were sent to different geographical areas (ranged from rural to semi-urban). According to Staddon and Genchev (2013), potential sources of bias may confound attempts to interpret results including:

a. Social desirability bias—where respondents may opt for choices they think portray them in a more favourable light, rather than opting for their 'true' preferences;
b. Acquiescence bias—where respondents may agree with a statement simply because it seems authoritative or indeed because they don't quite understand it;
c. Information bias—where respondents opt for responses related not to their own underlying attitudes or preferences but rather informed by information given by the researchers verbally or on the questionnaire itself;
d. Instrument bias—linked to information bias, this can occur where a given question or series of questions unfairly 'leads' the respondent or puts her in an impossible (e.g. 'Why do you hate the environment?' as a first order question is predicated on the assumption that respondents do hate the environment);
e. Learning bias—where respondents learn over the course of the survey and begin to integrate that new learning into their subsequent answers. Unless one is specifically undertaking 'deliberative research' where learning is part of the object of the exercise, such learning biases need to be carefully controlled for through elimination of unnecessary cues and data and neutral implementation of the survey.

To combat and reduce bias as much as possible, the questionnaires were written in such a way that it was easy to comprehended. It was proven to be comprehensible with the responses received from the pilot studies. So once an address had been selected, a questionnaire was sent to that household. A prepaid return envelope was included for participants to send back response. The prepaid envelope was coded as AS for Aberdeenshire, HL for Highland, SB for Scottish Borders, and ED for Edinburgh so as not to confuse responses received at the same time from different study areas. Furthermore, the questionnaires were also coded based on the first month it was initially sent to also distinguish responses from all the areas. It was coded as SB_042014 for Scottish Borders, AS_062014 for Aberdeenshire, HL_062014 for Highland and ED_092014 for Edinburgh. Additionally, in the questionnaire, a link was included for participants who were unable to mail their return to respond online. For the city of Edinburgh, the website www.192.com was used to find addresses of people on MWS. Once the addresses/postcodes were randomly sent a questionnaire, a file on addresses sent questionnaires was created to avoid repetition and to keep track of wrong or outdated addresses. Four surveys were then created individually using lime survey to represent each study area. Responses from the questionnaires that were received were manually entered onto lime survey for each study area and were then exported to SPSS.

The Scottish Borders was used as a pilot to test the questionnaire survey. Before the questionnaires were sent out, three options were decided upon: to send the questionnaires through the post, on social media (facebook and twitter) and personally to households (door to door). Due to ethical reasons, it was decided as a pilot to send the questionnaire by post and if it failed, social media was to be the next option and when critical, a door to door method. When questionnaires were distributed by post, responses were received within the first week it was sent out. The expected response rate exceeded what was initially targeted, and participants preferred the postal version as to online and only one person drew attention to typos. Thus, after the pilot study, the results showed only minor changes were needed to be made in the form of typos. The success of the pilot studies meant that few adjustments were required before launching the main survey. The mode of distribution as described above was also convenient therefore the same procedure was repeated for AS, HL and ED. Questionnaires that were returned not filled and undelivered because of wrong address were replaced. They were considered as void questionnaires and were not counted as part of the questionnaires received. Hence an additional 41 questionnaires were added to the 1,000 questionnaires delivered to households on PWS to replace the void questionnaires.

For the households in the city of Edinburgh, the list of addresses was determined using EH postcode areas. The post codes chosen were EH1 to EH17, post codes outside Edinburgh EH18 onwards were not considered. Using the website www.192.com, a total of 1,640 addresses were randomly chosen and collated into a single data. Questionnaires were randomly sent to the different postcodes. The number of questionnaires sent differed: 58 questionnaires to EH3, EH4 and EH17; 59 questionnaires were sent to EH1, EH5, EH6, EH8, EH9, EH10, EH11, EH12, EH13, EH14, EH15 and EH16 and 60 questionnaires to EH2. A total of 39 questionnaires were sent to replace void questionnaires which were approximately 95% because of wrong address.

3.3.5 Questionnaire structure

The questionnaire (appendix IV-V) consisted of 40 questions in 4 sections (A-D) and was divided into 4 sections: participants and their water supply, awareness, and experience of RWH, climate change, weather and water resources and demographics. The choice of themed sections is further explained below. Closed format questions in the form of multiple choice questions and Likert scale were used in all the questionnaires. The reason for using closed questions was that they can be more specific, thus more likely to communicate similar meanings to participants and furthermore they are can be more easily analysed. Further it was assumed that closed format questions take less time for the participants to answer, thus employing them in this study. Moreover, closed questions were used because since PWS users and MWS user were being compared, it allowed the questionnaire to access the different groups (MWS and PWS) at different intervals to efficiently track their opinion. However, participants were asked in the last part of the questionnaire to add additional comments if any. This was to get feedback or clarity or ask a question about the survey. They were also asked if they were willing to participate in focus group discussion and their availability and contact details were asked as a closing part to the questionnaire.

Likert Scale questions use fixed choice testing to measure beliefs, attitudes and opinion (Bowling, 2002; Burns and Grove, 2005). Therefore, in managing the demand for water and ensuring sustainability requires knowledge not only in how people use the water as a resource, but also in the relationships between social and technical aspects of water use (Seidl *et al*., 2010). Hence to understand or explore opinions on attitudes, behaviour, and perceptions of RWH, water use and climate change impacts on water resources in Scotland, exploring belief, desire and intention through Likert scale seem appropriate for this study. Not only that, they were chosen for this study because it is easy to understand them. Since the survey was a quantitative data, it is easy to draw conclusions, reports, results, and graphs from the responses. Moreover, because Likert Scale questions use a scale, people in the study areas were not forced to express an “either-or opinion”, rather it allowed them to be neutral should they choose. The Likert scale used was mostly on a 5-point scale except a few which had a 3-point scale and a sixth option in the form of “never” or “I don’t know”. The 5-point scale was to get an in-depth response by having a stronger strength/intensity response to some questions on how much they agreed or disagreed with a statement. On the other hand, the 3-point scale was used for quick responses which can be easy to analyse. The choice of Likert scale words used were: influential, likely, acceptable, consider, extent, important, extent, consider, disagree, probable and effect. The table of Likert scale questions were not consistent in the questionnaires to encourage participants to think about each question before they answered.

Likert scale questions were used in all four sections of the study but particularly in sections B and C and multiple choice questions were mostly used in sections A and D.

3.3.5.1 Section A: You and your water supply

The purpose of this section was to understand how participants were using their water and if there were any water efficient measures used in households. This section differed in terms of households on PWS and those on the MWS, but all study areas had questions that asked what their water was primarily used for, water saving devices used in homes and also accessed the measures of water consumption in through of use of water for domestic activities. Householders were further asked if some common domestic activities like making a cup of tea/coffee, running the dishwasher was related to their energy bills. This was to assess participants’ perception of the relationship between energy and water usage. As discussed in Chapter 2.6, people were willing to modify their behaviour in order to reduce household energy consumption and environmental damage (Mansouri *et al*., 1996). Therefore, this section was also to explore the correlation between consumer demand for water and the amount of energy needed to warm water. Some of the questions asked included: “*do you have any water* *saving devices*", "*how much water do you and your household use in a day*", and "*to what extent do you think these activities are related to your energy bills (on a scale of 1-5, which of these influences your energy bills; 1 being "not at all influential" and 5 being "extremely influential")*". Additional questions like: "*is Scottish Water mains supply available in your neighbourhood*", "*why do you use private water supply*", "*what is the source of your private water supply*" and "*is your private water source shared with other users*" were asked of households who were on PWS.

3.3.5.2 Section B: Awareness and experience of rainwater harvesting

The purpose of this section of the survey was to explore householders' awareness of RWH and their preferences in relation to RWH practice (e.g. communal vs individual systems). The social and economic drivers for participants to implement RWH were explored in this section. As well, participants were asked if it was important to conserve water through RWH. Prior to the questions under this section, the meaning of RWH was explained to participants in the questionnaire's introduction.

This section also explored participants' attitude to RWH for domestic purposes. The literature revealed that there were no water quality standards for RWH (Brewer *et al*., 2001; Leggett *et al*., 2001; Woods-Ballard *et al*., 2007) and this has resulted in public health concerns as a perceived barrier to people using RWH. Consequently, the importance of this section in the questionnaire was to achieve the aim of exploring the attitudes, perceptions, and behaviour towards implementing RWH in Scotland. In meeting Objective 1, it was observed that RWH in terms of perceptions, attitudes and behaviour was limited in Scotland compared to England. Thus, this section asked questions like: "*does your house have any form of rainwater harvesting such as a water butt or a storage tank that specifically collects rainwater*", "*would you be willing to implement RWH in your house*", "*if RWH is implemented in your house, how likely will you use it for these purposes? With 1 being "extremely unlikely" and 5 being "extremely likely*", and "*do you think having RWH in your house will be financially beneficial to you and your household*".

3.3.5.3 Section C: Climate change, weather and water resources

This section of the questionnaire explored awareness of climate change through the media, friends, or community and not their experience of climate change happening or if they believed it was happening. From literature reviewed, it is assumed that climate change will increase the demand for water use, for its use in cooling and most importantly in energy supply (Bates *et al*., 2008; WWAP 2009). Therefore, the climate section was set to explore the perceptions of householders on climate change impact on their source of water resources and if it corroborates with current research findings. The meaning of climate change was explained to participants in the questionnaire's introduction.

The main theme set in this section was the influence of "climate change" and "weather" on water neutral development concept as RWH. Participants were asked if climate change will affect Scottish water resources. Furthermore, participants were asked if they felt climate would reduce water supply and quality of water for human consumption through water pollution, flooding and drought to assess how much they know about the negative impacts of climate change. Additionally, householders were asked if reduction in good quality water through climate might increase energy needed to treat water for consumption. Some examples of the questions asked included: "*are you aware of climate change*", "*do you think climate change could impact on water resources and supply in Scotland*", "*do you think that climate change will lead to poor water quality*", "*will reduction in good quality water through climate increase energy needed to treat water for consumption*", and "*do you think the effect of the weather can impact on water resources and supply in Scotland*".

For intentions to be achieved it is dependent on desires and beliefs; according to Schank & Asbelson, (1977), the beliefs and desires factors lead to intentions; it is formulated that people will follow a course of action whereby their behaviours are guided by underlying principles. Thence participants were asked their willingness to do something to reduce the impact of climate change if they knew it would affect their source water supply.

3.3.5.4 Section D: Personal and household information

The last section was on demographic to quantify the characteristics of the respondents. Participants were asked of their gender to ascertain if responses from males might be different from females since most research shows females tend to be more environmental conscious; that is they have a positive attitude towards green behaviour and will be willing to pay more for it (McIntyre *et al*., 1993; Banerjee and McKeage, 1994; Laroche *et al*.,(2001); Han *et al*., 2009). The age group of participants were asked as well and they were grouped into six categories: 16-24; 25-34; 35-44; 45-54; 55-64 and 65 years and above. Respondents were further asked if they owned their homes or it was rented and the type of accommodation was asked to determine if retrofitting will play a part in their preference for a community or individual system for their homes. The access to a garden (private or communal); patio or yard in householders were important to understand if they were willing to use RWH for example watering plant in the gardens since in literature rainwater is known to be good from chlorine therefore very good for plant growth.

3.3.6 Stakeholder interviews

The purpose of the interview was to get feedback from stakeholders on my results and to investigate if results from their research corroborated with this study. Additionally, it was to explore the views, experiences, beliefs of RWH; climate change impact on Scottish water resources and the preference of some respondents' on PWS for untreated water. The format of the interview was semi-structured (draft in Appendix VI). Although some questions were listed, some key questions that help to define the areas to be explored like feasibility of RWH in Scotland; incentives towards RWH in Scotland, retrofitting, policies on water conservation in Scotland, climate change and Scottish water and the non-treatment of PWS. A lot of the questions dealt with policies and incentives to implement RWH.

8 Stakeholders of the Scotland water resources and 2 companies involved in RWH in England which was made up a total of 13 participants were interviewed on their perception and the feasibility of RWH, PWS use and climate change impacts on water resources in Scotland. The stakeholders and companies comprised: Citizen Advice Bureau Scotland; Hydro Nation (water division); Drinking Water Quality Regulator (DWQR); Scottish Water; UK RWH Association; Environmental Health Officers from Aberdeenshire and Stornoway Councils, Scottish Environment Protection Agency (SEPA) and the Water Industry Commission for Scotland (WICs). They were selected based on availability and if there is the need for a policy change, it was perceived they would be more resourceful and inclined to implement it.

Prior to the interview, interviewees were sent a summary of results from the residents' questionnaire survey. A semi-structure interview questionnaire was set up and grouped into 6 themes namely: Promotion of RWH, Financial barriers and incentives to RWH, Water quality; attitudes and perception towards RWH, Public health hazard of PWS uses, RWH and climate change and climate change perceptions. These themes were selected based on what stood out from the analysis of the questionnaires. A consent form to use their quotes for this study was sent to interviewees before meeting them face to face for the interview. 12 participants had their interviews conducted face to face and 1 on the telephone. A personal mobile, iPhone 6s Plus was used to record participants. During the interviews, the questions under the themes were not restricted; it was flexible to allow for the discovery or elaboration of information that may not have previously been thought of as pertinent in the designed theme. After the interviews, they were manually transcribed using an online transcribing application from Wreally studios by listening to the interview and typing simultaneously. The transcribed interview was then exported to word format and grouped into themes manually. The themes were selected based on what was most consistently said during the interviews e.g., feasibility of RWH in Scotland, retrofitting for RWH implementation, climate change impacts on Scottish water, non-treatment of PWS and the carrot and stick approach to RWH implementation. Furthermore, the exported word transcripts were put in wordle to check if it will show similarities to the generated themes.

3.4 DATA PROCESSING AND ANALYSIS

3.4.1 Questionnaires

After setting up the questionnaires, the best way to represent the results were reviewed (Figure 3.3). It was then decided that the primary data obtained from the questionnaires will be analysed using SPSS and Excel. SPSS was chosen for statistical analysis and Excel was for pictorial representation of results. Responses from the questionnaire also included non-numerical data which were included in the discussion as quotations.

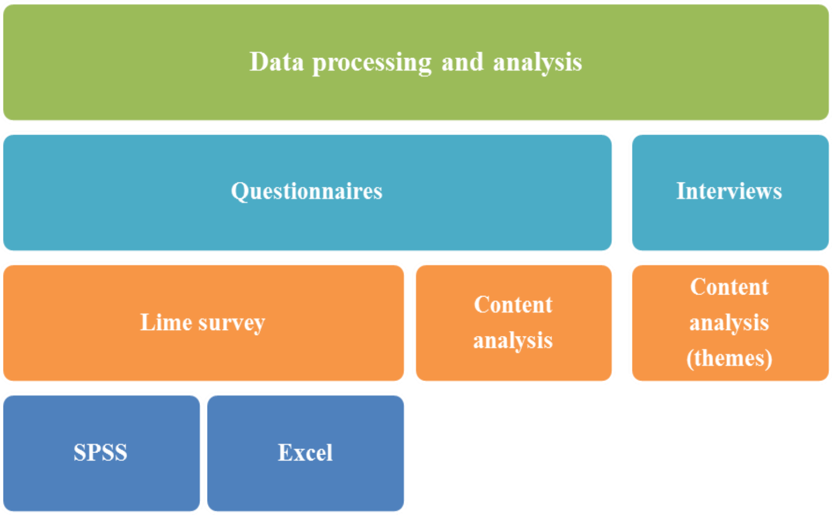


Figure 3.3: Data analysis structure

The response rate expected from the survey was set at 20% and it was calculated as the number of people who completed the survey divided by the number of people who make up the total sample group (1,000). However, for individual study areas, the completion rate instead of response rate was reported. Overall 482 responses were received. Before the data was processed, it was checked for errors to verify if it corresponded with the paper version. Therefore, accuracy was ensured for the lime survey data exported to SPSS before any analysis was done. The responses were then grouped into three themes to make it easier for analysis. The first two themes were on RWH and explored the social and economic acceptance of RWH and the attitudes, perceptions, and behaviour of RWH. The last theme was on climate change and explored awareness, attitudes, and perception of climate change impacts on Scottish water resources. The relationship between climate change and RWH was also analysed in this theme.

Since most of the data were on Likert scale and ordinal, the Spearman correlation and Chi-square test were used to test for association and also if some of the parameters and results were statistically significant. As a rule, mean and standard deviation are invalid parameters for descriptive statistics whenever data are on ordinal scales, as are any parametric analyses based on the normal distribution. Nonparametric procedures which are based on the rank, median or range were appropriate for analysing these data, as are distribution free methods such as tabulations, frequencies, contingency tables, and chi-squared statistics. In the analysis, this study followed lesser stricter assumptions which nonparametric analysis can accommodate and since the study had a smaller sample size, a nonparametric analysis was used. However, all the survey data were not analysed statistically as there was some non-numerical data. They were analysed as quotations in the discussion to emphasize participants' thoughts.

Although complex social phenomena are more likely to be multivariate, this study employed mostly bivariate analysis. This was because per Staddon and Genchev (2013), analysis like the multiple linear regression models that can explain enough of the variation in environmental attitudes and behaviours is a little more controversial since it involves non-interval data and data from this study was non-interval so much analysis was focused on bivariate analysis.

3.4.2 Interviews

Themes were generated during the non-statistical analysis of the questionnaires as a starting point for the interviews (Appendix VI). The main themes explored were: promotion of RWH, financial barriers and incentives to RWH, water quality; attitudes and perception towards RWH, public health hazard of PWS, RWH and climate change and climate change perceptions. The themes were chosen because they were exceedingly highlighted by participants during the data analysis of the questionnaires. Therefore, it was important to understand stakeholders' views. The data acquired after transcription of the interviews were grouped again into different themes to make the discussion and comparison to the already developed themes. This was done by comparing the transcripts of each interviewee/stakeholder and categorizing what stood out the most. It was then qualitatively analysed without statistical methods. After that a detailed description, direct quotations, and observations from the interviews were provided as the foundation of the discussion. The quotations were put in different coloured boxes to represent the various stakeholders to distinguish the comments.

3.4.3 Limitations

Some participants had unusual handwriting so there were some initial difficulties in imputing responses on lime survey. Therefore, some responses were deemed as invalid or uncompleted. Furthermore, transcriptions of interviews were time consuming and laborious. It was difficult to understand some accents and some quotations were left out of the transcripts due to inability to comprehend what was being said. Since interviews were manually analysed, it took a while before getting appropriate themes as transcripts of interviewees had to be read more than once.

3.5 CONCLUSION

The methodology set out to group the responses into themes for easier discussion as observed from the data analysis. The questionnaire survey was grouped into four themes, however during data analysis it was reduced to three themes. These three themes were climate change, acceptability of RWH and attitudes, perceptions, and behaviour towards RWH. Furthermore, based on responses from participants and data analysis of the questionnaires, themes were developed for the interviews in conjunction with the analysed questionnaires themes. The purpose of the themes was to analyse them separately and bring them together in the discussion.

Data was manually checked for errors, this was to verify if it data extracted from lime survey corresponded with the paper version and it was observed they were accurate. For drawing out themes for the interviews, since data was not large, it was manually done using tables and wordle to draw out most frequents words and to some extent it was assumed to be accurate.

Chapter 4- STUDY AREAS AND THE USE OF PRIVATE WATER SUPPLY

4.1 INTRODUCTION

This chapter begins with a description of all the four study areas in terms of population, geography and rurality and distribution of PWS. It then summarizes the number of questionnaires that were distributed and outlines the demographic characteristics of the respondents. Responses from households on PWS are analysed and further discussed. Participants' were asked if they had MWS available in their neighbourhood to ascertain their preference for PWS but these questions were eliminated from those on the MWS. Furthermore, why participants were using PWS was analysed with regards to moving on to the mains if it was available in their neighbourhood. The latter bit of this section focuses on the regulation of PWS, the sources of PWS and the health risks of PWS are further discussed in this chapter. Results obtained from the three study areas on PWS are compared in the discussion.

4.2 STUDY AREAS

A total of 4 study areas were used for this study; 3 have high rates of PWS and 1 was on the MWS. The study areas were Aberdeenshire, Scottish Borders and Highland which were on PWS and the city of Edinburgh which were on the MWS. The criteria for selecting the study areas on PWS was due to the fact they had the highest PWS users in Scotland as of 2012 and Edinburgh was based on proximity (as discussed in Chapter 3). Majority of the PWS type was type B in all the 3 areas on PWS.

4.2.1 Aberdeenshire

Aberdeenshire is a predominantly rural area in the north east of Scotland and extends to 6,313 sq. km and a density of 41.3 inh. /sq. km thereby representing 8% of Scotland's overall territory (Aberdeenshire Council, 2015). The major towns by population in 2012 estimate are: Peterhead (18,450); Fraserburgh (13,140); Inverurie (12,760); Westhill (11,600); Stonehaven (11,370) and Ellon (10,100). The different areas are further shown in the map of Aberdeenshire in Figure 4.1. Aberdeenshire has numerous rivers and burns, a coastline with vast sandy beaches with numerous bays and estuaries along the seacoast. Traditionally, it has been economically dependent upon the primary sector (agriculture, fishing, and forestry) and Aberdeenshire is Scotland's foremost fishing area (Aberdeenshire Council, 2015).

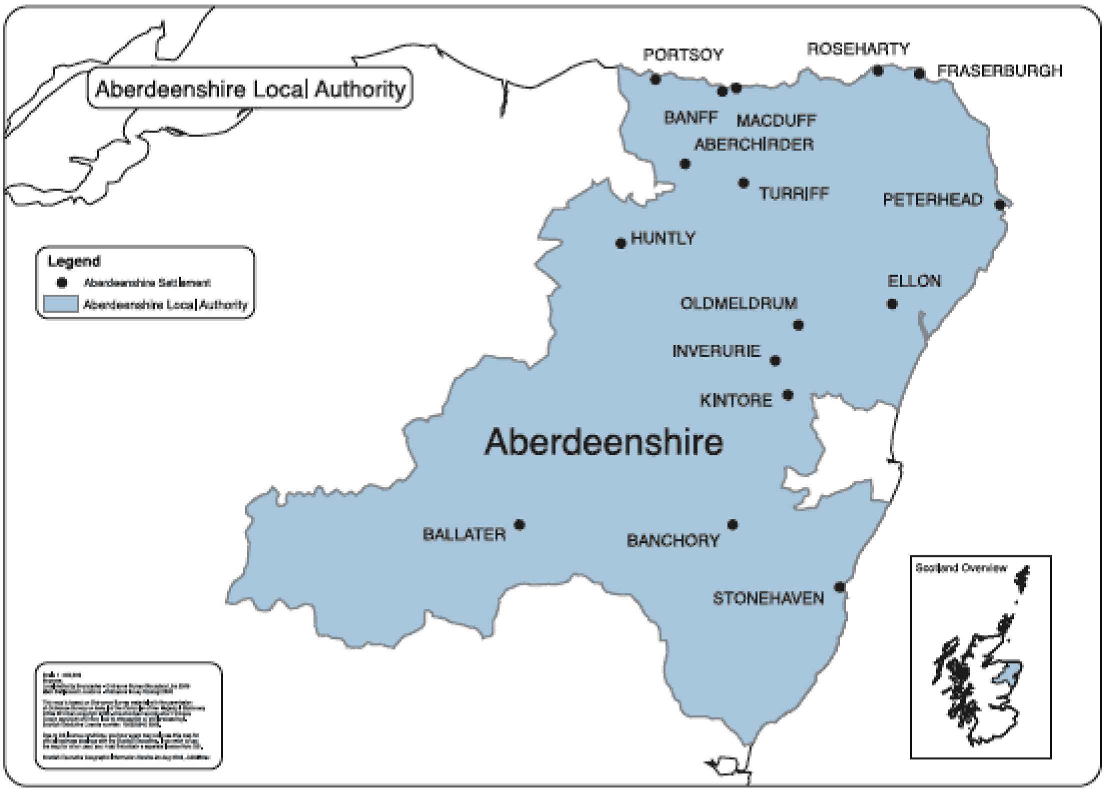


Figure 4.1: The map of Aberdeenshire showing its administrative areas (Source: Aberdeenshire Council)

The Aberdeenshire Council area has 7,676 PWS serving both domestic and commercial properties (Scottish Government, 2013). The majority are type B supplies (7,453) which serve only domestic premises with 10m^3 of water per day with less than 50 persons supplied. Currently there are 14.15% of the population in Aberdeenshire are served by PWS (Scotland and Drinking Water Quality Regulator for Scotland, 2015).

In 2014 Aberdeenshire's population was 260,500, approximately 5% of Scotland’s total population of 5,327,700 and its total number of households was 107,128 (National Records of Scotland, 2015a). It is estimated that 54.4% of the population are aged between 16 to 59 years and persons aged 60 and over make up 23.9% of the population (National records of Scotland, 2015a). This was fairly similar to the ages reported for correspondents in this study (Table 4.1). In 2013, 50.3% of Aberdeenshire’s population was women and 49.7% men (Aberdeenshire Council, 2015). This is also similar to

Scotland's overall population where 49% are men and 51% are women (National Records of Scotland, 2015). In 2014, there were 129,478 males and 131,022 female population including 0-15 years (National records of Scotland, 2015a). However, the men respondents were more than women in this study (Table 4). By 2037 the population of Aberdeenshire is projected to increase by 17.3% at 299,813, as compared to the population in 2012 (National records of Scotland, 2015a). According to the Scotland National records, the total house estimate in 2014 was 108,381 with 114,086 dwellings. The types of dwelling in Aberdeenshire are grouped into: flats (13%); terraced houses (12%); semi-detached houses (29%) and detached houses (46%). However, in this study, detached houses were more represented with no flats (Table 4.1). The total number of households in Aberdeenshire is projected to change from 106,018 in 2012 to 128,982 in 2037, which is an increase of 22%.

4.2.2 Highland

Highland Council covers the largest land area of all Scottish local authorities and consists of the most remote and sparsely populated parts of the United Kingdom (Highland Council, 2015). It is also the 7th highest population of the 32 authorities in Scotland and includes 15 inhabited island communities. Highland is predominantly a rural area and this presents a significant challenge to the service in relation to the accessibility and sustainability of services (Scotland and Social Work Inspection Agency, 2007). It has the highest coastline in Scotland; the length of coastline including islands at low water is 4,905 km which represents 21% Scotland (Highland Council, 2015). The population by area in 2013 are categorized in descending order is; Inverness (79,415); Ross and Cromarty (54,124); Caithness (26,067); Lochaber (19,943); Sutherland (13,841); Badenoch and Strathspey (13,561); Skye and Lochalsh (13,045) and Nairn (12,954) (Highland Council, 2015). The towns located in some of these areas are further identified in Figure 4.2.

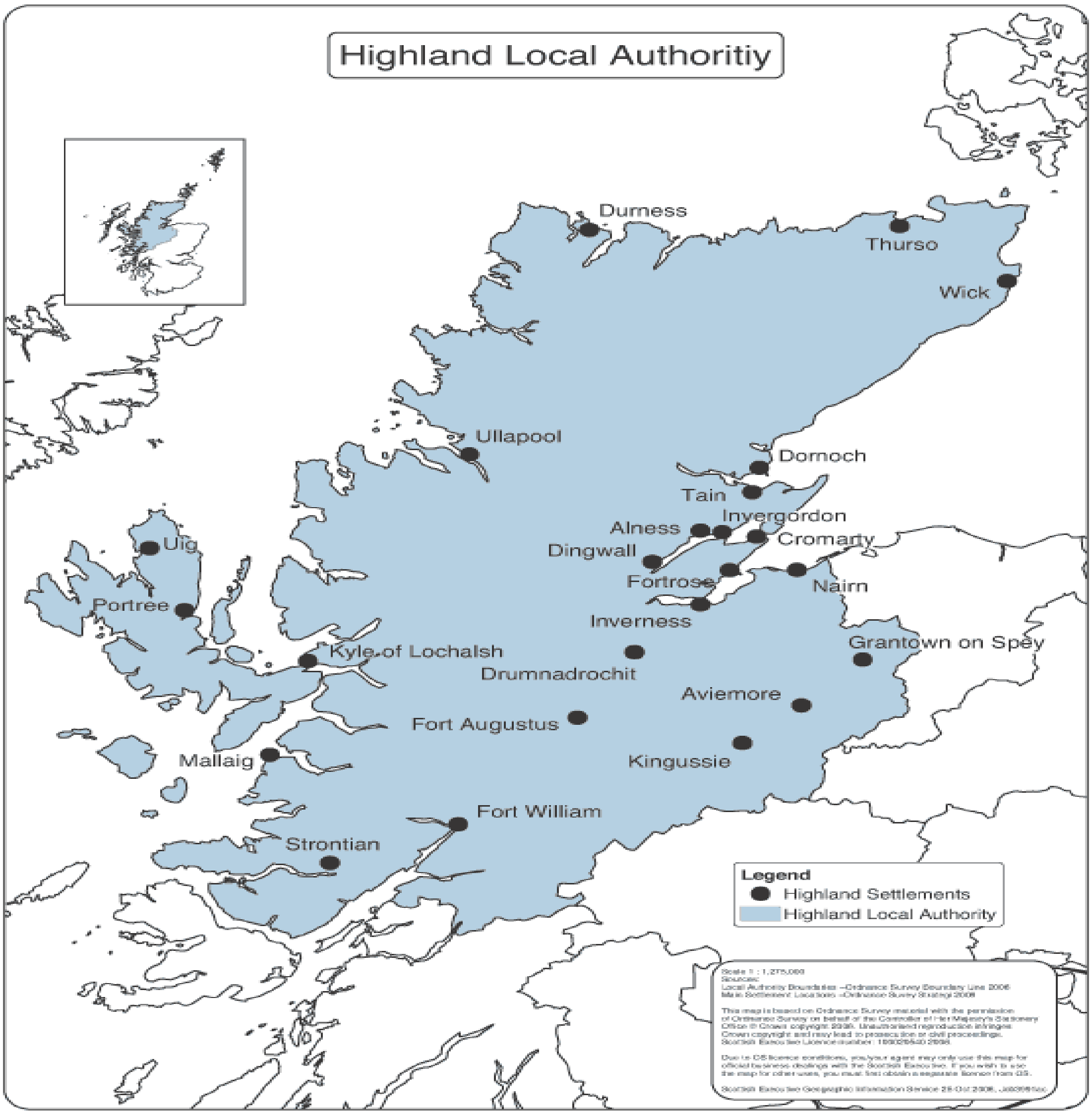


Figure 4.2: The map of Highland with the major settlements (Source: Scotland and Social Work Inspection Agency, 2007)

The 2014 population for Highland was 233,100 and accounts for 4.4% of the total population of Scotland (National Records of Scotland, 2015b). The area of Highland is 25,659 sq. km density of 9.1 inh. / sq. km. According to Highland Council, Highland generally has an older population profile than that of Scotland with a slightly higher percentage of children, but higher proportions in all the age groups above 45 years (Highland Council, 2015); 16-44 represents 76,428 and 45-64 represents 69,449 of the population. In terms of age range, 55.2% of the population are aged between 16 to 49 and 27.5% of the population are above 60 years (National Records of Scotland, 2015b). This is quite true because it reflects with the age profile of respondents to the questionnaire where relatively high proportions were old (Table 4.1). There are approximately 114,068 men and 119,032 women and this was reflected in the gender percentage that answered the questionnaire (Table 4.1) and also similar to gender population in Scotland (National Records of Scotland, 2015). However, there were more men respondents than women (Table 4.1). By 2037 the population of Highland is projected to be 243,493, an increase of 4.5% compared to the population in 2012 (National Records of Scotland, 2015b).

There are 2,338 PWS in Highland which consist of 1,619 type B and 719 type A (Scottish Government, 2013). Approximately 14% of the population in Highland are served by PWS (Scotland and Drinking Water Quality Regulator for Scotland, 2015). There is a total of 105,711 household with114, 603 dwellings as of 2014 (National Records of Scotland, 2015b). The types of dwelling known are flats (13%); terraced houses (18%); semi-detached houses (24%); detached houses (41%) and 4% are unknown. This is represented in results from the survey where detached houses dominated the dwelling types available (Table 4.1). The total number of households in Highland is projected to change from 103,317 in 2012 to 116,513 in 2037, which is an increase of 13% by the Scotland National Statistics.

4.2.3 Scottish Borders

Scottish Borders has a population of 114,030 accounting for 2.1% of the total population of Scotland (National records of Scotland, 2015c) and covers 4,732 sq. km of Scotland. With a population density of 24 people per sq. km, it is the seventh least densely populated authority in Scotland (Scotland and Social Work Inspection Agency, 2009). There are 53.1% of the population aged between 16 to 59 and 30.1% are 60 years and above (National Records of Scotland, (2015c). The population is made up of 55,316 men and 58,714 women and by 2037 the population of Scottish Borders is projected to be 113,725, an increase of 0.0 per cent compared to the population in 2012 (National Records of Scotland, (2015c). However, there were fewer females' respondents compared to men respondents (Table 4.1). In Scottish Borders the population by towns are classified as: Hawick (14,294); Galashiels (14,994); Peebles (8,376); Kelso (5,639); Selkirk (5,784); Jedburgh (4,030); Eyemouth (3,546); Duns (2,753); Innerleithen (3,031); Coldstream (1,946); Earlston (1,779) and Melrose (2,307) (New Ways Partners, 2011). The map of Scottish Borders is shown in Figure 4.3.

Figure 4.3: The map of Scottish Borders showing the major towns (Source: Scotland and Social Work Inspection Agency, 2009)

There are 1,420 PWS in the Borders and made up of 1,263 type B supplies and 157 type A supplies (Scottish Government, 2013) serving 12.26% of the population (Scotland and Drinking Water Quality Regulator for Scotland, 2015). Majority as observed are type B as well in the Borders and serves only domestic premises with 10m^3 of water per day with less than 50 persons supplied as opposed to the type A which serves more than 50 persons and are mostly used for commercial purposes. Households in the Borders are estimated to be 53,157 with 57,274 dwellings. The type of dwellings in the Borders are made up of flats (28%); terraced houses (22%); semi-detached houses (21%); detached houses (28%) and 1% is unknown; this was represented in the study in the same chronological order (Table 4.1).

4.2.4 Edinburgh

The city of Edinburgh has a population of 492,680 and accounts for 9.2% of the total population of Scotland (National Records of Scotland, 2015d); and the second largest population of the 32 authorities covering 264 sq. km (Scotland and Social Work Inspection Agency, 2008) . With a population density of 1758 per sq. km, Edinburgh is the third most densely populated authority in Scotland (Scotland and Social Work Inspection Agency, 2008). A higher proportion of inhabitants are between 16 to 59 (64.8%) as to inhabitants of 60 years and above which are 19.9% (National Records of Scotland, 2015d). There are 239,922 men and 252,758 women and by 2037, it has been estimated that the population of the City of Edinburgh to be 618,978, an increase of 28.2% as compared to the population in 2012 (National Records of Scotland, 2015d). The proportion of males to females was reflected in responses form the questionnaire; there were more females' respondents (Table 4.1). However, in Edinburgh the proportion of women that answered the questionnaires were relatively higher than men which were a contrast to the other study areas where majority of respondents were men (Table 4.1). The map of Edinburgh is shown in Figure 4.4.

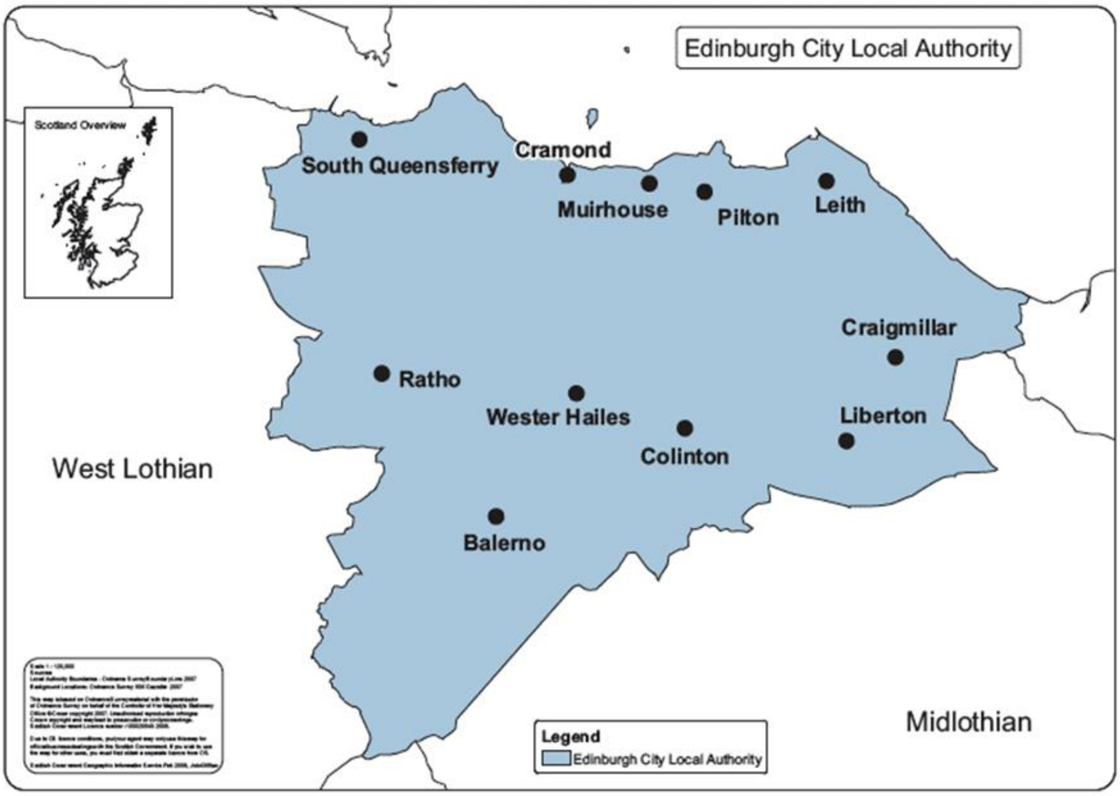


Figure 4.4: The map of Edinburgh with the city's Local Authority (Source: Scotland and Social Work Inspection Agency, 2008)

The city of Edinburgh has a total of 14 PWS: 12 are type B and 2 are type A (Scottish Government, 2013) representing 0.05% of the inhabitants being served by PWS (Scotland and Drinking Water Quality Regulator for Scotland, 2015). The 2014 estimate of the number of households in City of Edinburgh is 231,470 with a total of 239,525 dwellings (National Records of Scotland, 2015d). The number of households is projected to increase from 224,875 in 2012 to 313,033 in 2037, which is an increase of 39%. The type of dwellings found in the city of Edinburgh are categorized into flats (68%); terraced houses (12%); semi-detached houses (10%) and detached houses (10%). From the responses received, higher proportions were living in flats as compared to the other types of dwellings (Table 4.1).

Table 4.1: Summary of gender, age, tenure, and dwelling types in the study areas compared to Scotland's 2011 census (Source: Scotland's Census, 2011)

Study areas		**Scotland**	**AS**	**HL**	**SB**	**ED**
Gender (%)	Male	48.5	58.9	52.3	53.2	40.7
	Female	51.5	41.1	47.7	46.8	59.3
Age (%)	16-24	*16-29 (18.5)	0	1.5	2.2	5.8
	25-34	*30-44 (20)	5.4	3.1	4.3	20.3
	35-44	*45-59 (21.1)	12.3	15.4	10.8	10.9
	45-54	*60-74 (15.5)	27.4	16.9	22.6	18.1
	55—64	*≥75 (7.7)	31.5	33.8	29.0	16.7
	≥65	*≥65 (16.8)	23.3	29.2	31.2	28.3
Tenure (%)	Owned outright	62	66.2	67.7	64.9	72.3
	Shared ownership	n/a	0	0	1.0	1.4
	Rent (public)	13.2	1.4	3.1	4.1	6.4
	Rent (private)	12.4	18.9	18.5	12.4	14.9
	Other	**11.1	13.5	10.8	17.5	2.1
House type (%)	Detached	21.9	83.8	64.6	87.6	10.9
	Semi-detached	22.8	10.8	20.0	6.2	2.9
	Terraced	18.6	1.4	10.8	0	3.6
	Flat	36.4	0	1.5	2.1	82.6
	Other	***63.4	4.1	3.1	4.1	0.7

***age range is followed by the percentage of the age in brackets**

****other social rent**

*****house or bungalow**

Overall, some demographics were not representative of Scotland's, for instance except for Edinburgh, more men were represented as opposed to women (Table 4.1). Also, as opposed to the Scottish age where there is a relatively low proportion (16.8%) in the age category of 65 years and above, this study had more people in the 65 years and above age category (approximately 28%). This had an impact on the widespread applicability of the findings since most respondents were slanted towards the age group of 55 years and above (Table 4.1) very different to 65 years and over per the 2011 Scotland census.

Although the proportion of detached houses in Scotland are relatively few (22%), higher proportions of households in detached properties are found in the more rural areas (Scotland Census, 2011). Therefore, it was not surprising that a higher percentage of house type were detached (Table 4.1) since the areas questionnaires distributed were rural to semi-rural and did not conform to the Scottish demography (Table 4.1).

4.3 STATISTICS FROM THE QUESTIONNAIRES

This sub chapter summarizes how the questionnaires were distributed and further gives the demographic of the answered questionnaire.

4.3.1 Questionnaire summary

The results obtained from the four study areas are summarized in a table below (Table 4.2) as: AS (Aberdeenshire); HL (Highland); SB (Scottish Borders) and ED (Edinburgh). Valid questionnaires received form PWS users' area was 237 and the response rate was approximately 24% exceeding the targeted response rate which is represented as follows: Scottish Borders (6.5%); Aberdeenshire (7.4%) and Highland (9.8%) (Table 4.2). However, the number of questionnaires expected from Aberdeenshire was marginally below target. On the other hand, valid responses received from Edinburgh were 141 with a response rate of 14.1% which was below the 20% expectant rate (Table 4.2). In individual areas, though the total variation is small, a nonparametric analysis can always be used as a statistical method as was in this case. Given the nature of the survey work, there will always uncertainty in the statistics which represent the expressed opinions. The numbers although were relatively small; AS (74), HL (98), SB (65) and ED (141), small sample sizes of other studies have typically been between 5 and 30 users total; a size very common in usability studies (Sauro, 2013) but this study exceeded it. These data should therefore not be seen as definitive but they do provide an indication of the opinions held by the community. Nonetheless the completion rate was high in all areas (Table 4.2). The detailed questionnaire distribution is further summarized in Table 4.2.

Table 4.2: Summary of the number of people that responded to the questionnaires

		AS	HL	SB	ED
Questionnaires sent	Total	410	369	257	1039
	Valid	400	350	250	1000
Questionnaires expected back		**80**	**70**	**50**	**200**
Void questionnaires	Undelivered	3	10	4	37
	No response	7	9	3	2
Questionnaires received	***Full responses**	**74**	**98**	**65**	**141**
	Incomplete	18	4	2	3
	Total responses	92	102	67	144
Completion rate		**80.4%**	**96.1%**	**97%**	**97.9%**
Response rate		**7.4%**	**9.8%**	**6.5%**	**14.1%**

***valid responses**

Though Edinburgh had the highest number of questionnaires received, it was the area with the least received responses compared to the other areas compared to the target that was set (Table 4.2). Aberdeenshire and Edinburgh were just marginally below the target of questionnaires expected back, however Aberdeenshire had the most incomplete surveys. Even though Highland and Scottish Borders exceeded the expected number of questionnaires, overall questionnaires expected were 400 of which 378 were received; hence, approximately 95% of valid questionnaires expected were received.

4.4 TOWNS

Questionnaires in the city of Edinburgh were sent randomly to addresses within the Edinburgh city council, thus it was regarded as Edinburgh city and there was no town or city recorded. On the other hand, in the areas using PWS, the questionnaires were randomly sent from a list of households using a PWS obtained from their councils. The total towns in the areas are as follows: AS (42); HL (46) and SB (40). It should be noted that the questionnaires were sent randomly, therefore there was no control on which town it goes to in a council using the list of households on PWS. The different towns in each council is listed in Table 4.3 with Highland having the most places covered and this was unusual since it was the largest by area of the 3 councils on PWS.

Table 4.3: Towns showing the distribution of questionnaires in each of the 3 councils that was on PWS that responded to the questionnaires

Aberdeenshire	Highland	Scottish Borders
Aboyne	Newtonmore	Abbey St. Bathans
Banchory	Kingussie	Hawick
Torphins	Carrbridge	Oxton
Drumoak	Grantown-On-Spey	Galashiels
Ballater	Nethy Bridge	Selkirk
Kincardine O'neil	Argyll	Ettrick
Fettercairn	Muir of Ord	Jedburgh
Tarland	Invergarry	Peebles
Braemar	Brora	Drumelzier
Longside	Dornoch	Bonchester Bridge
Maud	Ardgay	Duns
Cruden Bay	Lairg	Kelso
Edzell Woods	Sutherland	Eddleston
Peterhead	Alness	Heriot
Strathdon	Ullapool	Stow
New Deer	Ross-Shire	Ettrickbridge
Aberdeen (Marycutler; Blairs, and Banchory Devenick)	Tarvie	Grantshouse
Drumlithie	Garve	Fountainhall
Laurencekirk	Strathconon	Broughton
Johnshaven	Munlochy	Lauder
St. Cyrus	Aviemore	Ashkirk
Stuartfield	Inverness-Shire	Lonformacus
Stonehaven	Laggan	Innerleithen
Lumphanan	Nairn	West Linton
Portlethen	Fort Augustus	Newlands
Alford	Inverness	Skirling
Longmanhill	Beauly	Westruther
Angus	Tomatin	Bowland
Inverbervie	Dunbeath	Earlston
Banff	Acharacle	Manor
Turriff	Ardgour	Melrose
Huntly	Wester Ross	Preston
Portsoy	Glencoe	Tweedsmuir
Aberchirder	Highland	Cranshaws
Mintlaw	Isle of Skye	Gordon
Kincardineshire	Morayshire	Greenlaw
Auchenblae	Strontian	Denholm
Newtonhill	Hemlsdale	Cockburnspath
Fordyce	Evanton	Roberton
Ellon	Dingwall	Ettrick Valley
Cornhill	Caithness	
Hatton	Achnasheen	
	Isle of Eigg	
	Achiltibuie	
	Kinlochleven	
	Inverie	

4.5 HOUSEHOLDS

The mean household size from the 4 different areas was 2 (Table 4.4) and this is similar to Scotland where the average number of persons per household is 2.2 (Scotland Census, 2011). The mean number of bedrooms per household was 3 for PWS users and 2 for the city of Edinburgh (Table 4.4) which was slightly different from Scotland's average number of bedrooms per household.

All 373 respondents identified their gender of which 50.4% were women and 49.6% were men (Table 4.1). Majority of respondents were older (55 years and above); approximately 54%. Most householders were using their water for domestic purposes; approximately 94%; few householders were using their water both in public and PWS for commercial and industrial purposes which were 5.8% and 0.3% respectively. Majority of participants, 77% on PWS areas and 76% on public water supply owned their houses outright but the type of accommodation varied between householders on the public mains water and PWS users. In Edinburgh, 82.6% lived in flats compared to 83.3% of PWS users who lived in a detached house (Table 4.1).

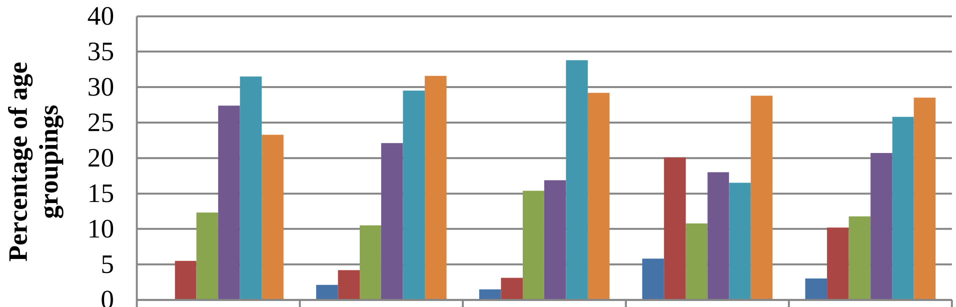
Table 4.4: Summary of household size as compared to the 2011 Scotland Census (Source: Scotland Census, 2011)

Study areas	Scotland	AS	HL	SB	ED
Mean household size	2.2	2	2	2	2
Mean number of bedrooms	3	3	3	3	2

4.5.1 Age and Gender

Age of respondents was grouped into 6 categories: 16 to 24; 25 to 34; 35 to 44; 45 to 54; 55 to 64 and 65 years and above. There was a relatively similar distribution between the age categories of: 45 to 54 years (21%); 55 to 64 years (36%) and 65 years and above (28%) (Figure 4.5). The age group 16 to 24 years was under represented in all the study areas: AS (0); HL (2%); SB (2%) and ED (6%) compared to the other age categories. This is quite similar to the Scottish population where the age category 16-29 years is under represented compared to other age categories (Scotland Census, 2011). Overall 65 years and above were the mostly represented in the study areas but in individual study areas, there was variance in most of the age category that was more represented (Figure 4.5). In Aberdeenshire and Scottish Borders, the age category 55 to

64 years were more represented, 31.5% and 33.8% respectively in households that answered the questionnaire as compared to Highland (31.6%) and Edinburgh (38.8%) where the age category 65 years and above was more represented. However, in the last Scottish census, the age 65 years old and over was 16.8% (Scotland Census, 2011).



	AS	HL	SB	ED	ALL
16 to 24	0.0%	2.1%	1.5%	5.8%	3.0%
25 to 34	5.5%	4.2%	3.1%	20.1%	10.2%
35 to 44	12.3%	10.5%	15.4%	10.8%	11.8%
45 to 54	27.4%	22.1%	16.9%	18.0%	20.7%
55 to 64	31.5%	29.5%	33.8%	16.5%	25.8%
65 years and above	23.3%	31.6%	29.2%	28.8%	28.5%

Figure 4.5: What is your age group: the percentage of age category used in the questionnaire showing the age range of respondents and the percentage that answered: AS (Aberdeenshire); HL (Highland); SB (Scottish Border); ED (Edinburgh); ALL (the four study areas together)

The age groupings were simplified into young age (16 to 54) and older age (55 years and above) (Figure 4.6). This was because there has been conflicting research on the age category likely to answer surveys. A school of thought believes younger people are more likely to participate than older people (Goyder, 1986; Moore and Tarnai, 2002) whilst other research has also shown that older adults (55 years and above) in rural communities are more likely to return a survey if it was handed to them by someone they knew (Edelman *et al*., 2013). Moreover, earlier research suggested that age was positively correlated with environmental concern (Harry *et al*., 1969). Thus, the age distribution in this study was split into two to test which of the hypothesis was true. In deciding the cut off points for older, other researches where age was used was taken into consideration and it was realised most researchers e.g. Petry, (2002), considered the age 55 and above as older.

In this study, there was a relatively high proportion of older respondents' (54.3%) compared to young respondents (45.7%). Edinburgh was the only study area that had highest proportion of respondents' in the young age category (54.7%) and Scottish Borders and Highland had the highest older age category; 63% and 61% respectively (Figure 4.6).

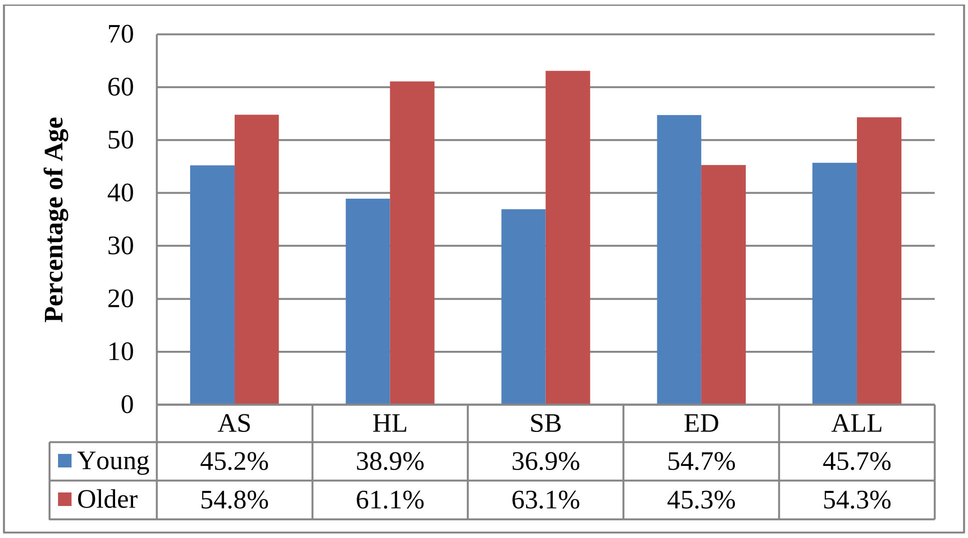


Figure 4.6: Percentage of the age category (Young/Older) that answered the survey

Of the 372 gender that answered the survey, there were more women (187) than there were men (185). Women are more likely to participate than men (Curtin *et al*., 2000; Moore and Tarnai, 2002; Singer *et al*., 2000) and women are most often known to display a higher level of environmental concern and behavioural adjustments relative to men (Hunter *et al*., 2004). Majority of the young age category were women (101) and it was the opposite for the older age category were majority were men (116) (Table 4.5). Nonetheless there were more women who answered the survey as compared to men.

Table 4.5: A table showing the Age (young/old) female and male distribution the study areas

		Female	Male	
Age (Young/Old)	Young	101	69	170
	Old	86	116	202
Total		**187**	**185**	**372**

In the age category, women were more represented than men in 4 age categories; the ratio was: 16 to 24 years (6 to 5); 25 to 34 years (29 to 9); 35 to 44 years (24 to 20). The men were more represented in 2 age categories than women; and the ratio was: 45 to 54 years (53 to 43); 65 years and above (63 to 43) (Table 4.6).

Table 4.6: Age group female and male distributions in all the study areas

		Female	Male	Total
Age group	16 to 24	6	5	11
	25 to 34	29	9	38
	35 to 44	24	20	44
	45 to 54	42	35	77
	55 to 64	43	53	96
	65 years and above	43	63	106
Total		**187**	**185**	**372**

In total, the percentage of women to men were relatively similar; 50.4% women to 49.6% male but were quite different in proportion in the different study area when analysed separately (Figure 4.7). In Aberdeenshire, Highland and Scottish Borders, majority of men were represented.

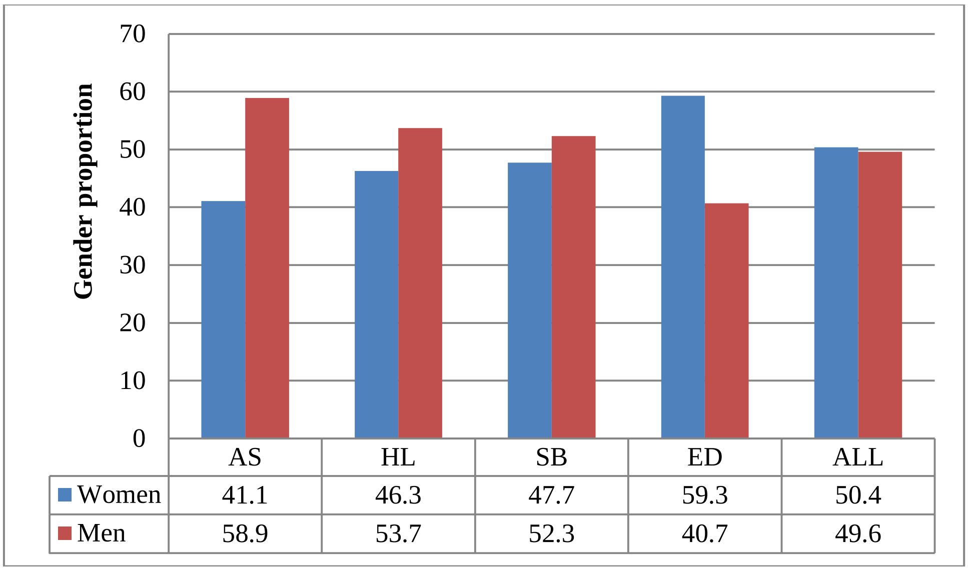
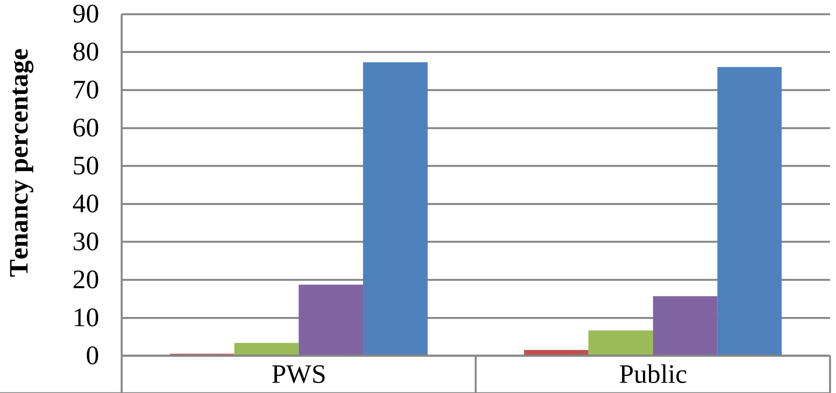


Figure 4.7: Women to men proportion who answered the survey in the study areas

4.5.2 *Tenure*

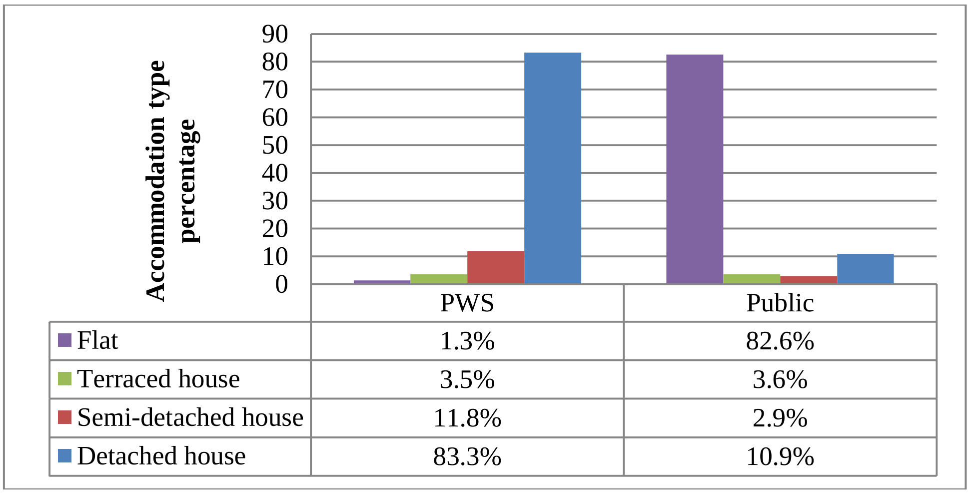
The type of tenure was grouped into two: PWS users and public water supply users. The type of tenure was important to understand householders' attitude to implement RWH. To provide sufficient storage of rainwater to make the system viable, a large storage tank is usually necessary (NHS, 2013). Therefore, who buys such a tank and or maintain might affect householders' attitude to implement RWH. Furthermore, people who are not landlords might not be likely to implement RWH, thus it was included in the questionnaire to see if there will be differences in attitudes towards RWH by people who were landlords and those who were renting. In PWS, approximately 77% of the respondents are owner occupiers and 76% in the public water users (Figure 4.8). Both PWS users and public water users followed the same pattern in terms of tenancy type with a shared ownership being the least 0.5% in PWS and 1.5% in public water users respectively. Rent privately was the second highest of type of tenancy: PWS users' 18.7% and public water users 15.7%; rent from the public was the second least with PWS users respondents representing 3.4% and public water users' respondents representing 6.7% respectively (Figure 4.8).



	PWS	Public
Shared ownership	0.5%	1.5%
Rent Public	3.4%	6.7%
Rent Private	18.7%	15.7%
Own outright	77.3%	76.1%

Figure 4.8: Do you or other household member own or rent your home: The type of tenancy existing in the study areas: PWS (Private Water Supply)

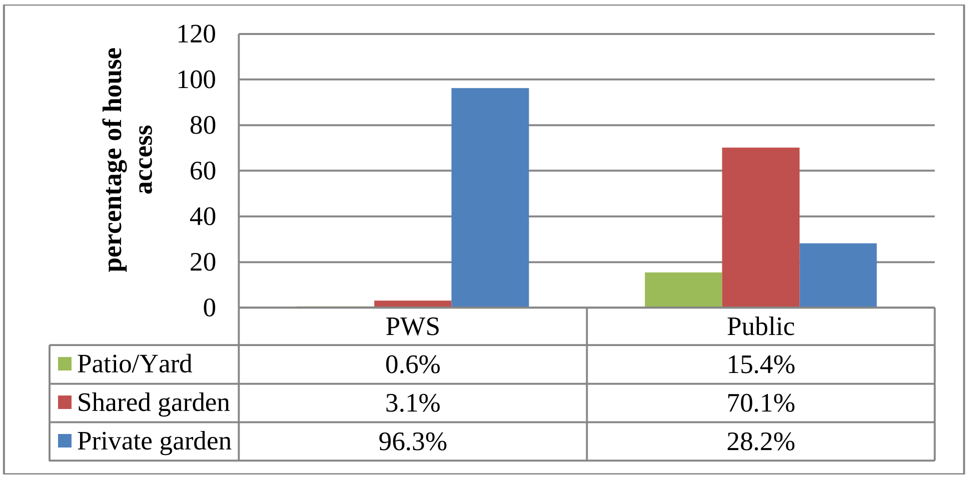
On the other hand, the type of accommodation differed between PWS users' and public water users'. Approximately 83% of PWS users lived in detached houses whereas in the public water users approximately only 11% lived in detached houses (Figure 4.9). The design or the accommodation type has an influence on RWH implementation. In contemplation of domestic water supply, RWH using roof catchments is most common (Gould and Nissen-Petersen, 1999). Also the buildings used for harvesting rainwater needs to have a well-defined information, such as area (scale) and usage, to evaluate the effectiveness of rainwater harvesting and its utilization (RWHU) (Kim and Furumai, 2012).Therefore the type of accommodation is deemed to have an influence on householders' attitude to RWH implementation. Majority of respondents from the public water users lived in flats; approximately 83% and a few, 1.3% in the public water users'. Participants that lived in semi-detached houses represented 11.8% in PWS and 2.9% in public water users', 3.5% participants lived in terraced houses compared to 3.6% in the public water users.



	PWS	Public
Flat	1.3%	82.6%
Terraced house	3.5%	3.6%
Semi-detached house	11.8%	2.9%
Detached house	83.3%	10.9%

Figure 4.9: What type of accommodation do you live in: the type of accommodation existing in all the study areas: PWS (Public Water Supply)

Houses in the study areas had access to a garden: 96.3% had access to a private garden in PWS users' while 70.1% had access to a shared/communal garden in public water users' (Figure 4.10). The access to a garden was related to the house type; householders who lived in flats had a shared garden compared to those in detached houses (Figure 4.10). As observed in Figure 4.9 majority of participants on the public mains lived in flats and those on PWS lived in detached houses. Furthermore, few respondents in the PWS areas had shared garden, 3.1% and patio/yard as compared to respondents on the public water supply.



	PWS	Public
Patio/Yard	0.6%	15.4%
Shared garden	3.1%	70.1%
Private garden	96.3%	28.2%

Figure 4.10: Do you have access to: the access to amenities in respondents' homes

4.6 PRIVATE WATER SUPPLY

This section explores why participants were using PWS; their source of PWS and if their PWS was shared with other users. However, these questions were omitted from the questionnaires distributed in the Edinburgh study area. The purpose of this section is to understand why participants will be willing to implement RWH based on how they perceive and or value their PWS.

4.6.1 Availability of mains water supply (MWS)

Participants were asked if water mains supply were in their neighbourhood (Figure 4.11). Comparing the three study areas, Aberdeenshire had a high proportion of MWS being in participants' neighbourhood (43.9%) as compared to Scottish Borders (24.1%) and Highland (25.6%). Overall, approximately 31% said Scottish mains water was available in their neighbourhood.

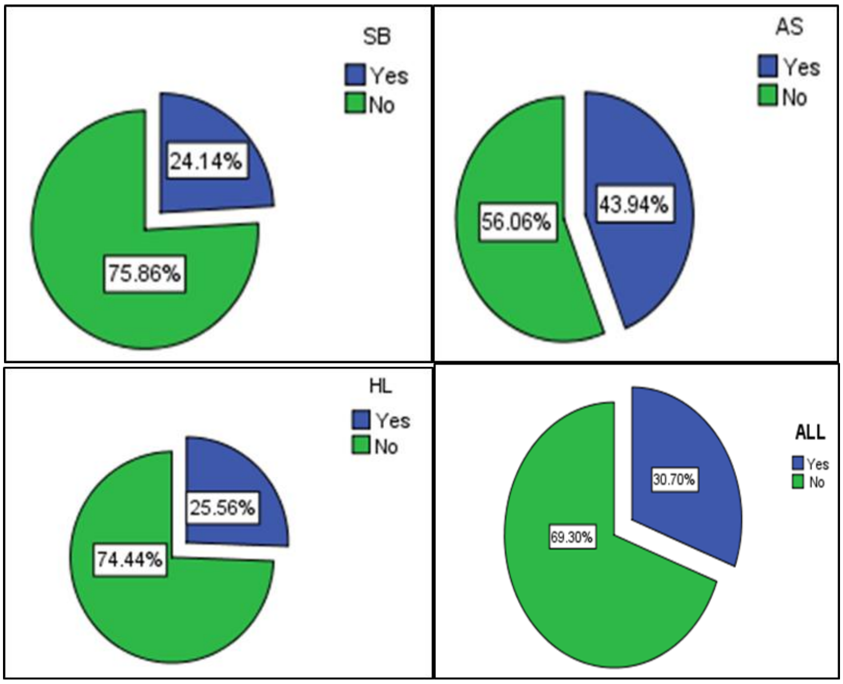
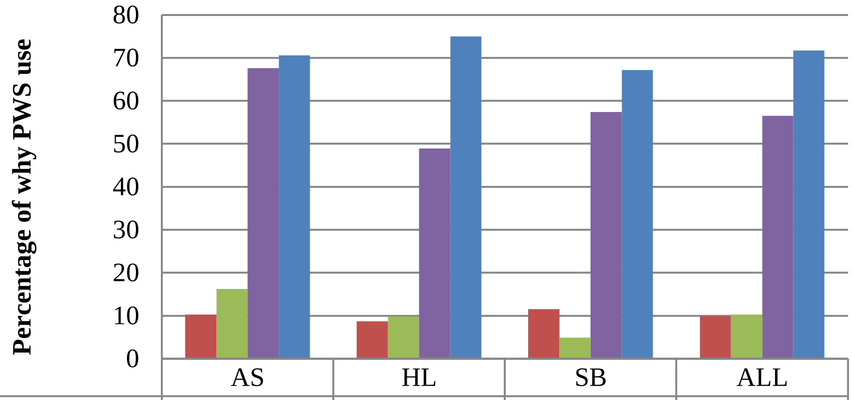


Figure 4.11: Is Scottish Water mains supply available in your neighbourhood: the availability of Scottish mains water supply in neighbourhood

4.6.2 Reasons for using private water supply

Even though some participants said MWS was available in their neighbourhood, most participants were using PWS because it was the only water supply available or it was already there when they moved in (Figure 4.12). In total, 72% of participants in all the 3 study areas were using PWS because there was no other water supply. A minority of participants said they were using PWS because it was good for the environment and to save money (Figure 4.12). However, approximately 10% of the participants said they were using PWS to save money and or if it was good for the environment.



	AS	HL	SB	ALL
To save money	10.3%	8.7%	11.5%	9.9%
Good for environment	16.2%	9.8%	4.9%	10.3%
Already here	67.6%	48.9%	57.4%	56.5%
No other water	70.6%	75.0%	67.2%	71.7%

Figure 4.12: Why do you use private water supply: participants' reason for using PWS

In the UK, (private drinking water supplies are not provided by the statutory water undertaker) (Reid *et al*., 2001). PWS use is the responsibility of their owners and users. A high proportion of participants, approximately 72% were using PWS because there is no alternate water supply. Some households that had MWS available in their neighbourhood said that the costs of connecting their properties to MWS made it expensive for them to do so. But this is a minority since those that expressed are using PWS to save money was roughly 10% (Figure 4.12). This can account for the higher percentage of participants expressing "no other alternative water supply" to be their sole reason for using PWS. Another observation is although some felt it is expensive being connected to MWS, a minority of participants wanted to be put on the on it because they felt it is a burden using PWS. However, it is observed in Scottish Borders people use PWS more as a heritage not because there is no alternate water supply; it is more to do with family tradition (Table 4.7).

Alongside using PWS as tradition, and MWS being too expensive to be connected to their homes, other participants expressed interesting comments on their preference for PWS use. Some proportion could not and or will not be connected to it due to the following reasons:

1. Family had used PWS for 170 years so it was more of a tradition and did not want to change.
2. The water from PWS was not tainted (no chemicals were added).

3. The quality of the water was excellent because it has no chlorine.
4. They had Scottish Water pumped a quarter mile so they have connected to it through private pipes and reservoir to their house thus did not consider being on Scottish mains water supply.
5. They preferred the quality of PWS to the mains.
6. The water tasted better than the mains water supply.
7. They preferred untreated raw water.

Moreover, there were some interesting observations from residents surveyed concerning their source of PWS and why they were using PWS. These comments are summarized in Table 4.7.

Table 4.7: Why do you use private water supply: Summarized themed comments from participants' on why they use PWS

	Scottish Borders	Aberdeenshire	Highland
Water quality	Good	Prefers untreated water	• Better quality compared to mains • Superior quality • No chlorine; does not leach iodine
Taste of water	• Untainted • No chemicals • Yummy minerals	• No additives • Tastes pure • Tastes peaty after rainfall (good)	• Moreish taste • No chemicals • Excellent water
Tradition	In the family for 170 years	It has been on the estate for 33 years	
Risk/danger	Even though there are UV filters, too dangerous to use		
Water unavailability/ shortage		• Freezes in winter • Dries up in hot dry and summers • Many interruptions to supply during hotter summers (up to 6 weeks)	No shortage of water during the drought of 1976
Diseases		Pure water, therefore no Alzheimer cases in area	
Mains vs PWS	Prefers Mains	Prefers PWS	Prefers PWS
Environment		Good	Good

4.6.3 The preference for untreated water and immunity

From literature, it was discovered that approximately 3% of the Scottish population relied on PWS for drinking water and other domestic purposes (Section 2.4) and maintaining their PWS was their responsibility (Section 2.4.1). At the same time, approximately 70% had Scottish Water not available in their neighbourhood (Figure

4.11); thus, it is not surprising to discover the reasons they assigned to their preference for untreated water. Furthermore, the cost of using PWS as compared to MWS was cheaper since PWS users did not have to pay for water as part of their council tax bill. Although they had to pay for maintenance of their PWS, from the responses received on why the use of PWS, what stood out and was unexpected at the beginning of this study was that PWS users were not treating/maintaining their water. They preferred their water to be in its natural state.

> *I have actually have people especially in the Aberdeen area who have went from a spring water unto the mains but then went back to the spring water supply because they feel that the natural water was better altogether.*
>
> **Business Development Manager, GRAF UK**

A stakeholder quoted this. Contrary to some residents surveyed belief that untreated water was better than the treated MWS, research by Nemec (2013) in America and some parts of Europe shows a wide scale failure of many small, principally rural, domestic PWS against microbiological and chemical criteria (Kay *et al*., 2007; Thompson, 2003; Levin *et al*., 2002). This is evidenced in comments from stakeholders in this study who believed PWS users were not treating their water and that it had failed bacteriological standards in the past and mirrors participants stating their preference for untreated water:

> *Despite the fact that they maybe failing bacteriological standards and you know there may be a number of issues; because we know from the drinking water quality regulator side, their concern is that a lot of the PWS just don't meet the basic requirements. So, then it becomes an issue about how do you cost effectively connects these customers and also how do you get them willing to connect.*
>
> **Director, WICS**

Although it poses as a public health hazard, in the UK, not everyone believes that drinking untreated water poses a serious risk to health even though evidence shows PWS regularly fail to meet appropriate standards (Nemec, 2013). They perceive they have become immune to any health risk associated with untreated water because they have been drinking it over a long period. This corresponds to this study. As evidenced from the results from the survey, 72% (Figure 4.12) expressed there was no alternate water supply as one of the reasons of using PWS and approximately 31% (Figure 4.11) had MWS available in their neighbourhood. The build-up to immunity by householders as explained by Nemec (2013) is implied as "…*prior exposure, through the consumption of contaminated water, it helps build immunity to illness*". Thus, it can be said they have been used to PWS all their lives and might perceive to have developed immunity to any risk associated with untreated PWS. However, contrary to their belief, a report written on behalf of the *E. coli* Task Force considers personal immunity as something that must not be relied upon (Reily, 2001). And moreover, some people may only [illegible] s to ther [illegible]

> *Something dramatic has to happen before something is done.*
>
> **Analyst, WICS**

> *I am aware of one incidence, probably in the last 2 or 3 years where somebody had requested about their supply being tested. It was a domestic PWS, a type B supply, and when the results came back, there were bacteria in it that shouldn't have been there. So, we made them aware of that and because they were concerned because if their grandchildren coming up to visit who have been brought up on public water supply. So, their concern was that if their grandchildren will fall ill.*
>
> **Environmental Health Officer, Hebrides**

Some households perceived it was disease free because they had not encountered or seen diseases related to drinking untreated PWS in their area which was what was believed by some stakeholders will be the driving factor for them to treat their PWS. Therefore, because of the taste of PWS and non-evidence of diseases related to PWS; some were unwilling to connect to MWS even if it was available in their neighbourhood (Figure 4.12). These comments lead to the observation that the use of untreated PWS has become a cycle over a period. It starts from the taste of PWS being superior to MWS, then being exposed or used to untreated PWS they perceive to have become immune since there is no evidence of diseases in the area. This then makes it difficult to convince people to treat water or connect to the MWS if it's available in their neighbourhood (Figure 4.13). Moreover, connecting to the mains may be expensive and since the cost of using PWS is negligible compared to MWS, it further becomes difficult to convince households of the public health risk drinking untreated water when they themselves have not fallen ill. This is further discussed in the sections below.

Figure 4.13: A scheme showing some potential reasons for the use of untreated PWS

Indeterminably, although the people in the local community may have got resistance to the untreated water supply, visitors are largely at risk if they should visit such a community. This was echoed by several stakeholders and felt there was the need for this to be addressed:

> *Somebody who is not immune to it, hasn't drunk that water supply for 40 years, you know, the consequences could potentially be quite grave.*
>
> **Policy Adviser, Scottish Water**

> *Yea, they have become immune to the parasites and whatever that is in it. However, visitors come to the house, should relatives come to the house, should friends come to the house and you know, they obviously don't have immunity.*
>
> **Director, WICS**

> *It's not just about their own consumption, there may be fauna in the water which they are used to, but if other people come into their area and drink their water from their PWS, well then, we may find they have different reactions to it so it's a public health concern for us, the quality of PWS. Some of them are good, there is no question about that, some of them are perfectly good. But there will be others who to be frank don't know how good it is and some of them will be poor and we know that some of them are poor.*
>
> **Manager, Hydronation**

> *But where then it causes problems is if you've got someone who should come visit in that property who has never drunk from a PWS before, they might not have the necessarily immunity and that is when the problem arises.*
>
> **Environmental Health Officer, Hebrides**

> *There are issues with the sort of transit communities especially tourists coming along into areas, and there have been incidences where there has been really quite alarming, health conditions we've come across as a result of drinking PWS from people who are tourist so you know there are areas who used to in the past have E. coli for instance which has caused serious brain damage to people camping and so on.*
>
> **Policy Adviser, Scottish Water**

Although stakeholders feel non-treatment of PWS in Scotland should be addressed, according to Reid *et al*., (2001), the system for monitoring microbiological quality of PWS in Scotland is flawed. And this might not have improved over the years since results from this study showed some PWS users were not treating the water so as not to taint the taste of their water supply. Some participants also preferred PWS because it was not treated and had no chlorine compared to the MWS. This if continued for a long time poses a serious health hazard. This is because in all the study areas, majority of PWS as observed in the Chapter 3 were type B supplies serving only domestic premises which meant they were small supplies and thus maybe contaminated if not treated. Therefore, this research agrees with the need for an adequate treatment applied before the water is used for consumption (DETR/DWI, 2001).

Moreover, in 2004, it was exposed in a research by Clapham, (2004) that there were 56 potentially pathogenic organisms that can be found in drinking-water and a greater number of waterborne outbreaks in PWS were caused by *Campylobacter, E. coli O157, Cryptosporidium and Giardia* (Scotland and Scottish Executive, 2006). Additionally, a study conducted in 2000 for UK PWS resulted in Scotland having the highest micro-organisms including *Cryptosporidium* and *Giardia* CREH (2001). The samples found to contain cysts percentage of *Cryptosporidium* and *Giardia* in Scotland were 75% and 50% respectively in phase 1 which were more than samples from South-west England which was 2.4% each. Furthermore, tested samples taken from 91 wells in the UK in the late 1990’s showed that the microbiological quality of the water in small supplies to be generally poor, with almost 50% of the supplies failing to meet the required quality standards on at least one occasion (Fewtrell *et al*., 1998). In Scotland alone, it was discovered between 1945 and 1987 that private supplies caused 21 out of 57 waterborne disease outbreaks which represented (37%) of the UK (Benton *et al*., 1989). Therefore, Fewtrell *et al*., (1998) concluded their research stating that: “*…given the high level of sanitary failures, there was the possibility that harmful microorganisms could be* *present, and that a significant risk to health could not be discounted*". Hence the fact that participants perceived themselves to be immune to pathogens in untreated water, it cannot be abated the threat it poses to the consumption of untreated PWS over a long period. This is because although majority responses were for the preference for untreated water due to the quality, there were some participants from the survey who said the water quality of their PWS was poor and felt it needed to be addressed.

> …*Because of poor quality water (high in bacteria) I had a UV filter system fitted at the end of the house (outside) about 4 years ago. However, I am still not 100% sure this is working so I am now using bottled water for all drinking, including making tea/coffee. I use the other water for cooking, washing etc. daily*…**P84, HL**
>
> …*The water at the moment is bad. Not got it right in 15 years and had a (grant). NOBODY CARES*…**P91, HL**

Along these lines, it can be further stated that immunity is a perceived problem in dealing with the untreated PWS in communities that are on PWS in Scotland since there is a perceived perception that untreated PWS reduces diseases. This is further attested in Table 4.7 where a participant expressed using PWS in their area has led to a case of no Alzheimer recorded in their neighbourhood and also the water was pure and thus had a better quality compared to MWS:

> …*Just a small note; there are no Alzheimer cases in the area. Possibly due to the pure water quality with no chemicals*…**P33, HL**

As a deduction, this study observed that visitors' health was at risk in Scotland from such a perception because people new to the supply were unlikely to have such immunity.

4.6.3.1 The lack of evidence associated with non-treatment of private water supplies (PWS)

However, it is challenging to link microbiological contamination with a specific incidence of illness as water samples from the time of exposure are in a few cases available with some organisms being difficult to detect, (Tillett *et al*., 1998). Not only that, there lack research and case study examples that links diseases to the use of untreated PWS in the selected study areas and that could probably be the reason participants expressed no diseases in their neighbourhood as a result of drinking untreated PWS. The lack of research was echoed by several stakeholders during the interviews. One stakeholder is quoted stating not only are there no case studies, but having microbiological contamination can be also due to certain factors like contact with farm animals:

> *I mean what we are lacking at the moment is some case studies for it to say somebody drunk this water. I mean there has been cases but they are poorly documented and quite often there is a number of risks factors so you know somebody got ill, they have E. coli or several whatever, but he's on farm so they are in contact with animals, they are in contact with water so we are trying to work out to match up with the water quality data with the health data. Overall, we are trying to get some case studies to have a bit of some evidence to the health message. There is work going on to promote the health, there is leaflets that we have got that the councils give out.*

Therefore, research into diseases associated with PWS need to be done to separate it from other microbiological risk. As far as risks of using PWS in Scotland goes, nothing concrete has been evidenced or linked to certain supplies as dittoed by a stakeholder who further calls for documentation of illness associated with PWS as proof that it exists:

> *As far as the risk goes, about 2 years ago, now there was a case at a boy's nursery, there was a suggested link to a PWS, not at the nursery but one of the children who brought the infection to the nursery lived on a property that had a PWS. Now it's only a suggestion that there is a link because it was never totally proved. But I was involved in the investigation. Now the child who was mainly affected was very young, developed haemolytic uraemic syndrome (HUS), and he was shipped down to a hospital in Glasgow. He has had several operations, he is brain damaged, kidney damaged, part of his bowels had to be removed. I believed and he can't eat as far as I know of him, and that was as a result of an E. coli 0157 infection. Now anybody comes to me and says PWS is healthy, I point them to that case and say do they want themselves or their grandchildren to be at risk of that.*
>
> **Technical Officer Infrastructure Service, Aberdeen Council**

Moreover, a report by Said *et al*., (2003) established that a variety of pathogens, including *E.coli O157*, as was the case with the nursery boy, had been linked to disease as a result of water consumption. The most severe disease caused by *E.coli O157* is haemorrhagic colitis and so as a group they have been called enterohaemorrhagic *E. coli* or EHECs and are generally referred to as *E.coli O157* (Reily, 2001). According to Nemec (2013), children under 5 years of age are the most at risk of developing HUS which is characterised by acute renal failure and haemolytic anaemia. However, it cannot be substantiated from some researches if it is because of using PWS or the MWS, because people using PWS had no more gastrointestinal symptoms than those on the mains supply. Nonetheless, research shows that there have been an incomparably more people using PWS that had antibodies to *E. coli O157* and also excreted it (Said *et al*., 2003).

In addition, outbreaks are not easy to detect (Hunter *et al.*, 2001) and this is evidenced in Scotland where there seems to be no data on health risk associated with PWS. Notwithstanding the deficiency in data documentation through outbreak of diseases and or illness associated with untreated use of PWS, much of what we know about the burden of disease is evident from documented outbreaks of public supplies is that harmful pathogens have the potential to reach a large body of consumers (Risebro, 2005). And this can result in substantial economic and health-related costs, as happened Milwaukee in the state of Wisconsin in the USA during the April 1993 *Cryptosporidium* outbreak (Mackenzie *et al*., 1994). In England and Wales, contrary to Scotland, there have been symptoms recorded with untreated PWS use. The most common symptoms were gastrointestinal which resulted in several hospital admissions (Nemec, 2013) but there has not been any record of secondary cases of death. Though there have not been any deaths recorded, it was assumed by Clapham (2004), that the real figures of gastrointestinal cases are underestimated due to the general under-reporting of incidences associated with gastrointestinal illness as a result of drinking untreated PWS. In a review on PWS use in UK by Nemec (2013), he reports a supported evidence by Wheeler *et al*., (1999) for the under-reporting of gastrointestinal illness; for every case of infectious intestinal disease identified by the national surveillance system, another 1.4 were identified by laboratories (Wheeler *et al*., 1999). Therefore with an estimated 9.4 million estimated cases of infectious intestinal disease, only 1.5 million were presented to a general practitioner (Wheeler *et al*., 1999), thus that is the only record known.

Even though limited research has been conducted on the outbreaks of infectious illness as a result of the consumption of PWS (Fewtrell and Kay, 1996), drinking water treatment and especially disinfection is of proven value in protecting public health (WCC, n.d.). However, water treatment is not installed in every PWS especially at the source which may have faecal materials; even when installed they may not be operating under optimum conditions (Whitten, 1992; Jackson *et al*., 2001). In Rutter's report on the data from the first 2 years of the PWS database data collection (Rutter *et al*., 2000), the principal treatments used in PWS were chlorination, UV irradiation and filtration.

Chlorination was the most effective water disinfection treatment for PWS. But some participants expressed their preference for PWS because it did not have chlorine thus making the taste unique. This is serious because according to Fewtrell and Kay, (1996), larger water supplies are of better quality than smaller supplies. Since the PWS mostly used in the study areas were type B supplies, it is assumed the source of water thus is relatively small and might have a high microbiological failure rate therefore might not have good quality water.

Lastly, it was discovered through the interviews with stakeholders that to convince people you need to present the evidence of PWS as a possible threat if not treated:

> *One thing that we do know is when you drink a supply you become immune to the strain of crypt that you are having and you become immune. So, what we discovered from speaking to certain groups is that they have become immune, so you get tourist coming up, they don't fall ill until they get home, you know, and that's why there are no records to relate public health to untreated PWS.*
>
> **Sustainable rural communities, Scottish Water**

If not, it was perceived by stakeholders that it will be difficult to convince people about the public health hazards of drinking untreated PWS especially when they believe they are immune. Also, visitors who might fall sick drinking untreated water might not be recorded or known, therefore loosing evidence of it being a public health hazard. Therefore, it is important to address evidence related to non-treatment of PWS when it comes to educating and convincing people.

4.6.3.2 Attitudes and behaviour towards private water supply

Despite that, behaviour of users also plays an important role in their attitudes towards their unwillingness to treat their PWS. They thus become very protective of their water. As a stakeholder puts it:

> *People are quite personal about their water; it's quite something that people will appreciate enough. A lot of customers basically don't want to change, they are happy with what they have got. Even though they don't quite understand why we have to upgrade or why we need to improve. They are really quite protective of their water.*

Therefore when people are used to a certain taste of water over a long period of time, it becomes difficult to change since consumer behaviour is often strongly influenced by subtle environmental cues (Dijksterhuis *et al*., 2005). And of such behaviour as observed in this study is which influences their attitude to not treat their PWS is “sensory”. Responses from participants show that the taste, smell, and nature (natural and no chlorine) had an impact on their attitude not to treat their PWS. These were echoed in some of the responses received from some residents and further corroborate stakeholders' views of why some people will never want to upgrade their PWS:

> *We love our private water supply for the taste, even when it is quite peaty after rain, and do not filter it as some neighbours do*…**P72, HL**
>
> *My water quality id superior to the town as it is spring that feeds into the local loch which feeds the town and it get it before the chemicals are added!*...**P82, HL**
>
> *We get of lots of yummy minerals in the mud in our drinking water*...**P35, SB**
>
> *…and comments from visitors on its moreish taste*…**P61, AS**

Furthermore, in reference to a research in Canada on public perception of drinking water from PWS, participants' perceptions of the sensory quality of drinking water from their private supplies were overwhelmingly positive and they reported their water to be "excellent" in taste, "fresh", "no chlorine" and "no smell" (Jones *et al*., 2005). This is similar to this study thus it is not surprising residents surveyed related to the above opinions. Moreover, it was discovered that some participants especially in the Scottish Borders and Aberdeenshire see it as a tradition, something which runs in the family (Table 4.7) and are highly unlikely to stop using it. Not only that, some residents surveyed had also adapted to PWS use over the years, thus a transition was something they could not do.

> *I would be unwilling to use treated water even if it were available*…**P23, AS**
>
> *I AM 88 YEARS OLD AND LIVED IN MY HOUSE FOR 50 YEARS. IT IS A SMALL CROFT AND I WOULD NOT BE MAKING CHANGES*…**P47, AS**

In all scenarios, it will be difficult convincing such people if they have not been treating their water to treat it, or if they have MWS available in their neighbourhood which was approximately 31% (Figure 4.11) to switch. It is like they have developed a certain attitude and or behaviour to their supply and thus has become very protective of it and feels it is superior. As reflected by a stakeholder:

> *I think there are some people you could tell them about health risks forever and they will never believe you. I think there is a coming off that there is real attitude for people that the best water is water strike off from the hills and that Scottish water is the best in the world because it comes out of the hill side, crystal pure and all this sort of stuff. It's in the culture almost and that sort of generalization is completely untrue to just have their private well and that's absolutely rubbish that it doesn't go through the treatment works. And obviously, the health evidence doesn't support that, but we need, I think what we need is to change people's attitudes with some good case studies and good solid case studies which we haven't got unfortunately because these things are difficult to supply, because probably a lot of cases we only get reported are because people are visitors, they go away again or people have come for holidays.*

Furthermore, even though participants confirmed that MWS was available in their neighbourhood, not only are case studies needed to support untreated PWS and diseases, the real problem is a change in people's behaviour and attitude by getting people to believe as reiterated by a stakeholder:

> *We are trying to work with health protection Scotland to get some proper health evidence to support. I mean there have been loads of studies done, but it's just getting people to believe it to some extent as well, I think there is a main resistance there to that.*
>
> **Operations Team Leader, DWQR**

It is refreshing to know that a lot is being done to document untreated PWS use and illness to reduce the public health risk by changing attitudes, perceptions, and behaviour, but sometimes it is not just a family tradition, or sensory qualities of the water, but rather these water supplies are what people have known or been exposed to all their lives and may not necessarily see and or feel something was wrong with their water. To such a degree, people will be unwilling to move even if another alternate was offered. This can further be linked to the immunity concept as discussed previously.

4.6.4 Challenges associated with enforcing the treatment of private water supply

Stakeholders perceived the one thing different from the mains were that PWS didn't have to meet the same kind of standard as the mains quality. Despite equal standards applying to PWS and public MWS, PWS have been recognised as being of poorer quality than public water supplies (DWI/DEFRA, 2014). The DWQR, (2009) corroborates this by stating the quality of PWS can be variable; some have adequate treatment and are well managed, but others undoubtedly present a risk to health due to the quality of the water. A household in Highland was not happy to be put on the mains but resorted only on the mains to avoid excessive charges to their PWS; the householder preferred untreated water:

> *Would only prefer to go on mains because the council make me have a UV system for the water as it is used in the holiday house. The cost of the system + annual testing, 6 monthly filters & UV bulbs + septic tank everything is a lot more than the water rates. My water quality is superior to the town as it is spring that feeds into the local loch which feeds the town and it get it before the chemicals are added…* **P82, HL**

What's more as observed from some participants' responses in preference for untreated water, there can be an unidentified health risk hazard with their consumption of PWS. Although a variety of treatment strategies are used to treat private supplies, often at times there is no treatment at all, and disinfection is both much less prevalent (DETR/DWI, 2001) which was observed in this study with participants expressing their preference for water without chlorine. Additionally, the preference for untreated water may pose an important implication for human health due to the risk of infectious intestinal disease and chemical exposure (DWI/DEFRA, 2014). This can be seen as true as according to Smith *et al*., (2006), PWS are not directly regulated by the Drinking Water Inspectorate, but rather it's the responsibility of local authorities environmental health departments to register and approve supplies based on them passing chemical and microbiological analysis of water samples.

The Private Water Supplies (Scotland) Regulations 2006 further reiterates this stating local authorities are to PWS which is meant to be used for drinking, washing, and cooking or food production purposes and can require improvements to be carried out where necessary. However, according to (Scotland and Scottish Executive, 2006), with private supplies a variety of treatment strategies are used, but often there is no treatment at all and it was observed that there were challenges with local councils trying to regulate the treatment of PWS:

> *The challenge is how do you enforce the regulations and I think all drinking water, whether it is public or private should be treated to a standard that requires with regulations.*
>
> **Water Policy Analyst, CABS**

As quoted by a stakeholder. But during the interviews, it was further discovered that although the regulations are in place, the problem was how it was being enforced with some assumptions that it was not being enforced at all. A stakeholder is quoted as:

> *It's up to the local authorities and they don't, that is the bottom line. And now there are all sorts of reasons as to why local authorities might not be enforcing measures on private individuals to upgrade their supply. I suspect that the real reason is of resource that the local authorities don't have individuals that can go out and check properties. We recognize that the reality is that local authorities are not enforcing so we are working as a group to try and find better solutions for PWS in rural areas.*
>
> **Manager, Hydronation**

Accordingly, it can be inferred with confidence that there is a problem with the regulation of PWS in Scotland. As expressed by the stakeholder, it might have to do with not having enough resource personnel to monitor water quality of PWS users and also the unwillingness of PWS householders registering their supply with their local authorities:

> *So, if somebody is out in the hills in Scotland doing their own thing, nobody will know what they are doing. But in terms of the law, if they are using a PWS, they are required by law to register with the local council and the council is required by law to come and declare it fit to use and then check it periodically.*
>
> **Director, UK RWHA**

However, it has been observed from this study that there are not enough resource personnel to monitor PWS users and ensure it was being treated. Contrary to what was said, this same interviewee expressed that although there was a law, the law did not necessarily state that the water had to be treated:

> *But it does say the water has to be wholesome if you are drinking it, cook in it or bathe in it, wash your hands or anything. So, the definition of what wholesome water is in terms of, you know percentages of this certainly other bacteria and stuff which I'm not an expert at, means the water has to be tested and the testing of the water is fairly reasonable legislation and has always been like this.*
>
> **Director, UK RWHA**

Therefore, it is not clear what constitutes treatment of PWS because the wholesomeness of water is debatable. What constitutes to the water being wholesome; is it by perception or by taste or by the smell or by the number of microbiological contamination, or by the colour of the water. This poses a flaw in the law and the law needs to be clear.

Notwithstanding, one of the biggest challenge with enforcing treatment of PWS discovered in this study was the "choice" aspect. In terms of treating the PWS, it was felt by some stakeholders that it was supposed to be the choice of the homeowner to treat their water. According to two stakeholders in two of the councils:

> *When water fell under the local authorities here, moves were made to try and ensure that everybody as far as possible was connected to the mains supply. So as a result, those that are still on PWS have got PWS because that means that they made that conscious choice or they are living in a location where there is no access to the mains water supply.*
>
> *It has been a household choice in terms of whether they choose to treat it or not. And in some cases, they will, they have approached us on it and in other cases; they won't if they like drinking their raw water.*
>
> **Environmental Health Officer, Hebrides**

Furthermore,

> *If it is your own property, there is a facility in the law to enforce treatment. But this council hasn't used that because it is felt that people should be able to make their choice. We would recommend to them that they connect to the public. Well they put treatment into their system or connect to the public supply. But at the moment we have not forced them.*
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Thence, what is observed is that PWS individual users are not obliged to treat their water; it was rather a personal choice. So, if one feels their water is wholesome, as expressed by a stakeholder above, then they will not treat it. The whole concept of wholesome needs to be understood by setting a form of policies as echoed by a stakeholder:

> *In fact, it's not been enforced. We probably don't have a, we may or may not have a formal policy on it because the enforcement will be, I guess the water quality will be DWQR but I guess Scottish Water has some kind of remit, don't they for PWS?*
>
> **Specialist 2, SEPA**

Therefore, there is the need from the stakeholders' point of view to raise awareness on health issues that arises from not treating PWS to enforce the regulation. But according to another stakeholder, more needs to be done, not just raising awareness but expatiating more on the risks involved in use non-treated PWS:

> *It is something local authorities are working to overcome but I think more needs to be done. It is just raising the awareness of health risks and people aren't aware of the health risks. I mean people like the local authorities often gets included in the regulation of PWS, often gets the message "[we have drunk this water all our lives, our children drunk it, our grandparents and no one gets ill]". Which is fine to an extent but then you've got visitors, business you run like hotels and probably if you are immune you can't taste E.coli or enterococci, you know the water's going to look perfectly clear but it could be unsafe microbiologically and so there is no physical, so there is a real sort of problem getting the risk across to people, getting to explain the risk.*
>
> **Operations Team Leader, DWQR**

In addition, the Operations Team Leader expressed enforcing treatment was one of the biggest issues DWQR has and it is something they spend a lot of time discussing.

Notwithstanding, one stakeholder out of the 13 participants interviewed, felt treatment were being enforced, but further referred to the individual ensuring the treatment themselves which goes back to the issue of choice:

> *It is actually being enforced. But then if somebody on PWS feels, then they have to either put treatment in their supply, or they are on a boiled water notice so that is they are boiling their water before it is used so that bacteriological it is safe to drink.*
>
> **Environmental Health Officer, Hebrides**

Therefore, although people are under a legal obligation under the current PWS regulations to ensure that it is fit for drinking and cooking water, the choice rests with the household. And from this study, it has been observed that some participants given a choice would not want to as to treat their water so as not to taint the water and alter the taste.

4.6.5 The cost of using private water supply

From literature reviewed and stakeholders interviewed, households are responsible for the cost of maintaining their PWS.

> *But the difficulty with PWS is that it comes at a cost which is borne by the owner both in terms of the community and financially*.
>
> **Water Policy Analyst, CABS**

However, there is a grant for treatment of PWS but according to a CREW report, most households were not aware of this grant and even if they were aware they had not applied for it low due to a combination of lack of awareness, and the perception that their water supply did not need improvement (Blackstock *et al*., 2015).

> *I mean it depends on how far away you are from the mains. I mean there is a subsidy to people to connect. So, it is subsidized but if they require it can be quite expensive for people, even for a short distance for the pipe to get there. So before Scottish Water can connect, the plumbing system has to be up to the good quality standard as well. So though that could be a sort of an extra £1,000 which when you think as far as those people are on PWS, that they are not paying any money for potentially to have to pay out a £1,000 extra and then to pay regular water rates to Scottish Water that's quite a big expense that people don't have*.
>
> *Because also we have got cases where the water public mains run through pass their house and yet they still want to stay on the PWS and I think there is the cost that comes in as well.*
>
> **Operations Team Leader, DWQR**

This is a possible inhibiting factor on why some participants were not treating their water or moving unto the MWS if available in their area. Because it was discovered relatively 31% (Figure 4.11) of participants had MWS network in their neighbourhood. And Local Authority officers' reports that there are water quality issues in terms of bacterial and pathogen contamination with both surface water and ground water supplies, thus it will be expected that they will be willing to move unto the MWS or take grants for the treatment of their PWS. Moreover, it was also reflected in a response from a surveyed participant that the cost of moving unto the MWS was a prohibitive factor:

> *There is a Scottish Water main in my neighbourhood but cost prohibits supply to my house*…**P17, AS**

Although a relatively low percentage; approximately 10% (Figure 4.12) were using PWS as a means of saving money, the cost compared to the MWS is negligible since households do not pay a fixed bill every month as compared to those on MWS. Thus, participants will say their water was of good quality in order to avoid being moved unto the MWS if available in their neighbourhood. Or they will give excuses like they enjoy the untreated water as seen in this study not to be moved unto MWS if available in their neighbourhood. Furthermore, it is the owner's responsibility to be aware of the quality of the supply and the risks associated with it and they must bear any cost that comes with the treatment. Thus, the cost again might be an inhibiting factor to people not treating their water as echoed by some stakeholders.

Albeit, there is a one time off grant of £800 available per property for PWS as mentioned by several stakeholders, it was discovered that it was not enough to cover the expense of moving unto the mains and further paying for it through the council tax bill which is fixed. Therefore, participants give all sorts of excuses to remain on PWS or even not to treat them as suggested by some stakeholders.

> *Once they connect to the mains system, then they then pick up new water charges and often if it's just a fairly rudimentary PWS, you know it doesn't tend to cost them a lot. If it happens, then you have to put in new piping and whatever but generally speaking there is an ongoing cost which obviously as soon as they connect to the mains water supply there is a charge*
>
> **Director, WICS**

> *I think that their real thoughts are that it is cheaper to get a PWS.*
>
> *It is cheaper compared to the mains and they use all these sort of excuses, you know, that it's better, it's healthier, there's really nothing wrong with the chlorinated water that we are drinking most of the time. If you think there is a chlorine taste and you want to get rid of it, you just draw some water and put it in the fridge and the chlorine will dissipate overnight. So, I can't see any particular problem. A lot of people want to stay on their PWS because they think that it's cheaper.*
>
> **Technical Officer, Infrastructure Services, Aberdeen Council**

It seems the grant structure is also not an enough incentive to convince people to connect to the mains as expressed by a stakeholder. But per the same and different stakeholders, the Scottish Government is looking at ways to reduce the cost of getting on the mains:

> *Again, the government are looking up the possibility of giving grants for that and we had hoped that, that legislation will be through before Christmas time this year but I was told that it probably will be another year before they can get that.*
> **Technical Officer Infrastructure Service, Aberdeen Council**

> *All I know is on the government's and DWQR's radar. It's a very tricky area because the nature of private supply is that as private, it's the home owner's responsibility. To increase the quality of the water will involve basically property owner paying for certain treatment technology to treat it to high quality standard. Unfortunately, you can't force a property.*
> **Sustainable Rural Communities, Scottish Water**

> *At the moment, we are working on a project on rural supplies, so people on PWS. And we found that the ones that are able to connect to mains it's quite difficult to encourage them to do so and it's purely because of the grant structure that we have, doesn't seem to be enough to incentivize them to want to connect I think probably.*
> **Director, WICS**

Therefore, much needs to be done. As suggested by other stakeholders, maybe a community water development may reduce the cost of treating PWS as compared to an individual cost. This is because although grant amounts have not increased since 2006, yet the cost of both materials and labour has increased since then (Blackstock *et al*., 2015). Thus, if households were not willing to move onto the MWS due to the cost, a communal treatment grants might be helpful for households (discussed in detail in Section 4.6.6).

4.6.6 *Dealing with the health risk of untreated PWS*

The burden of disease associated with PWS in developed countries according to Richardson *et al*., (2009), has not been thoroughly investigated and this seems to be the case of PWS users in Scotland. The reason why there might not be data is the compliance of sampling frequency was above 50% for type A supplies in the all 3 study areas. According to DWQR, in Aberdeenshire the sampling frequency compliance was 92.72%; in Highland it was 95.18% and 69.08% in Scottish Borders (Scotland and Drinking Water Quality Regulator for Scotland, 2014). Even though sampling frequency was relatively high, according to DWQR, out of 31 local authorities, only 4 achieved full compliance with their check sampling duties and clearly needs to be improved upon (Scotland and Drinking Water Quality Regulator for Scotland, 2014).

Not only that, research by CREW reports that Local Authority officers in Scotland reported that there were water quality issues in terms of bacterial and pathogen contamination with both surface water and ground water supplies (Blackstock *et al*., 2015). But aside that, there is not enough literature on research with associated disease of untreated PWS usage in Scotland. Though there has been some studies in the UK in the past examining the microbial quality of PWS (Rutter *et al*., 2000; Shepherd and Wyn-Jones, 1997; Humphrey and Cruickshank, 1985; Fewtrell *et al*., 1998; Reid *et al*., 2003 ; Reid *et al*., 2001; Whitten, 1992 and Kay *et al*., 2007), only studies by Benton *et al*., (1989) emphasised on Scotland. According to Richardson *et al*., (2009), the nature of the past studies should be restricted to local authorities and not the entire country. This agrees with this study where there is paucity of literature and research on water quality of PWS use in Scotland yet much on England. However, results on PWS in UK confirm private drinking water supplies have the tendency to be at risk of contamination and the microbial quality of drinking water from these supplies is poorer compared with mains water supplies (Richardson *et al.*, 2009). Therefore, it is necessary to deal with the health risks associated with drinking untreated PWS.

When stakeholders were asked if they were aware of the issue of untreated PWS and how it was being dealt with, there were diverse assessment of the situation but what stood out most was education, incentives and using the carrot-stick approach. Two stakeholders are quoted as:

> *For people to want to consume untreated water again there is the need for education. There's a need for both, again it's carrot and stick, if you are educating people and again you are incentivising, then managing a PWS efficiently, effectively, safely and then there is the stick which is the legislation but that has to be enforced and I think the fact is that is a challenge at the moment because which is what we are looking at as part of a government working group.*
>
> **Water Policy Analyst, CABS**

> *I think what is difficult is there are two things; there is the carrot and stick approach. So, the carrot approach is saying that if you are on the type A supply and that supply is legionella, then you putting yourself and your potential visitors to your property at a health risk. And what you often find is that, you know the reaction you often get is oh I've been drinking this for 20 years and look at me, you know.*
>
> **Director, WICS**

This further leads to the concept of immunity; but in 1993, it was estimated that 38,000 supplies of PWS was available in Scotland serving a population of 60,171 which represented 1.18% of the Scottish population (Reid *et al*., 2001) and currently (2015), around 150,000 people in Scotland rely on a PWS for their drinking water (Scottish Government, 2015). This represents 3.5% of the population that are using PWS in Scotland which means users of PWS in Scotland are increasing and not decreasing. It should be noted that this percentage of users does not take into consideration PWS use through hotels, guesthouses, and campsites. Thus, there is the need to enforce testing and treatment of PWS as in commercial and MWS which are subjected to the most stringent monitoring by local authorities (Richardson *et al*., 2009).

However, it is difficult since some people feel they have become immune to their PWS even if it has been contaminated, and for this reason, education is very necessary in employing the carrot-stick approach. Some stakeholders felt people should be encouraged to move onto the mains if possible and if not possible, grants should be given to make it possible when using the carrot and stick approach, this according to a stakeholder has been done in Northern Ireland:

> *So, there is an education type thing where you say, look you supplies are failing and you need to know the consequences of that and you need to know the benefits of moving to a better supply, you know and one that meets the statutory requirements. So, it's an education for the carrot bit. There's definitely financial carrot, and interestingly we have been looking at it now in Northern Ireland where they've got around and said to people you can connect to the mains system and here's a certain amount of money, it's quite substantive. Yea, so that, there is the financial thing and if you do it as a scheme which closes, you know so you've got the nearest guys to connect to the system if you happen to be close enough for it to be reasonably be economic. And we will pay €12,000 or whatever towards it, then that's a way of persuading people as a carrot, you know, that is the opportunity now and it is a limited opportunity to get them unto mains water supply. So, there is that sort of things. But then else is the stick approach, at least in theory, the local authorities have responsibility for policing the quality of these supplies and if your supply is found to be failing, then you can served with a notice, I've forgotten how the whole thing works, but basically you get served with a notice, an improvement notice and*

In theory, this sounds good but the question to be asked is can households be influenced in terms of their behaviour and attitudes towards untreated water through conditioning? This is because the carrot bit as expressed by some stakeholders is an incentive, which can work very well if the individual finds the incentive appealing and in this case most participants on PWS might not find chlorinated water appealing, thus it becomes very difficult to implement a carrot approach. The stick approach on the other hand in the form of enforcing legislation and serving properties with fines and or notices maybe represented as fear and punishment which may produce immediate results that derive from prompt compliance. However, in most cases it becomes useful only for a short term and then backfires over a long term if properties fail to register their PWS over time or local councils become short of staff to effectively monitor PWS as seen from this study thus making it ineffective.

Alternatively, instead of encouraging people to the mains:

> *I would like to see a staged process where people who could connect to the mains should be forced into connecting to the mains. People who can't connect to the mains because it is too far away should be grouped and until we can get a mains extension we should be looking at getting their own treatment on the system. But gradually I will try to extend the public mains into all areas so that people have the opportunity to take mains water.*
>
> **Technical Officer Infrastructure Service, Aberdeen Council**

This was expressed by a stakeholder in dealing with the non-treatment of PWS. Whereas it was not possible to move people unto the mains, another substitute was to:

> *The obvious thing will be to regulate it the way public water supplies are regulated. I mean there is no particular, no reason why people should not be drinking water to the same standard. I guess the effect of that will be to, some PWS will then be found not fit for purpose, I would imagine. So, they will either have to treat or go onto mains water supply and what I don't know is you know how practical that would be in all instances. Clearly some of them will be reasonably near to mains water supply and they would be relatively straight forward to put them on to it. But if somebody is from a very remote area, I don't know how that would work.*
>
> **Specialist 2, SEPA**

As expressed by a stakeholder. These suggestions are good, but they all come with a cost, and who bears the cost? It was assumed to a larger extent that Scottish Water will be responsible to carry this suggestion out. This might not be feasible and even if it is feasible, it might be very expensive to do as according to (Scotland and Social Work Inspection Agency, 2007). Most parts of the study areas are predominantly rural except Edinburgh and this presents a significant challenge to the service in relation to the accessibility and sustainability of services. Therefore, the best option will be to treat the water on a communal level than trying to move everyone onto the mains water network.

On the other hand, Scottish Water was not so keen on connecting everyone to the mains as according to them it will be very expensive or nearly impossible to do so in some areas which were quite remote:

> *But the issue always does come back to what Scottish water could do in terms of this. The fact that you know 90% people on public water supplies lives close by enough our network to do that. It's all about in terms of our duties and what we do is what is reasonable to do and what's practical to do at a reasonable cost. And for some of these things that some of these communities live, it's quite a distance away from the treated water mains so it's difficult in our expenses to put an infrastructure and from our perspective from our customers as a whole, if you are going to spend say maybe a couple of a million pounds or for example if you are trying to get someone miles away from our mains, we would need to justify that in terms of you know the investment and the proxies we need to bill our customers and if things are a reasonable cost. So always there's a payment balance to put in place and I think about perspectives I think from our customers...*
>
> **Specialist 2, SEPA**

Thence,

> *I think education, if you see some of their answers there better be education because if they are saying this quality of water is good because there is no chlorine...*
>
> **Sustainable Rural Communities, Scottish Water**

But according to a different stakeholder, it is not just education, but rather:

> *The health risk I think has to come through awareness and education and I think understanding communities barriers to manage the health risk; what are the barriers? Because unless we understand the barriers, it is very difficult to come up with policy or an approach that would help resolve that. So yea we need to understand what the community issues are and then we need to look at what needs to be put in place either temporarily or permanently to overcome that. And I think the other thing we need to be very mindful of is the cost of purifying water because for some communities that could be 20 to 30,000 pounds to get their system up to a level where it is safe and who funds that? If it is a community that is predominantly retired people then it becomes prohibitive...*

Another stakeholder not from Scottish water also expressed:

> *I mean there are quite a number of PWS in Scotland you know, and in some council areas, you know there are significant numbers. In Aberdeenshire and Argyll and Bute but it is about saying that looking at it from a Scotland PLC level, connecting all these people up to Scottish water system is prohibitively expensive, you know. It will cost a huge amount of money and it's the realization that's probably not the most sustainable either financially or environmentally sustainable way of delivering compliant water to these people.*
>
> **Director, WICS**

Therefore, what is gathered is cost wise, it is not feasible for all people on PWS to be connected to the mains network. What looks feasible might be treating PWS on a communal level.

4.6.7 Community water development for private water supply

Community management as seen in the literature review is known to be the leading model for implementing rural water supply systems but at most times, many communities struggle with their management tasks and many water systems break down after some years (Schouten, 2006). According to Schouten, (2006), scaling up approach which advocates continuous support to communities in their water services can be used to strengthen community management. A stakeholder expressed raising awareness and working together with local authorities, stakeholders and the community was the way forward in dealing with the public health risk of untreated water which reflects Schouten's approach:

> *Well information is what people need primarily, they need to be aware of the risk of operating a PWS, and they need to be aware how to do it properly. So, we are looking at: making sure they have got the right advice. I am working with the local authorities and I think the enforcement option is very much our last resort. We don't want to just encourage local authorities to come down on people who are operating with a supply with which they are perfectly happy and aren't real potential problems. But at the same time, we need to cautiously address the potential of public health risks and those kinds of areas. So, we are working in a partnership with DWQR, with WICS, with consumer advice Scotland, with local communities. So, we are setting up some projects actually as pilots in some rural areas to look at just these sorts of issues and just try to move it along. It is becoming more of a priority for hydro nation to improve the quality of private supplies in rural areas. So, we recognize that it is a real issue.*

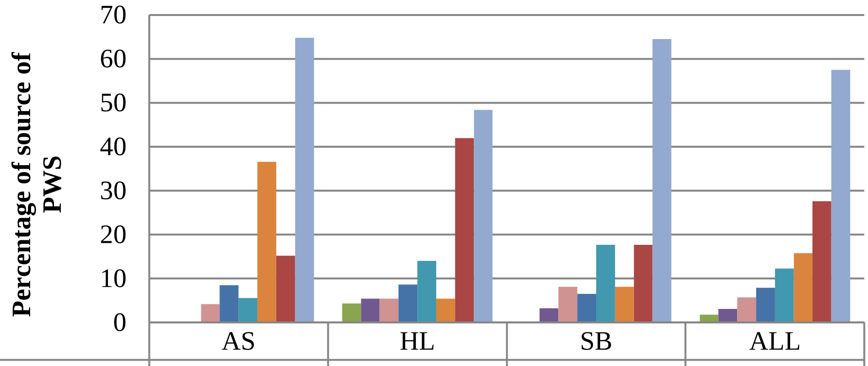
This is relatively similar to understanding the barriers communities face before effective policies can be implemented as echoed by the previous stakeholder. Therefore, to improve supply and treatment of PWS, there should be a form of policy legislation that enforces PWS treatment. According to another stakeholder, this can only be possible if it is coming from the European Union:

> *I don't think that's the approach the regulators of Scottish government are going to take in terms of you know, they've tried to develop the PWS legislation you know to comply with the EU directives. It's as best as it can be but I think until further pressure comes from the European side of things, it may influence you know, it may will come along one day and ok we will have to make a decision, do we force people to essentially upgrade their water supplies you know?*
>
> **Policy Adviser, Scottish Water**

However, CREW reports that Local Authority officers identifies that it will be very difficult to have a communal water treatment and this doesn't happen very often as "getting communities together is not the easiest thing" (Blackstock *et al*., 2015). Their reason being households having to bear the financial commitment themselves will hinder them from such a development. According to Local Authorities, "*one person opting out means the others doesn't want to pay the extra money. It's a bit of a nightmare, really*". Nonetheless, if there was a grant, or they could all put their grants together, there is a chance that household will be willing to have a communal water supply to treat their PWS.

4.6.7.1 Sources of PWS

Participants were asked their source of PWS since access to safe drinking water is a basic human right and is considered essential for health protection (Smith *et al*., 2006). Also, participants were asked this question to ascertain if they were already using RWH in their homes. Overall, approximately 58% were using spring as the source of their PWS, this was followed by watercourse (28%), well (16%), borehole (12%), rainwater (8%), didn't know (6%); reservoir (3%) and loch (2%) (Figure 4.14). Within individual study areas the source of PWS varied. In Aberdeenshire and Scottish Borders, participants' source of PWS did not include lochs; and in Aberdeenshire, there was no reservoir used as a source of PWS. A few participants; AS (4%), HL (5%) and SB (8%) did not know their source of PWS.



	AS	HL	SB	ALL
Loch	0.0%	4.3%	0.0%	1.8%
Reservoir	0.0%	5.4%	3.2%	3.1%
I don't know	4.2%	5.4%	8.1%	5.7%
Rainwater	8.5%	8.6%	6.5%	7.9%
Borehole	5.6%	14.0%	17.7%	12.3%
Well	36.6%	5.4%	8.1%	15.8%
Watercourse	15.2%	42.0%	17.7%	27.6%
Spring	64.8%	48.4%	64.5%	57.5%

Figure 4.14: What is the source of your private water supply? (Please select all that apply). The source of PWS: AS (Aberdeenshire); HL (Highland); SB (Scottish Borders): ALL (all the 3 study areas: AS, HL, SB).

The survey results about PWS sources are all in line with the DETR/DWI report in 2001 which showed the principal sources of PWS are springs, wells and boreholes. Streams according to DETR/DWI, (2001), is used but to a lesser extent because of the more variable quality of surface waters compared to groundwater. This is because according to DETR/DWI, (2001), streams offer more reliable yields but may be susceptible to pollution and may exhibit variable quality. However, in this study, watercourse (streams) was the second highest of PWS source used. In spite of the percentage being relatively low compared to the main source spring (58%), there is a risk associated with its usage as participants expressed their preference for untreated water. Additionally, DWQR attest that source types have a significant bearing on microbiological quality with groundwater sources, especially boreholes, far less likely to suffer from microbiological contamination than surface water sources (Scotland and Drinking Water Quality Regulator for Scotland, 2014). Therefore, it should be noted that water from streams may be susceptible to contamination and the quality of the water will generally not be as good as that from springs, boreholes and deep wells (Clapham 2010). Also, stream source are known to likely be contaminated with bacteria during variations in the weather like a high rainfall and warm weather (Clapham 2010; NIEA, 2010).

4.6.7.2 Shared PWS

Participants were then asked if they were sharing their source of PWS with other people in the community. This question was to understand if participant already were practising a communal water development. It was to a larger extent assumed if they were sharing a source of water, they will collectively be responsible for the water thus a communal RWH will not be a new to them. Out of 237 participants, 142 said they were sharing their source of PWS as compared to 57 who said they were not (Table 4.8). A few people did not know if they were sharing their source of PWS (Table 4.8). However, in individual study areas, responses varied and Scottish Borders contrasted the other areas. A relatively high number of people (27) did not know if their source was shared as compared to other study areas and few people (7) said their source was not shared.

Table 4.8: Is your private water source shared with other users? (The source of PWS as a shared use as answered by participants)

	ALL	AS	HL	SB
Yes	142	46	65	31
No	57	22	28	7
I don't know	38	6	5	27

There has not been any known socially acceptable and truly sustainable development for community water development in the world. But it was discovered in this study that community development and engagement was one way for people on a shared PWS to effectively manage their PWS in terms of quality as discussed previously.

> *So, you might have a community that works really well together, they take joint responsibility where everybody does their bit to make sure the waters are of good enough standard.*
>
> **Water Policy Analyst, CABS**

As dittoed by a stakeholder. Apparently DWQR had tried a community engagement on PWS users before and seems to have developed improvement with the quality of the water:

> *"Since the development of this community supply, the users have not had any issues with quality or quantity. Their supply has an annual maintenance check which is carried out by a local contractor. This is a very good example of a community (regardless of how small) working together to find a solution to their private water supply issues instead of individuals trying to find individual household solutions. In doing this they have found a solution to their private water supply issues as well as taking measures to ensure this is sustainable in future years"*…**DWQR**

In terms of this development by DWQR, most stakeholders expressed the need to get PWS users together on a community platform for an effective treatment. A typical example was:

> *We have been thinking quite recently actually about the scope for taking forward some mechanism by which we encourage a few planning schemes to come forward with community ownership. When the community itself is willing to engage in putting in some PWS system which is in the same mind of being the kind of Rolls Royce Scottish Water membrane plant; but might be something that is a bit more suitable at the community level.*
>
> *So, one of the things that we have been looking at is the extent to which particularly at a community level, there is a possibility of coming up with other ways of supplying them with water which are not the sleek conventional Scottish water.*
>
> **Director, WICS**

These the director feels might in some way solve the issue of drinking untreated PWS. Considering some other limitations known within a community water supply may include imitations within the community dynamics, political or social conflict, failure to generate sufficient tariff income, failure to account transparently for funds generated, lack of preventive maintenance, lack of community cohesion and lack of capacity (Schouten, 2006); other stakeholders felt it might not go well with shared PWS community treatment and maintenance when it comes to who takes responsibility. A stakeholder expressed:

> *You might have a community where people don't really talk to each other, they don't function well as a community and if there are on a PWS, who is responsible, do they engage with one another or how do they work together to ensure that their water is of enough good quality.*
>
> **Water Policy Analyst, CABS**

This comment by the stakeholder reflects a householder's perception that a larger community degrades the community's water supply:

> *The private water supplies us and about 14 other properties, it started as a 2-acre rainwater collection point but as demand increased springs and wells were added to increase demand. Now new rules mean the whole system has to be degraded. I was happy with it as it was…* **P12, AS**

However, another stakeholder expressed that if the economics were calculated very well, the concept could be well developed with incentives and offer a rudimentary low cost of water treatment on a community level:

> *Well, it gets interesting because it could be that if the concept of doing these things is fairly rudimentary low cost way, it's feasible, then it could be some of these communities are actually potentially could be paying less than the standard rate, you know. And that gets interesting, it's easy when it's more expensive because then you say the generality of customers will subsidized that more expensive requirement. But what about the situation where the potential could be paying less, should you still charge them the harmonized rate or the lower rate? So, yea the economics overall are quite interesting. But I think what we are quite keen to do is to explore the extent of which there are lower cost and market solutions to delivering PWS in a certain community.*

Thus, there is a need for clear definition on policies and legislations on who is responsible for such a community engagement. It was expressed by a different stakeholder that the 2006 private water legislation does refer to relevant persons for maintenance but it is not cleat as to who that relevant person is:

> *If it's a type B, which is a smaller number of people but it still could be shared, then you would be looking at the people on the supply sharing responsibility for it. The legislation refers to relevant persons and in the 2006 regulations there was a confusing definition pf relevant person. The legislation is, we believe following various representations the Scottish government going to be changed. So, that it makes it clearer that all users will be responsible for that system.*
>
> **Technical Officer Infrastructure Service, Aberdeen Council**

Nevertheless, there is some initial work by the DWQR to understand the benefits of community supplies and the steps required to encourage communities to work together (Scotland and Drinking Water Quality Regulator for Scotland, 2014). With this project, they hope for communities to develop solutions by improving and taking responsibility for their PWS.

4.7 CONCLUSION

This chapter has provided an overview of the selected study areas, responses received, household size, and demography of the area and an in-depth discussion of PWS use in the study areas. This was to understand better the inclination of participants to RWH and what influences their decision to implement RWH. Overall participants' age and gender profile was similar to that of the general Scottish population. A relative high number of women (187) answered the questionnaires as to men (185). However, in individual study areas, there were more responses received from men than women except in Edinburgh. Additionally, a comprehensive description showed that the mean household size, the tenure, and accommodation type were all similar to that of the general Scottish profile.

Overall, 378 responses were received out of the 400 that was expected back. The completion rate was above 90% and response rate was approximately 24% for PWS survey exceeding the expected. However, MWS responses fell below the target at 14%.

Participants were asked if they had MWS available in their neighbourhood to ascertain their preference for PWS and to understand their willingness to implement RWH. Approximately 31% had MWS in their area. Participants were then asked why they were using PWS and were given five options: no other supply, good for the environment, was already here, save money and other. However, no other supply (71.7%) and already here (56.5%) were what most participants gave as reasons for using PWS. Moreover, they ascribed other reasons like no chlorine, the taste, untreated and tradition for using PWS. Not intended and not part of the research objective, non-treatment of PWS was thoroughly discussed in this chapter. It was observed that the preference for untreated water was as a result of the taste and the water being pure. They further believed it was safe and disease free because they were no illness in their area associated with use of untreated PWS and they had developed immunity to untreated PWS. Therefore, their sensory attitude played a role in their behaviour for preference for untreated water.

Hence, the non-treatment of PWS was perceived as a challenging issue in areas using PWS. However, the biggest challenge was enforcing the treatment since the legislation did not categorically state how wholesome the water must be as discovered through the stakeholders' interview. Furthermore, it was observed that some council left the choice to treat PWS to the owners. Also, it was realized that there were not enough personnel to monitor and keep record of failed PWS and some households were not registering their PWS. However, the DWQR has been leafleting houses as a campaign strategy to create awareness on the risk of drinking untreated PWS.

However, it was observed that the cost of using PWS was relatively cheaper than using MWS thus households according to stakeholders will give excuses to be on PWS. Along these lines, it was considered that the public health hazard of untreated PWS has to be addressed. Most of the stakeholders suggested a communal water development where the PWS are treated using grants from the Local Authority since most of the participants 142 out of 199 said their source of PWS was shared. However, it was perceived by some stakeholders that if grants were not given and households were paying for treatment themselves, it will be difficult to implement a communal water development.

Chapter 5- CLIMATE CHANGE AND SCOTTISH WATER RESOURCES

5.1 INTRODUCTION

Climate change is expected to alter precipitation patterns in the UK with more inter-regional and inter-seasonal variability (Ritson *et al*., 2014; Stocker *et al*., 2013). Despite the perception that it rains a lot and there are abundant water resources in Scotland (Fewkes, 2012), some areas are expected to be dry and other areas are expected to be wet and experience drought and floods respectively. There is also expected to be high impacts, such as the damaging storm clusters experienced during the winter of 2013/2014 along the western coasts of the UK (Wadey *et al*., 2014). Thus Objective 2: "*understanding the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland*".

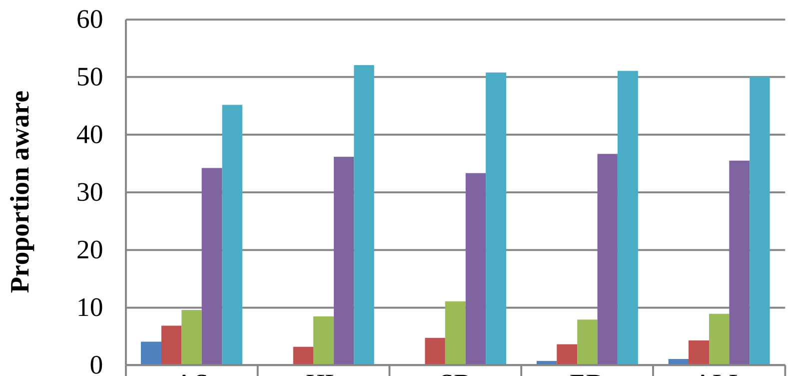
To discuss householders' perceptions on climate change, in the questionnaire, participants were asked their perceptions on climate change impacts on their own and Scotland's water resources. The purpose was to study if participants can discern it was the same thing. Additionally, this chapter was to confirm if RWH can be part of climate change mitigation plan as it has been observed from literature that RWH can be used to control flooding.

This chapter also explores on how to bridge the gap between climate change and water resources through the interviews conducted with stakeholders. Stakeholders were also asked the likely priorities in relation to water resources in Scotland during the interviews to ascertain if the impact of climate change was higher on the agenda of water stakeholders in Scotland.

5.2 CLIMATE CHANGE AWARENESS

Householders were asked if they were aware of climate change not as in experienced it but awareness through friends, family, community, social media and the media and the potential impacts it might have on Scotland's water. This is because climate change has been predicted to alter rainfall and water catchment hydrological responses across the world (Watts *et al*., 2015). In the UK, climate change is expected to cause a rise in temperatures, modify the precipitation patterns and cause an increase in frequent and extreme weather events (Ritson *et al*., 2014). Even though climate change may have an impact on UK, the impact in Scotland might be severe and different due to the fact that Scotland has a wide range of climatic, physical, economic and other features that distinguish it from the rest of the UK, UK Climate Change Risk Assessment (CCRA), (2008).

Householders were asked to rate their awareness of climate change on a 5-point Likert scale: not at all aware, slightly aware, somewhat aware, moderately aware and extremely aware. Overall, about half of the participants (50.1%) were aware or have heard of climate change (Figure 5.1). This was similar in all the study areas except in Aberdeenshire which was marginally below 50% (45.2%) (Figure 5.1). In spite of that, comparing the level of awareness, those that were extremely aware were higher than those that were not aware (Figure 5.1). In the different study areas, the order of awareness was the same, from the highest to the lowest it was: extremely aware, moderately aware, somewhat aware, slightly aware and not at all aware (Figure 5.1). For households on PWS, all respondents were aware of climate change, it was only in Aberdeenshire that 4.1% expressed not at all being aware of climate change (Figure 5.1). Additionally, in Edinburgh, a minority (0.7%) were not at all of climate change as well.



	AS	HL	SB	ED	ALL
Not at all aware	4.1%	0.0%	0.0%	0.7%	1.1%
Slightly aware	6.8%	3.2%	4.8%	3.6%	4.3%
Somewhat aware	9.6%	8.5%	11.1%	7.9%	8.9%
Moderately aware	34.2%	36.2%	33.3%	36.7%	35.5%
Extremely aware	45.2%	52.1%	50.8%	51.1%	50.1%

Figure 5.1: Participant's awareness of climate change (Are you aware of climate change?)

As stated earlier, the awareness of climate change question aimed to test public awareness of climate change in terms of relevant knowledge and concern through the media, friends or community. Though about half of participants expressed they were extremely aware of climate change, approximately 50% (Figure 5.1), they did not believe it is happening and if it is, it has been beneficial to them through their comments; this is further discussed in Section 5.3 on perceptions on climate change in Scotland. The lack of perceived awareness in terms of negative impact of climate change perchance is as a result of the UK Westminster 2008 Climate Change Act not implementing on public engagement; especially for inhabitants in rural and peri-urban communities on PWS. A similar act, Scottish Holyrood Climate Change (Scotland) Act 2009 also does not implement on public engagement. According to Lockwood, (2013), the Westminster 2008 Climate Change Act is a difficult policy therefore has become a policy problem due to low political salience and immediate cost and has failed to produce political certainty and investor confidence; therefore, this might have resulted in public engagement being in theory more than in implementation. This act is no different from the Holyrood Climate Change (Scotland) Act 2009, so the same sentiments are shared.

Even though a relatively high proportion of respondents were aware of climate change, the minority few that were not aware can be attributed to lack of knowledge and or information on climate change. This was established in comments from residents surveyed. In Edinburgh, some participants from the survey forenamed:

> *Do not have a clue on the impacts of climate change on water resources*…**P5, ED**
>
> *I am not at all aware of climate change*…**P87, ED**
>
> *Probably require more information about climate change- whether patterns affect the health etc., engineering requirements and costs*…**P127, ED**
>
> *I am not able to answer Section C questions with regard to climate change. I do not have enough knowledge/information on impacts of water supply/quality, etc. due to climate change*…**P19, ED**

In Aberdeenshire, Highland and Scottish Borders, most of the responses from residents reflected comments from Edinburgh and examples are:

> *Do you think climate change will affect your own source of private water supply? ANSWER: I don't know. Being a spring supply under a seam of clay, if deep boreholes locally trapped into this supply it could reduce or stop our supply*… **P53, HL**
>
> *I do not have enough knowledge of climate change to comment*… **P8, AS**

I cannot subscribe to the notion of climate change… **P25, SB**

According to literature, research shows that there is a general awareness of public perceptions on climate change (Lorenzoni *et al*., 2007) and in the UK only 1% of the English public have not heard of climate change (DEFRA, 2003). In spite of that, there is a prevalent awareness of climate change in England, self-reported knowledge is erratic: 59% of the British public say they know ‘a fair amount’ or ‘a great deal’ about climate change (Norton and Leaman, 2004), whereas one-fourth claim they are ‘well informed’ (Hargreaves *et al*., 2003). One being aware of climate change does not necessarily mean they have a detailed understanding of climate change and its impacts whether negative or positive. The response in UK further emulates identical findings in the USA where respondents’ general awareness of climate change did not harmonize with a comprehensive understanding of causes, consequences and solutions of climate change (Kempton, 1997). This further confirms this study where most respondents had heard of climate change in Scotland but through their comments they did not believe it was happening and or did not have enough knowledge on it. This is further discussed in Section 5.3 on participants’ and their perceptions of climate change.

By virtue of the fact that the depth of understanding of climate-change issues is suggested to depend on individual characteristics such as educational level and age, gender (Aoyagi-Usui *et al*., 2003; Ester *et al*., 2004); age and gender of participants were in addition analysed to see if there was a difference in response of perceived awareness.

5.2.1 Gender and climate change awareness

Climate change has been suggested not to be gender-neutral ((Dankelman, 2010) and women are more vulnerable to the effects of climate change especially in developing countries where they have to meet with the changes in the access and quality of natural resources (Haines *et al*., 2006; NAPCC (2008:14). Furthermore most research suggests that women are more concerned about the environment, and with regards to climate change, women were significantly more concerned about climate than men in a research by (Semenza *et al*., 2008). For this reason, since we got approximately 99% (Figure 5.1) expressing some form of awareness of climate change, it was assumed that women will be more conscious or might have heard and had some knowledge on climate change; thusly the null (H_o) and alternative (H_1) hypotheses were defined as:

H_o: *There is no association between gender and climate change awareness*
H_1: *Females are more aware of climate change than men*

A chi-square test for association was conducted between gender and awareness of climate change. Majority of the expected cell frequencies were less than five thus the assumption was violated so the "likelihood ratio" results were used (Table 5.1; Appendix VIII). Overall, there was no statistically significant association between gender and climate change awareness, χ^2 (1) = 5.196, p = .268, hence the null hypothesis was accepted. The awareness of climate change was not related to gender (Table 5.1; Appendix VIII). This was the similar with households on PWS: AS (χ^2 (1) =.111, p = .999); HL (χ^2 (1) =.564, p = .905) and SB (χ^2 (1) = 4.489, p = .204); thus, the null hypothesis was accepted; there was no association between climate change awareness and gender (Table 5.1; Appendix VIII). However, in Edinburgh, those on the mains, there was a statistically significant association between gender and climate change awareness, χ^2 (1) = 15.237, p = .004 and there was a very strong association between gender and awareness for, φ = .305, p = .012. Therefore, the null hypothesis was rejected in Edinburgh and the alternative hypothesis was accepted (Table 5.1; Appendix VIII).

Except for Edinburgh, it was observed that there was no association between gender and climate change awareness as has been suggested by some researchers. The results in this study could be attributed to the fact that participants in Edinburgh were in the city as compared to those on the PWS who were in rural and peri-urban areas. It can be inferred but not concluded from this study that the women in the city might have had exposure through the media, the community they find themselves in, colleagues at work than women in the rural and semi-rural. However research in Wales shows that female respondents on the public perceptions of climate change were more concerned about climate change than are males (Capstick *et al*., 2013).

5.2.2 Age and climate change awareness

According to (Liere and Dunlap, 1980), there was a hypothesis on age that younger people tend to be more concerned about environmental quality than older people. Moreover, earlier research suggested that age was positively correlated with environmental concern (Harry *et al*., 1969). However, most studies do not support this argument; rather age was negatively correlated with environmental concern (Liere and Dunlap, 1980).

In this study; the age which was grouped into 6 categories were further reduced to 2 categories: younger (16-54 years) and older (55 years and above). It was observed from the results that participants who were younger were mostly part of those who were not extremely aware of climate change (Table 5.2).

Table 5.1: Awareness of climate change * Age (Young/Old) Cross tabulation (Are you aware of climate change?)

Climate change awareness		Age (Young/Old)		Total
		Young	Old	
Awareness of climate change	Not at all aware	1	3	4
	Slightly aware	7	9	16
	Somewhat aware	16	17	33
	Moderately aware	68	62	130
	Extremely aware	77	106	183
Total		**169**	**197**	**366**

Missing cases =12

Since it has been suggested that younger people tend to be more concerned about environmental quality than older people, an association between age and climate change was analysed to test if there was an association. The null (H_0) and alternative (H_1) hypotheses were defined as:

H_0: *There is no association between age and climate change awareness*

H_1: *Young people are more aware of climate change than old people*

A chi-square test for association was conducted between gender and awareness of climate change (Table 5.3; Appendix IX). Majority of the expected cell frequencies were less than five thus the assumption was violated so the "likelihood ratio" results were used (Table 5.3; Appendix IX). Overall, there was no statistically significant association between age and climate change awareness, χ^2 (1) = 4.075, p = .396, hence the null hypothesis was accepted; there was no association between age and climate change awareness in this study (Table 5.3; Appendix IX). In individual study areas, however, the null hypothesis was accepted as well except in Scottish Borders where it was rejected: AS (χ^2 (1) = 2.183, p = .702); HL (χ^2 (1) = 3.363, p = .339); ED (χ^2 (1) = 6.999, p = .136) and SB (χ^2 (1) = 10.059, p = .018) (Table 5.3). Nonetheless, there was a very weak association between gender and preference for age and climate change awareness, φ = 0.353, p = .049 in Scottish Border, thus the alternative hypothesis was accepted (Table 5.3; Appendix IX). Although there was an association between gender and awareness of climate change in Scottish Border, it was very weak and therefore it is not accepted.

There was no association between age and climate change awareness, however research on public perceptions of climate change in Wales showed that older and younger age groups tend to show minimal concern about climate change effects and older people were least expected to express a willingness to change their behaviour to help address climate change (Capstick *et al.*, 2013). This is similar to this study where even though older respondents were more aware of climate change, responses from some of them suggested:

a. They did not know what it was and or were not aware of climate change.
b. Although they have heard about climate change, residents surveyed did not believe it was happening.
c. Residents believed if climate change will impact on Scotland's water resources it will be in later years (100 years from now).
d. Lastly, residents surveyed were not willing to do anything about climate change impacts on Scotland's water resources.

Some of their comments from residents surveyed were:

> *I also know little about possible effect of climate change on water supply, so again it is hard to give an informed opinion on your statements…* **P39, ED**
>
> *I am not at all aware of climate change. The carbon dioxide thesis is only very practical plus the government has got this totally wrong. Water vapour is a many times more powerful greenhouse gas than carbon dioxide and it is not understood well enough to computer model with confidence. Carbon dioxide has risen last 12 years but average world tech has been static. Ice cores etc. show tough rise before carbon dioxide: - evidence does not support the role of carbon dioxide! - fist part of it; expect time scales are 100 years…***P87, ED**
>
> *Changes in climate pattern have been observed all over the world through rising global temperatures which are causing more extreme weather events, like flooding and heat wave. -IT'S A LIE…* **P49, AS**
> *I cannot subscribe to the notion of climate change and doubt if I will ever notice it. (Like in 100 years?). And if it is proved beyond doubt nothing will really be done…* **P25, SB**

Climate change will not affect our water supply… **P97, HL**

So, although age did not relate to climate change awareness in this study, older participants were most likely not to believe climate change was happening through the final comments (Appendix VII) received from analysing responses and corresponding with their age.

5.3 CLIMATE CHANGE, WATER RESOURCES AND WATER PRIORITIES IN SCOTLAND

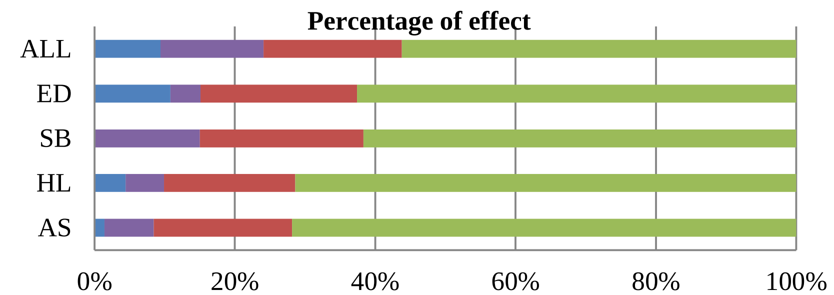
5.3.1 Climate change and water resources in Scotland

The Scottish Government has acknowledged climate change will have an extensive effect on Scotland's economy, its people and its environment and is determined to play its part in tackling climate change (Scottish Government, 2015). The government passed a Climate Change (Scotland) Act by the Scottish Parliament in 2009 which was followed by a publication on "*Low Carbon Scotland: Meeting our Emissions Reduction Targets 2013-2027 - The Second Report on Proposals and Policies (RPP2)*" on 27th June 2013 (Scottish Government, 2015). The report, one of a whole series of Scottish policy document on carbon emissions/reductions creates a framework for reducing greenhouse emissions by 80% in 2050. This report also ensures delivery of this target by the Scottish Ministers who are to set annual targets, which include public bodies.

Though the government has made a commitment to dealing with climate change issues and its impacts, there remains a low level of public engagement in tackling climate change and mitigation actions by Scottish inhabitants especially those in rural and peri-urban communities. Due to that, since 3 study areas involved rural communities, after participants were asked on their awareness of climate change, they were further asked if they perceived climate change will have an impact on Scotland's water resources and in addition their own water resources. This was to test their knowledge and awareness of climate change by trying to see if they will see the similarity in these two questions. Both questions were rated on a 6 Likert scale; climate change impact on Scotland's water resources were scaled from extremely unlikely to extremely likely and included an "I don't know" option but was further reduced to 4 (extremely likely and likely were merged and so was unlikely and extremely unlikely) to make it more easy during the analysis. The question on climate change impact on own water resources was scaled from “to a great deal” “to never” and also included an “I don’t know” option.

Comparing the two questions: impact of climate change on Scottish water resources and own water resources, it was observed that participants perceived climate change to likely have an impact on Scotland’s water resources (56.2%) (Figure 5.2) but “to a great extent” would not impact on their own resources (8.2%) (Figure 5.3). They rather perceived climate change will “somewhat” (32.3%) have an impact on their own source of water supply (Figure 5.3). It should be noted that the somewhat represents “unsure” or “scepticism”. If there will be an impact, overall, a relatively high proportion of participants aside “somewhat” perceived a little effect (27.4%) on their own source of water supply (Figure 5.3). Relatively, few people were unsure (9.4%) that climate change will have an impact on Scotland’s water resources (Figure 5.2) as compared to their own water resources (15.5%) (Figure 5.3).

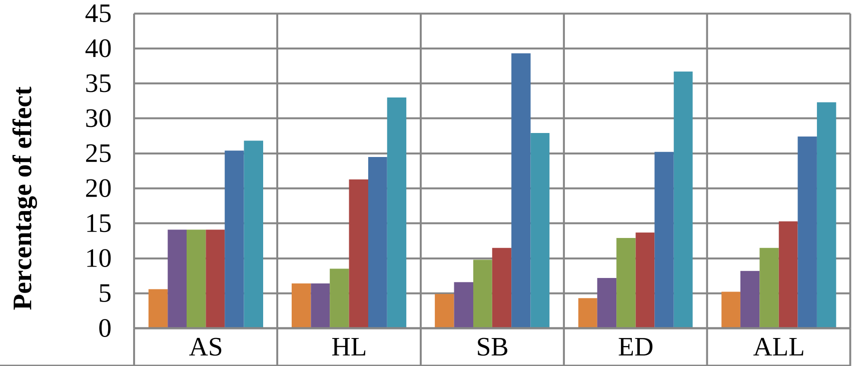
In individual study areas, the results for climate change impact on Scotland’s water were similar and followed the pattern (highest to lowest): “likely”, “unlikely”, “neutral” and” I don’t know” except in Edinburgh where there were more I don’t know (10.8%) than neutral (4.3%) (Figure 5.2). In Scottish Borders, there was no “I don’t know” and a relatively high proportion (15%) were “neutral” on the impact of climate on Scotland’s water resources as compared to the other areas (Figure 5.2). A relatively high proportion in Aberdeenshire (71.8%) and Highland (71.4%) perceived climate change will have an impact on Scotland’s water resources as compared to Edinburgh (62.6%) and Scottish Borders (61.7%) (Figure 5.2).



	AS	HL	SB	ED	ALL
I don't know	1.4%	4.4%	0.0%	10.8%	9.4%
Neutral	7.0%	5.5%	15.0%	4.3%	14.7%
Unlikely	19.7%	18.7%	23.3%	22.3%	19.7%
Likely	71.8%	71.4%	61.7%	62.6%	56.2%

Figure 5.2: Participants' view on the impact of climate change on Scottish water resources (Do you think climate change could impact on water resources and supply in Scotland?)

On climate change affecting "own" source of water supply, it also followed the same pattern except Scottish Borders which differed: "somewhat", "little", "I don't know", "much", "to a great extent" and "never". Scottish Borders had more participants saying climate change will have little impact (39.3%) than somewhat (27.9%) (Figure 5.3). In Aberdeenshire, responses to effects were similar (14.1%) for "much", "to a great deal" and "I don't know", whereas in Highland it was similar (6.4%) for "never" and "to a great deal" (Figure 5.3). Furthermore, a relatively high proportion in Highland (21.3%) did not know if climate change will affect their own source of water supply compared to the other study areas.



	AS	HL	SB	ED	ALL
Never	5.6%	6.4%	4.9%	4.3%	5.2%
To a great deal	14.1%	6.4%	6.6%	7.2%	8.2%
Much	14.1%	8.5%	9.8%	12.9%	11.5%
I don't know	14.1%	21.3%	11.5%	13.7%	15.3%
Little	25.4%	24.5%	39.3%	25.2%	27.4%
Somewhat	26.8%	33.0%	27.9%	36.7%	32.3%

Figure 5.3: Participants' view on the impact of climate change on their own source of water supply (Do you think climate change will affect your own source of water supply?)

It was observed that there were contrasting views between the effects of climate change on Scottish water resources and their own water resources even though they are the same source of water supply and or resource. Research studies based on surveys on public opinion on climate change have proposed that many people misconstrue the science of climate change and, in particular, are confused about the nature, causes and consequences of climate change (Bord *et al.*, 2000; DEFRA, 2003). This can be attributed to the fact that participants could not distinguish that their own water supply and Scotland's water supply was the same thing and the impact as a result of climate change is the same thus their contrasting responses on the effect of climate change. Moreover, it was observed in Section 5.2 that that some residents surveyed had no knowledge on climate change:

> *I also know little about possible effect of climate change on water supply, so again it is hard to give an informed opinion on your statements…* **P39, ED**

> *I do not have enough knowledge of climate change to comment on its effect on Scottish water supplies…***P8, AS**

> *Do you think climate change will affect your own source of private water supply? Answer: To a great deal for stream; for borehole, I don't know…***P53, HL**

This further reflects research by Bord *et al*., (2000) on misunderstanding of climate change and it's impacts on the environment. According to a stakeholder:

> *I think for any wording we use it needs to be explained and I think one of the problem is we probably get a bit 'jargony' in the industry because we are dealing with these terms every day and we know what it means but not everyone necessarily knows what that is.*
>
> **Water Policy Analyst, CABS**

This was asserted as a reason people misunderstood climate change. Further, some residents surveyed perceived:

> *Let's leave the word 'climate change' out of the question if you want an answer. If it rains there is water, if it doesn't rain for a long time there's no water- SIMPLE. If it doesn't rain at all for 6 weeks in July and August, we may have to ration our water or we may run out!...* **P35, SB**

> *Climate can do no other than impact on water supply, either way (dry or wet) …* **P27, SB**

This in addition reflects on the misunderstanding of climate change and as expressed by a stakeholder:

> *Most people don't understand what climate change means. It over took global warming, because with global warming everybody assumed it was going to get warmer but it's not quite the fact it's going to change over time.*
>
> **Environmental Health Information Officer, Aberdeenshire Council**

Therefore, some stakeholders suggested to get the message of climate change across, the name should be localized to the effects climate change will have in an area.

> *Scottish Water ends up having to do two things for climate change; you know the adaptation and mitigation bit. And the adaptation bit is quite pronounced, you know, there is more flooding so we are seeing the impact of higher intensity of local rainfall producing more stress on the drainage systems and that does impact on people, you know. So there is an adaption thing where they will have to spend money and then they have to use customers' money on changes to the system to deal with the impact of climate change coming through. Now whether people here recognize that is another question. Now does changing the name, you know, I don't know what you will call it, you will call it climate impact or something or you know something other than like climate change. But you know, if people are not yet realizing the impact that will have on the water system, then maybe that's something that Scottish water and other entities could be starting to promote. And the other thing is obviously you'll get caught up in the mitigation bit, they have to look at the operations and think of ways of being less carbon intensive which is a*

This was expressed by a stakeholder, that instead of changing the name, people should be made to understand the impacts using experience, example as in flooding. Though this idea sounds good, it will be challenging since some residents surveyed perceived climate change to be beneficial:

> *Our farm has got wetter over the last 40 years. Climate change is making our supply more secure…* **P50, AS**

Alongside the impacts of climate change on Scottish and households' own water resources; residents surveyed further expressed diverse opinions on climate change. This is discussed details in the next section as perceived perceptions of climate change in Scotland.

5.3.2 Climate change perceptions in Scotland

In analysing the questionnaire, it was summarized that residents surveyed perceived climate change to be:

1. A theory and government agenda to promote their "green" agenda;
2. A problem for other countries and not Scotland;
3. Untrue; and
4. Happen in 100 years from now.

Some perceived climate change to be untrue and attributed it to be one of the governments' agenda to frighten them by presenting some facts just to bring in their own "green" agendas:

> *I am slightly aware of climate change. There are always fluctuations, but beware of media and government trying to frighten you by presenting some facts but not others just to bring in their own "green" agendas. Things really aren't that serious…* **P35, SB**

> *We have lived in Scotland for five years, having moved from England. In England, we were appalled by profiteering private water companies and our last home in England had a water meter. It was very expensive and all most all my neighbours had a policy of only*

*flushing the toilet for No.2s, loading the dishwasher + washing machine to the max etc. I am very satisfied that warnings on water shortage are not much more than a ploy to raise prices, reduce the need to invest in better water collection + treatment infrastructure and reduce leakage. I do not believe there is insufficient rainfall to provide for all needs. Climate change is a gift to the water companies…***P94, HL**

According to Capstick & Pidgeon (2014), doubts about climate change exists in the form of scepticism and it is often related to the lack of clarity in previous work as to what exactly "scepticism" comprises. Scepticism has also been known to be associated with low environmental awareness and low risk awareness (Engels *et al*., 2013). Scepticism was reflected in this study where overall a relatively high proportion (32.3%) perceived climate change to "somewhat" (unsure) impact on their own source of water supply (Figure 5.3). Though participants were aware of climate change, their doubt that it was happening can be attributed to them not having enough knowledge on what climate change really is and how they can be affected as suggested by Engels *et al*., (2013). The lack of education and misinformation was reflected in a comment by a stakeholder:

What we know is that there was some sort of scepticism amongst the general public about climate change. There is quite a lot of misinformation out there, again I think all that is natural when you consider what the anticipated impacts are for this part of the world and it is difficult for people to lift their eyes and look further afield, make that connection between our consumption you know patterns at the impacts that has on water use in their parts of the world. People just don't tend to think that way. It is much more localized that is down to the family level, it is about what are the costs for me and raising my family, that is what they are mostly thinking. So yea, we will say that it is consistent, it's a fairly typical tail of misinformation and disinformation and low priority.

Manager, Hydronation

What is more, scepticism among residents surveyed was evident because they believed that the climate changes: winter, spring, summer, and autumn; therefore, they doubted the negative impacts of climate change but believed in the favourable effects of the climate changing in terms of more rainfall. Likewise, they perceived the theory of climate change was wrong:

The carbon dioxide thesis is only very practical plus the government has got this totally wrong. Water vapour is a many times more powerful greenhouse gas than carbon dioxide and it is not understood well enough to computer model with confidence. Carbon dioxide has risen last 12 years but average world tech has been static. Ice cores etc. show tough rise before carbon dioxide: - evidence does not support the role of carbon dioxide! - first part of it; expect time scales are 100 years… **P87, ED**

This observation of doubt was further more pronounced where most of the residents surveyed in addition perceived they were aware of climate change but it was not really that serious because they felt if the terminology 'climate change' was taken out of the questionnaire and replaced with: "*do you think change in climate change could impact on water resources and supply in Scotland*"; the answer to that question they felt should be simple yes in terms of, "*if it doesn't rain for a long time there's no water*", so to them they doubted the negative impacts of climate and attributed it rather to luck in terms of rain or no rain when the climate changes: winter, spring, summer and autumn.

Not only did residents surveyed lack information, or are misinformed as suggested by the stakeholder above, they also do not understand the impact climate change may have on them as individuals. This is because some climate change problems (heat waves, cold winters, floods and droughts) have been recognised in the UK by the UK Climate Projections (UKCP09) (Jones and UK Climate Projections, 2009) but these have been partly addressed in subsequent improvements (Ritson *et al.*, 2014). If climate change leads to flooding in the UK, it impacts on lives and properties. In the UK, records suggest that tens to hundreds of thousands of people were drowned from events in 1099, 1421 and 1446 (Gönnert, 2001). Moreover, literature suggests that ice sheets are melting yet scenario for Scotland is not understood yet. Notwithstanding, minority of participants surveyed believed climate change could have an impact on Scotland's water resources:

> *Climate change could gently affect us warmer and dryer summers may limit the supply*…**P6, AS**
>
> *I agree climate change will lead to poor water quality. Scottish water abstract from rivers so will require even more process cleaning to produce potable water. We would need substantial investment in our infrastructure if climate change is to further affect us*…**P41, AS**

This was also observed in the study where a relatively high proportion (27.4%) perceived climate change has "little" impact on their own water supply as compared "to a great deal" although they perceived the impact to be high on Scotland's water (Figure 5.3) but not on their own source of water. Considering in terms of differences in Scotland's climate, publication from the UK Climate Projections published in 2009 (UKCP09) predicts Scotland to experience increasing average temperatures throughout the year, an increase in average rainfall in winter, a decrease in average rainfall in summer and rising sea levels (UK CCRA, 2012). This can be evidenced in the observational weather data obtained from the Meteorological (Met) office which shows that the climate in Scotland has changed significantly over the last 40 years since 1961 with average temperatures increasing by 0.5°C with most of the areas experiencing a significant rise in precipitation. Looking at the Met data, precipitation increase was more pronounced in the winter months with the East of Scotland experiencing a 36.5% increase and the North and West of Scotland receiving an increase of 67% to 69% between 1961 to 2004 (Barnett *et al*., 2006). A stakeholder likewise expressed that climate change was already happening in Scotland:

> *Water dries up. But on the west coast yes, over here no. Quite often we can get really dry summers. This is an unusual year, but if you look at the rainfall figures for both sides of the country you will see a dramatic difference.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

This same interviewee further expressed that:

> *The difficulty with any of these things is once you get a PWS drying up, there is no guarantee that when the rain comes that will start up again. Because it may find another way, you know you are actually tapping into the water table or into a spring or something of that nature. It may find another way to reach the surface and disappear. it might not even get to your well, so we are, this is the time of the year that we see the most failures on supplies as far as drying up because it will have gone through the summer and now they have probably had 4 or 5 months without too much rain in normal years, this year has been a bit different. But September is when people are absolutely desperate for water.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Adapting to these precipitation changes is a pressing challenge since over the past few years there has been pronounced observation of major flooding and landslides becoming more frequent in some parts of Scotland which has not been compatible for a sustainable development (UK CCRA, 2012).

Aside doubts, there were some surveyed participants that perceived climate change was untrue and or would not affect their water supply:

> *Climate change will not affect our water supply*…**P97, HL**

> *Climate change effects on Scottish water: Scotland seems at smallish of those "...changes in climate pattern have been observed all over the world through rising global temperatures which are causing more extreme weather events, like flooding and heat waves.-IT'S A LIE*…**P68, ED**

> *Questions under climate change is rubbish*…**P36, SB**

It has been suggested that the indifference towards climate change mirrors a widespread perception amongst the public that the issue is generally perceived to be removed in space and time (Lorenzoni *et al*., 2007). This could be attributed to the reason why participants felt climate change will not affect their water to a great deal (Figure 5.3). Not to mention, the literature on public understanding of climate change further implies that there is a widespread awareness and general concern on climate change, however there is a limited behavioural response (Lorenzoni *et al*., 2007); and lack of response can be associated with people being aware but not believing it was true. Aforementioned, a relatively high proportion were aware of climate change (Figure 5.2) confirming with the behavioural response. Moreover, whilst climate change is recognized as being socially relevant, most individuals do not feel it's a personal threat (Lorenzoni and Pidgeon, 2006) and this further corresponds to this research where participants assumed climate change will not have an impact on their own water supply source (8.2%) or did not know (15.3%) (Figure 5.3). Additionally, research in UK shows that a relatively high number of people believed that climate change will have 'little' or 'no effect' on them personally (BBC, 2004, Poortinga *et al*., 2006) also confirming results in this research where a relatively high percentage although below 50% perceived climate change to have little effect on their own water supply thus not being affected themselves. In the BBC survey, only 13% thought climate change would affect them a great deal which was marginally higher than results in this research (8.2%).

Gifford *et al*., (2009) and Lorenzoni & Pidgeon (2006) state that "*climate change is often seen by people as a temporally distant phenomenon primarily affecting other places, times or peoples*. In the UK for instance, a survey in 2009 revealed that 15% of Britons worry about climate change and how the world's respond to them and were the most pessimistic in the world to believe it was happening (The Telegraph, 2009). As observed in this study, some participants perceived climate change to be happening but they did not think Scotland will be permanently affected by any reduction in water supply or quality but maybe in the near future. In fact, residents surveyed believed Scotland has abundant water resources to be affected by climate change:

> *Climate change is happening. I don't think Scotland will be permanently affected by any reduction in water supply or quality though for the foreseeable future, so I have no concerns. If I lived in southern England, I would have more concerns*...**P23, HL**

*Here no, elsewhere, yes…***P61, AS**

They perceived if climate change should happen in Scotland, they will rather gain more as they have witnessed increase in rainfall over the years hence there will be no negative impacts on their water resources. Furthermore, research by the Energy Savings Trust in 2004 found that 85% of UK residents believe the effects of climate change will not be seen for decades (Poortinga *et al*., 2006). But some water stakeholders in Scotland on the other hand perceived on the contrary if climate change should happen in Scotland:

> *But we will probably, if the climate changes as they are predicting, we will probably find that it will become even drier in the summer time*.
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Nonetheless, to a great deal, participants believed climate change had a 6.6% (in Scottish Borders); 6.4% (in Highland); 7.2% (in Edinburgh) and a 14.1% (in Aberdeenshire) chance of affecting their source of own water negatively (Figure 5.3). This is not surprising as in 2006 research by Lorenzoni & Pidgeon (2006) observed that the perceived risk of climate change was seen as a distant threat and of a limited personal importance. Seeing climate change as a distant phenomenon was also evident in this study because comments from participants in all the study areas perceived climate change to be a lie and even if it will happen it will be in one hundred years from now or when they were dead. Others subscribed to the notion that southern England should rather have more concerns for impact on their water resources and a change in climate as seen from above. Recent studies have also noted declines in the public's acceptance of climate science in terms of the climate changing and the perceived absence of government policies that target combating impacts felt by climate change (Spence *et al*., 2010; Leiserowitz *et al*., 2010; Pidgeon, 2012). Therefore, some respondents perceived climate change does not exist as portrayed by the media and even if it was proven beyond doubt nothing will really be done about it.

Participants that perceived climate change was happening were happy because they felt they had benefited from it and expressed due to that they were not worried. They were rather concerned with other environmental issues that they felt should be addressed by the government. It was observed in Figure 5.3 where participants surveyed felt it had an impact on their source of water but through the final comments (Appendix VII), they expressed the effects of climate change in a positive way. A participant made the comment:

> *Our farm has got wetter over the last 40 years; climate change is making our supply more secure*…**P50, AS**

What is more according to Nisbet & Myers (2007), the impacts of climate change could be attributed to lower priority than other social and environmental issues and in relation to this study, it was evident in some respondents being more concerned about pollution and diseases for the future. So not only did they perceive climate change to be a good thing, some residents surveyed felt:

> *Whilst I am worried about climate change globally and locally, the local part (I don't think will have much effect on my water supply - an increase if anything); however, globally there may well be problems with supply, pollution and disease*…**P5, HL**

> *Somewhat (I am more concerned about growth of nearby commercial tree plantation!)* …**P82, HL**

Attesting to the fact that priority to some people was not necessarily on climate change in this study but rather other environmental issues. Confirming to this research on priorities, other researchers have suggested that although people associate climate change with negative feelings and maintain that they are very concerned, it's mostly their least environmental concern, rather they are worried more about health, security and other social issues (Poortinga and Pidgeon, 2003; OST and MORI, 2004; Bord *et al*., 2000; Norton and Leaman, 2004). Comparing health, security and other environmental concerns expressed by participants to climate change, it is observed that these are issues are what participants actually feel the direct impacts of the effects whereas with climate change, participants might not directly feel its impacts directly. In such a way, it is assumed that climate change will become a concern and cause a change in behaviour when people feel the impacts directly. But a stakeholder perceived even if there was evidence it will be difficult for people to change their attitude since it is difficult to distinguish between man-made climate change and natural climate change:

> *You can get weather patterns that last several years. So, I guess that's make it harder to see whether or not there's man made climate. But I also think in general people don't want to change their behaviour*.
>
> **Specialist 2, SEPA**

Thus the interviewee suggested:

> *So, in general it's probably natural to look at natural dangers if you like rather than man-made changes and think well how do we separate them out and I think it's very difficult to separate them out. But I still think that it will be overwhelming to know this is a man-made climate change is happening*.
>
> **Specialist 2, SEPA**

In the case of man-made climate change, research shows that the most reputable climate scientists from around the globe have consistently asserted that man-made climate change is a serious problem that must be addressed immediately (Boykoff and Boykoff, 2007). Thus it is important to point that evidence to people to let them know climate change was real and equally important as IPCC has asserted that there is a discernible human influence on the global climate (Boykoff and Boykoff, 2007). One way to achieve that is drawing attention of people through recent weather events such as deadly heat waves and devastating floods for them to know climate change is real and should be a global concern. This is because research on public perception in different countries has indicated that the real and perceived periods of high temperature strengthen people's climate change beliefs (Taylor *et al.*, 2014).

5.3.3 Climate change and weather on Scottish water resources

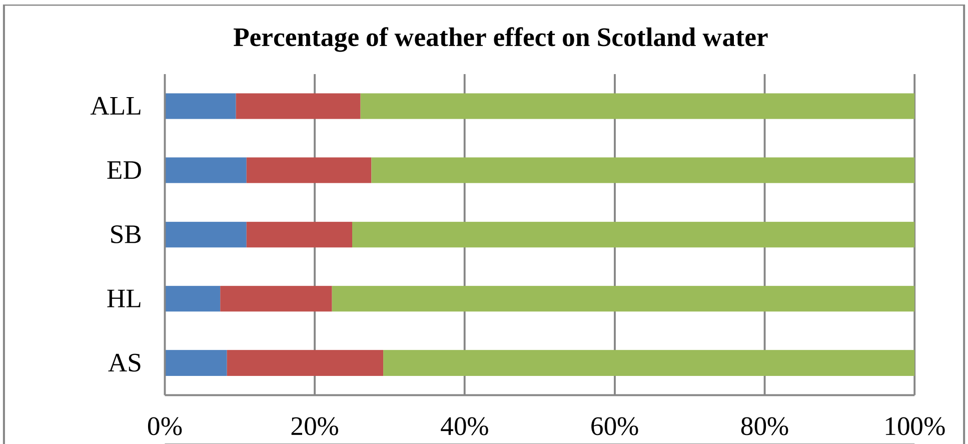
The weather is what we experience day to day and what is forecasted (not deterministic, but certainly there is a good idea of what the weather will be like). The average weather we experience is called climate and it is the probability of predicting how the weather will be in future. Sometimes people confuse weather and climate change; climate is the average weather, and observations and statistics of the changes in weather over time is what identifies climate change. Changes in climate pattern have been observed all over the world through rising global temperatures which are causing more extreme weather events, like flooding and heat waves (McCarthy and Intergovernmental Panel on Climate Change, 2001; Parmesan and Yohe, 2003; Ybert *et al.*, 2003).

As suggested, reality consists of what is available to the senses that is, what can be seen, smelt, touched (Gray, 2013), therefore participants were asked about the impact of the weather on their water resources to also test if they can differentiate between climate change and the weather. It was assumed participants could relate more with weather impacts on their water resources than climate change impacts since change in weather was something participants were more likely to notice. Not only that, it was also to analyse if participants will feel the impacts of the weather on their water resources and make a connection to climate change since it has been suggested that people confuse weather and climate change.

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time (NASA, 2005).

There has been observed evidence in the climate changing in Scotland; the Met Office has shown a mixed pattern of changes in rainfall since 1961 which shows that summer rainfall decreased in parts of the north of Scotland by as much as 20% (Sniffer, 2014). Therefore, participants were asked if they perceived the weather will have an impact on water resources and supply in Scotland and source of their own water supply (which were the same as the climate change questions in Section 5.3). Responses to both questions were rated on a Likert scale: for own source of water supply, it was scaled on a 5 Likert scale (no effect, minor effect, neutral, moderate effect and major effect) whereas water resources in Scotland was rated on 5 Likert scale which was further reduced to 3 (agree, neutral and disagree).

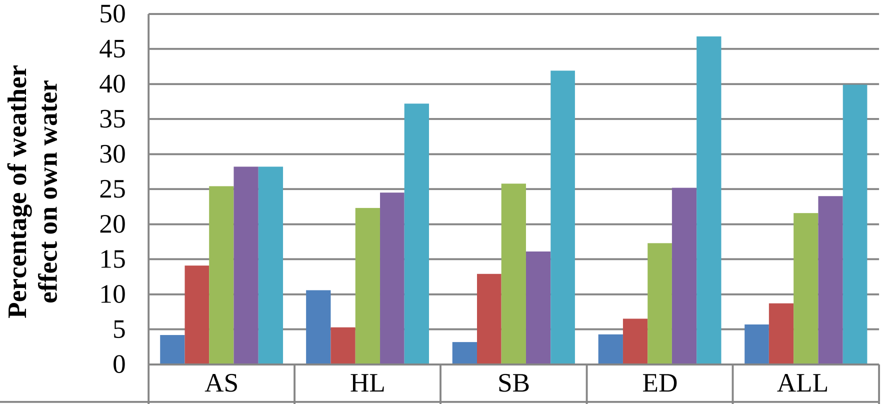
It was observed that participants perceived the weather to have a high impact (Figure 5.4) on Scotland's water resources (73.9%) which was directly proportional to some form of effect on their own water resources (85.5%) (Figure 5.5). For their own water, most felt it will have a "moderate effect", approximately 40% (Figures 5.5) as compared to other effects. In individual areas, a higher proportion agreed the weather will influence Scotland's water and followed the pattern: "agree", "neutral" and "disagree" (Figure 5.4). This was similar to the pattern of the overall analysis. In Highland, it had the most responses in terms of agreement (77.7%), being neutral (20.8%) and less people disagreeing (7.5%) to the impact of weather on Scotland's water resources as compared to other areas (Figure 5.4).



	AS	HL	SB	ED	ALL
Disagree	8.3%	7.4%	10.9%	10.9%	9.5%
Neutral	20.8%	14.9%	14.1%	16.7%	16.6%
Agree	70.8%	77.7%	75.0%	72.5%	73.9%

Figure 5.4: Participants' perceptions on the effect of weather on Scottish water resources (Do you think the effect of the weather can impact on water resources and supply in Scotland?)

For the weather impact on own water resources, most households perceived weather to have some effect as either in the form of moderate (39.9%), major (24%) and minor (21.6%) to their own source of water supply as compared to no effect at all (5.7%) (Figure 5.5). Majority perceived the impact to be moderate as compared to being major. Except for Scottish Borders and Highland, all study areas followed the same pattern as observed in the overall analysis (Figure 5.5): "moderate effect", "major effect", "minor effect", "neutral effect" and "no effect". In Scottish Borders, most people (25.8%) perceived the weather to have a minor effect as to a major effect (16.1%) on their own water resources and in Highland most people (10.6%) perceived the weather to have no effect than neutral effect (5.3%) (Figure 5.5). Aberdeenshire residents' responses for major and minor effects were the same (28.2%) and it had the least responses for an effect. Scottish Borders on the other hand had the least responses for major effect (16.1%) and no effect (3.2%) whilst Edinburgh had the most responses for moderate effect (46.8%) (Figure 5.5).



	AS	HL	SB	ED	ALL
No effect	4.2%	10.6%	3.2%	4.3%	5.7%
Neutral	14.1%	5.3%	12.9%	6.5%	8.7%
Minor effect	25.4%	22.3%	25.8%	17.3%	21.6%
Major effect	28.2%	24.5%	16.1%	25.2%	24.0%
Moderate effect	28.2%	37.2%	41.9%	46.8%	39.9%

Figure 5.5: Participants' perceptions on the effect of weather on their own source of water supply (Do you think the effect of the weather can affect your own source of water supply?)

Research on public perception in different countries has indicated that the real and perceived periods of high temperature strengthen people's climate change beliefs (Taylor *et al*., 2014). But in our studies, this was contradicting to our results. It was observed that participants perceived the weather to have an impact on their own source of water supply (Figure 5.5) but they did not think climate change will have an impact on their own source of water supply (Figure 5.3) through comments. Or they did not link extreme changes in weather to climate change. Although it has been suggested that an increase in temperature may contribute to an important role in people's beliefs about climate change (Krosnick *et al*., 2006; Ratter *et al*., 2012; Weber and Stern, 2011); it was the opposite in this research. Majority of participants perceived climate change not to have an impact and even if it will have an impact, they will be positive. However, they could relate more to weather impacts on their water resources than climate change impact.

> *The water supply has been in place since 1973 and the only weather-related interruption to supply has been during periods of sustained hard frost, when the supply pipe freezes…***P98, HL**

> *Do you think the effect of the weather can affect your own source of private water supply? Answer: Minor effect for borehole and major effect for stream…***P53, HL**

These were echoed by some residents surveyed whom have had a weather experience on their supply. Some participants on PWS also expressed they were looking for alternative:

*…we hope to rebuild parts of it when we can afford, making it as eco as possible. Our source of water supply was a spring, but has just dried up so we have to find an alternative source…***P83, HL**

These were comments from PWS users even though a relatively high proportion from Edinburgh (89.3%) expressed weather will have some effect on their own source of water supply (Figure 5.5). Moreover, a stakeholder confirmed that PWS normally dries and or freezes up:

I mean we regulate here about supplies that dry up especially with less case of freezing in the winter. It tends to be most of the drying up in the summer.

Operations Team Leader, DWQR

To some extent, since PWS users are responsible for maintaining their water, they rather pay more attention to what happens to their source as compared to those on the MWS. Along these lines, this can be attributed to why they could relate more to the weather impacts and commented more as compared to those on the mains.

Due to contradicting comments between climate change and weather impacts, and the assumption that an extreme change in weather is assumed to cause a change in climate; a spearman's rank -order correlation analysis was performed to test if "weather" and "climate change" were associated in this study. This was because, in the US, it was proposed by the Environmental Protection Agency that although establishing the most likely causes behind an extreme weather event can be challenging due to combinations of multiple factors, including natural variability, scientists have been able to draw a connection between some types of extreme climate patterns and climate change (USA Climate Change Science program, 2008).

A Spearman's rank-order correlation was run to assess the relationship climate change impact on own water supply and weather impacts on own water supply. Since there was no hypothesis, the statistical significance was ignored. Overall, there was a weak positive correlation between climate change impact and weather impact, r_s (363) = .253 (Table 5.4). In individual study areas, the correlation results were the same; there was a weak correlation between climate change impacts on own water supply and weather impacts on own source of water supply: AS (r_s (71) = .386), HL (r_s (93) = .202), SB (r_s (71) = .386) and ED (r_s (71) = .386) (Table 5.4). However, in Scottish Borders, the association was very weak. Comparing all the areas, it cannot be concluded if change in weather causes climate change from this study since correlation does not imply causation and furthermore the association was weak. Therefore, it could be other factors like participants seeing a change in weather patterns through freezing and or their source of water drying up; so, they could relate more with weather effects on their source of water supply more than climate change.

Table 5.2: Spearman's rank-order correlation between climate change and weather effects to test if there was an association between the two

ALL Correlations		
	Climate change could impact on your source	Weather: Can affect your water resources

Spearman's rho	Climate change could impact on your PWS source	Correlation Coefficient	1.000	.253**
		Sig. (2-tailed)	.	.000
		N	365	363
	Weather: Can affect your water resources	Correlation Coefficient	.253**	1.000
		Sig. (2-tailed)	.000	.
		N	363	366

**. Correlation is significant at the 0.01 level (2-tailed).

AS Correlations

			Climate change could impact on your source	Weather: Can affect your water resources
Spearman's rho	Climate change could impact on your PWS source	Correlation Coefficient	1.000	.386**
		Sig. (2-tailed)	.	.001
		N	71	71
	Weather: Can affect your water resources	Correlation Coefficient	.386**	1.000
		Sig. (2-tailed)	.001	.
		N	71	71

HL Correlations

			Climate change would impact on your source	Weather: Can affect your water resources
Spearman's rho	Climate change would impact on your PWS source	Correlation Coefficient	1.000	.202
		Sig. (2-tailed)	.	.052
		N	94	93
	Weather: Can affect your water resources	Correlation Coefficient	.202	1.000
		Sig. (2-tailed)	.052	.
		N	93	94

**. Correlation is significant at the 0.01 level (2-tailed).

SB Correlations

			Climate change could impact on your source	Weather: Can affect your water resources
Spearman's rho	Climate change could impact on your PWS source	Correlation Coefficient	1.000	.115
		Sig. (2-tailed)	.	.382
		N	61	60
	Weather: Can affect your water resources	Correlation Coefficient	.115	1.000
		Sig. (2-tailed)	.382	.
		N	60	62

ED Correlations

			Climate change could impact on your source	Weather: Can affect your water resources
Spearman's rho	Climate change could impact on your source of water resources	Correlation Coefficient	1.000	.290**
		Sig. (2-tailed)	.	.001
		N	139	139
	Weather: Can affect your water resources	Correlation Coefficient	.290**	1.000
		Sig. (2-tailed)	.001	.
		N	139	139

**. Correlation is significant at the 0.01 level (2-tailed).

5.3.4 Water priorities in Scotland

Water supply in Scotland is perceived not to be under threat, but climate change could mean there will be a problem in the future if action was not taken now (Waterwise, 2007). So, stakeholders were asked on what they perceived to be the pertaining issues currently related to water resources in Scotland. There were diverse views from stakeholders on water priorities in Scotland. Except for Scottish Waters none had climate change impacts, adaptations and mitigation on Scotland water resources in their plans. Although it has been supposed by some researchers that climate change impacts will be most immediately felt through direct impacts on water resources with extreme events such as floods, droughts and a decline in the quality of water in the years to come (Rockström *et al.*, 2009; Millennium Ecosystem Assessment (Program), 2005; Bates *et al.*, 2008; DEFRA 2008); from the stakeholders' interviews the likely priorities associated with water resources were to do with:

1. Managing leakages:

> *I think that purely in terms of resources, I think the priority is around managing what we have got better. So, that brings in the likes of leakage control, getting the right supply demand balance, so Scottish water is doing quite a bit of work looking at the resilience of the system and to make sure that you know, they do not run out of water. But also, if they were to get catastrophic events, you know if a reservoir was to fail or a major treatment was to fail or something like that, then are the resilience from our supply-demand point of view and again there is potentially quite a lot of investment associated with that.*
>
> **Director, WICS**

> *So, pressure reduction in terms of saving Scottish water costs, it does on the leakage side. Because leakage reduction, I don't know if you have followed it or not, they've had quite dramatic reductions with leakage over the last 10 years. Partly because they just started, you know, they focused on more and it's come down about 40%, so it's quite dramatic.*
>
> **Director, WICS**

2. Ensuring constant supply without interruptions:

> *So, from point of view of resources, they are quite resource rich, because Scotland are perennial place but it is making sure that the supply to people's houses, the network that gets you from the rainfall into the house is resilient. And also, as I say leakages as well as about managing supply-demand balance.*
>
> **Director, WICS**

3. Being energy neutral and reducing emissions as climate change mitigation:

> *Well I guess one another thing that we are trying to do is we are looking at how efficiency is across the supply and treatment of water to reduce the energy demand. So, that's really our responsibility. We are looking at can we use our assets to generate more electricity? Can some of our treatment works sort of effectively be energy neutral, they produce the energy, they need themselves to clean the water, you know so, it's those kind of responses, that is our climate change response and a lot of that is driven through work the Scottish water do. So, it is around technology and for example, we deal with more of energy generation across Scottish waters' assets and there is a path we took to increase the percentage of renewable electricity that Scottish water use, so all of that reduces emissions and also reduces cost for customers.*
>
> **Manager, Hydronation**

4. Extending the mains:

> *I think the priority is improving the water mains and extending it.*
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

5. Environmental effect:

> *Well our priorities are to do with certainly the environment. So, we would look at whether or not an abstraction is or a proposed abstraction, or proposed abstraction mediation, we would look at the effect that that has on the water environment and whether or not it complies with the water framework directive. So, the potential effects it might have on the ecology of the river or fish passage.*
>
> **Specialist 2, SEPA**

> *Then we would have to look at the effect of what they are proposing will have on the environment. But in the end, for those kind of applications, human health will override the environment, so you might have fishes using the river but if it is a choice between that and a serious issue with public water supply, public water supply will take precedence.*
>
> **Specialist 2, SEPA**

6. Water efficiency measures:

> *The legal priorities are any new building need to have geo flushing toilets and I think it is very slow response in Scotland.*
>
> **Water Policy Analyst, CABS**

These six were the main water priorities in Scotland as expressed by water stakeholders through the interviews. It should be noted that there was no mention of climate change and its impact on Scotland's waters or what was being done to ensure water resources in Scotland are not affected. On the other hand, an independent advice network interviewed believes that even though climate change is not a priority in Scotland RWH should be considered as part of water efficiency measures in Scotland and recommended engaging the public:

> *I think more really need to be done to address water use in Scotland and it is not just about water efficiency, it is about things like RWH, using greywater, what can we do with it? You know get people using their imaginations, get kids' school projects going, get thinking about it because a lot of it is changing behaviour, changing habits, and it's the same as what the energy efficiency. We have been hearing about energy efficiency now for a good 10 years, we don't hear about water efficiency on the television. So, yea I think more definitely needs to be done. If we want to support the hydro nation, we need to be thinking about one of our most precious water resources that we have so much of in Scotland.*
>
> **Water Policy Analyst, CABS**

This confirms research by (Hartley, 2006) that suggests that promoting communication and public dialogue is critical to building and maintaining public confidence in water resource management and water reuse decision-making.

5.4 CLIMATE CHANGE AND RWH

Climate change has been reported to likely increase the variability of precipitation and the number of flood and drought episodes (IPCC, 2007). Though Scotland is known to have abundant water resources, by 2050, reduced summer flows are projected across most of Scotland's rivers because of higher temperatures and lower rainfall (SEPA, 2015). According to SEPA (2015), although there are uncertainties with the climate change modelling scenarios, they have been able to predict possible future scenarios. Such of these scenarios include twice an increase in the frequency of extreme summer low flow events by 2050 and increases in summer temperatures, resulting in an increased demand for water resources, not just for domestic consumption but also for crop irrigation (SEPA, 2015). Their prediction is detailed below in Figure 5.6. Thus, according to Waterwise, while it is raining regularly, it is the right time for people to start collecting rainwater to use during the drier months (Waterwise, 2007).

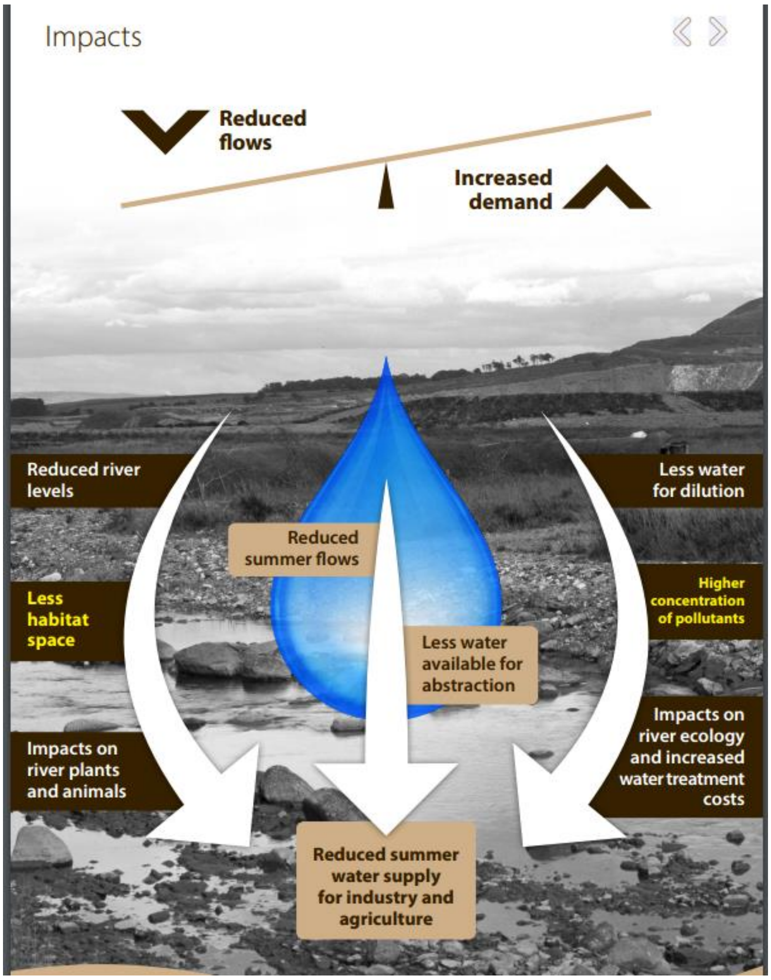


Figure 5.6: Predicted climate change scenarios on Scottish water resources (Source: SEPA)

These predictions emphasize the need to adapt water management to new and challenging environmental and socio-economic conditions (Domènech and Saurí, 2011). RWH may play a central role in widening water security and reducing impacts on the environment (El-Sayed Mohamed Mahgoub *et al*., 2010) by turning hazards like floods and polluted water into local resources (water for non-potable uses). Therefore, stakeholders were asked on their view on RWH as a possibility of one of the climate mitigation solutions in Scotland. 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), therefore, there is the need to conserve water through harvesting rainwater for non-potable uses like flushing the toilet, gardening and car washing.

According to (Pandey *et al*., 2003), literature reviewed on RWH as a climate change mitigation shows evidence that RWH has been used as a response to aridity and drought conditions in some parts of South America, North America and the Arabian Peninsula. So, to an extent it is perceived that RWH is synonymous to only dry climates.

> *In terms of climate change the main popular forecasting at the moment is we are going to have longer wetter winters and longer drier summers so we need to conserve water during the summer time. Not that you will get this year, because it has been horrible but you know, as a rule that's what we need to consider.*
>
> **Water Policy Analyst, CABS**

A stakeholder echoes this. The interviewee was focusing RWH for the drier period and not the wetter period where it can reduce flooding. What has been predicted for Scotland seems to be on two extremes and it is difficult to predict where RWH can fit into it. If RWH is used as part of a climate change mitigation solution, the question is, will it be used to reduce flooding or as a backup for PWS users should in case their water dries up or both? Further will the supply be on communal or individual basis, what will be the size of the tank and who is responsible for maintenance? All these are valid questions that need to be taken into consideration in using RWH as possible climate change mitigation during drier summers. A stakeholder further expressed these questions:

> *I don't think that will apply locally here, because most of the PWS are surface waters: either lochs or streams. We have got very few boreholes, so the result of that if we are heading for wetter winters and drier summers as a result of climate change, then I can't see where RWH would likely survive as a backup. Because when the supplies are likely to go dry will be in the summer months and if there is less rain falling, then there might not be enough for the rain to provide a backup to the local lochs or streams.*
>
> **Environmental Health Officer, Hebrides**

The stakeholder on the other hand expressed some concerns, it was perceived from the concerns that climate change may not seem to have a major impact on Scotland’s water resources thus RWH was not necessarily needed as a climate change mitigation solution. But to some extent it can reduce the impact of flooding. Flooding does not just impact on individuals, they are also known globally for their devastating impacts, particularly in regions exposed to large storm surges which are densely populated and low-lying (Gönnert, 2001). But most stakeholders’ comments make it seem RWH is only important and or necessary for dry areas where there seems to be water shortages without having regards for the role RWH can have to reduce flooding. Some perceive flooding to be the major effect climate change can have on water resources in Scotland which to some extent might even be minor:

> *I think if we thought there was a good sufficient pressure on water resources as a result of climate change we would be reacting but as you know the scenarios for Scotland are if anything more water, more rain, warmer wetter summers, okay drier winter periods, but not to the extent of we anticipate that there'll be water shortages as a result. So, we don't see there being an acute problem that needs to be addressed as a result of climate change pressures on water supply. In fact, we are accepting climate change obviously; we are not anticipating significant impact on water supply in Scotland.*
>
> **Manager, Hydronation**

> *To be honest, more to the issue is more around localized flooding, you know, it's at an intense rainfall seems to be coming more often.*
>
> **Director, WICS**

…as alternate to having drier summers. Furthermore, even if RWH was perceived to be as one of the many climate change mitigation solution, uptake by households will be challenging. As will be observed from Chapters 6 and 7, a minority of people were willing to implement RWH themselves without any financial incentive. Consequently, to promote RWH in households, there need to be some form of financial incentives. This was confirmed in Chapter 6 were majority of households were willing to implement RWH if paid by the local authority or given some form of grants either as annual, monthly or a one-time off. A stakeholder further expressed that alongside giving grants, education and promotion by local authorities are a key in adopting RWH as one of the climate change mitigation solution since it is difficult to change behaviour and perceptions:

> *I think it will definitely encourage people to think about using it (climate change) and I think if it was promoted locally it will get people thinking about it and I think without promotion it is difficult to change people's behaviour and perceptions so yes it will definitely help.*
>
> **Water Policy Analyst, CABS**

This was because although people were aware of climate change, it was not an enough incentive for them to adopt RWH systems since many uncertainties with regard to the magnitude of climate change exists (Mwenge Kahinda *et al*., 2010).

> *For some individuals who are concerned and are knowledgeable, I think undoubtedly climate change issues more play a part in their decision-making processes. But I wouldn't expect it to normally be the driving factor.*
>
> **Manager, Hydronation**

People are more likely to do something once or if their water appears to be unreliable and normally they react when they feel the immediate effect. From Section 5.3, it was observed that participants relate climate to a distant phenomenon although they were aware of it and according to a stakeholder:

> *If incidence is supposed to be carrying on unreliably then in fact that 20 or 30 years in advance if something might happen, people don't generally think that far ahead.*
>
> **Specialist 2, SEPA**

And the fact that there exist some uncertainties on climate change impacts also exacerbates adoption of RWH as one of the climate change mitigation solution as explored in this research:

> *…where you can't say exactly what is being caused by climate change, exactly what is being caused by some natural pattern, I don't mean that climate change is not happening, I think it is happening obviously, but I just think that you can't look at a particular drought and say this one is due to climate change or this one isn't. So, I suppose what I am saying is people with PWS I don't know, I am not sure of the reason for it becoming unreliable. It will matter unless it was to do with the river being diverted or something.*
>
> **Specialist 2, SEPA**

This was echoed by the previous interviewee as part of uncertainty when using RWH as an adaptation and mitigation solution. Therefore, if there is no evidence, it will be difficult changing behaviour and accepting RWH even if local authorities endorses RWH to be a climate change mitigation solution. As observed in Section 5.3.3, weather patterns were perceived to have an impact on water resources more than climate change because participants had felt the direct impact weather has on water resources for instance water drying up in summer or freezing in winter. Along these lines, climate change will not affect their behaviour so much, it's just the fact that they think the weather is making their water supply unreliable and not necessarily as a result of climate change. This was confirmed by a stakeholder:

> *It will be an indirect factor if they felt there was a cost implication which was as a result of climate change. They wouldn't necessarily make the connection, all they will see is my bills have gone up, my water is costing more, and will it better for me to reduce the cost by harvesting RWH? So, I think people will think what their wallets to more of a degree than they will think about climate change, behavioural terms.*
>
> **Manager, Hydronation**

Therefore, direct evidence and or a personal state of connection is necessary for public acceptance. The impacts of climate change should be felt and associated directly by households before they see it is happening. Nonetheless majority of stakeholders perceive RWH to be a challenge and it is not necessarily good as a climate change mitigation solution since the impact in Scotland might be minor and Scotland has abundant water resources.

5.5 CLIMATE CHANGE, ENERGY, AND WATER QUALITY

Participants were asked if they perceived climate change will lead to a reduction in water quality and supply through flooding, drought, and water pollution. This was because from literature, it was discovered climate change was synonymous to droughts; when you talk about climate change and water resources, the first thing that comes to people's mind is less water, water scarcity and or droughts. The question was rated on a 5 Likert scale which was further reduced to 3: "disagree", "neutral" and "agree" (Appendix IV-V). Furthermore, exploring on participants' perception on climate and water quality, they were further asked if they perceived climate change to lead to poor water quality and if reduction in good quality water through climate change will increase the amount of energy needed to treat water for consumption. Perceptions on climate change and poor water quality were scaled on a 5 point Likert scale which was reduced to 3: "disagree", "neutral" and "agree" (Appendix IV-V) and energy were scaled on a 5 point Likert scale which was reduced to 3: "improbable", "neutral" and "probable".

Majority of participants perceived climate change will reduce water supply and quality through flooding, droughts, and water pollution (Table 5.5). Overall approximately 64% (flood) and 70% (drought and water pollution) agrees the impact of these as a result of climate change will have an effect on water quality and reduce water supply (Table 5.5). They all followed the same pattern: "agree", "neutral" and "disagree" being the least except in Edinburgh where people disagreed (20.8%) more than were neutral (15.2%). Although there were variations between different study areas, a higher proportion in all the areas agrees climate change impacts like flooding, drought and water pollution will reduce water quality and water supply (Table 5.5).

For flooding, responses from households were all more than 60% except Highland (58.8%) and Scottish Borders (57.4%), but they were more than 50% (Table 5.5). Edinburgh showed the least disagreement (10.1%) of flooding reducing water supply and quality and Scottish Borders has the highest number of responses that were neutral (28.9%) with flooding impacts (Table 5.5).

With regards to droughts, Edinburgh seems to have less agreement responses (64%) as compared to other areas however it was more than half. Aberdeenshire showed the highest neutral response (21.7%) and were the least to disagree (2.9%) that droughts will impact on water resources because of climate change (Table 5.5).

Apart from Edinburgh in terms of water pollution because of climate change which was the highest (73%), the rest were relatively the same at 67% (Table 5.5). Responses from Edinburgh showed the least of being neutral (17.5%) in terms of effect and Aberdeenshire showed the least disagreement (6%) as compared to other areas (Table 5.5).

Comparing flooding, droughts, and water pollution, it is observed that participants to a higher extent perceived that drought (69.9%) and water pollution (69.7%) to affect water quality and supply as compared to flooding (63.8%) (Table 5.5). But, in individual study areas, the results were different, drought and water pollution were different from the overall where they were relatively similar in value. Majority considered drought to have more severe impacts than water pollution (Table 5.5). Also, most participants on PWS (Aberdeenshire =75.4%, Scottish Borders =74.5%, Highland =70.9%) agreed that drought will cause a change in water supply and quality as compared to those on the MWS (64%). For Edinburgh, majority perceived water pollution to have an overall major impact and for water pollution it was the other way around. Majority on MWS (73%) perceived the impact to be severe as compared to those on PWS which was approximately 67% (Table 5.5). The impacts that are reduction in water quality and water supply caused by flooding were the least but it was above 50% thus it can be considered relatively high.

Table 5.3: Participants' response to climate change reducing water supply and its quality through flooding, droughts and water pollution (Do you think climate change would reduce water supply and quality for human consumption through the following? Please which one do you tend to agree to or disagree to?)

	AS	HL	SB	ED	ALL
Flood					
Disagree	15.2%	18.8%	16.7%	10.1%	14.3%
Neutral	19.7%	22.5%	28.9%	20.9%	21.9%
Agree	65.2%	58.8%	57.4%	69.0%	63.8%
Drought					
Disagree	2.9%	10.5%	7.3%	20.8%	12.2%
Neutral	21.7%	18.6%	18.2%	15.2%	17.9%
Agree	75.4%	70.9%	74.5%	64.0%	69.9%
Water pollution					
Disagree	6.0%	9.5%	8.9%	9.5%	8.7%
Neutral	26.9%	22.6%	23.2%	17.5%	21.6%
Agree	67.2%	67.9%	67.9%	73.0%	69.7%

SEPA predicts that with climate change, Scottish water resources will experience frequent extreme low flows and this in turn will affect water supply, water quality and the ecological health of Scottish rivers (SEPA, 2015). The low flow events in Scotland is important because although people assume Scotland has abundant water resources, when there is low flow event because of climate change, water available from Scottish rivers and lochs will be reduced and these waters are vital for a range of industries and public water supply and also supports a healthy aquatic ecosystem. Although a minority (8.2%) (Figure 5.3) perceived climate change not to have an impact on their own source of water, a majority however perceived climate to reduce water supply and quality through flooding, droughts, and water pollution (Table 5.5). This agrees to SEPA's climate change prediction of climate change impact on Scotland water resources. However, it was contradictory for participants not to perceive climate change to have an impact on their water supply but rather perceive it to have an impact through flooding, drought, water pollution to cause reduction in water supply and quality. The only reason for such results can be attributed to lack of knowledge on the part of households or not understanding the question on climate change.

When participants were specifically asked if climate change will lead to poor water quality, a relatively high proportion were unsure (45.6%) (Figure 5.7) as compared to those that agreed (42.8%). This further confirms the initial assumption that the difference in responses could be attributed to lack of knowledge on climate change and its impact. Because comparing the effect of drought, water pollution and flooding to the reduction in water quality, responses were extremely higher approximately 70% (Table 5.5) as compared to just saying climate change will cause a reduction in water quality which was 42.8% (Figure 5.7) even though in Edinburgh a half agreed (50.7%) it was not close to 70%. As was observed from the weather impact on water resources, people will want a personal state of connection to the impact before they can acknowledge any effect. Participants are often able to relate more to flooding, droughts and water pollution:

> *I strongly agree that the effect of weather can impact on water resources and supply in Scotland. Yes, if drought, and yes if flooding causes contamination*...**P41, AS**

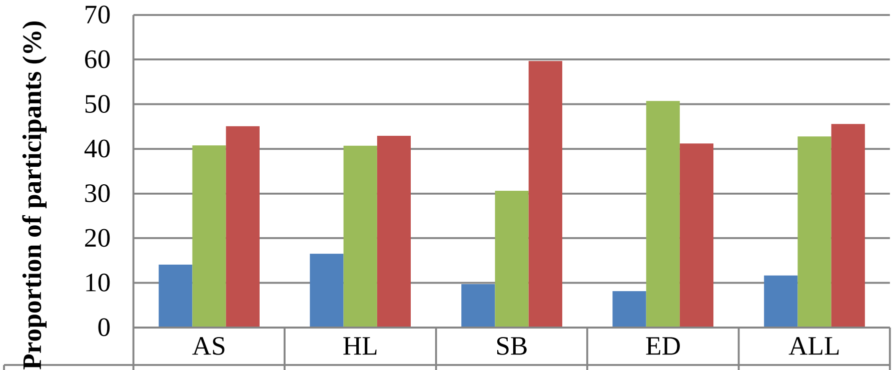
As was observed, the wording is important if discussing the impact of climate change whether negative or bad. Residents surveyed could associate more to flooding, drought and water pollution because they directly feel and see it affect them and or affect their water quality and further reduce their water supply. However, when only climate change is used they cannot perceive it to have a major impact on their water quality and supply:

> *I'm neutral with regards to climate change leading to poor water quality; it depends on how we manage it*…**P22, HL**

This is because they might see it as a distant phenomenon, something that might happen somewhere:

> *Reduction in good quality water through climate change will increase energy needed to treat water for consumption for the fussy city people*…**P35, SB**

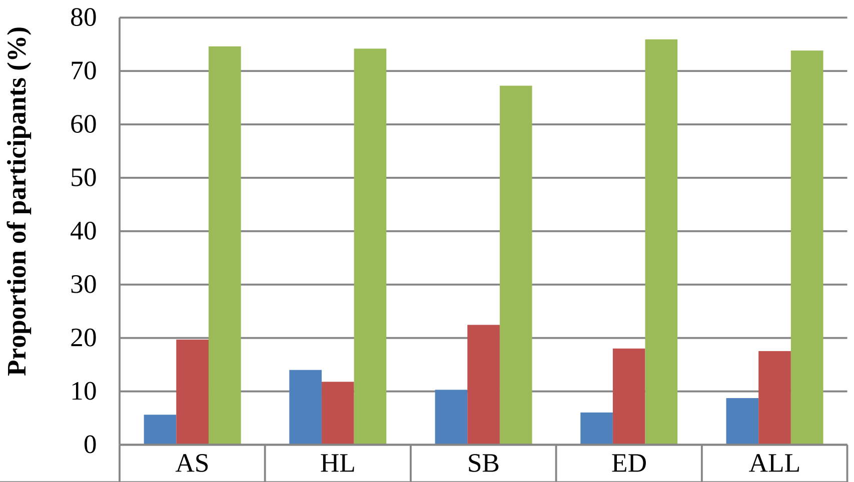
or lack the understanding of it as discussed in previous chapters.



	AS	HL	SB	ED	ALL
Disagree	14.1%	16.5%	9.7%	8.1%	11.7%
Agree	40.8%	40.7%	30.6%	50.7%	42.8%
Neutral	45.1%	42.9%	59.7%	41.2%	45.6%

Figure 5.7: Participants' perceptions on whether climate change will lead to poor water quality (Do you think that climate change will lead to poor water quality?)

When participants were asked if they perceived "*reduction in good quality water will require more energy to treat water for consumption as a result of climate change*", their responses were overwhelmingly in agreement as opposed to reduction in water quality. Overall approximately 74% (Figure 5.8) perceived that reduction in good quality water as a result of climate change will lead to an increase in energy to treat water. In individual study areas, responses for probable were extremely high: (Edinburgh =75.9%, Aberdeenshire =74.6% and Highland =74.2%) than Scottish Borders (67.2%) which was also high (Figure 5.8).



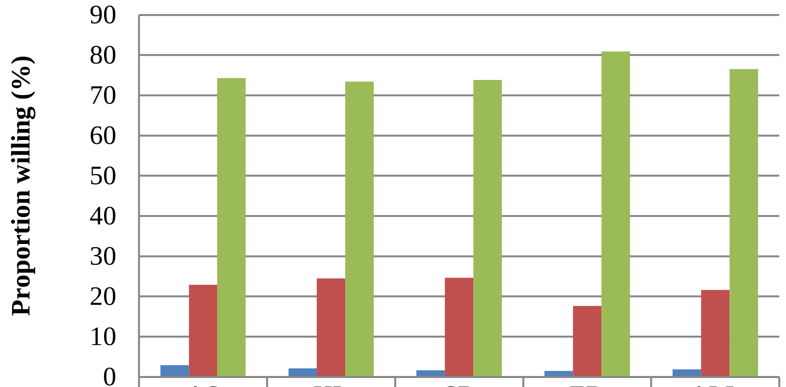
	AS	HL	SB	ED	ALL
Improbable	5.6%	14.0%	10.3%	6.0%	8.7%
Neutral	19.7%	11.8%	22.4%	18.0%	17.5%
Probable	74.6%	74.2%	67.2%	75.9%	73.8%

Figure 5.8: Participants' responses to more energy needed to treat water to good quality as a result of climate change (Will reduction in good quality water through climate increase energy needed to treat water for consumption?)

Comparing energy and water quality results, it should be noted that in both questions the wording was different (Appendix IV-V; no.26 and 27). The question 26 for climate change and water quality used "climate change" to start whereas question 27 for energy and climate change used "reduction in good quality water" to start. This confirms earlier results where when flooding, drought and water pollution were used participants perceived climate change to have an impact. As observed, most participants' perceived reduction in water quality will increase energy to treat water for consumption (74%; Figure 5.8) than climate change reducing the quality of water (43%; Figure 5.7). The assumption is that risk perceptions and actions correlate (O'Connor *et al*., 1999), thus people will want to see an impact they can relate to before they are willing to take an action. And as observed from this study, people can relate more with weather changes, flooding, drought, water pollution, reduction in water quality and energy as compared to climate change. Furthermore it has been noted that the public anxiety over global warming tends to wax and wane with weather fluctuations (Bord *et al*., 2000) and this is in agreement with this study where impacts of the weather elicited more response than climate change.

5.6 WILLINGNESS TO REDUCE THE IMPACT OF CLIMATE CHANGE

Despite there were varied perceptions as to whether climate change was real or not and most participants related it to government and private companies' agenda to create complex policies, majority of them (76.5%) were willing to reduce the impact of climate change if it will directly affect their source of water (Figure 5.9). A relatively high proportion was neutral (21.6%) as compared to will not consider (1.9%) (Figure 5.9). In all the study areas, Edinburgh (1.5%) and Scottish Borders (1.6%) showed the least willingness "not to consider" but it was relatively not far off from Aberdeenshire (2.9%) and Highland (2.1%) (Figure 5.9).



	AS	HL	SB	ED	ALL
Would not consider	2.9%	2.1%	1.6%	1.5%	1.9%
Neutral	22.9%	24.5%	24.6%	17.6%	21.6%
Definitely consider	74.3%	73.4%	73.8%	80.9%	76.5%

Figure 5.9: Participants' to reduce the impact of climate change if it will affect their source of water supply (If you knew climate change would affect your source of water supply, would you be willing to do something to reduce the impact?)

Though existing work indicates a distinct difference between individual intentions to engage in mitigation and actual action (Pidgeon *et al*., 2008), participants in all the study areas showed a relatively low minimal hesitancy (1.9%) in helping to reduce the impact climate change may arise in terms of low water quality, flooding and droughts. According to (Sharples, 2010), there remains a surprising low level of public engagement in tackling climate change although the public are not totally ignorant of the climate change issues but rather falls short in understanding the key aspects (Lorenzoni *et al*., 2007). But this was the opposite in this study, although majority of residents surveyed were aware of climate change and did not believe it was happening through their comments, they were willing to reduce the impact of climate change.

> *Even if I didn't know climate change would affect my source of private water supply, I would to do something to reduce the impact…* **P11, SB**

This was expressed by a participant who was willing to reduce impact of climate change to ensure constant supply of water. The key aspect in this study as observed was using words like reduction in "water quality", "flooding" and possible effects of "drought" in Scotland perceived to have abundant rainfall was an enough incentive to make them willing to reduce the impact and be water neutral. Also in all three areas, the questionnaires somehow created awareness of climate change (which was not intended to). Hence, it was analysed to see if responses will differ across gender and age. A surveyed participant was also quoted saying:

Occupant's age (75) that is why I would not consider to do something to reduce the impact of climate change on the source of my private water supply if I knew it will be affected…**P43, SB**

And moreover, a current research study has suggested that women ranchers and farmers shows greater concern and more scientifically accurate knowledge about climate change than men *(Smith et al*., 2014). Thus, it is assumed women will be more willing to reduce the impact of climate change compared to men. Thus, the null and alternate hypotheses were defined as:

H_0: *There is no association between gender willingness to reduce the impact of climate change*

H_1: *Females are more likely to do something to reduce the impact of climate change than men*

A chi-square test for association was conducted between gender and the willingness to reduce the impact of climate change (Appendix VIII). Majority of the expected cell frequencies were less than five thus the assumption was violated so the "likelihood ratio" results were used. Overall, there was no statistically significant association between gender and willingness to reduce the impact of climate change if it will affect their source of water supply, χ^2 (1) = 4.246, p = .120, hence the null hypothesis was accepted (Appendix VII). This was represented in all the study areas: AS (χ^2 (1) = 3.319, p = .190); SB (χ^2 (1) = 1.865, p = .394); HL (χ^2 (1) = 4.817, p = .090); ED (χ^2 (1) = 4.115, p = .128) (Appendix VII). Therefore, it can be stated that willingness to reduce the impact of climate change if one knew it will impact on their source of water supply was not related to someone's gender in this study.

The test was further repeated for age:

H_0: *There is no association between age willingness to reduce the impact of climate change*

H_1: *Young people are more likely to do something to reduce the impact of climate change than older people*

A chi-square test for association was conducted between age and the willingness to reduce the impact of climate change (Appendix IX). Majority of the expected cell frequencies were less than five thus the assumption was violated so the "likelihood ratio" results were used. Overall, there was a statistically significant association between age and willingness to reduce the impact of climate change if it will affect their source of water supply, χ^2 (1) = 11.347, p = .003. But the association was very weak (φ = 0.155, p = .013) between age and willingness to reduce the impact of climate change (Appendix IX) thus the association is not acceptable. However, in individual study areas, the null hypothesis was accepted because there was no statistically significant association between age and willingness to reduce the impact of climate change if it will affect their source of water supply: AS (χ^2 (1) = 3.268, p = .195); SB (χ^2 (1) = .877, p = .645); HL (χ^2 (1) = 2.088, p = .352) and ED (χ^2 (1) = 5.517, p = .063) (Appendix IX). Therefore, it can be stated that willingness to reduce the impact of climate change if one knew it will impact on their source of water supply in each individual study area was not related to someone's age in this study.

5.7 BRIDGING THE GAP BETWEEN CLIMATE CHANGE AND WATER RESOURCES IN SCOTLAND

Stakeholders engagement in empowering decision-making for adaptation through the UK Climate Impacts Programme has been generally regarded as vital to ensure that research meets the needs of decision-makers for information (Hedger *et al*., 2006). Even though there is increasing scientific deposition that human-induced climate change poses a major risk to human and natural systems, there seems to be a decline in the action to reduce this risk (Griggs and Kestin, 2011) therefore stakeholders were asked on their opinion on how the gap between climate change impact on water resources and public awareness can be bridged to effect a change in policy. There were diverse views from the stakeholders on what they felt should be done. Stakeholders suggested education, summarizing the risks and or having some form of evidence before there can be an effective policy change to adapt to climate change in Scotland.

The first suggestion was education:

> *Education, education, education, education, education, seriously, it is the only way this is going to do and we need to inevitably to get people not thinking, but feeling enthusiastically about it and understanding as well that when you waste water that comes out of your tap that comes out at a cost. Water is not free in Scotland. It is expensive to produce clean, safe drinking water. So, the less we waste of them, the less money the industry has to spend in producing it and what the positive impact it will have on our bill. Then again that's another incentive is getting people to think about that because I think at the moment they don't.*
>
> **Water Policy Analyst, CABS**

Public acceptance of climate change all over the world, including the UK has not been consistent despite the astounding evidence for human-induce climate change (BBC, 2010; Newport, 2010; Griggs and Kestin, 2011). According to the BBC report, there has been a decline in perception of UK citizens in terms of climate change happening thus education as suggested by the stakeholder is very important and key in letting people understand what climate change actually means and the perceived effects it will have on their water resources.

There are a lot of misunderstandings of what climate change is and misuse of key terminology and as observed from Sections 5.2-5.3, there lacks understanding in what climate change is or it’s impacts whether positive or negative.

> *I think we need to understand, and the public would need to understand what the implications of climate change are, before they realize and relate it to their water resources. And that is a dialogue. That has not been articulated, you know we have not articulated that for the public, so I wonder who is "is". You know, who is telling the public that as a result of climate change we think that rainfall will be impacted and in this way and if you are on a PWS this might be the following. I have not seen. I doubt if there will be research around this area, but I have not seen it. And if I have not seen it, you can bet that the Scottish public has even less chance to see it. So, I think it is probably about awareness raising. It is understanding the nature of the issue, it's there real problem here, you know? As I suggested earlier on that our climate change scenarios don't suggest that our water resources are going to be significantly affected by climate change. However, other people's water resources might be and that may have an implication on the attractiveness of or not of the water that we have.*
>
> **Manager, Hydronation**

As suggested by the stakeholder, it is understanding of the concept, and this can be achieved by engaging the public. The public needs to be engaged in understanding the impact it might have on their water resources to result in an effective policy change.

Furthermore, it has been suggested that for an effective policy response in terms of both mitigation and adaptation to climate change impacts, especially on the anticipatory interventions intended to enhance resilience of social and natural systems; they are difficult to formulate and most at times they are based on educated guesses (Arvai *et al*., 2006). Thus, engaging the public and also as suggested by another stakeholder, mapping evidences and the risks is very critical in effecting a policy change in Scotland:

> *I think we have to try to summarize the risks for it better than we do at the moment because there are all sorts of risks. You have got the risk of less water drying up, it's not just drying up but the quality will deteriorate because there's less of water and you are drawing the last drains out of your well and it will be all the mud and muck at the bottom and all that sort of thing. So, you have got that side, on the side where you have got too much water, your washing material from the fields into streams and to eventually to the water-table, your underground water-table, even if you get very heavy rain you can wash ground contamination into storage tanks, into wells and all those sort of thing which again is a risk. So, you have got risks on both sides; too much and too less. When really what we want to get is something that's maintained and stable and healthy*.
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

This clearly is important if households are meant to change their behaviour and help reduce the impact of climate change on Scottish water resources. As was observed, households felt more connected and could better relate with weather impacts, droughts, flooding, water pollution and more energy needed for water quality than with climate change. So, if all the risks or evidence were mapped and explained as a likelihood impact of climate change, households might have a change in their behaviour towards the use of water in Scotland since they can relate more to these and understand the effects and impacts more.

However:

> *…potentially I mean we tend to limit ourselves to quality, but there is some evidence and we are trying to quantify that evidence that the qualities of some waters maybe changing over time and such as especially and humic acids and organic matter in the water so this is the public water supply, some of Scottish waters supply will increase in natural organic matter in the whole water which might make the water harder to treat and that might be due to increased intensity rainfall but it might also be due to the fact that catchments sizes and activities in the catchments such chemistry that sort of thing and changes in, that sort of thing so it is very hard to identify one cause. But there is some evidence that the water quality is changing which is giving problems, it might not be part due to climate change. We do not have that mapped evidence to say that and if it is affecting the public supply then it would be affecting private supplies as well. So, we haven't got enough data; quality data on PWS to say same as urban*.
>
> **Operations Team Leader, DWQR**

As expressed by a stakeholder, although evidence is needed, sometimes the evidence accumulated might not necessarily be as a result of climate change. Thus, to come up with a policy that changes attitudes and behaviour to climate change, it might be difficult and not convincing enough. According to Verdon-Kidd *et al*., (2012), non-climatic influences on water resources has been one of the gap between end user needs and climate science capability. Global Climate Change (GCC) according to Cunha *et al*., (2010) is a problem and the aftermath effects are likely to be less severe if mitigation and adaptation measures are planned and applied in accordance to local or regional specificities. Hence to create an action plan, there is the need for a framework which bridges the gap between the attitudes, behaviour, and perception of people towards climate change and the impact it might have on their water resources to create socio-economic policies and also improve water course quality whiles protecting the natural environment. Nevertheless, from this study, it has been observed that if climate change is connected to certain environmental parameters like flooding, water pollution and droughts, households are highly willing to reduce their impact (Figure 5.9).

In terms of driving towards an effective policy to deal and reduce climate change impacts on Scottish water resources in Scotland, a stakeholder expressed that a lot has already been done in the area:

> *Oh, that seems you want to change the problems of the year. It's a slight a tricky question. To be honest, there is quite a lot of activity in that area anyway driven by EU legislation but SEPA is now licensing abstractions. It is monitoring abstractions, it's looking more closely to the various water framework directive studies that are going on and they are targeting areas where there is water; local water resource issues, not enough water in the river to keep the fish alive that sort of thing. And therefore, some of them will have an impact on Scottish water; they may be looking forth to take the sources from different places. So, there is already quite a lot of activity in that area, you know so I feel generally happy that the policy framework is working reasonably well. There is an issue on surface water management, you know, and to who is the kind of authority for dealing with surface water you know and tackling things like flooding etc. But that's something that requires a little bit of joint working between lots of parties*.
>
> **Director, WICS**

But reinstated that more needs to be done in terms of surface water management. However, this contradicts another stakeholder who perceived that:

> *You know who is telling the public that as a result of climate change we think that rainfall will be impacted and in this way and if you are on a PWS this might be the following. I have not seen. I doubt if there will be research around this area, but I have not seen it. And if I have not seen it, you can bet that the Scottish public has even less chance to see it*.
>
> **Manager, Hydronation**

This contradictory response might be because of different departments within the stakeholders group working on different aspects of climate change mitigation and adaptation thus results may not be coherent unless they compare their findings. Furthermore, though the potential impacts of climate change have been considered in UK water resources planning for a decade (Arnell and Delaney, 2006 ; Subak, 2000), nothing has been implemented for Scotland in terms of PWS usage. The CCRA has considered the main opportunities and threats (UK CCRA, 2012) that may result from the impacts of climate change but there is no policy or implementation of policies concerning peri-urban and rural areas. There is the need for an integrated policy for both PWS and MWS since the impact might be felt across all of Scotland and not just MWS sources.

5.8 CONCLUSION

One of the objectives of this study was to understand perceptions of climate change and its effect on water supply in Scotland. This study has shed valuable light on the issue of public perceptions of climate change of residents in Scotland adding weight to the climate change debate.

It was observed that water priorities in Scotland are much focused on water efficiency and other environmental issues and not climate change; this included both stakeholders' views and households' views. Stakeholders perceived the impacts of climate change on Scotland's water to be minimal.

Majority of participants were aware of climate change in terms of the media, friends, and community but in terms of happening they perceived it was not. There was a relatively few people who did not know or had not heard anything about climate change. However, the general perception that climate change may impact negatively on water resources and people was perceived to be a myth and participants believed climate change to be good. It was observed the "wording of climate change" means the climate is constantly changing and it was a continuous action, thus it was assumed the wording not to be understood by participants. They further attributed climate change as not a new thing of which private companies and government institutions were relying on to make profits through complex policies.

Participants' perceived weather to have an impact on their water supply more than climate change would. It was observed climate change impact on Scotland's water resources was directly proportional to impact on their own source of water supply which was opposite for climate change impact. Participants could relate with the weather impacts on their water supply more than climate change impacts. As would have been expected, PWS users were more concerned with weather impacts on their water supply more than MWS users.

There were contradicting responses on climate change impacts. If the climate change wording was used, there were a lot of neutral outliers and negative responses but when wording like weather, flooding, droughts, and water pollution were used, there was a positive response and climate change was assumed to have an impact on Scotland's water resources. More than half of participants responded that they were willing reduce the impact of climate change if it will affect the source of their water supply.

It was also observed that gender was not associated with climate change awareness as suggested by some research, however in the city; there was a positive correlation between gender and climate change awareness but it was not conclusive. There is the need for more research to understand the difference in views between those in the city and those in urban or semi-urban areas in terms of gender and climate change awareness. Also, age was not related to willingness to reduce the impact of climate change.

RWH as one of the climate change mitigation solution was perceived not to be feasible in Scotland; it was assumed not enough to reduce flooding and if there is more flooding and not enough to store water for drier seasons. Most stakeholders associated RWH with drier climates and were of the view that for it to be adopted, it should be promoted using incentives if not it was nearly impossible. But they did not see it as one of the climate change mitigation solution.

Lastly stakeholders perceived that for an effective policy to bridge the gap between climate change impact on water resources and public awareness to effect a change in policy, there needs to be education, evidence of climate change impacts happening in Scotland, understanding of climate change and its impacts and mapping all the risks involved with a localized Scotland scenarios. This it is believed to some extent can effect a change in behaviour of participants to believe climate change was happening and be more willing to reduce the impact of climate change.

Chapter 6- ACCEPTABILITY OF RWH

6.1 INTRODUCTION

The purpose of this chapter is to analyse the acceptability of RWH by understanding the drivers for RWH implementation. This was to meet Objective 3: "*exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders' views*". The purpose was to establish if financing was a barrier to the implementation of RWH since it was observed in literature that RWH has widely been adopted in countries like Japan, Germany, and Australia as a result of the financial incentives by their governments. The financial analysis was made with householders' willingness to implement RWH if they were given some form of incentives through grants (one time off, annual, and monthly) and or reducing their water bill. And the feasibility of the system was analysed with respect to the easiness of installing and maintaining such a system.

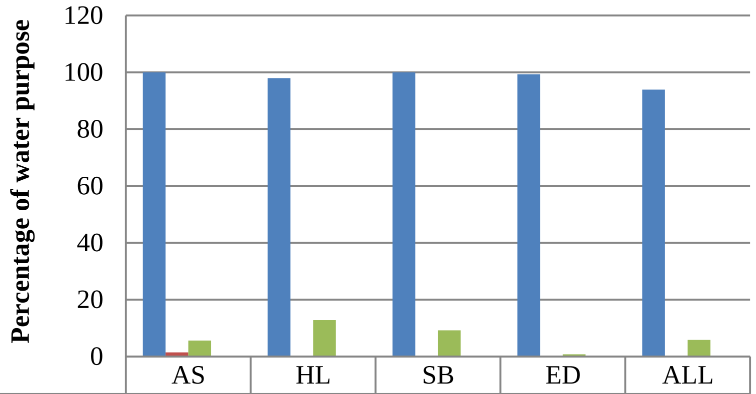
To do this, it was important to understand participants' home water and energy behaviours and how they interrelate. Both PWS and MWS were asked questions on their daily and weekly water consumption to aid in the understanding of the financial motivations for them to use RWH and also to understand their willingness to conserve water. In addition, questions on water saving devices in homes, the main use of water, grant incentives through the local authority, borne by community or the individual to implement RWH to also understand the acceptance for an individual or a communal system. Respondents were also asked if they thought RWH to be financially beneficial to them and their households, and their thoughts on conserving water through RWH. For RWH to be acceptable to participants, they were again asked if it they would adopt the system if it was easy use, ensure constant supply of water and will reduce their water bills. It was observed that respondents answered the questions based on their own personal experience.

6.2 MEASURES OF WATER CONSUMPTION

There are 2.3 residents in the average UK home, 2.2 in Scotland (Office for National Statistics, 2011), which is higher than the average occupancy in this study (2 persons) and water consumption per household is estimated at 349 litres of water each day (Energy Saving Trust, n.d.). In Scotland, water consumption per household is estimated to be 347.4 (Scottish Water, 2015). Waterwise states that Scots use around 146 litres of water every day and this was increasing but small behavioural changes can make a real difference (Waterwise, 2007). Although the water supply in Scotland is not currently under threat, there could be a problem in the future if action is not taken now to prevent long term water shortages in the future (Waterwise, 2016). So, in order to understand if RWH was feasible economically and as a social responsibility of conserving water, participants were asked what their water was mainly used for and if they thought water conservation was important. Due to that they were also asked if they had any form of water saving device in their homes. As per Barnard and Reed, (2015), water re-use is a critical pathway to water efficiency, thus a positive response from this was believed to make participants be inclined towards water saving or compensate the amount of water use by harvesting rainwater so they will be willing to implement RWH. The energy water relationship was assessed by asking participants if they perceived the use of energy for water related purposes.

6.2.1 Water use

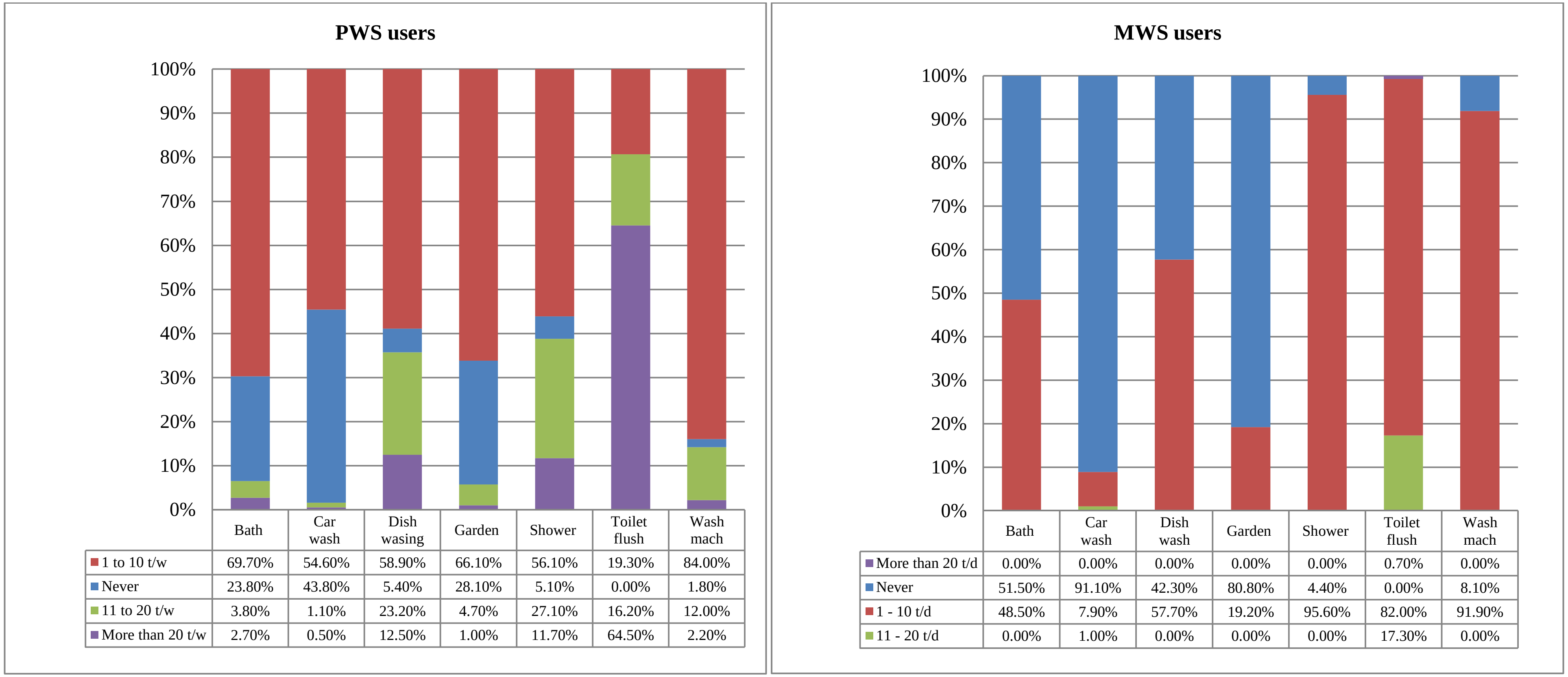
In the UK, water is used in three main areas of the home: the bathroom, the kitchen and the garden (Energy Saving Trust, n.d.). Household use of water is more compared to non-household uses, for instance in England and Wales non-household water use accounts for 30% whereas in Scotland and Northern Ireland, the figure is approximately 35% (Waste and Resources Action Program, WRAP, 2011). So, for most participants in this study, the main use of water was for household use confirming earlier research and it was for domestic activities (Figure 6.1). Other non-household use of water included industrial and commercial use but they were a few proportions: Industrial (5.8%) and commercial (0.3%) (Figure 6.1). Aberdeenshire was the only place that had industrial use (1.4%) and Edinburgh had the least (0.7%) use for commercial activities as compared to other areas (Figure 6.1). Participants on PWS expressed that aside domestic use they were also using their PWS for the following activities: agricultural, farming livestock, watering horses, child minding, equestrian, local functions and visitors' accommodation, bed, and breakfast, gardening only in the summer, other estate properties, river micro-hydro scheme and as a holiday resort.



	AS	HL	SB	ED	ALL
Domestic	100.0%	97.9%	100.0%	99.3%	93.9%
Industrial	1.4%	0.0%	0.0%	0.0%	0.3%
Commercial	5.6%	12.8%	9.2%	0.7%	5.8%
I don't know	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 6.1: Household water uses (What is your water mainly used for?)

For domestic activities, a high proportion of water use in participants' home was for toilet flushing, approximately 65% more than 20 times/week for PWS users and 17.3% 11-20 times/day for the city of Edinburgh (Figure 6.2), MWS users. Consequently, it was not surprising dual flush toilets were the highest water saving devices used in homes (Figure 6.3; Section 6.2.2). Water use frequency is more detailed in (Appendix X). For MWS users, households were asked water use per day instead of per week as done for PWS users. Households on MWS were using water more than those on PWS (appendix X). For instance, 16.2% of responses on PWS were flushing their toilets 11-20t/w whereas 17.3% respondents from the MWs users were flushing their toilets 11-20t/d (Figure 6.2). According to Waterwise UK, nearly a third of the water used in UK homes is literally flushed down the toilet (Waterwise, 2012) which corroborates this research where water the highest water frequency was for flushing the toilet (Figure 6.2). Furthermore, for PWS users, the next most frequent use of water (11-10 t/w) was for taking a shower (27.1%), running the dish washer (23.2%) and running the washing machine (12%) (Figure 6.2). This represents what is known to be the most frequent use of water in UK homes since showers, lavatories, baths, and bathroom sinks consume more than two-thirds (68%) of household water (Energy Saving Trust, n.d.). But for MWS users the most common use was (1-10 t/d), which was for taking shower, running the washing machine, taking a bath, and running the dish washer. The rate of water use by MWS users was relatively high than those on PWS users (Appendix X).



PWS users

	Bath	Car wash	Dish wasing	Garden	Shower	Toilet flush	Wash mach
1 to 10 t/w	69.70%	54.60%	58.90%	66.10%	56.10%	19.30%	84.00%
Never	23.80%	43.80%	5.40%	28.10%	5.10%	0.00%	1.80%
11 to 20 t/w	3.80%	1.10%	23.20%	4.70%	27.10%	16.20%	12.00%
More than 20 t/w	2.70%	0.50%	12.50%	1.00%	11.70%	64.50%	2.20%

MWS users

	Bath	Car wash	Dish wash	Garden	Shower	Toilet flush	Wash mach
More than 20 t/d	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.00%
Never	51.50%	91.10%	42.30%	80.80%	4.40%	0.00%	8.10%
1 - 10 t/d	48.50%	7.90%	57.70%	19.20%	95.60%	82.00%	91.90%
11 - 20 t/d	0.00%	1.00%	0.00%	0.00%	0.00%	17.30%	0.00%

Figure 6.2: Comparing water use frequency in the study areas: PWS (Private Water Supply) users; MWS (Mains Water Suppky); t/w (times per week); t/d (times per day) (How much water do you and your household use in a week for PWS users and in a day for MWS users)

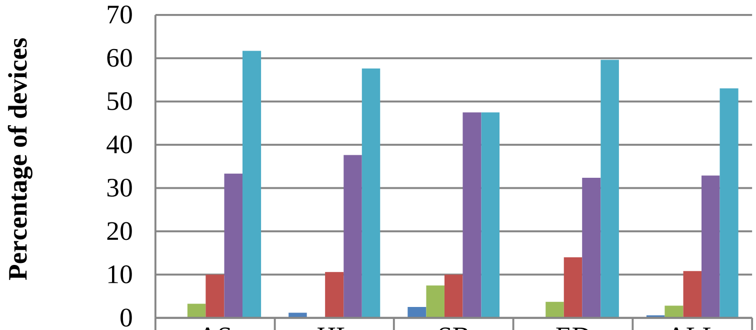
Chapter 2 discussed the role of RWH in reducing domestic water consumption in the UK and consequently in reducing the demand for potable water (Fewkes, 2012). But from reviewed literature, popularity of RWH was more in England and Wales as compared to in Scotland. The results for water use frequency show a relatively high percentage of water used by householders for non-potable uses like flushing the toilet, running the dish washer, and washing machine, gardening and car washing and this can be substituted by using RWH. Substituting RWH for some of these non-potable sources do not help to conserve water in homes but in the long run also save water companies money and the amount of energy needed to treat and pump cold water. Because of that, rainwater tanks in urban areas are internationally perceived to be a low cost source substitution option for many end uses or micro-components like toilet, clothes washer, irrigation of water demand (Talebpour *et al*., 2014).

6.2.2 Water saving devices

People often consider that Scotland would not suffer the same issues as the South East of England (Waterwise, 2007); this was also affirmed in Section 5.3 where some participants perceived climate change to have impact on water resources in England and not Scotland. But a recently published Scottish Executive sponsored study predicted there will be significant changes in weather patterns over the next 70 to 80 years with summers becoming generally drier therefore resulting in a 40% reduction in the South and East water resources (Waterwise, 2007). Actions on water efficiency needs to be taken to prevent stresses on Scotland's water supply similar to those experienced in the South-East of England (Waterwise, 2006) and one way is ensuring water saving devices are used in homes to ensure water use efficiency. So, householders were asked if they had any water saving device in their homes.

Just over half of the participants (53%) said they had no water saving devices in their homes (Figure 6.3). Those who did were using dual flush toilets, approximately 33% (Figure 6.3). A relatively low proportion of participants had compost toilets (0.6%) and hippos (2.8%) as compared to a low flow shower head (Figure 6.3). The hippo is a simple, proven, and low cost water saving device to help conserve water in toilet cistern. Aberdeenshire had the highest responses (61.7%) saying they did not have any water saving device in their homes (Figure 6.3). The city of Edinburgh and Aberdeenshire householders did not have composting toilets in their homes and

Highland did not have a hippo (Figure 6.3). Scottish Borders had the least responses (47.5%) to having "no water saving device" in their homes.



	AS	HL	SB	ED	ALL
Compost toilet	0.0%	1.2%	2.5%	0.0%	0.6%
Hippo	3.3%	0.0%	7.5%	3.7%	2.8%
Lowflow shower	10.0%	10.6%	10.0%	14.0%	10.8%
Dual flush toilet	33.3%	37.6%	47.5%	32.4%	32.9%
None	61.7%	57.6%	47.5%	59.6%	53.0%

Figure 6.3: The use of water saving devices in households (Do you have any water saving devices?)

Some participants in Scottish Borders expressed they had loads of water which when not used flows away so they felt there was no need to ration water but surprisingly they had the lowest number (47.5%) of "no water saving devices" (Figure 6.3). Most at times, the understanding of relative water savings associated to water efficient devices is not enough to encourage consumers of the expenditure of the capital cost to upgrade fixtures (Willis *et al*., 2013) and coupled with the assumption that there are abundant water resources in Scotland, it seems it is less likely for householders in Scotland to have water saving devices in their homes. From the data, in individual areas except for Scottish Borders, more than half had no saving devices and this can be attributed to the perceived abundance water resources of Scotland. According to a stakeholder:

> *We have a lot of water, we have a lot of rain and consequently the public view of the value of water as a resource is not very developed and their belief is that the value of their resource is not low and when something is plentiful that is the natural reaction.*
>
> **Manager, Hydronation**

Not only did the interviewee express that, a householder from Edinburgh was of the view that:

> *I don't have any water saving devices. Why, we live in Scotland!!! We don't have to save water!! I disagree water resources in Scotland are under pressure; it is Scottish water responsibility to ensure its infrastructure is good…***P79, ED**

In the past water used to be abundant and was a low-cost resource and due to that, wastewater could be discharged to surface water or to the sewer system without excessive costs and restrictions (Dvarioniene and Stasiskiene, 2007). However, according to Anderson (2003), the rising costs of dependable water supplies and wastewater disposal have increased the economic incentive for implementing technologies that can ensure efficient use of natural resources. Such of these technologies are the use of a low-flow shower head and the dual flush toilets. Research shows that upgrading a standard toilet to a dual-flush toilet can save more than 7,000 litres of water per person per year thereby cutting a four-person metered household's annual water bill in England and Wales by around £80 (Energy Saving Trust, n.d.). In England and Wales, 4 out of 10 homes (41%) are known to have dual-flush toilets and only 17% of households who had pre-2001 toilets were reported to have a cistern displacement device as researched by the Energy Saving Trust. In the study areas, the dual-flush toilet was the most common water saving device used in homes of Scots which was on par with England and Wales (Figure 6.2) although it has been phased out in the UK (Chivers *et al*., 2001). It once used to be mandatory in the UK for new domestic properties but because people repeatedly used the short flush when the long flush was required, it negated any possible water saving (Chivers *et al*., 2001).

Although low-flow shower head was the second highest water saving device used in households, it was relatively a small percentage, overall it was 10.8% with Edinburgh having the highest number, 14% (Figure 6.3). It has been confirmed that the installation of high efficiency, low-flow showerheads saves considerable volumes of water (Mayer *et al*., 2004). Yet, in the study areas, there a relatively low percentage was using the low-flow shower head. The reason as expressed by a stakeholder might be to do with the pressure which may be ineffective:

Yea because as again, reducing the pressure in the house, you know tends to be something that customers view negatively because it takes longer to fill or get water. And there is a minimum standard; there is a point at which they must supply the water at.

Then going into the house situation and you say, well if you reduce the pressure, the toilet will use the same amount of water just that it takes longer to fill so you haven't actually achieved anything. Likewise, when you are filling a kettle, if the pressure is lower, it just takes you longer to fill it, but you still fill it to the same standard as you otherwise would. So, the only areas where pressure reduction makes a difference is in things like showers where you know, you assume that people will only have 5 minutes of shower so therefore if the pressure is lower, they'll save but that again it doesn't work as you might stand under the shower for longer.

For low-flow showers, the rationale for its efficiency based only on minimum flow raises some doubts, since behavioural factors, related to comfort, can negate the savings resulting from application of a low-flow product (Rodrigues and Afonso, 2015). Hence, though some householders were using low flow shower head, considering the comfort aspects a higher total volume of water might be consumed due to its lower flow rate and extending its duration as ones take a shower, thus it might be the reason majority of householders did not have it in their homes. Though the previous interviewee felt the consumers might feel the pressure reduction of shower heads to be negative, the stakeholder expressed that:

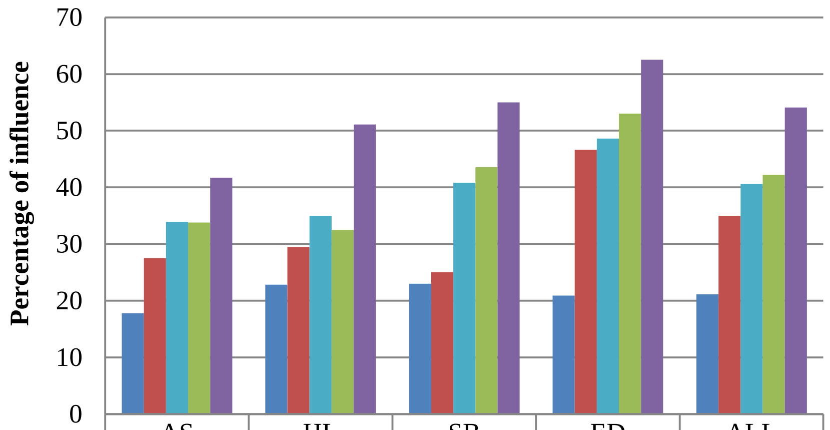
So, you know it's the practicality of some of it, but having said that, there are things that have been different, something like low water use washing machines, you know, dish washers, the reduction in water use in these sort of appliances have been quite significant. Does it reduce cost, yes to some extent because it does two things: at a fairly minimal level it reduces the treatment cost so they don't have to put too much chemical because there's less inflow of water etc. so that's one benefit.

Director, WICS

However, research using models by (Dvarioniene and Stasiskiene, 2007) showed that high efficiency water fixtures and appliances showed the least cost in planning strategy for water conservation. This is a good starting point for policy makers according to (Stewart *et al*., 2010) before the higher cost of water supply or demand solutions are commissioned. However, people need motives to save water (Corral-Verdugo *et al*., 2003) and people will only engage in water-conservation practices to save money and water for cooperating with a conservation campaign (Corral-Verdugo, 2002) and for paying less for the consumed resource (López *et al*., 1994). Nonetheless, results from this study showed a relatively low number of householders having a water saving device in their homes.

6.2.3 Water and energy relationship

Householders were asked if they considered normal household activities were influential on their energy bills (Waterwise, 2012). Overall, participants felt using the washing machine (54.1%) had an influence on their energy bills (Figure 6.4). Households thought in descending order: running the washing machine, bath, dish washer, taking a shower and making coffee/tea had an influence on their energy bills (Figure 6.4). This was the same for individual study areas except in Highland where running the dish washer (34.9%) had more influence on energy bills than running a running a bath (32.5%) (Figure 6.4). In Aberdeenshire, responses were relatively similar for running a bath (33.9%) and running the dish washer (33.9%) (Figure 6.440). Edinburgh had the highest responses in terms of showering, dish washing, bathing and running the washing machine having an influence on their energy bills. More than half of Edinburgh thought running the washing machine (62.5%) and the bath (53%) influenced their energy bill (Figure 6.4).



	AS	HL	SB	ED	ALL
Coffee/Tea	17.8%	22.8%	23.0%	20.9%	21.1%
Shower	27.5%	29.5%	25.0%	46.6%	35.0%
Dish washer	33.9%	34.9%	40.8%	48.6%	40.6%
Bath	33.8%	32.5%	43.6%	53.0%	42.2%
Wash mach	41.7%	51.1%	55.0%	62.5%	54.1%

Figure 6.4: Household activities that are influential on households' energy bills (to what extent do you think these activities are related to your energy bills?)

In dealing with water efficiency, water-related energy demand of domestic water end-users is an area which has been under researched. In Scotland, 17.7MWh is the average final energy consumption per household (Scottish Government, 2013). According to Waterwise, (2012), 25% of household's energy bill comes from heating water, and this domestic hot water accounts for 5% of UK greenhouse gas emissions. Heating water to take a shower, running a warm bath, doing laundry in the washing machine impacts on energy bills which results in the release of GHG, linking it to climate change (Waterwise, 2012). The energy bills and carbon emissions can be cut or reduced by being more conscious on how of how water is used; less use of water reduces energy bills and also reduces emissions (Energy Saving Trust, n.d.). The least perceived influential activity on households' energy bill was making coffee/tea but according to the Energy Saving Trust, 40% of households boil the kettle four times or more a day and it was observed that majority (75%) boil more water than they needed (Energy Saving Trust, n.d.).

The results from the study show that householders felt using the washing machine had the most influence on energy bills, approximately 63% in Edinburgh, disregarding other uses. Although majority felt making tea/coffee was not influential, one resident perceived:

For making tea or coffee it is moderately influential…**P20, AS**

Therefore, there is the need to link hot water and energy use when dealing with water efficiency. According to a stakeholder:

> *The thing around water efficiency, most of the benefits from an environmental point of view is associated with hot water, you know. So, it's when you get the linkage to the water and that's where lots of the environmental benefits are*.
>
> **Director, WICS**

"…*The availability, demand and use pattern of water and energy per se have been the subject-matter of a number of available studies and a vast amount of information is available on various aspects of water and energy individually*" (Malik, 2002). There have been lots of studies on saving energy in buildings and at the household levels, but there seems to be paucity of data when it comes to water-related energy demand of domestic water activities. According to Malik, (2002), a minority of researchers have only treated water and energy closely as related issues, therefore very little is known about the energy profile of the water chain in its entirety.

There has been diverse strategies that has been adopted to enhance water and energy efficiency around the world (Talebpour *et al*., 2014). However in a lot of countries, although water management programmes have been developed to meet water shortages with a major focus on energy savings (Malik, 2002), it still lacks of integration in most water and energy programs (Cheng, 2002). This according to Cheng, (2002), has resulted in lower than expected savings due to the inefficient synergy created between the two resources.

In Scotland, there is the assumption that there are abundant water resources, some householders' perceived water to be overly plentiful in Scotland hence there was no need for water conservation or water efficiency. Some residents surveyed are quoted saying:

> *I do not feel water is in scarce supply in Scotland and that floods can be coped with more*…**P15, ED**

> *I don't have any water saving devices. Why, we live in Scotland!!! We don't have to save water!!*...**P79, ED**

> *Living on the west coast with lots of rains I find it hard to imagine we will run out*… **P96, HL**

These comments were dittoed by most of the stakeholders who expressed that:

> *Folks believe water is free in Scotland.*
> **Policy Adviser, Scottish Water**

> *A lot of people do, especially those on benefits.*
> **Water Policy Analyst, CABS**

Thus, linking water efficiency with hot water and energy for people to conserve and use water efficiently may be quite challenging. Moreover, when asked the extent householders perceive their domestic activities (Figure 6.4) were related to their energy bills a householder perceived it had no influence on their energy bills because the community provided their own energy:

> *We generate our own electricity (hydro)*…**P68, HL**

However, as echoed by a stakeholder:

> *And it comes back to you know, despite that it comes out of truth that there is a huge resource of water in Scotland. You know, so we are not in a way that you would see certainly as in England, we are not water constrained. And it's not to say it doesn't have an environmental impact and that we should waste it, you know, absolutely right. But from you know, from a water efficiency point of view it's about customer behaviours, it's less about, you know, a resource constraint. So, you know, the use of other things in water constraint areas down south, you know these hippo things in the toilets and you know low flow showers, I mean I know myself that I got one, and then I fitted and everyone complained the shower was rubbish, and it's not been used again since.*
> **Director, WICS**

It is known that improved energy efficiency is one of the most important ways of reducing the negative effects of some trends in people's behaviour and perception, and has been like that over the past decades (Hiller, 2015). The use of hot water is also known to be associated with the quality of life, (Pimentel-Rodrigues, 2015) and according to International Energy Agency, (2010), the energy-related behaviour of households plays an important role in achieving energy-efficient measures in a compelling way which can influence the gap between potential and actual energy efficiency levels. Therefore, if linking householders' energy bill to water use, householders might be conscious and thus employ water efficiency measures to reduce their energy bill. This was evidenced with one householder in Scottish Borders who perceived heating cold water to be associated with energy bills:

> *I AM EXTREMELY ANNOYED THAT OUR ELECTRICITY BILLS ARE EXTREMELY HIGH NOW because it is only possible to buy 'cold-fill washing machines' which have to heat cold water. We have an open fire with back-boiler, and therefore plenty of hot water. Why can't we use the hot water we already have in our washing machine. THE GOVERNMENT REALLY SHOULD DO SOMETHING ABOUT THIS- We always used to have a washing machine which used our hot water! Now it is impossible to buy one!...***P35, SB**

6.2.4 Conservation of water through RWH

Some water demand management professionals have suggested that rainwater tanks (RWTs) as an effective way to reduce the demand on potable supplied water (Willis *et al*., 2013). And practising water efficiency in the UK can save a third of water consumption and together with RWH savings can reach 50% (Waterwise, 2007). It was assumed that participants who have water saving devices in their homes will be willing to implement RWH and might see RWH as a form of water conservation. A stakeholder indicated that:

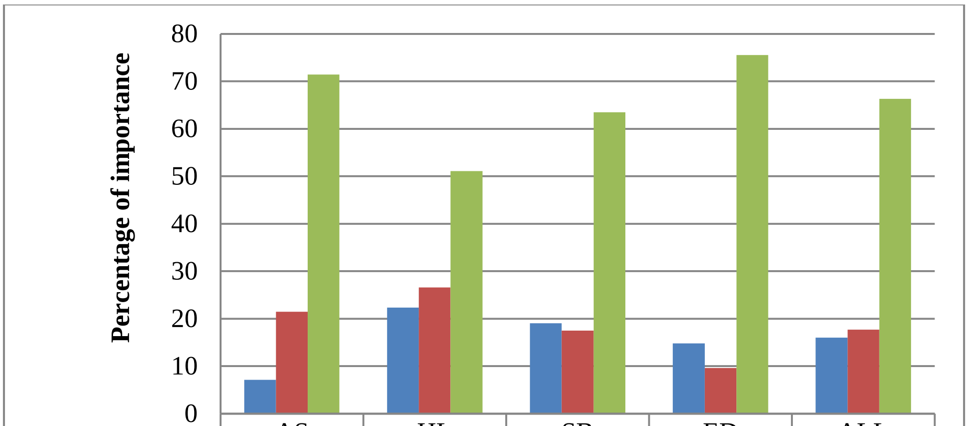
> *So, the overall budget for the water efficiency, RWH is certainly a part of it and it falls within this sort of great program, it's just one of the measures in terms of how we are trying to look into ways we are treating water*.
>
> **Policy Adviser, Scottish Water**

As well as observed from figure (6.3), 47% of participants had water saving devices in their homes. Therefore, a question asked was if participants felt it was important to conserve water through RWH. As such participants were asked if they thought it was important to conserve water by implementing RWH

Even though it rains regularly in Scotland, it is the right time for people to start implementing RWH since saving water makes good economic sense and has environmental and social benefits (Waterwise, 2007). This was corroborated by a stakeholder who felt some parts of Scotland were not that blessed with abundant rainfall:

> *This is the time of the year that we see the most failures on supplies as far as drying up because it will have gone through the summer and now they have probably had 4 or 5 months without too much rain in normal years, this year has been a bit different. But September is when people are absolutely desperate for water. The difficulty with any of these things is once you get a PWS drying up, there is no guarantee that when the rain comes that will start up again.*
>
> **Technical Officer Infrastructure Service**

So, when participants were asked if it was important to conserve water (through RWH), the majority of participants (66.3%) felt it was important to conserve water (Figure 6.5). In individual areas, they followed the same pattern in descending order: “important”, “neutral” and “unimportant” except Scottish Borders were participants thought it was unimportant (19%) to conserve water (through RWH) than being neutral (17.5%) (Figure 6.5). Participants from Edinburgh (75.6%) and Aberdeenshire (71.4%) had the most responses in agreement to the importance of conserving water (through RWH) (Figure 6.5). In individual areas, a relatively high number of participants were neutral in terms of water conservation (through RWH) as to it being unimportant (Figure 6.5).



	AS	HL	SB	ED	ALL
Unimportant	7.1%	22.3%	19.0%	14.8%	16.0%
Neutral	21.4%	26.6%	17.5%	9.6%	17.7%
Important	71.4%	51.1%	63.5%	75.6%	66.3%

Figure 6.5: Participants view on the importance of conserving water through RWH (Is it important to conserve water through other alternatives like RWH?)

Most people thought water conservation (through RWH) was important however just over half of participants (53%; Figure 6.3) had no water saving device in their homes. From literature, it was realized that the motivation for RWH in the UK stemmed from the large amount of water use per day by homes, the average water usage is approximately 150 litres per person per day with significant variability linked broadly to affluence or socioeconomic group (Butler *et al*., 2010). It had been observed that domestic water use increased over the last two decades; it has increased from 110 litres per person per day to 157 litres per person per day (EA, 2001). This increase is due to assumed factors such as demographic changes, socioeconomic factors and climatic variation and the population was predicted to increase in the UK over the period 1997-2025 by 3.3 million (EA, 2001). In Scotland, over the last two decades, water consumption has risen by 6% due to changes in household size and changes in usage patterns (Waterwise, 2006). This has led to pressure on water resources but because Scotland is a rainy place, people do not fully understand the importance of water efficiency (Waterwise, 2007). RWH could have a significant future role in reducing domestic water consumption in the UK, and consequently in reducing the demand for potable water (Fewkes, 2012). This was mirrored by the view of a stakeholder who perceived that:

> *We also need to look at capturing RW to run appliances in households such as toilets that perhaps don't need potable water to water gardens, to clean your car, to do a lot of other things where you don't need drinking water to do that.*
>
> **Water Policy Analyst, CABS**

But when participants were asked if it was important to conserve water through alternatives like RWH there was mixed reviews from both householders and the stakeholders. A minority of householders, except in Scottish Borders which are relatively higher (Figure 6.5), perceived conservation of water through RWH unimportant in Scotland for diverse reasons. It was observed that householders who perceived RWH unimportant were because of:

1. Lack of knowledge on RWH:

> *Sorry! Cannot answer most questions as I do not have enough knowledge!! It is important to conserve water through other alternatives like RWH-Do not know. Water falls out often sky almost daily…***P92, ED**

*Conserve water through other alternatives like RWH? (Neutral) - Who knows...***P18, AS**

2. The assumption that there are abundant water resources in Scotland:

*For me it is unimportant to conserve water through RWH usually unless the burn runs dry but for most people probably very important…***P35, SB**

*Our water supply has an overflow which runs constantly baring burst pipes. This excess washes discharges over the hillside. At present, we are fortunate that water shortages are not an issue otherwise RWH would be very important…***P62, SB**

*It's silly. In other parts of the world it is important to conserve water through RWH but not here in Scotland. I don't think RWH is necessary in Scotland…***P79, ED**

*Loads of water-if we don't it just flows on down the burn. No need to ration it in our area usually!...***P35, SB**

3. And lastly the cost of water being free:

*The water supply is free already…*P11, SB

*Similarly, we do not pay for our water only for maintaining the system"; "our water supply costs us nothing…***P35, SB**

It should be noted that most of the comments (Appendix VII) were from Scottish Borders even though most responses saying water conservation (through RWH) was unimportant was from Aberdeenshire (22.3%; Figure 6.5). Although RWH systems in the UK are not new concept (Mustow *et al*., 1997), the lack of knowledge concerning RWH was not only limited to Scottish Borders, it was also reflected in responses from some householders in Edinburgh and Highland (Appendix VII):

*This survey raises some interesting questions but it is difficult to complete as I had never heard of RWH before and so find it hard to say how I feel about it…***P39, ED**

*I don't know much about RWH except that they are building a communal scheme in the village in France where I also own a house…***P18, ED**

*I would like to collect rain water but how does this feed into the holding tank in the house? I have concerns that standing water will become polluted. I would be reluctant to have an ugly installation on my property. How does the rainwater get into my plumbing system...***P10, HL**

*I don't know much about RWH to comment properly. We are a small community who are completely reliant on our own supply as Scottish Water say there is no funding to give to mains water…***P65, HL**

Over a decade ago, there were reports which suggested that there was a shortage of interest in installing RWH systems and the technology has been ignored and readily disregarded around the world (Heggen, 2000; Shaffer and Leggett, 2002). In the UK, most places with RWH are in England and Wales with less in Northern Ireland and Scotland. Although RWH is becoming popular in England and Wales, in Scotland it will be difficult to convince people to use it was a water conservation tool. This is because in a place thought to have plentiful water, it will be difficult to convince them to do so especially if water related issues are not priority on people's list.

> *And there will also be an element of the public who will be prepared to take up steps themselves if they felt it was a responsible action; a responsible environmental action. But you are talking at the thin end of the population with environmental issues and again you should know are not higher priorities within the Scottish public. And I know that water is just a subset which probably comes at the bottom end as well so you have to look at incentivising uptake and how you will do that I am not sure of financial incentives, the normal methodology. I think it will be quite difficult.*
>
> **Manager, Hydronation**

As recalled by a stakeholder.

The assumption that Scotland has a lot of water resources thus impeding water conservation through RWH was not also limited to stakeholders, it was observed in Scottish Borders, Edinburgh, Highland and Aberdeenshire (Appendix VII). However, in Highland, it was further discovered a few householders perceived RWH not to be reliable:

> *Our rainwater system is not 100% reliable and we sometimes run out and have to use a spring instead…***P26, HL**

Thus, their reason for not using it as an important conservation alternative. In addition, residents surveyed expressed that:

> *Over the years, we have suffered from many interruptions to our supply during hotter summers, sometimes being without water for up to 6 weeks. When our (5) children were all at home we took every measure possible to save water and now have installed a holding tank for collecting rainfall. Sometimes even this isn't enough…***P6, HL**

> *Private supplies in my neighbourhood regularly freeze-up in very cold winters and dry up in hot, dry summers. A dry winter/spring can cause water shortage as is happening more frequently (thankfully ours is still good!). The source of my PWS is rainwater (run-off from hill-side), loch (back-up supply only). I think for most people e.g. mains supply, it is important to conserve water through other alternatives like RWH…***P11, HL**

Yet the last and recent market intelligence suggests RWH is becoming more widely adopted in England (Fewkes, 2012). On the other hand, the concept of RWH is not developed very well in Scotland. According to Ward *et al*., (2013), little research has been done on RWH in UK and their most recent studies on RWH systems were in

South-West of England. According to a stakeholder from a manufacturing RWH, storm water management and waste water treatment products and plastics:

> *We've had very limited number of people doing RWH in Scotland. The people in Scotland are more looking at RWH tend to be farmers and agricultural where they do get a charge for water. The Scottish market isn't the same as English market and I think the main reason for that is that they've got their water bill separate from the council tax bill.*
> **Business Development Manager, GRAF UK**

This again comes to the fact that people in Scotland assume water is free which was echoed by the stakeholder as well:

> *I don't think there's ever going to be a problem in Scotland with water. Yea I think that is part of that, that people think we have got plenty water so why do we need to recycle. So definitely yea, that's the main idea.*
> **Business Development Manager, GRAF UK**

Although the concept is not well developed in Scotland, a relatively high percentage (66.3%) believed it was important to conserve water through alternatives like RWH (Figure 6.5). A householder in Aberdeenshire asserted that:

> I *think private water supplies are important environmentally; rainwater use is part of that…***P8, AS**

This conveys the opinion of a stakeholder who thinks:

> *In principle, we should be valuing our water more, it is a natural resource, we shouldn't be wasting it.*
> **Water Policy Analyst, CABS**

Since Scotland relies predominantly on surface water abstraction it is more likely to susceptible to short-term variability in climate which might affect rainfall patterns in Scotland (Waterwise, 2006). When this happens, although Scotland is known to have abundant water resources, rainfall variability due to climate change could lead to resource problems in some parts of Scotland especially in the East (Waterwise, 2006). So there is the need to conserve water and use it efficiently.

6.2.5 Gender and water conservation through RWH conservation

Water conservation has been observed to epitomize one of the most important pro-ecological activities which have been developed for a sustainable way of life on earth. Research on gender differences in environmental concerns has been known to expose discrete variations between men and women; and women are most often known to display a higher level of environmental concern and behavioural adjustments relative to men (Hunter *et al*., 2004). In this study observing final comments (Appendix VII) from participants, it was considered that women gave positive comments in relation to conserving water through alternatives like RWH as compared to men. Some females indicated that:

> *This survey has made me think once more about what we are all doing to our planet earth. Thank you!*...**P31, ED**

And were using RWH to wash their hair:

> *I hope you can turn your research into reality. I loved washing my hair with water from rain water butt in Essex*…**P123, ED**

Another female expressed that:

> *Private water supplies are important and environmentally, rainwater use is part of that*…**P8, AS**

Most men that commented perceived RWH to be:

> *Silly; in other parts of the world it is important to conserve water through RWH but not here in Scotland*...**P79, ED**

Didn’t have enough knowledge:

> *Sorry! Cannot answer most questions as I do not have enough knowledge!! It is important to conserve water through other alternatives like RWH-Do not know. Water falls out often sky almost daily*…**P92, ED**
>
> *For me it is unimportant to conserve water through RWH usually unless the burn runs dry but for most people probably very important*…**P35, SB**

To quote a few, most male participants perceived water to be abundant in Scotland:

> *Walk in the Pentlands and our reservoirs are full and they always have and always will be. We live in Scotland!!! We don't have to save water!! I disagree water resources in Scotland are under pressure*…**P79, ED**

As well as water, will never be extinct thence there was no need for water conservation:

> *Just going to get myself a glass of water. Very privileged that you can turn on a tap and the best water in the world come out*…**P79, ED**
>
> *Living on the west coast with lots of rains I find it hard to imagine we will run out*…**P96, AS**
>
> *It is Scottish water responsibility to ensure its infrastructure is good*…**P79, ED**

Responses from the different gender in this study confirmed Hunter *et al*., (2004) assertion that women are most often known to display a higher level of environmental concern and behavioural adjustments. For this reason, it was assumed that women will be inclined to feel water conservation is important through water saving techniques like RWH. Thence this question was asked: "…*is there a relationship between a person's sex and the importance of conserving through other alternatives like RWH?*" And to test this non-directional hypothesis, the Chi-square test was used to test for association and or differences. Along these lines, the null and alternate hypothesis was defined as follows:

Null hypothesis (H_0): *There is no difference between genders saying it is important to conserve water through alternatives like RWH.*

Alternative hypothesis (H_1): *Women are more likely to say it is important to conserve water through alternatives like RWH.*

A chi-square test for association was conducted between gender and whether it was important to conserve water through alternatives like RWH (Appendix XI). Considering it was more than a 2x2 table, the assumption for a table bigger than 2x2 was followed. The assumption is that the expected count is not less than 5 or 20% of the cells have expected count greater than 5; if not then the assumption is violated and the "***likelihood ratio***" is used instead of the chi-square test for association. The results from the test are highlighted in yellow (Table 7.5; Appendix XI).

All expected cell frequencies were greater than 5(20%) except Aberdeenshire which had 2 (33.3%) cells with expected count less than 5 (Table 7.5; Appendix XI). Therefore, the assumption was violated only in Aberdeenshire and the result of the likelihood ratio was used. In the rest of the study areas; Highland, Scottish Borders and Edinburgh, the result of the Pearson Chi-Square was used (Appendix XI). This was because if the assumption is not violated and one or both variables has more than two categories, the Fisher's exact test cannot be used, thus the result of the Pearson Chi-Square was used. In all the individual study areas, the *p* value was greater than 0.05 (Table 7.5; Appendix XI); in AS [χ^2 (1) = .998, p= .607], HL [χ^2 (1) = 2.918, p= .232], SB [χ^2 (1) = 4.756, p= .093] and ED [χ^2 (1) = .979, p= .613]. Therefore, there was a statistically non-significant association between gender and water conservation through alternatives like RWH and the null hypothesis was accepted. Consequently, it can be confidently stated that water conservation through other alternatives like RWH was completely independent of (not related to) someone's gender in all the study areas.

Although considerable studies have categorically focused on gender variation and the results showed that women were generally more concerned with environmental issues relative to men, in this research there was no statistical association with gender; albeit comments from women exhibited they were more concerned than men. According to (Arcury *et al*., 1987) , there has been several theories which have been made to predict gender variations in relation environmental issues, none have been conclusive and the results have generally been weak. Furthermore, other studies show that there is unclear evidence concerning the effect of gender on environmental attitudes and behaviours (Mohai, 1992; Van Liere & Dunlap, 1980). This confirms the results from the chi-square test analysis which did not conclude that there was a relationship between gender and importance of water conservation since water conservation through RWH was completely not related to someone's gender. Nonetheless, women commented more on the importance of water conservation through alternatives like RWH as compared to men. This can be attributed to the fact that over all, a relatively high percentage of women (Tables 4.1, 4.6.9; Figure 4.7) answered the questions although in AS, HL, and SB there were relatively more males than females (Tables 4.1, 4.6; Figure 4.7).

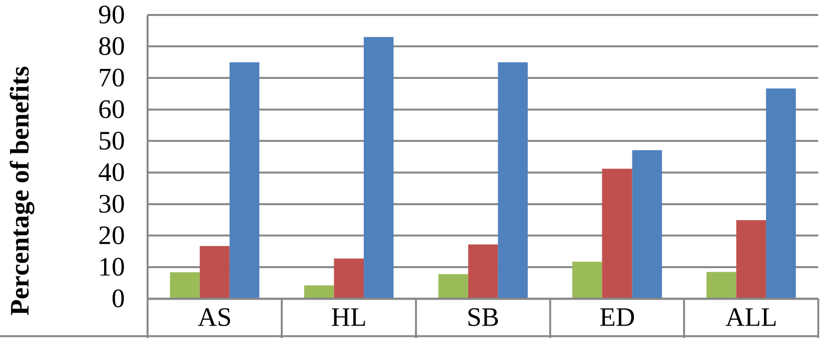
6.3 FINANCIAL INCENTIVES

To understand participants' inclination towards grants for RWH implementation, there need to be an understanding if they feel RWH harvesting is financially beneficial to them. Participants were therefore asked how financially beneficial they perceived RWH to be and if offered some form of financial grants will they be interested in RWH implementation. This was because it was assumed that if participants thought RWH was financially beneficial and grants were given, they would be willing to implement RWH (Figure 6.5). For this reason, a question was asked if householders perceived RWH in their house would be financially beneficial to them. Subsequently, to understand the economic aspects of implementing RWH, participants were further asked if RWH was paid for by their local authority, themselves and or community and if given some form of grants, would they be willing to implement it as depicted in Figure 6.6.

Figure 6.6: Exploring the leading factors to incentives households in Scotland to implement RWH

6.3.1 RWH financially beneficial to households

Participants when asked if RWH will be financially beneficial to them and their households majority (66.7%) felt having RWH would not be financially beneficial to them and their household (Figure 6.7). Responses from individual areas followed the same pattern in descending order: “not at all”, “somewhat” and “to a great extent” (Figure 6.7). There was a distinct difference between PWS users MWS users with RWH implementation being financially beneficial to them. A relatively high proportion of PWS users perceived RWH not to be financially beneficial to them (Figure 6.5): Highland (83%), Scottish Borders (75%) and Aberdeenshire (75%). Whereas a relatively low proportion on MWS (41.7%) felt it was not at financially beneficial to them (Figure 6.7). Furthermore, a relatively minor percentage on PWS; AS (16.7%), HL (12.8%), SB (17.2%) felt RWH was somewhat financially beneficial to them and their household. Contrary to that, a relatively higher portion of households on the MWS (41.2%) expressed RWH was somewhat financially beneficial to them and their household. To a great extent, those on the MWS (11.8%) felt implementing RWH in their household will be financially beneficial to them (Figure 6.7).



	AS	HL	SB	ED	ALL
To a great extent	8.3%	4.3%	7.8%	11.8%	8.5%
Somewhat	16.7%	12.8%	17.2%	41.2%	24.9%
Not at all	75.0%	83.0%	75.0%	47.1%	66.7%

Figure 6.7: The extent to which participants believe RWH is financially beneficial to their household (Do you think having RWH in your house will be financially beneficial to you and your household?)

RWH has provided a water source for communities around the world which dates to around 1500 B.C and continues to serve populations today, mainly in poor, rural or dry regions of the world and island communities (Bill Hicks, 2008). In areas with persistent water issues and limited natural water resources as in Spain, Australia, Israel, Bangladesh, Malaysia, RWH is beginning to become an accepted and normal part of everyday life (Friedler *et al*., 2006; Mohd. Shawahid *et al*., 2007; Friedler, (2008). This is in contrast to the UK, where persistent water issues are only now being recognised as an ongoing challenge (Ward *et al*., 2013). In Scotland for instance, water issues till date are not recognised as an issue except in the East which normally tends to be dry. Moreover, communities with abundant water resources may not see it is financially beneficial and for such communities, it will be difficult to convince them of the benefits of RWH as in the case of Scotland. In the UK, England will more likely find RWH financially beneficial than Scotland. As noted by a stakeholder:

> *I think we have to get back to why would we encourage the public to participate in RWH? The issue in Scotland with water as a resource, as I'm sure you know as having experienced it is that we have plenty of it. We have a lot of water, we have a lot of rain and consequently the public view of the value of water as a resource is not very developed and their belief is that the value of their resource is low and when something is plentiful that is the natural reaction. So there clearly will be an issue in building a case to persuade the general public and to a larger extent to the developers of the merits of RWH to need to send that out. It will be in terms of the reduced cost for households that are using this kind of technology which have to be offset against their initial investment cost. S,o there is an argument there, but water charges are quite low in Scotland so there will be I think quite a difficult task, not an impossible one.*
>
> **Manager, Hydronation**

This reason is not far from the truth because as observed from this study, a lot of comments revolved around Scotland being known to have more water resources. In addition, the receptivity to RWH likely to be more accepted in England than in Scotland is Scotland is presumed to have abundant water resources than England and water bills in Scotland are paid as part of the council tax whereas in England it is paid separately. Furthermore, it is paramount to note that only properties fitted with a water meter will benefit financially from RWH systems (Renewable Energy, n.d.) as a result of saving and using less water thus a reduction in their water bills. Households without a meter paying a flat rate for their water will not see much in financial returns on their bills, as the amount of drinking water saved will make no difference to the eventual bill as in the case with Scotland. A stakeholder dittoed this:

> *You'll probably need a financial incentive for people to do it because it will cost them money for them to install. I suppose if you have houses with metering, then you've got an incentive to reduce your water use and then at the very least you would have an incentive to use something else other than the garden.*
>
> **Specialist 2, SEPA**

But in Scotland, most of the houses are not metered and those who have meters in their homes pay for it themselves therefore it is not an enough incentive. Moreover, the assumption that Scotland has "abundant water resources", and the "non-payment of water" makes it less financially appealing to participants and this could be attributed to why a majority of participants (66.7%) felt it would not be financially beneficial to them. Additionally, comments from residents surveyed:

> *We pay a fix rate for water so don't think RWH will be financially beneficial in my house*…**P56, ED**
>
> *In terms of reducing my water bill, it wouldn't*…P20, AS
>
> *Having RWH in my house won't be financially beneficial to my house since I have private water supply*…**P29, AS**
>
> *Will you consider RWH if it will reduce your water bill? ANSWER: no water bills*…**P78, HL**

…further validated the reason a relatively high percentage perceived RWH was not at all financially beneficial to them and their household.

The perception that water is free and abundant in Scotland is not just limited to only households in Scotland. Likewise, according to some stakeholders in Scotland:

> *Still some folks believe water is free in Scotland. It's a historically sort of position that we have always been in by the fact that water charges are being incorporated in the council tax. I know various way we are trying you know to up the customer perceptions through social media. Every year we get these leaflets through the door explaining exactly the charges, so whether they read it or not yea, it's one of the incremental things you know.*
>
> **Policy Adviser, Scottish Water**

Thus, it seems stakeholders think so too so it is challenging and may take a while for people in Scotland to actually see RWH to be financially beneficial even if implemented. However, some stakeholders aware of the perception have done a couple of research to create awareness. A stakeholder expressed they had done quite a lot of research to create awareness:

> *And actually, the awareness rate of the fact that people do pay for water and sewerage treatment is a lot higher is now certain to be 80%. So now that awareness is there. More people are now aware; I think there is a higher realization of that.*
>
> **Water Policy Analyst, CABS**

This response can be attributed to the reason those on the mains perceived to a higher extent as compared to those on the PWS that RWH will somewhat (41.2%) and to a great extent (11.8%) will be financially beneficial to them and their household (Figure 6.7). Furthermore, some participants in Edinburgh expressed that:

> *If water rates were reduced, RWH will be financially beneficial to my house*...**P116, ED**
>
> *I will consider RWH if it will reduce my water bill*…**P77, ED**

Some stakeholders however were of the view that for households to see the financial benefits of having a RWH system, it had nothing to do with Scottish Water but rather on the perception of householders understanding on how the charging system worked in Scotland:

> *The only thing that the issue that I see coming is, and it's not Scottish Water issue, it's very much about the perception and the experience of the householder is that our charging system.*
>
> **Policy Adviser, Scottish Water**

Therefore, the interviewee perceived it will be challenging to identify who is on RWH for it to effectively be financially beneficial since water bills are not linked to individual use:

> …*and will not be able to pick up if somebody is on a RWH system and adjust the charges. In Scotland at the moment there is a charge that is banded by rate through the council tax. So, that's how we receive our charges, it's not linked to the individual's use. So therefore, in order to provide incentives, from first perspective, if I put in a RWH system and I was half of my water usage I would be expecting to pay Scottish water less.*
>
> **Policy Adviser, Scottish Water**

Alternatively, two stakeholders expressed that:

Rather than linking it directly to the bill, it's just better to communicate to people that you know, in terms of the cost that you will pay for your water, there are higher than they will otherwise be.

Director, WICS

I think that the biggest factor will be Scottish Water to start charging people. I think that will be the tipping point really.

I think it will get to a point that Scottish Water start billing people separately for it, then a lot of people will say, right if we are paying a lot of water from the mains, and then we will start using RWH

Business Development Manager, GRAF UK

It was also discerned that the perception of abundant water resources in Scotland and non-payment of water bills were not the only reason, some residents surveyed were either indifferent:

How it is paid for does not influence me…**P8, AS**

Or they were not directly bearing the cost for their water supply:

Cost of maintaining current supply paid entirely from "farm" accounts. Currently water costs me absolutely nothing personally…**P50, AS**

With regards to these comments, it is further observed that there is a potential for RWH if households perceive it to be financially beneficial. A minority of households felt RWH was financially beneficial:

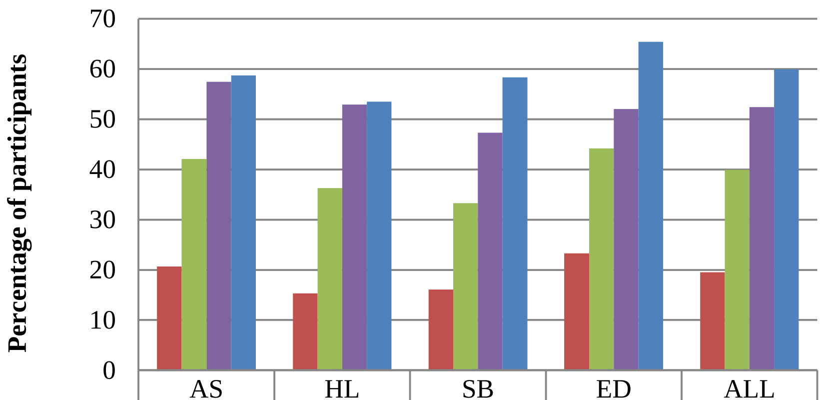
Rainwater harvesting is already in use in my house and to a great extent it is financially beneficial to my household and implementing it for domestic purposes…**P13, AS**

RWH (i.e. our water-butts) are beneficial for when our water supply runs dry (this is less often than once in a year) …**P35, SB**

Therefore, for RWH to be financially beneficial to households as observed, households should be able to see the financial returns on their bills. Without that, it will be nearly impossible and might not seem tangible to householders to invest in RWH if there were no gains in it.

6.3.2 Likelihood of adopting RWH

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. The survey asked householders under what circumstances would they be likely to adopt/implement RWH. Just over half of participants were willing to implement RWH if it was paid by their Local Authority (59.9%) and if they were given grants (52.4%) (Figure 6.8). Only a minority of respondents (19.5%) were willing to fund RWH themselves. In individual areas, it followed the same parting in descending order: Local Authority, grants, community, and you (Figure 6.8). Comparing households on PWS and MWS, responses were relatively similar. In both households, over half of the participants were willing to implement RWH if paid for by the Local Authority and were given grants except Scottish Borders. I Scottish Borders only 47.3% (Figure 6.8) were willing to also implement RWH if given some form of grants. Edinburgh had the highest responses (65.4%) with regards to the Local Authority paying for RWH implementation. In Aberdeenshire and Highland, response from participants was similar in terms of RWH being paid for by the Local Authority and being given grants (Figure 6.8).



	AS	HL	SB	ED	ALL
You	20.7%	15.3%	16.1%	23.3%	19.5%
Community	42.1%	36.3%	33.3%	44.2%	39.9%
Grants	57.4%	52.9%	47.3%	52.0%	52.4%
Local Authority	58.7%	53.5%	58.3%	65.4%	59.9%

Figure 6.8: The inclination towards RWH implementation as answered by participants if paid for (How likely will you use RWH if it was paid for by the following people)

According to a stakeholder:

> *All these things cost money, the incentives and finance are the key things here.*
>
> **Director, WICS**

…And overall, it was realized that householders showed a clear preference for some form of grant either from a Local Authority (60%) or personal grants (52%) (Figure 6.8). This result corresponds to research by Ward *et al*., (2011); Islam *et al*., (2011) and Parson *et al*., (2010), where participants were willing to implement and or consider RWH if the government provided some incentive in the form of subsidies. According to a stakeholder:

> *You can have the government financing housing associations or local authority's properties to go in and do a retrofitting internally on the properties. I think if you are waiting for people to do it voluntarily, you may have to wait a long time.*
>
> **Water Policy Analyst, CABS**

Therefore, people need to be incentivised before they will be willing to implement RWH and this is observed where approximately 20% of householders (Figure 6.8) were likely to implement if paid by them. Further research in the UK shows financial and economic constraints have been a barrier to the installation of RWH in new houses and will remain until governmental incentives are introduced (Parsons *et al*., 2010). Therefore, it is not surprising that respondents are willing to implement RWH if grants are given. However, per one stakeholder, it might be quite challenging if funds are to come from Local Authorities.

> *I think they are not insurmountable but there are considerable challenges at the moment in the current environment and it is very hard to see a local authority unilaterally introducing a scheme to support RWH because of the same local authority finances at the moment. So, I think it is extremely challenging and I'll say I don't think as an issue it is sufficiently recognized as a problem in the agenda that will catalyse the partners coming together, so we really need to develop a scheme to support RWH, it is just not at that point. So, I will be pessimistic about the chances of a funding package developing anytime very soon to support it.*
>
> *Potentially if the local authority is convinced that RWH is the best way to go, then there might be grant money by also improving the RWH system or that that will go in for a new system. But I doubt that most local authorities will sort of encouraging the own and the use of the supply to actively seek other options before going on that route. So, it is unlikely we wouldn't support some financial money being financial support being made just for RWH. But if it is the only option, then it will be money to improve that.*
>
> **Manager, Hydronation**

…as expressed by the stakeholder. This comment is understandable especially if the government has not done any feasibility studies on RWH in Scotland to know both the financial, social and environmental benefit of implementing RWH. But RWH installation could be linked to planning permissions as has been done in some bits of the US e.g. in California in the USA (The California Rainwater Capture Act of 2012; 2013 California plumbing code). New apartment has to save water so RWH has been incorporated into new builds and old builds are encouraged to install water saving devices.

Also, the former interviewee thought RWH was:

> *An interesting area, I mean, and what do we want as a nation? We want to maximize the value of our water resources so that means a lot of different things, that means squeezing every aspect of financial value of the resources and that may very well mean deflecting pressure on the system rather than extracting and pumping water as a cost associated with that and using RWH will have an impact.*
>
> **Manager, Hydronation**

So, although it is an interesting concept and might reduce the cost on pumping water, has research in Scotland actually proven that and is it financially worthwhile even if socially acceptable? There is lack of data that supports the possibility of reducing the cost of water pumping in homes and the cost must be calculated to understand the cost and benefit analysis before perhaps grants are given. The financial cost and the returns should be beneficial both to the government and householders for it to be effective as has been done in developed countries like Germany, Australia and U.S.A. *(Parsons et al*., 2010). As noted by the same interviewee:

> *You are thinking in cost terms for households. But there is a cost, there is investment cost there and we will like to see the calculation because I think that's what people will look for, they will look for a return in their investments, much the same way as they do with photo-voltaic panels. People will look at how much will this cost. They understand, you know the climate change context under which they are investing it without necessarily knowing the details. So, they would want to know how much does this cost, how quickly does it pay back? And I think the difficulty with water harvesting would be that the payback will be a very long time indeed and perhaps you are only looking at people who think it is the right thing to do and have got a disposable income to make that change. So, I think:*
>
> *a) It's a big hurdle to get over, why the "a" it doesn't feel like there's a big financial gain to be made.*
> *b) It is inconvenient and you have to whatever it is that you do, is to stick a tank on a roof or in the garden or whatever and I have to pay for it all myself. And might consider if there was a small grant available but even so, you it's still going to take 15 years, 20 years, I don't know what the payback will be, it will depend on your usage. But we are talking largely about domestic here and I think that is a long term.*
>
> *So, I don't think people see that as a very attractive preposition financially, so they are going to be have to be based and made on different grants of this is responsible thing to do. That may appeal to people's civic duty.*
>
> **Manager, Hydronation**

This confirms the need for a research to understand the social, financial and environmental benefits of RWH.

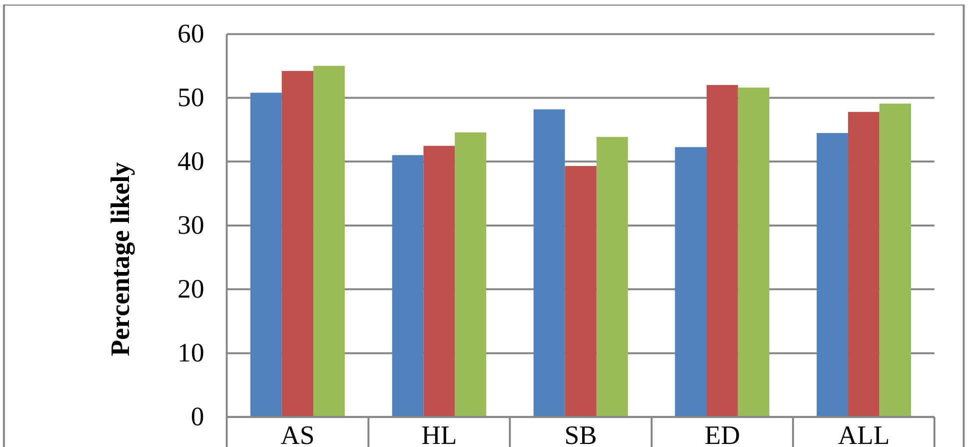
Although water stakeholders strongly felt it will be challenging for local authorities to finance RWH in Scotland, new regulations and incentives that foster the use of rainwater are increasingly being developed worldwide by governments at both the local and regional levels (Domènech and Sauri, 2011) 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*., 2005; Ministry of Urban Development and Water Supply Sri Lanka, 2005; Environmental Agency UK, 2008; Domènech and Sauri, 2011). 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, 2005); 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 (Australian Government, 2009) and in Germany where rainwater harvesters are exempt to pay storm water taxes (Hermann and Schmida, 1999). Aside rebates in Germany, a stakeholder expressed that:

> *In Germany I think they said that the cost of water in Germany for private households is double what it cost in the UK on average. And for commercial uses it is four times. Now once the water cost twice as much as it does in this country or four times as much, then you are better of collecting it on your own, investing in the equipment you need to do that and using it rather than tap water because it is cheaper. So, those are the drivers for using RW in Germany*.
>
> **Director, UK RWHA**

Rebates are offered in the UK, but only in England and the amount of the rebate is very small and almost no one takes it up. Therefore, householders were asked what form of grant will likely make them to implement RWH.

A relatively high proportion of participants: AS (55%) and HL (44.6%) were likely to implement RWH if a grant was given annually. However, a relatively high proportion of householders in SB (48.2%) preferred only a one-off grant and in ED (52%)

preferred a monthly grant, if a grant was to be given to implement RWH as compared to an annual grant (Figure 6.9). It should be noted that in ED, a monthly (52%) and an annual (51.6%) grant was relatively similar (Figure 6.9). However, in all the study areas, it was realized the proportion of grants householders preferred were relatively similar. Furthermore, it was only in SB where a relatively few people (39.3%) were likely to implement RWH if given a monthly grant as compared to all the grants (Figure 6.9).



	AS	HL	SB	ED	ALL
One time off	50.8%	41.0%	48.2%	42.3%	44.5%
Monthly	54.2%	42.5%	39.3%	52.0%	47.8%
Annual	55.0%	44.6%	43.9%	51.6%	49.1%

Figure 6.9: The different forms of grant likely to be taken by householders for the implementation of RWH (How likely will you use RWH if it was paid for by the following)

Comparing individual areas, Aberdeenshire had the most willing responses with regards to grants (just over half) to implement RWH if given any of the three grants were given. In Edinburgh, more than half were willing to implement RWH if they were given a monthly and an annual grant. Although participants were willing to implement if some form of grants were given, in Scotland, compared to England where some form of rebates is given; there are no known financial incentives for the uptake of RWH. According some stakeholders in Scotland:

> *I think you'd have to have a very good look at value for money, you know if you are putting tax payers' money into it especially given that it's not as if councils have a lot of spare money, you'd have to look at whether or not it's financially worth it for the tax payer to be paying that and I don't know what it would be.*
>
> **Specialist 2, SEPA**

> *The one that you have to watch in everything on charging is, it's either some game so the cost of providing their network have to be got from somewhere so the more you put in incentives for people to reduce their cost burdens, so you give them that major benefit from reducing cost, somebody else has to pick up those cost. So, you know, it's all about balance at the end of the day.*
>
> **Director, WICS**

…and coupled with the assumption that water is abundant in Scotland, even though participants were likely to implement RWH if given any form of grants, RWH has to be a top priority and the overall benefits should be understood before such incentives will be given. This was further confirmed by a stakeholder who expressed that:

> *The main driver that you need for everybody to say I'll have the system, yes, I want it, it's either economic, it gives you cheaper water which at current UK prices it doesn't, or if government legislates.*
>
> **Director, UK RWHA**

But there is not any known research that confirms the benefits of RWH in Scotland, thus it will be difficult for the government to see the value in it and implement it. But according to Ward *et al*., (2008), RWH has been identified as having dual benefits and one of such benefit is a storm water detention method to help relieve urban flooding and with Scotland assumed to have abundant water resources, if we are going by the climate change scenarios predicted for Scotland where there will be wetter winters and drier summers it will be worthwhile looking into RWH as a way to reduce floods even though there is the Sustainable Urban Drainage System (SUDS) in place:

> *The issue of SUDS, so there are, you know every new development has to be built with a sort of SUDS.*
>
> **Policy Adviser, Scottish Water**

…as echoed by a stakeholder. Therefore, the benefits for Scotland on a local scale needs to be researched into, and a value assigned to it to make people see the returns if not financially.

Hence as put by another stakeholder:

> *Talking about something like RWH, it's undoubtedly a good thing to be doing for you know for lots of reasons. But you need to be clear about what you are trying to achieve with it so what are we trying to do? Are we trying to reduce the amount of water we take out of the environment, you know and it's that worthy or not, you know it's there an issue with raw water resources in Scotland or not and what are the cost implications because at the end of the day it's all about money.*
>
> **I.C.T., WICS**

Therefore, the value and importance of RWH should be communicated and understood before it can be implemented. Sometimes it will be challenging especially for a country which to some extent has abundant water resources:

> *I think the challenges are changing the way that people think and changing behaviours where they value RWH more than not thinking at all about where water goes once it falls from the sky and once it comes out from people's roofs.*
>
> **Water Policy Analyst, CABS**

…as echoed by an interval stakeholder. The interviewee further felt water was not high up on people's agenda in Scotland and it should be made so through messaging:

> *I think a lot for me is messaging. I think water is not really high up in people's psychology in Scotland because we have so much water and it rains so much and people have very simplistic level of thinking we got lots of rainwater without worrying why we have to catch it from the roof and why can't we just turn the tap on and fill a bucket.*
>
> **Water Policy Analyst, CABS**

The interviewee felt for RWH to be effective aside the giving of grants:

> *It is changing the way that people see water, it is changing the value hold they have for water. I think a lot of it will need to be done through messaging, education, campaigning and much as the same way we have done for energy efficiency which is also part of water efficiency. And I think without that engagement coming right into people's lounges or living rooms when they are watching TV or radios when they are driving their cars or primary schools, secondary schools, getting them to talk about it, to get projects going, there is a myriad of ways which we can try and encourage behaviours, like documentaries, TV shows, you know get them looking at building and convictions, building regulations which should be promoting water efficient products. In industry, especially, there is huge areas for RWH, for water efficiency, for cost saving, it is basically helping people to understand that yes you may pay your water based on your council tax banding, but the more water that we are actually saving we advise them the less your bill are to go up. So, that it will help people understand those links and that can only be done through education.*
>
> **Water Policy Analyst, CABS**

Research in England showed that 70% of participants believed that a higher visibility of appropriate information would increase their receptivity to RWH which perchance may encourage them to consider implementing RWH (Ward *et al.*, 2013). Although it is assumed to some extent that in England they value water much more than Scotland due to some parts being drier and water bills relatively expensive as compared to Scotland (Fitch and Price, 2002), that could be the reason for their inclination towards RWH. However, sometimes, information alone is not enough for implementation to be accepted, there is a need for financial incentives as well. The same research shows that information provision alone is not enough to encourage householders to consider installing RWH systems, other support mechanisms are also required (Ward *et al*., 2013) and this can be in the form of grant incentives. Notwithstanding, some residents surveyed were either indifferent to grants:

> *How likely will you use RWH if it was paid for by the following people: Once it's paid for can't see what difference it makes!*...**P46, HL**

Or were sceptical of the government given grants for RWH:

> *We were very poor. It took ages to save up for water-butts (one at a time). If RWH was paid through a one time off grant, annual grant, monthly grant and the community I won't accept it because I'm very worried of "strings attached" and small print*…**P35, SB**

…nonetheless, a relatively high proportion was likely to implement RWH if any form of grant: annual, monthly or a one-time off grant was given. As echoed by (White, 2010) and (Ward *et al*., 2013) financial matters are a primary factor affecting householders' receptivity to and consideration of installing RWH systems. Furthermore, considering as asserted by a stakeholder:

> *I think if they were funded, then, a lot more people would. I think most people like the idea of it because it's either becoming more eco-friendly and people are looking to save money and save energy and all that. I think probably the biggest factor is the cost involved.*
>
> **Business Development Manager, GRAF UK**

So it will be worth researching into the benefits of RWH in Scotland since it's been known that at present in the UK new policies do make mention of RWH and there has been a small number of change agents who advocate its appropriate use (Ward *et al*., 2013) but speaking to water stakeholders in Scotland, they did not seem aware of any such policies. Maybe these policies are only related to England and Wales.

A stakeholder interviewed on the other hand felt if the government was not ready to give grants; the best way was to legislate RWH as was done in England in 2004 with the now defunct code for sustainable homes (Bell, 2015):

> *Through the code of sustainable homes, that was legislation, they didn't give you any grants but you had to do it anyway as part of the house.*
>
> **Director, UK RWHA**

Or through:

> *Not unless the government does what the Welsh Government has done. If the Scottish government says, you know, that the first priority now to avoid floods, that's everybody's first priority. Floods are very damaging, we don't get many droughts, therefore why worry about it? And the reason we say you should worry about it, is first of all scientist predicting we are going to get more of them in the future, more severity and secondly if we are going to tackle future droughts by installing RWH as part of the solution you need to start doing that now, not in 20 years' time. We are short of water now, because it takes time to build up that plastic, so that is the sort of thinking that's going on now in Wales.*
>
> **Director, UK RWHA**

This might be difficult to implement since an installation of RWH may come as an extra cost to householders and the legislation might not be effective as discovered with the defunct code for sustainable homes in England and Wales which was abolished in 2010. Furthermore, as expressed by another stakeholder:

> As *an organization, we have looked predominantly at people in low incomes and the areas in low incomes is probably not going to go down the route of RWH if there is a cost attached because they will have so many other priorities. So, I think when it comes to income levels you would only hit a success rate with those who have disposable income enough to maybe make certain decisions as to what to spend their money on and may choose if they have got an awareness or environmental kind of view.*
>
> **Water Policy Analyst, CABS**

Hence legislation alone is not effective since some people might not have disposable income to implement RWH if no grants are given. According to a different stakeholder, there needs to be a balance by both the customers and the government:

> *I think there's a balance to be struck between how much you know government is willing to pay towards this, how much are the water customers willing to pay and then how much is the individual water customers is willing to pay. And it's about getting that balance right. And there are different drivers there, I mean at the moment if other than PWS, people who are connected to the mains, there's harmonized charges across the whole Scotland. So, whether or not you are exceeding your water supply, in the West Niles or in Central Glasgow, you are paying, you know based on your council tax really. You are paying about the same rate. Now that inevitably means it's coming across a subsidy because it is far more expensive to provide in rural locations water supply. So the question will be if you then start to bring PWS into that framework should they be paying the cost associated with their particular supply or would you prefer to keep that, you know that link to standardize harmonized charging.*
>
> **Director, WICS**

Since householders on MWS are on a fixed council tax bill for their water, it will be challenging because it is not like England where water bills are visible:

> *In Scotland, the water bill is within with the council tax and people don't realize the chunk of that because it isn't a separate bill so, the attitude they have is that water seems to be free and people aren't aware of it so unless they are actually given a separate bill. Until that point is achieved, and then people won't be bothered too much about RWH.*
>
> **Business Development Manager, GRAF UK**

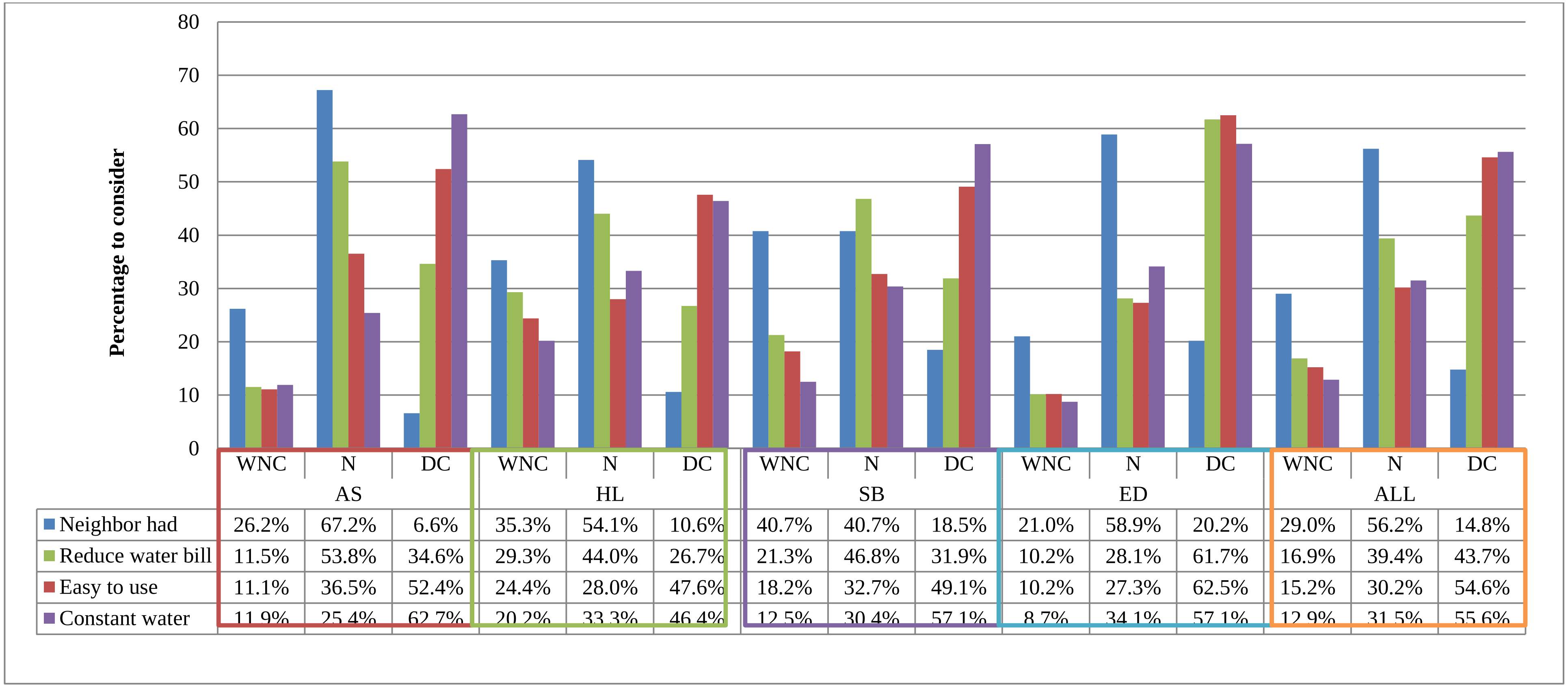
A different stakeholder further reiterated this. So, this all goes back to changing the way people see water in Scotland and having to understand its value before a balance can be struck between customers and the government to effect in a policy for the likelihood of adopting RWH.

6.4 FEASIBILITY AND EASY ADAPTATION OF 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 water bills, or was something the neighbors had. Overall, a larger number of householders were willing to consider RWH if will ensure there was always constant water available (55.6%) and if it was easy to use (54.6%) (Figure 6.10). In individual areas, it varied for instance in Aberdeenshire a relatively high number of participants 62.7% and 53.8% were neutral to consider RWH if their neighbour had it and if it will their water bill respectively (Figure 6.10). They were also definitely going to consider RWH if it was easy to use (52.4%) and if it will ensure constant supply of water (62.7%). In Scottish Borders, quite a number of participants (40.7%) were neutral and will also not consider RWH if their neighbor had it (Figure 6.10). Likewise, if it will reduce their water bill, 46.8% were neutral (Figure 6.10). Quite a number were also willing to definitely consider RWH if it will ensure constant supply of water (57.1%) and was easy to use (49.1%) (Figure 6.10). In Highland, about half of participants (54.1%) were neutral to consider RWH if their neighbor had it (Figure6.10). It was the highest response received. They also expressed they were neutral to consider RWH if it will reduce their water bill (Figure 6.10). Quite a number also responded that they will definitely consider RWH if it was easy to use (47.6%) and if it will ensure constant water (46.4%).

Edinburgh had the highest responses to definitely consider RWH if it was easy to use (62.5%), will reduce their water bill (61.7%) and will ensure constant water (57.1%) as compared to the other areas (Figure 6.10). looking at the results, participants on MWS were more likely to consider RWH. Also over half of respondents in Edinburgh (58.9%) were neutral to consider RWH if their neighbor had it (Figure 6.10). Comparing participants on MWS and PWS, it can be inferred from the results of this study that participants on PWS were more unwilling to consider RWH if:

a) Their neighbor had it.
b) It will reduce their water bill.
c) It was easy to use.
d) It will ensure constant water supply.



	AS			HL			SB			ED			ALL		
	WNC	N	DC	WNC	N	DC	WNC	N	DC	WNC	N	DC	WNC	N	DC
Neighbor had	26.2%	67.2%	6.6%	35.3%	54.1%	10.6%	40.7%	40.7%	18.5%	21.0%	58.9%	20.2%	29.0%	56.2%	14.8%
Reduce water bill	11.5%	53.8%	34.6%	29.3%	44.0%	26.7%	21.3%	46.8%	31.9%	10.2%	28.1%	61.7%	16.9%	39.4%	43.7%
Easy to use	11.1%	36.5%	52.4%	24.4%	28.0%	47.6%	18.2%	32.7%	49.1%	10.2%	27.3%	62.5%	15.2%	30.2%	54.6%
Constant water	11.9%	25.4%	62.7%	20.2%	33.3%	46.4%	12.5%	30.4%	57.1%	8.7%	34.1%	57.1%	12.9%	31.5%	55.6%

Figure 6.10: Would you consider RWH if: Adaptations and inclinations to implement RWH: WNC (would not consider): N (neutral); DC (definitely consider)

The feasibility of RWH primarily depends on the amount of rainfall, the rainstorms type, the length of dry periods and the availability of other water sources, community skills, the availability of local materials and labors (Islam *et al*., 2011). Accordingly, it can be said from the four study areas most respondents were willing to consider RWH if it will ensure there was constant water available and was easy to use. According to (Barthwal *et al*., 2014), 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). 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 (Domènech and Sauri, 2011). And in Canada RWH systems have been used in rural areas for more than fifty years as an alternate drinking water source due to inadequate water supply or contamination of their groundwater in Nova Scotia (Parsons et al., 2010a). This can be attributed to the response of participants willing to consider RWH if it will ensure there was constant water was available always.

In Aberdeenshire on the other hand, there was a relatively high percentage, approximately 63% compared to the other study areas that were definitely going to consider RWH if it would ensure constant water was always available. This was because according to an interviewee from the Aberdeenshire council, PWS users in Aberdeenshire normally do not have enough water in summer:

> *This is the time of the year that we see the most failures on supplies as far as drying up because it will have gone through the summer and now they have probably had 4 or 5 months without too much rain in normal years, this year has been a bit different. But September is when people are absolutely desperate for water. The difficulty with any of these things is once you get a PWS drying up, there is no guarantee that when the rain comes that will start up again.*
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Therefore, it was not surprising that there was a higher percentage in Aberdeenshire who would definitely consider RWH to ensure constant supply of water.

Interestingly, among PWS users, consistency of supply was more important to them than the cost of reducing their water bill. Those on PWS assume they do not pay water bills so to them consistency was more important. For instance, a relatively high number of participants in Aberdeenshire and Scottish Borders were more willing to consider RWH if it will ensure there was constant water supply than reducing their water bill (Figure 6.10). This was contrary to those on the MWS who perceived reducing their water bill was far more likely to push them to consider RWH. According to a stakeholder:

> *We have done quite a lot of research and actually the awareness rate of the fact that people do pay for water and sewerage treatment is a lot higher is now certain to be 80% so now that awareness is there. More people are now aware; I think there is a higher realization of that.*
>
> **Water Policy Analyst, CABS**

This can be attributed to the reason householders on the mains are highly more to consider RWH (approximately 62%) if it will reduce their water bill, indirectly reducing their water bills which are paid with their council tax bill. It can be observed that the realization that water was free in Scotland was not the case for those on the MWS. Furthermore, PWS showing a preference for constant water supply instead of reducing their water bill 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. And it should be noted those on the PWS were in rural and peri-urban areas and were not paying water and sewerage charges as part of the council tax bill whereas those on the mains were in the city and were paying sewerage and water charges thus the differences in their response. Not to mention, research has shown that metered customers tend to benefit more from a reduction in their water bill, since they receive a water bill and thus see the direct benefits of paying for the lower volume of mains water used and subsequently a reduced sewerage charge (Butler, 2010). According to (Ward *et al*., 2010), those not on meters can benefit in some water company areas, which have revised surface water drainage charging arrangements, but this I believe might be limited to England since there is only one water company in Scotland, Scottish Water.

Moreover, apart from ensuring constant water and reducing their water bills, householders are more likely to consider RWH if it was easy to use as compared to their neighbour having it. Per Ward *et al*., (2011), "…*mainstreaming RWH as a concept is not that difficult to achieve - a large number of people have water butts in their gardens. What is difficult to achieve is the mainstreaming of the concept of* *implementing a system to supply rainwater into buildings*". RWH system should be feasible enough for householders to adopt, according to a stakeholder:

> *Well anybody that has a garden could have a water butt so it's clearly feasible on some scale. Whether is feasible on a large scale, or, you need quite a lot of space so you know how feasible will it be, say you had a block of flats with no communal garden. How feasible will be that, I am not sure. I suppose you could have tanks, I don't know feasible it will be to fit it retrospectively. I suppose it should be feasible in new builds, it should be, and then you could build it in as part of the building. I don't see an issue with it in any particular part of Scotland; it's more to do with volume. And if it was going into the actual water supply, then you have got a whole issue of treatment*.
>
> **Specialist 2, SEPA**

Additionally, research has established that perceived ease of use is an important factor influencing user acceptance (Venkatesh, 2000). A householder on a PWS who commented strongly felt the ease of use was important and was willing to pay an extra cost to get water:

> *Currently we have a very good water supply but if we were likely to be short of water we would certainly consider RWH but ease of use would be important in determining how much we would use it. If water supply was inadequate, would then be prepared to pay some / all of costs ourselves*…**P45, HL**

Therefore, if householders were to implement RWH, they need to understand how it works and it should be an easy system for them to use and technically efficient, so that it will deliver or perform the anticipated functions. Thus, participants were not far off when they perceived they were more likely to consider RWH if the system was easy to use.

Although most participants were not likely to consider RWH if their neighbour had it, it is observed that a relatively high proportion of participants are neutral, overall approximately 56%. It is observed from comments that most of the houses in Aberdeenshire, Scottish Borders and Highland had no neighbours or their closest neighbour was far away:

> *I would not consider it because I am not close to a community to be feasible"; "our house is in remote rural area with relatively distant neighbours; "nearest neighbour is 1/2 mile" and "our supply has to be individual. There are no other properties within 1km*…**P20, AS**

However, some participants who had neighbours felt it were irrelevant and it was also impossible for the community to have RWH. The latter can be as a result of some participants expressing lack of knowledge on RWH and thus might not have known the feasibility of having it on a communal scale. According to Goyal and Bhushan (n.d), community-based RWH is the paradigm of the past and there has been successful communal RWH in India and still effective. Whereas in Edinburgh participants felt because they lived in flats it was impossible to have a community water supply for flats unless the government supports it:

> *I think that RWH should be implemented with community effort and government's support. Especially for people, who stay in flats*…**P19, ED**

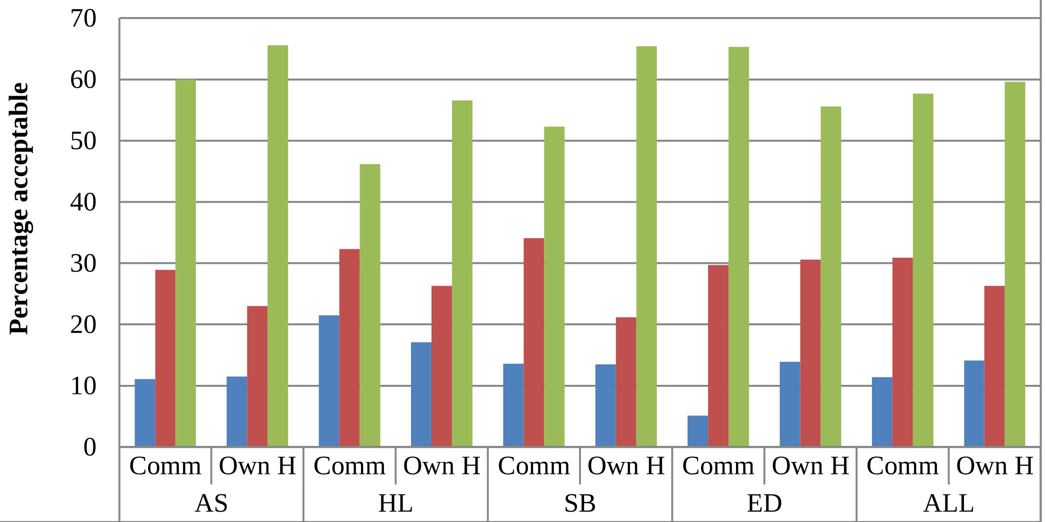
Furthermore, another householder in Edinburgh expressed that:

> *Living in a block of new build flats, I would be happy to use a RWH system whereby a collection unit served the entire block - is this something that is/ could be written into planning conditions for house builders to provide...***P96, ED**

However according to a stakeholder, that would involve retrofitting and this will be expensive and not worth it since there was no financial returns but for new builds coming up, it was highly possible.

6.4.1 Preference for community or individual

The social identification assumption assigns the individual within a group, by trying to determine how an individual will function and relate to 'their' group (Ward *et al*., 2013). Therefore, as part of the questionnaire and to test if a communal RWH development was feasible, householders were asked if they preferred a system for their home only or on a communal setting. Overall, a relatively high proportion found it acceptable for a RWH system in their own homes (59.6%) but it differed between PWS users and MWS users (Figure 6.11). It was observed that although majority (59.6%) found a system for their house more acceptable, it was relatively similar to those that felt having a communal RWH (57.7%) was also acceptable (Figure 6.11). There was a slight difference between PWS users and MWS users; a relatively high proportion on PWS preferred a system for their household whereas a relatively high proportion on the MWS preferred a system on a communal scale (Figure 6.11).



	AS Comm	AS Own H	HL Comm	HL Own H	SB Comm	SB Own H	ED Comm	ED Own H	ALL Comm	ALL Own H
Unacceptable	11.1%	11.5%	21.5%	17.1%	13.6%	13.5%	5.1%	13.9%	11.4%	14.1%
Neutral	28.9%	23.0%	32.3%	26.3%	34.1%	21.2%	29.7%	30.6%	30.9%	26.3%
Acceptable	60.0%	65.6%	46.2%	56.6%	52.3%	65.4%	65.3%	55.6%	57.7%	59.6%

Figure 6.11: The preference for communal RWH vs own house RWH: Comm (community); Own H (own house) (Would you prefer a system for just your house or one for your community?)

Communities according to Oxfam are most at times excluded from important aspects of environmental management although they can play a vital role in the management of their water resources. It was observed that a relatively high proportion preferred a communal RWH. In relation to this result, as noted in Section 4.6 and Table 4.7, where some PWS users were not treating their PWS, and could not be put on the mains, a communal water system can be set up since participants showed a preference for a communal system.

> *There are some of the people looking at community solutions to PWS. They are highlighting the fact that, your solution can be much lower cost if you use RWH, water recycling or any of these measures because at the end of the day you have a limited resource within a community and so you have better use that resource. So, if you come up with that mind-set, that this is part of a community solution to providing water, and then you know that is, I think that is where we will find more attraction.*

This was echoed by a stakeholder interviewed in terms of communal RWH. According to Cook *et al*., (2009) in addressing the global issue of sustainable water use, providing water on a localised scale is simple and economically feasible. Thus, treatment of PWS on a communal system can be rudimentarily cheaper instead of trying to put them on the mains. Also, per the same stakeholder:

> *Where you've a community, particularly one that is on a PWS that you are looking to bring up to a standard, then it could might have a role in there as well, you know as a way of ensuring that community can get the cost-effective supply. You know, the idea that you treat it to drinkable standards all the water you are using in your house is strange. But given that you know, that's the way the houses have been designed, you know retrofitting is a big issue.*
>
> **Director, WICS**

Again to some extent, especially for communities that have their PWS drying out during the summer, it was perceived for RWH on a communal system by an interviewee to serve as a supplementary water supply and also take away the pressure on their PWS:

> *Yea I think RWH for little communities in particular that use PWS resources would take the pressure of their actual PW supply.*
>
> **Water Policy Analyst, CABS**

Furthermore, it's been known that alternatives to the centralised water distribution system are receiving renewed interest in both new and existing building developments and can be decentralised as RWH systems in individual buildings or communally between buildings (Ward *et al*., 2012).

Research by Bruvold *et al*., (1981), on the other hand identified that communal projects that were presumed to be appropriate by engineers and other technical personnel, may not be similarly accepted by a neighbourhood or community. For the success or failure of a community based RWH programme, it will depend on consulting the inhabitants of the community and designing a programme that they see align with their needs (He *et al*., 2007). In this research for communal RWH to be successful for those on PWS, it was not based on the RWH design aligning with participants need but rather them not having a neighbour or the nearest neighbour being far away. Whereas for those on the MWS, they felt their buildings were not designed properly for RWH since majority of them lived in flats (82.6%; Table 4.1; Figure 4.9). Therefore, it is very difficult to conclude the sole preference of householders on the unacceptability for a communal vs an individual RWH system.

6.4.2 Regulatory and non-regulatory barriers

It was observed participants were not keen on RWH due to their living conditions and or the kind of house they lived in. In Table 10, it was recognized majority of householders in Edinburgh (82.6%) lived in flats as compared to those on PWS who lived in detached houses (83.3%; Figure 4.9). Not only that, some participants approximately 22% (Figure 4.8) from both the PWS users and MWS lived in rented building thus they felt it was not up to them to decide on RWH if they were even willing to do it. They felt it was up to the landlord to decide on implementation of RWH. Householders gave various reasons like:

> *RWH is not possible as we live in a high-rise block of flats*…**P100, ED**

> *We live in a flat that is rented so have little control on implementing RWH*…**P50, ED**

> *Main difficulty/barrier to implementing RWH would be that it would need to be landlord's decision, not mine. If I owned my own property my answers to would be different*…**P20, ED**

> *Extremely unlikely because it is rented from a private landlord who owns springs. If I owned such a property answer would be different*…**P29, AS**

…as to why they were unwilling to implement RWH even if it was easy, ensure constant water, grants were given. Moreover, it has been known that to improve water efficiency in existing buildings through appropriate refurbishment, there will be a significant challenges to implement sustainable water management measures such as RWH (Ward *et al*., 2013). Thence stakeholders were asked about the regulatory and non-regulatory barriers that might affect the adaptation of RWH in Scotland. Not only that, they were also asked if they perceived buildings should be mandated if ever there was a policy change in Scotland to have RWH as suggested by an interviewee who felt RWH should be included in new builds to help reduce flooding as done in Wales. This was because extensive research in England on RWH by Ward and Butler, (2011), assess that cost-effective policy development could overcome the barriers to the comprehensive adoption of RWH in the UK.

Several stakeholders interviewed expressed diverse opinions on the potential regulatory and non-regulatory barriers of RWH in Scotland. They perceived that it will be challenging with the absence of incentives, non-existent institutional and regulatory policies for RWH systems and house-builder attitudes towards it:

> *So, campaigning has started but I think it needs to be joined up with government policies, with building regulations, with Scottish Water messaging, with school projects you know we need a national strategy for water efficiency and things like RWH which at the moment we don't have*.
>
> **Water Policy Analyst, CABS**

The lack of information and knowledge, economic and financial constraints, absence of incentives, institutional and regulatory gaps, house-builder attitudes have been known to be the key barriers that affects the possible uptake of RWH (Suzenet *et al*., 2002); and this confirms with what was expressed by some interviewees on the non-existence of legislation and regulation:

> *I think legislatively to my awareness there is nothing in legislation at the moment that would categorically state you have to implement a water butt or something to harvest rainwater. I think within industry I certainly know that through the water efficiency works that some organizations are saying right okay, if we are buying a large amount of water from our water service provider every year, how can we maximize its use? For companies on the mains water supplies it will raise the awareness of it because they get huge bills every year*.
>
> **Water Policy Analyst, CABS**

> *There is no current regulatory regime that I am aware of it supports for RWH. There's no real barrier to developing one provided that the political will is there and I think that is the essential point I want to get across that we support in principle but it is not far up on the political agenda. If ministers turn around and say (quotes name), what are you doing about RWH, that changes everything. But they are more likely to say what are we doing anything about RWH, if not why not, you know and this we would have to consider the case. So, you know there's a good governance regime in Scotland that could be made to work together to support a policy around this area, there's no problem there. It is just getting the issue in front of people that's the challenge*.
>
> *Probably not very good for a review. The regulatory regime in Scotland is, I think we have a strong regime which comprises the Water Institute Commission of Scotland, the Drinking Water Quality Regulator, and consumer's advice Scotland and each of these three independent bodies are there to ensure the quality and continuation of supply treatment in Scotland for mains and private supply. And those bodies who will have a view on any scheme along with the Scottish government are to support RWH provided you can get the regulatory, and we have a good relationship, I should point out, and all of those and there is an ongoing dialogue between those partners and they all speak to each other all the time and I think that's what is needed if you were to devise a scheme. Even there is nothing to stop; if I say there is nothing to stop I mean I am not aware of any reason why an individual you couldn't decide to harvest your own RW. Undoubtedly somebody will be doing this*.
>
> **Manager, Hydronation**

However, in other countries, RWH policies have been put into place and are specifically formulated to encourage the capturing and usage of rainwater in certain specific regions of countries and have been successful (Kganyago, 2012). As well, policy instruments has been known to be an effective method to achieve a specified policy and thus prospective relevant policy instruments might include the introduction of water recycling schemes to encourage conservation (Jeffrey and Seaton, 2004).

On the other hand, in Scotland, there is no such policy. Due to the non-existent of policies and regulations, stakeholders felt for RWH to gain grounds in Scotland:

> *There needs to be some policy decisions and changes to the obstruction idea and well without changes to our scheme charges and the way that we do things it's not an easy thing to do. It's not an easy thing to change those; it's not as if it will require major policy change in order to do it basically.*
>
> **Policy Adviser, Scottish Water**

However, this comes with challenges unless the policies are applied to upcoming new builds only since retrofitting old builds might be expensive and then comes the challenge of who finances the cost:

> *The only ones on domestic will probably be new builds, so people are building new houses and they'll be looking at the future if they put it in just now then, that's it and the cost if they do not. But personally, we've had very few in Scotland approaching us saying I want to put RWH in my existing house.*
>
> **Business Development Management, GRAF UK**

…as echoed by a stakeholder. But for new builds, it was observed it will be relatively cheaper to install RWH than to retrofit in old buildings:

> *I still think initially it will be much more likely to work in the new builds. I was thinking about my house how it can be retrospectively fitted. You know if you've got houses with relatively old plumbing and you need a geo plumbing system, wouldn't you? So, the toilet flush, I mean the whole issue of watering the garden I think it's very straight forward one but once you get beyond that it's going to be quite expensive to put in any kind of retrofitting so that point I can't imagine people doing it. Unless there was a financial incentive and I don't know why, the main reason from financial incentive will be in areas where the alternative was that the mains supplier was going to need a new source of water. I suppose then it would be down to Scottish water to promote it, wouldn't it?*
>
> **Specialist 2, SEPA**

Even so some water stakeholders in Scotland were supportive of retrofitting through giving incentives. One stakeholder is quoted as:

> *I think sometimes there is a carrot stick approach; the stick being harder measures like legislation and the carrot being going to retrofitting your house or here is a free water butt, stick it under your drain pipe; that kind of thing. I think you need both to be honest.*
>
> *I think there are probably a few elements in there and one of them is retrospective adaptation of existing premises and facilities that it has. You can give someone some amount of money to go get a geo-flush toilet in their house if they have got an older property or water efficient fixtures fittings into place or a toilet that uses RW to flush; these are adaptation methods or you can have government financing industries to basically manufacture these things.*
>
> **Water Policy Analyst, CABS**

Likewise, the same stakeholder expressed that

> *I suppose there are new building regulations coming in that are focusing on water efficient projects and or retrofitting, that kind of thing. But I think the barriers at the moment are: it is not promoted, like putting an advert on television or linking it to a nectar card that they might have on home base and home base period to a certain number of points (numbering points), or give them a water butts. So, I think it is looking at how you incentivize people to engage with it.*
>
> **Water Policy Analyst, CABS**

Financial and economic constraints are perceived to a larger extent to impede the installation of RWH systems in new UK houses and will remain until governmental incentives are introduced (Parsons *et al*., 2010). However what sound feasible and will be less challenging to do is implementing RWH in new builds instead of existing ones, but still there is the cost-benefit analysis factor to consider how feasible and financially rewarding it will be in Scotland. In addition, a stakeholder expressed that:

> *Personally, for me RWH must come from a governmental directive so it needs to be for all these new house builds that are taking place, it needs to be something for them, the developers that say this is the standard you need.*
>
> **Sustainable Rural Communities, Scottish Water**

Not only that, another stakeholder felt for it to be part of the government's directive, managing rainfall immediately it falls was the key way to legislating RWH with new builds to encourage uptake of RWH systems instead of using water shortages scenario. This is quite true because convincing householders and building developers will be challenging if using short water scenario when Scotland is assumed to have unlimited water resource:

> *Just focusing on water shortages was not the way forward, particularly as so far there hasn't been great evidence that there are water shortages. One has to think more in terms of managing rainfall in the first instance to avoid floods because we have had plenty of floods and then whiles doing that, to take into account what the scientist are saying is you might not be short of water now but you will be in the future. And therefore, whatever you do, think about both aspects of rainfall when you do anything. Because what we don't want to do is spending 10 years tackling floods in a way, then that exacerbates water shortages.*
>
> **Director, UK RWHA**

The interviewee further links it to examples in Wales which was implied by the interviewee to have been successful and compares the scenario to England believes that should be the case for Scotland:

> *Now the Welsh government are entirely on top of this and so they say the way their logic, their rule goes is when you put up a new building you've got to make sure it doesn't add to the flood risk. The number one way of not having flood risk is to capture the water and reuse it. Now I have a set of rules for RWH which is a very far sighted thing for them to do because Wales has loads of water compared to South-East of England and it's got very few people. So, of all the countries, they are the least likely to suffer from water shortage. Wales are pretty well up on the list. But nevertheless their no. 1 way ahead of tackling flood avoidance it is to collect and use it. And there are other ways to do it as well. In England, that doesn't apply, which is stranger because we are short of water and we are highly populated so it is very strange. So, when you transfer it to Scotland, I think the dynamics there are slightly different, I would have thought that generally speaking they are more like Wales than England. In other words, they have got plenty of rain and they have got a relatively small population so there are unlikely to be short of water". The interviewee strongly believes for Scotland, "so what you will need for Scotland to get excited about RWH would be for them to take the same view as the Welsh government does, is now we are not interested in RWH but we are interested in avoiding floods and while we are avoiding floods, why don't we use the water instead of wasting it.*
>
> **Director – UK RWHA**

But research shows that UK housing developers have been known to exhibit a resistance to include RWH within development plans due to economic and financial constraints, absence of incentives, technical knowledge and the attitudes of the house builders themselves (Parsons *et al*., 2010).

> *So there was a period between 2004 and 2010 when the government did have a legislation in place that encourage you to install RWH when you are building a new home or when you are building a new commercial premise and that legislation was from an organisation called BRE, the British Research Establishment who published standards, one was called the Code for Sustainable Homes and the other was called BREEAM for commercial buildings and anybody building to those standards needed to economize water and the easiest way of doing that was by installing RWH. But in this country, England where we sit now, Government has backed away from that because the house building industry has managed to persuade the government that it all too difficult, we won't build houses if you make us do it.*
>
> **Director– UK RWHA**

And this was communicated by the same stakeholder to be one of the reasons housing developers were not in support of RWH. Not only was that, but the cost of installing RWH was not financially beneficial and appealing to house builders as echoed by Parsons *et al*., (2010) and Suzenet *et al*., (2002) and further asserted by the previous interviewee that:

> *Well you have got to buy it, it's you know, so yes if you have got to buy something it's going to add the cost, isn't it? So, the house building industry persuaded government that they never built houses if these expenses were added in. So, the government in this country has withdrawn any motivation to install RWH and therefore it is absolutely a personal thing you find commercial companies will be saying, ah well we have got our environmental credentials and therefore when we build our new headquarters we will put it in there. And you will find some of what we call self-builders, people who are having their own house built; they say oh we want all the environmental features so they have it in. But the people buying large who build properties, they build in the house building industry don't put them in it and there's nothing that says they have got to.*
>
> **Director, UK RWHA**

And

> *Well there are big financial barriers to RWH. So, the cost of building it depends upon the standard to which it is built and obviously, customer phasing aspects of that: of a nice bathroom, from a nice kitchen, nice garden; they see that as a sound investment because that will encourage people to buy. But things, like if a customer isn't concerned about where the water comes from, it doesn't matter to them whether it comes from a RWH system or a tap. And if it is going to cost Winnipeg £2,000 to put it in, and doesn't affect the selling price because the customer doesn't say, well I'll give you an extra £2,000 for that, then that £2,000 of profit disappears for the house builder and so the house builders quite naturally don't want to do it. The price of a house is not generally driven by its environmental credentials because most people when they buy a property are thinking well I've just moved jobs, I've got to buy this house, I've got to live somewhere, this will do me, I will only live in it for 4 or 5 years so I don't mind whether it is a particularly environmentally sound house or not. Because I will only benefit, I'm not going to pay a premium for a house that I am only going to live in it for 5 years. So, that has got to be achieved in some other way.*
>
> **Director, UK RWHA**

So, it was observed even though if house builders install RWH in new builds, mostly the cost of installation which as quoted by an interviewee is most at times £2,000 are not profited by the builders. Although house builders might not want to spend an extra cost on RWH for upcoming builds even though it is environmentally friend, maybe what needs to motivate them is research by Mulholland, Research and Consulting, (2004) which stated that "…*87% of new home-buyers want to know how their homes rate in terms of environmental performance in order to make an informed purchase decision with 48% regarded water efficiency as an important factor*"; in (Parsons *et al*., 2010).

Not to mention, it was noted that there is the possible problem of cross contamination between RWH systems installed in houses and the regular tap water. A stakeholder expressed it had happened in England before:

> *There is a kind of tension to the regulating in England because there were illegal cross connection between the two systems. So RW was getting something into the drinking water system and there were microbiological found in that as a result.*
>
> **Operations Team Leader, DWQR**

Thus, in terms of regulation if such a thing should happen, householders might not be aware and therefore cross contamination was perceived to be a barrier in addition to retrofitting, financial incentives, technical adaptations, and the attitude of builders to RWH implementation in Scotland. Ward et *al*., (2013) echoed this and further recognized that structural changes to buildings to accommodate RWH systems can have implications for water user behaviour, as well as the water-using practices. Furthermore, according to the UK RWH Association, when using RWH systems, a separate pipe work is needed in order to avoid potable water and non-potable water coming into contact. A householder might mistakenly use a switch for RWH for regular potable water use thus creating complications and might have to be conscious every time they use water. Not only is cross contamination perceived as a regulatory barrier:

> *The biggest thing for us is about disconnecting RWH drainage from the sewer system so where that bit run off from roads, because road drains at the moment typically goes into the sewer. Or from houses where you know, the roof drains into the sewers and the more you can do that, the more you would reduce the cost of the environmental impact of your sewerage system. So, there's quite a big drive, well, in new builds already they've had to have a, you know, a SUDS system, a sustainable urban drainage system.*
>
> **Director, WICS**

…as recalled by another stakeholder. This also comes at an extra cost and leads to the question if RWH is financially, socially, and environmentally beneficial in a Scotland setting.

Not to mention, the charging system in Scotland is another barrier perceived by some stakeholders to hinder the implementation of RWH in Scotland. If a householder is paying a flat rate for water, there is no financial incentive in implementing RWH.

Because all are going to say where is the benefit to me if put on the system. So, majority of them that used to be older houses so you probably need to have a lot of obstruction within the house to put the pipe working, to put the tanking, how do you do that? It's going to be a bit destructive so where's the customer going to see the benefits? They are not going to see any benefit because they are still going to get the exactly the same as what they have. All the benefits that going to be is for Scottish water for whoever it is and it is not necessarily them who is going to benefit and I think a lot of work has to be done to see what benefits can you give to that community or that person that takes this home and that needs to be done high up.

Sustainable Rural Communities, Scottish Water

As echoed by an interviewed stakeholder. This statement from the interviewee is discernible because if bills are not distinguished properly, householders may not directly see the financial benefits of having RWH and might feel Scottish Water will rather benefit. There is the need to consider the cost of RWH installation and the feasibility of installing RWH systems if a policy for mandatory implementation of RWH systems in the homes is to be designed in Scotland.

6.5 CONCLUSION

The aim of this chapter was to understand drivers for RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and the acceptability of community RWH and water neutral development. This was to meet objectives 4 and 5. Overall the responses between participants on PWS and MWS were relatively similar. They showed many more similarities than differences. Likewise, there were no differences between the gender and the response to the questions asked.

In this chapter, to understand the financial incentives and technical adaptation of RWH, participants were about their water consumption in homes to understand their water use, if their homes had any saving device, water conservation (through RWH) and the water-energy use in their homes. The most frequent use of water in households was for toilet flushing followed by taking a shower. MWS users were using water more than those on

PWS. This result corroborates with previous research in the UK which states that most use of water in homes is from the bathroom. Therefore, participants were asked if they had any water saving devices in their homes. Just over half (53%) had no water saving device and the most water saving device was a dual-flush toilet (32.9%) which was followed by a low-flow shower head (10.8%). Participants perceived Scotland had abundant water resources so there was no point to have a water saving device in their home. They were then asked about water conservation through RWH.

Although majority believed it was important to conserve water through other alternatives like RWH, it did not match with their enthusiasm to conserve water since water in Scotland was perceived to be free and unlimited. Most people thought water conservation (through RWH) was important even though just over half of participants (53%) did not have water saving device in their homes. Although RWH concept is not well developed in Scotland, a relatively high percentage (66.3%) believed it was important to conserve water through alternatives like RWH. The few that perceived water conservation (through RWH) was unimportant were a result of:

1. lack of knowledge on RWH;
2. the assumption that there are abundant water resources in Scotland; and
3. lastly the cost of water being free.

And most of the comments were from Scottish Borders even though Aberdeenshire had the most responses from the questionnaire saying it was unimportant to conserve water (through RWH). Also, views from MWS users and PWS users were similar. It was also observed that both stakeholders and households perceived the abundant water resource in Scotland was a stumbling block to water conservation through RWH. Those who thought it was not a stumbling block perceived RWH not to be reliable.

With regards to gender which has been suggested to have differences in environmental concerns, from the final comments (Appendix VII) from participants in this study, it seemed women were more willing to accept RWH as a water conservation measure. When Chi-Test analysis was conducted, water conservation through other alternatives like RWH was not related to someone’s gender in all the study areas.

When participants were asked if their domestic water activity had an influence on their energy bill, except for washing machine, they felt it had no impact. This was similar in both PWS users and MWS users. It was observed linking water efficiency with hot water for people to conserve water and use water efficiently was quite challenging because those that perceived their domestic water use had an influence on their energy bill was less than 50%. Bathing in Edinburgh however was perceived to have an impact on energy bills.

For RWH to acceptable, majority (66.7%) felt having RWH would not be financially beneficial to them and their household. There was a distinct difference between PWS users MWS users; high proportion of PWS users perceived RWH not to be financially beneficial to them whereas low proportion on MWS felt it was not at financially beneficial to them. However, both PWS and MWS users were likely to accept RWH if it was paid for by their Local Authority or they were given some form of grants. This result confirmed with other research where people need to be incentivised before they are willing to implement RWH. New regulations and incentives that foster the use of rainwater have increasingly been developed worldwide by governments at both the local and regional levels but water stakeholders in Scotland from this study felt strongly it will be challenging for local authorities to finance RWH in Scotland. For the grants, most participants in each of the study area were willing to accept RWH if they were given either an annual or a monthly grant. Although responses on grants were similar in both MWS and PWS users, Aberdeenshire had the highest response; just over half of the responses received as compared to the other areas.

Stakeholders in Scotland felt, for RWH to be adopted and accepted in Scotland, it is not just grants as participants wanted, but it had to do with messaging, education, changing behaviour, and the way people think and see water in Scotland, changing the value hold they have for water and campaigning like the same way it has been dome for energy efficiency. Their suggestion reinforces that there was not enough focus on water issues in general in Scotland since people did not put much value on their water resources. Water efficiency regulations should be put in place if a value is to be put on water in Scotland. This can lead to ways and means to save and conserve water because although Scotland is generally considered to have a wet climate, high population density in the near future means that some parts of the country have less water available per person than many Mediterranean countries.

A larger number of householders were willing to consider RWH if will ensure there was always constant water available (55.6%) and if it was easy to use (54.6%). Those on the MWS had the highest responses (more than half; approximately 60% and above) to consider RWH if it will reduce their water bill, was easy to use and it will ensure constant water. Comparing participants on MWS and PWS, it can be inferred from the results of this study that participants on PWS were more unwilling to consider RWH if:

a) their neighbor had it;
b) It will reduce their water bill;
c) It was easy to use; and
d) It will ensure constant water supply.

PWS users were more concerned about having constant water supply whiles MWS users will accept RWH if it will reduce their water bill and was easy to use. Some stakeholders confirmed Scotland can have water shortages and attributed it to the reason MWS users were willing to accept RWH. And also, they attributed MWS users accepting RWH because it will reduce their water bill because they have now become aware that they pay for water and sewerage treatment. Most were neutral to accept RWH if their neighbour had it and it was observed most PWS users did not have neighbours and MWS users felt it was irrelevant to have a communal system. The reason for MWS being neutral was attributed to lack of knowledge on RWH implementation. Scottish respondents have a low level of awareness about RWH, with little technical knowledge or understanding of the environmental benefits relating to RWH. Respondents showed varied acceptability of installing RWH systems, but what draws out most was that they would be willing to install RWH systems if it will ensure constant availability of water and were given some form of grants by their Local Authority. However, they did not know how to go about it and asked questions on how best to install RWH systems and were willing to participate in focus group discussions to learn more about RWH.

Lastly, for an acceptability of communal system or individual RWH system, a high proportion found it acceptable for a RWH system in their own homes (59.6%). Comparing PWS users to MWS users, a relatively high proportion on PWS preferred a system for their household whereas a relatively high proportion on the MWS preferred a system on a communal scale. PWS users preferred for their own homes they did not have a neighbour or the nearest neighbour being far away. The few that wanted an individual system on MWS attributed it to their buildings not being properly designed for RWH since majority of them lived in flats. Stakeholders on the other hand suggested that a communal RWH system was better because they perceived:

1. RWH can lower the cost of producing and treating water separately;
2. RWH to be attractive;
3. RWH to be easy to treat to drinkable standards if one wants to; and
4. for little communities, it will take the pressure off the mains water supply.

The preference for a communal system or an individual system generally was not established since some PWS users did not have closer neighbours. However, it is potentially feasible to engage the community for a communal system for RWH and PWS treatment.

Since some participants were not keen to implement RWH due to their living conditions or the design of their building, several stakeholders expressed diverse opinions on the potential regulatory and non-regulatory barriers of RWH in Scotland. They perceived it was challenging with the absence of incentives, non-existent institutional and regulatory policies for RWH systems and house-builder attitudes towards it. Thus, they suggested:

1. Campaigning to be joined up with government policies, with building regulations, with Scottish Water messaging, with school projects.
2. A national strategy for water efficiency like RWH which at the moment they did not have.
3. Water-butt legislation.
4. Changes in the scheme of charging water bills in Scotland.
5. New builds having mandatory RWH.
6. Regulations focusing on water efficient projects and or retrofitting.
7. Governmental directive.

While a considerable number of stakeholders perceive challenges to be associated with the implantation and acceptance of RWH in Scotland, there is the need to review the evidence of RWH in Scotland since much work on the benefits of RWH has not been done in Scotland. There were a lot of institutional gaps in relation to RWH; it was silent in a lot of water reuse schemes being promoted in Scotland. Participants acceptability of RWH if some form of grants is given has shed light on the need to research more into the financial benefits, incentives, environmental benefits and social benefits and the preference for a communal implementation need to be reviewed on a local scale. This will allow for its proper regulation if it is to be practised in Scotland.

Chapter 7- ATTITUDES TO USING RWH IN SCOTLAND

7.1 INTRODUCTION

This chapter is focused on Scottish residents' behaviour, attitudes, and perception of RWH. The aim of this chapter was to achieve Objective 4: that was to explore the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH. This chapter differs from Chapter 6 in the sense that whereas Chapter 6 looks at financial incentives to accept RWH, Chapter 7 looks at the risk involved in using RWH which affects people's attitudes and perceptions. Chapter 7 focuses more on the likelihood and acceptability of using RWH.

Behaviour influencing the uptake of RWH is explored in this chapter building on willingness to implement RWH if some form of grants were given from Chapter 6. To understand the behaviour, attitudes and perception towards RWH, participants were first asked if they were aware of RWH. As was observed in Chapter 6 in terms of economic feasibility and acceptability of RWH, participants were willing to implement RWH if some form of grants were given. This chapter further explores into details how grants affect the behaviour of households to implement RWH by looking at their attitude.

The perception is explored into details by looking at the risk of acceptability of RWH for domestic purposes and even if they found it acceptable how likely they were willing to use it. This chapter further analyses if gender, age, and willingness to implement RWH have an effect on a household behaviour and attitude to adopt RWH in Scotland. Participants were asked if their house had any form of RWH and was given an option of either yes or no. It should be noted that Edinburgh was the last study area for the questionnaires to be sent thus an additional question of have you heard of RWH was added. Householders were asked if they were aware of RWH before being asked if they had any form of RWH in their homes.

7.2 AWARENESS OF RWH

A relatively high proportion (62.4%) in Edinburgh had heard of RWH but a minority (3.5%) had any form of RWH in their homes (Figure 7.1). There was a vast difference between responses from those on the MWS and PWS; more PWS users were using some form of RWH: AS (35.1%), HL (25.5%) and SB (24.6%) as compared to those on the MWS (3.5%) (Figure 7.1). Participants surveyed said they had water butts which ranged from 1 litre (1L) to 1,200L and 2 gallons to 500 gallons (Appendix XII). Other forms of collecting systems expressed by participants were a greenhouse rain/irrigation system, a cask, barrels on greenhouse/ shed, small trays and buckets to feed plants in garden water, an old bath tub collecting rainwater from house roof, a holding tank taking water from stream (5,000 L), a plastic dustbin collecting rainwater, burn water and spring water into large holding/medal tanks (Appendix XII). Some respondents revealed that rainwater collected from burns where for non-potable use and from springs was for potable uses. Most of the participants were using their water butts for their garden (Appendix XII) while some participants used it for water on their farm (Appendix XII).

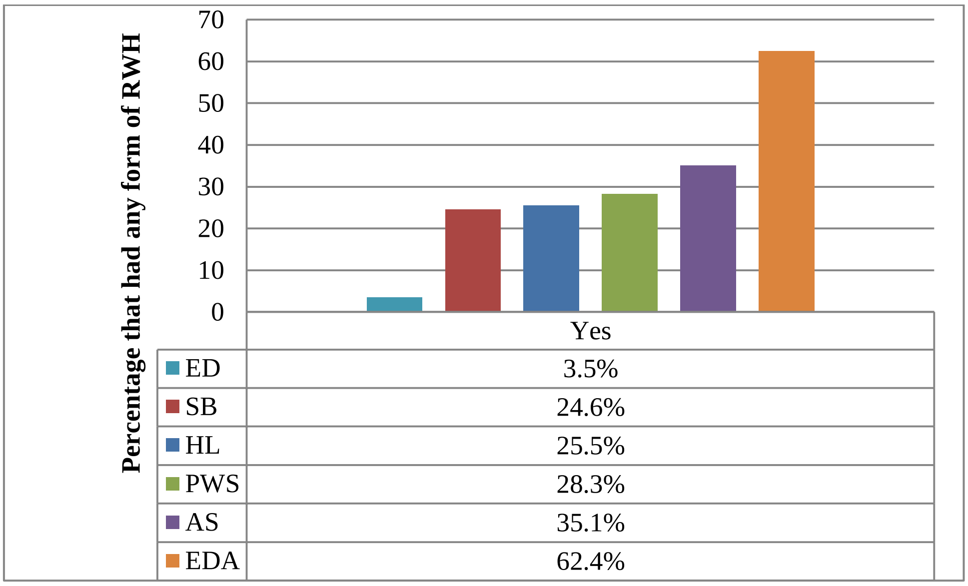


Figure 7.1: Participants answer to whether their house has any form of RWH (Does your house have any form of rainwater harvesting such as a water butt or a storage tank that specifically collects rainwater? EDA (Edinburgh participants: Have you heard of rainwater harvesting?)

For PWS users, a smaller proportion (overall approximately 28%) had water butts in their house and some participants said as observed in Chapter 6, they did not have enough knowledge of RWH systems to comment on the questionnaires. A participant in Highland said he was already harvesting rainwater:

Springs are fed by rain falling on the ground; groundwater is rain water harvesting…**P81, HL**

The lack of awareness of RWH can be linked to a relatively low proportion having water butts. But it cannot be concretely concluded as the reason for the low number of water butts. This is because in the same Highland, another participant was already using RWH in their house and further gave their serial number:

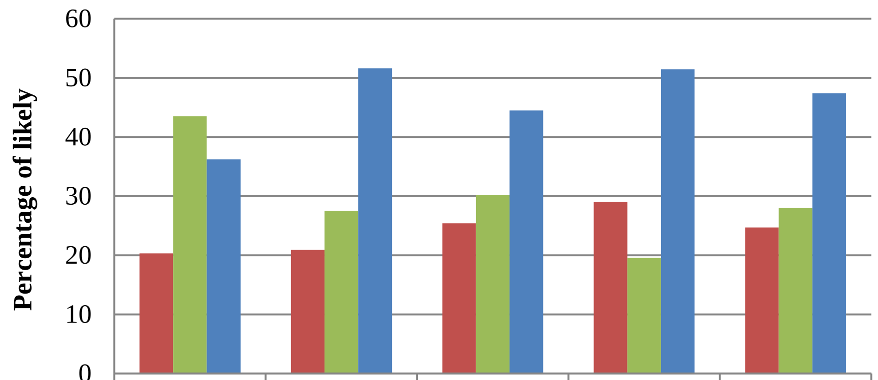
I already have one freshwater filter. Serial no. 11591…**P81, HL**

Despite that, in Edinburgh, a relatively high proportion (62.4%) was aware of RWH but minority (3.5%) had any form of RWH system in their homes (Figure 7.1). residents surveyed from Edinburgh gave reasons as the house type, living in flats and being tenants restricted them from having RWH even if they were aware. In reference to studies by (Ward *et al*., 2012), (White, 2010) and (Domènech and Saurí, 2011), unfamiliarity of the general public and trades people to the operation, technical, health, uncertainty of the system design and information are the issues were seen to are some of the barriers to RWH implementation. Along these lines, it can be inferred but not concluded that the lack of knowledge, health and safety fears might be the hindrance to householders in Edinburgh not having any form of RWH systems as well. Not only that, the assumption that Scotland has abundant water resources, might also be the reason participants on MWS if they had a garden might be using tap instead of RW. Results from water saving also showed approximately 60% on the MWS had no water saving device used in their homes (Figure 5.9) per the assumption that Scotland has abundant water resources. A householder in Edinburgh also confirms taking water for granted although in the past had some experience of RWH:

I am Australian and often visited the small town where my mother grew up which had no access to mains water. All water was collected from rainfall on the roof, stored in tanks or a store well or later was from a small dam on the property. No one drank this water (tank) directly as it usually has bits of insects in it, but it was used boiled first for tea. Originally no flushing toilets, just from dam to collect waste, so use dam water to flush indoor toilets was perfectly fine! These experiences affect my views. I have experience of rainwater harvest, am aware of the need to conserve water (much more in public awareness in Australia) but have developed bad habits since living in Scotland since there does seem to be no problem with water availability. I joke with my family in Australia that we could export some to them. So, I'm not typical. My main concern would be water quality for personal use and consumption…**P135, ED**

7.3 WILLINGNESS TO IMPLEMENT RWH

The success of a RWH system is based on the interest, enthusiasm and active support of the users (Islam *et al*., 2011). For someone to be receptive to a certain product, in reference to the receptivity model, they need to be aware, associate with it, acquire and then apply (Jeffrey and Seaton, 2004). After participants were asked if they had any form of RWH and or were aware of RWH, they were further asked how likely they were willing to implement it. It should be noted that the willingness question was asked before the grants question was asked (the grants question was discussed in Chapter 5 in relation to acceptability). This was to ascertain how inclined residents will want to use RWH without any incentive. Overall a relatively low proportion (28%) of respondents said they would be implementing RWH in their house (Figure 7.2). In individual study areas, they followed the same pattern with the exception of Aberdeenshire and Edinburgh. The responses were rated from descending order as: "unlikely", "likely" and "neutral" (Figure 7.2). Aberdeenshire householders were more willing (43.5%) to implement RWH as compared to other areas (Figure 7.2). Participants from Edinburgh (19.6%) were the least willing to implement RWH (Figure 7.2). Participants from Highland (51.6%) and Edinburgh (51.4%) were the most unwilling to implement RWH in their homes (Figure 7.2).



	AS	HL	SB	ED	ALL
Neutral	20.3%	20.9%	25.4%	29.0%	24.7%
Likely	43.5%	27.5%	30.2%	19.6%	28.0%
Unlikely	36.2%	51.6%	44.4%	51.4%	47.4%

Figure 7.2: Willingness to implement RWH in house (Would you be willing to implement RWH in your house?)

Participants in Aberdeenshire had the highest number of "RWH devices (35%); therefore, it was not surprising that they were more willing to implement RWH compared to other areas. Comparing Highland and Edinburgh, the percentage of participants in Highland (25.5%) having some form of RWH were more than the percentage in Edinburgh (3.5%). But participants from these two areas were less willing to implement RWH (Figure 7.2). In Edinburgh, it is understandable for this response. This is because the general perception of RWH, if one does not know, is most apparently linked to rainwater, and the first thought that comes to mind is the water availability when one opens the tap. Thus, more generally, the access to drinking water is readily available and accessible and one may immediately compare it to the quality of their tap water (Seidl *et al*., 2010) and would be highly unwilling to use it. That can be attributed to the reason participants were not likely to implement, especially those in Edinburgh (Figure 7.2). Furthermore, housing type is also a big influence in Edinburgh since most responses received lived in flats (82%; Table 4.1, pg. 96, Chapter 4) thus they might have felt it not to be suitable. However, for Aberdeenshire, which had the highest number of PWS, their unwillingness can only be attributed to lack of enough knowledge as expressed by some residents surveyed in Chapter 6 even though they reported the highest water-butts and other forms of RWH in their homes. Land tenure, housing type and ownership can also be attributed to unwillingness to RWH implementation. In Chapter 4, Table 4.1, there were different responses on the house type and tenure.

Most research on willingness to implement RWH has been that respondents will only consider it with the provision of financial assistance (*Parsons et al*., 2010; Islam *et al*., 2011; Ward *et al*., 2012) and this was confirmed with the studies. Maybe that was why although Aberdeenshire had the highest form of RWH systems they were unwilling to implement RWH. Another possible explanation for Aberdeenshire with the highest number of RWH devices to be unwilling to implement RWH was that they could be poor. It should be noted that when the willingness to implement RWH question was asked, there was no mention of financial incentives, therefore this negative response can be attributed to lack of money. Participants were willing to implement RWH if it was paid for by anyone but them (Figure 6.8). It was observed those that were willing to implement might have had no prior experience of RWH:

> *Likely- have only lived here for 10 days! We did have-last house*…**P65, AS**

> *I would willingly consider RWH but we are in a second floor flat on a main street (conservation area) so I think there would be significant practical challenges in using such a system in such an environment*…**P42, ED**

However, the majority that was unwilling to implement RWH unless if some form of financial grants were given also said it was because of the design of their building or their house type as explained above:

> *I am in a flat along with a number of other residents so extremely unlikely to implement RWH in my flat*…**P24, ED**

> *Use of RWH is not possible because of planning restrictions (b- listed building)* …**P105, ED**

> *Flat dwelling so not suitable*…**P141, ED**

Most of these comments were from Edinburgh and in Edinburgh most of the participants were living in flats (82.9%) as observed in Chapter 4. Moreover, it was observed the nature of the building was not the only impediment to RWH, as observed in Chapter 6. Some householders perceived RWH was impossible because of the kind of tenure they had. They said it was the responsibility and or decision of their landlords and thus it was out of their hands to implement it. Furthermore, some householders perceived RWH harvesting to be unnecessary and may not be environmental friendly:

> *Pointless- the springs are rainwater harvesting. We monitor the springs which supply 14 households and cattle troughs etc. I would argue that springs, such as ours, which flow to waste if we don't use the water, are rainwater harvesting. If we implemented RWH, houses would need pumps and more infrastructures i.e. increase energy consumption over correct systems therefore counterproductive in environment impact" and already had enough water*…**P71, AS**

> *Our supply is from a hillside burn. Water is dammed and either goes through filter to supply or straight into the sea, hence the negative response to harvesting*…**P34, HL**

…thus, were unlikely to implement it.

Another challenge of implementing RWH that was observed in this study was the storage as suggested by a stakeholder:

> *But the difficulty with RWH is if it is going to change to drier and wetter, you are not likely to be able to get enough storage to cover the dry periods unless you have some enormous system. And it is the dry periods when you really want the water because your other system may be affected.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Although some households are willing to implement RWH, the collection and storage facilities may also restrict and put constraints as to how much rainwater they can use. In the course of a heavy downpour the collection systems may not be able to hold all RW which ends going into the drains and rivers. Likewise, in the instance of areas with limited rainfall as in the case of eastern Scotland which receives less than 870 mm (34.3

in) of rainfall annually, sometimes little or no rainfall can limit the supply of rainwater. Therefore, it is not advisable to depend on rainwater alone in such areas. What's more if the system can store enough water, water quality thus becomes an issue if the water is not used for a long time as most at times, RW stored over longer periods may contain faecal coliform and the counts which are above the World Health Organization (W.H.O) stipulation for drinking water (Achadu *et al*., 2013). However, this is not necessarily a problem if water is not used for drinking, but if being used for drinking it can be treated prior before its use. For the concerns of water quality and storage, it has been recommended that plastic (PVC) tanks and well-constructed concrete tanks are the most suitable storage media for RWH (Achadu *et al*., 2013).

Consequently, some of the challenges can be overcome by understanding the local conditions of the area that RWH is to be implemented. This is because according to a stakeholder who was not enthused for RWH to be implemented in his council.

> *It was tried up here at Peterhead and they used some RWH for the toilets in one of the new schools. But they had to take it out. Because the smell was one of the problems and there were a lot of seagulls and they were dropping materials unto the roof where the water was being collected and this was getting washed in into the system and the systems went stagnant and smelly. It was blocking up because the debris was being dropped onto the roof as well, you know and filling up the pipe works so they just had to do away with it. There was many and so much effort put it to try and keep the system running when it wasn't really giving them a nice result. But it was easier for everybody just to revert back to using the water supply and save the money rather than spend it on all this maintenance.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

The same stakeholder also perceived maintenance to be an issue:

> *The difficulty we have is that you have to spend so much, or the experiences said that you need to spend so much from maintenance that only in situations where ordinary water supply was inaccessible will people begin to consider it.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Thus, felt RWH should only be the last option to choose from after every opportunity has been exhausted:

> *And to be honest at the moment if you are dealing with houses or any building, it would go connect to the mains and use the public water. If you can't do that, you will think about a borehole or a well for a PWS and only when that option has perhaps been exhausted, people come down to RWH and think well maybe we could look at that, but it's a very poor third down the line.*
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Accordingly, maintenance as perceived by the householder was confirmed by some stakeholders and it is thus perceived as a problem.

7.1.1 Grants and willingness

Financial barriers are highly significant to implementation of RWH in the UK (Parsons *et al*., 2010). Several stakeholders confirmed this:

> *The challenges are what we spoke about, trying to get people to spend their money on RWH systems.*
>
> **Business Development Manager, GRAF UK**

> *Also, there is no financial incentive for developers to do as well it.*
>
> **Policy Adviser, Scottish Water**

However, when Scottish Water was asked on giving incentives especially in the form of grants for RWH, they were perceived the decision was not up to them. According to the interviewee:

> *It's not something that we have explored and it's not something that we, as our system at the moment are capable of implementing. You know these things are getting reviewed all the time. These are the kind of things that we actually need to back to the government when we are making considerations on you know how to charge the customers essentially, how the directors charge the customers.*
>
> **Policy Adviser, Scottish Water**

A Spearman's rank-order correlation was run to assess the relationship between willingness to implement RWH and consideration of RWH if given grants. The null and the alternate hypothesis were defined as:

H_0: *Householders were indifferent to consider RWH even if given grants.*

H_1: *Householders showed willingness to consider RWH if some form of grants were given.*

The *p*-value was .000, therefore it was not interpreted as a significance level that is actually zero; it does in fact indicate that $p < .0005$. As *p* was $p < .0005$ in all the study areas (Table 7.1), it can be concluded that the correlation coefficient is statistically significantly different from zero. Overall, there was a moderate positive correlation between willingness to implement RWH in house and consider RWH if given a grant, r_s

(321) = .496, p < .0005 (Table 7.1). The alternative hypothesis was therefore accepted; householders showed willingness to consider if some form of grant were given. In individual study areas, the results were relatively similar, there was a moderate positive correlation in all study areas and the null hypothesis was rejected: AS (r_s (61) = .522, p < .0005); HL (r_s (82) = .516, p < .0005); SB (r_s (55) = .458, p < .0005) and ED (r_s (124) = .480, p < .0005) (Table 7.1).

Table 7.1: Spearman rank order correlation between willingness to implement RWH and consider RWH if given grant

ALL Correlations

			Willingness to implement RWH in house	Consider RWH if given a Grant?
Spearman's rho	Willingness to implement RWH in house	Correlation Coefficient	1.000	.496**
		Sig. (2-tailed)	.	.000
		N	361	321
	Consider RWH if given a Grant?	Correlation Coefficient	.496**	1.000
		Sig. (2-tailed)	.000	.
		N	321	328

**. Correlation is significant at the 0.01 level (2-tailed).

AS Correlations

			Willingness to implement RWH in house	Consider RWH if given a Grant?
Spearman's rho	Willingness to implement RWH in house	Correlation Coefficient	1.000	.522**
		Sig. (2-tailed)	.	.000
		N	69	60
	Consider RWH if given a Grant?	Correlation Coefficient	.522**	1.000
		Sig. (2-tailed)	.000	.
		N	60	61

**. Correlation is significant at the 0.01 level (2-tailed).

HL Correlations

			Willingness to implement RWH in house	Consider RWH if given a Grant?
Spearman's rho	Willingness to implement RWH in house	Correlation Coefficient	1.000	.516**
		Sig. (2-tailed)	.	.000
		N	91	82
	Consider RWH if given a Grant?	Correlation Coefficient	.516**	1.000
		Sig. (2-tailed)	.000	.
		N	82	85

**. Correlation is significant at the 0.01 level (2-tailed).

SB Correlations

			Willingness to implement RWH in house	Consider RWH if given a Grant?
Spearman's rho	Willingness to implement RWH in house	Correlation Coefficient	1.000	.458**
		Sig. (2-tailed)	.	.000
		N	63	55
	Consider RWH if given a Grant?	Correlation Coefficient	.458**	1.000
		Sig. (2-tailed)	.000	.
		N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

ED Correlations

			Willingness to implement RWH in house	Consider RWH if given a Grant?
Spearman's rho	Willingness to implement RWH in house	Correlation Coefficient	1.000	.480**
		Sig. (2-tailed)	.	.000
		N	138	124
	Consider RWH if given a Grant?	Correlation Coefficient	.480**	1.000
		Sig. (2-tailed)	.000	.
		N	124	127

**. Correlation is significant at the 0.01 level (2-tailed).

Comprehensively, it was established that grants had an influence on RWH implementation as seen in Section 6.3 and the Spearman correlation also confirms it. But some stakeholders in Scotland felt there needed to be evidence on the financial benefits of RWH before grants could be given out for RWH. According to one stakeholder who was interviewed:

> *I think RWH could do have financial benefits in Scotland. I have not seen any concrete examples because I am not aware of research that has been carried out that would indicate that it has a conclusive benefit. But I think that from my common-sense point of view in rural communities on a PWS, again population may increase by 300% in the summer time if it is a holiday area, then the people who harvest RW then it can only help support the sustainability of the PWS.*
>
> **Water Policy Analyst, CABS**

Like so, before grants could be given, there need to be ascertained financial returns in implementing RWH in Scotland even though some participants were willing to implement it without grants.

7.3.1 Gender and RWH willingness

During data analysis, it was observed women were more willing to implement RWH compared to men (Figure 7.3). Therefore, this research tried to explore whether obvious characteristics like age and gender shaped views received form the residents during the survey. Majority of men 105 as compared to women (65) were highly unwilling to implement RWH (Figure 7.3). Overall, women were split between likely and unlikely and were less negative as compared to men (Figure 7.3). The ratio of women to men likely to implement RWH was distributed in each study areas as follows: AS (14:16), HL (19:6), SB (14:5) and ED (18:9) (Figure 7.3). It was only in Aberdeenshire that the men were marginally higher than women (Figure7.3).

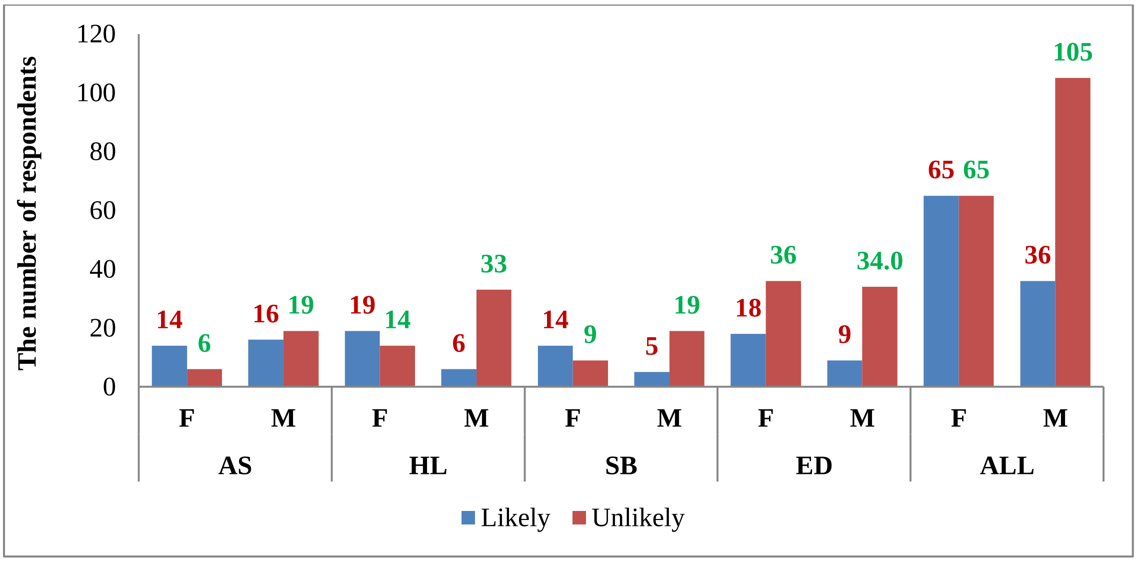


Figure 7.3: Gender and willingness to implement RWH prior to incentives question: F (females); M (males)

Comparing MWS to PWS, men on PWS were more unwilling to implement RWH as compared to men on MWS (Figure 7.4). The ratio of men unwilling to men willing was 71:34 (Figure 7.4). Fewer women on MWS were willing to implement RWH as compared to those of PWS; men were more unlikely as compared to females (Figure 7.4).

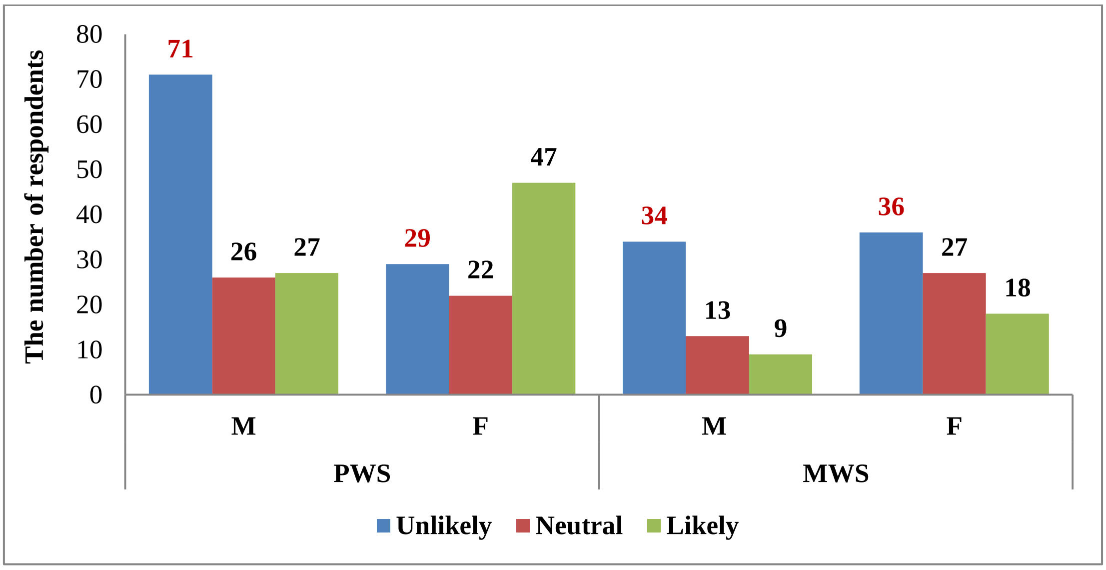


Figure 7.4: Gender and willingness to implement RWH prior to incentives question: F (females); M (males)

Therefore, a chi-square test for association was conducted to see if RWH willingness was associated with gender. The null and alternate hypothesis was defined as:

H_0: *There is no difference between genders in willingness to implement RWH in their house.*

H_1: *Females would be more willing to implement RWH in their homes.*

When the data was analysed collectively, all the expected cell frequencies were greater than 5 (20%) (Appendix XIII), thus the assumption was not violated and the Pearson Chi-Square "results" was used (Table 7.2). Collectively (i.e. all the case study area put together), the association was statistically significantly different from zero between gender and willingness to implement RWH since *p*-value of .000, thus it is not interpreted as a significance level that is actually zero; it does in fact indicate that $p < .0005$; therefore χ^2 (1) = 18.872, *p*= .000 (Table 7.2). There was a strong association between gender and willingness to implement RWH, $\varphi = .229$, $p = .000$ (Appendix XIII). Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted: women would be more willing to implement RWH in their homes compared to men.

When the data was analysed in individual study areas separately however, the results were different. In Aberdeenshire and Edinburgh, the *p* value was greater than 0.05 (Table 7.2); AS [χ^2 (1) = 3.813, *p*= 1.49] and ED [χ^2 (1) = 3.512, *p*= 1.73] whereas in Highland and Scottish Borders, the *p* value was less than 0.05; HL [χ^2 (1) = 14.063, *p*= .001], SB [χ^2 (1) = 7.960, *p*= .019] (Table 7.2). Therefore, for Aberdeenshire and Edinburgh, it can confidently be stated that there was a statistically no significant association between gender and willingness to implement RWH, thus the null hypothesis was accepted. Consequently, it can be stated that willingness to implement RWH was not related to someone's gender in Aberdeenshire and Edinburgh.

This was not the case for Highland and Scottish Borders, the null hypothesis was rejected and the alternative hypothesis was accepted. There was a very strong association between gender and willingness to implement RWH in Highland and Scottish Borders; HL ($\varphi = .395$, $p = .001$) and SB ($\varphi = .355$, $p = .019$) (Appendix XIII). Along these lines, it can be confidently stated that willingness to implement RWH was completely dependent on someone's gender and women were more likely to implement RWH than men. Literature review by (Zelezny *et al*., 2000) revealed that most research shows that women report stronger environmental attitudes and behaviours than men which were consistent with their research as well across 14 different countries. Hence it was expected that females will be more willing to implement RWH in our study areas.

Table 7.2: Chi-Square Test Analysis for gender and willingness to implement RWH (Would you be willing to implement RWH in your house)

ALL Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	18.872[a]	2	.000
Likelihood Ratio	19.082	2	.000
Linear-by-Linear Association	18.318	1	.000
N of Valid Cases	359		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 43.88.			
AS Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.813[a]	2	.149
Likelihood Ratio	3.950	2	.139
Linear-by-Linear Association	2.766	1	.096
N of Valid Cases	69		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.48.			
HL Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.063[a]	2	.001
Likelihood Ratio	14.519	2	.001
Linear-by-Linear Association	13.505	1	.000
N of Valid Cases	90		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.20.			
SB Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.960[a]	2	.019
Likelihood Ratio	8.198	2	.017
Linear-by-Linear Association	7.442	1	.006
N of Valid Cases	63		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.62.			
ED Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.512[a]	2	.173
Likelihood Ratio	3.533	2	.171
Linear-by-Linear Association	2.711	1	.100
N of Valid Cases	137		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.04.			

To conclude, willingness to implement RWH was not related to gender in Aberdeenshire and Edinburgh but was related to gender in Scottish Borders and Highland (Table 7.2). As has been suggested by other researchers that gender was gender and are factors that influences the concern for the health of the environment (McIntyre *et al*., 1993; Banerjee and McKeage, 1994; Laroche *et al*.,(2001); Han et *al*., 2009) in this study there was mixed results. Women are known to be more likely to participate than men in surveys (Curtin *et al*., 2000; Moore and Tarnai, 2002; Singer *et al*., 2000) and are most often known to display a higher level of environmental concern and behavioural adjustments relative to men (Hunter *et al*., 2004). Thus, it was not surprising to find some of the results where gender was related willingness to implement RWH in some areas (Table 7.2).

7.3.2 Age and RWH willingness

Earlier research suggests that age is positively correlated with environmental concern (Harry *et al*., 1969). Younger people tend to be more concerned about the environment as compared to older people. From the previous chapter, Section 5.2.2 where it was suggested that young people tend to be more concerned about environmental quality than older people, an association between age and willingness to implement RWH was analysed to test it there was a correlation between them.

Responses received from participants showed that younger people (16-54 years) were willing to implement RWH as compared to older people (55 years and above) (Figure 7.5). It was observed that 35.6% of younger people were willing to implement RWH as to 59% of older people who were unwilling to do so (Figure 7.5). Scottish Borders was the only area younger people (45.8%) were more unwilling to implement as compared to older people (43.6%). There were younger people on PWS supply willing as to younger people on MWS (28.8%). In individual study areas, the proportion of younger to older was relatively similar except in Edinburgh. Younger people (28.8%) were willing to implement RWH as to only 7.9% older people (Figure 7.5). Older participants from Highland (65.5%) and Edinburgh (68.3%) were the most unwilling to implement RWH (Figure 7.5). Younger participants in Aberdeenshire (19.4%) were the least willing to implement RWH (Figure 7.5).

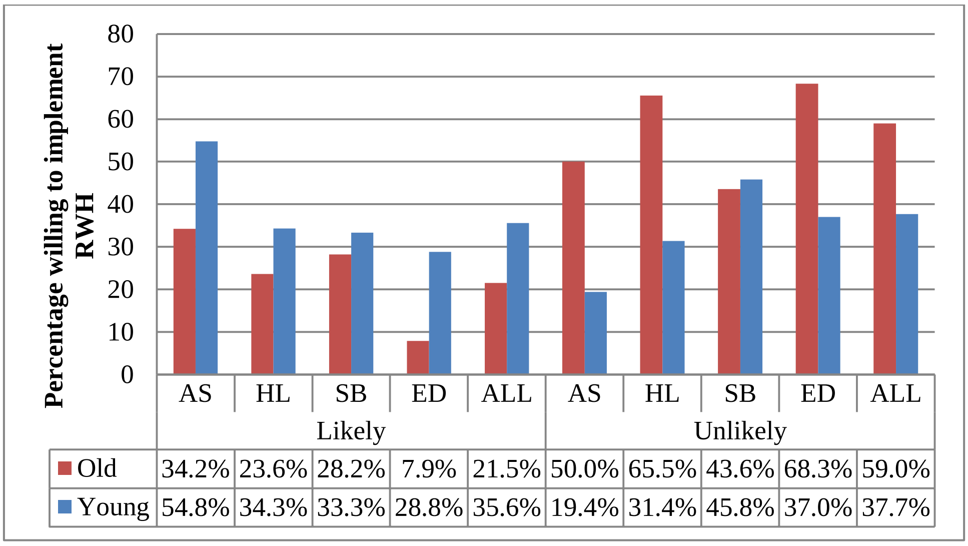


Figure 7.5: Overall results of willingness to implement RWH and individual study area's willingness to implement RWH

The hypothesis that young people tend to be more concerned about the environment quality was therefore tested in this using willingness to implement RWH for the minority of participants that were likely to implement RWH. The null and alternate hypothesis was defined as:

H_o: *There is no difference between age and willingness to implement RWH.*
H_1: *Younger people will be more willing to implement RWH.*

A chi-square test for association was conducted between age and willingness to implement RWH (Appendix XIV). All expected cell frequencies were greater than five. When the data was grouped together the association was statistically significantly different from zero between age and willingness to implement RWH since *p*-value was .000. This is not interpreted as a significance level that is actually zero, it does in fact indicate that $p < .0005$; therefore, RWH, χ^2 (1) = 22.694, $p = .000$ (Table 7.3). However, there was a very strong association between age and willingness to implement RWH, $\varphi = .252$, $p = .000$ (Appendix XIV). Accordingly, the null hypothesis was rejected and the alternative hypothesis was accepted; young people are more willing to implement RWH in their homes compared to old people.

When individual areas were analysed separately, except for Scottish Borders, all study areas showed a statistically significant association between age and willingness to implement (table 6.3): AS [χ^2 (1) = 6.940, p= .031]; HL χ^2 (1) = 11.459, p= .003; SB χ^2 (1) = .464, p= .793; ED χ^2 (1) = 15.351, p= .000 (Table 7.3). Hence alternative hypothesis; young people will be more willing to implement RWH was accepted in Aberdeenshire, Highland and Edinburgh and there was a strong association between age and willingness to implement RWH: AS (φ = .317, p = .031); HL (φ = .357, p = .003) and ED (φ = .336, p = .003) (Appendix XIV). In Scottish Borders on the other hand, the null hypothesis was accepted because p was >.05 therefore it was not statistically significant (Table 7.3). Willingness to implement RWH was not related to someone's age in Scottish Borders.

Although in Highland a slightly higher number of older were willing to implement RWH compared to younger (Figure 7.5), it was statistically significant (Table 7.3). With "unlikely" to implement RWH, there was a relatively high proportion of older that was unlikely as compared to younger (Figure 7.5). Furthermore, there were younger people who were neutral in willingness to implement RWH as compared to older (Appendix XIV). Therefore, this can be attributed to the fact that it was statistically significant in Highland.

Table 7.3: Chi-Square Test Analysis for age and willingness to implement RWH (Would you be willing to implement RWH in your house)

ALL Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.694[a]	2	.000
Likelihood Ratio	22.988	2	.000
Linear-by-Linear Association	19.077	1	.000
N of Valid Cases	358		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 40.07.			
AS Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.940[a]	2	.031
Likelihood Ratio	7.214	2	.027
Linear-by-Linear Association	5.586	1	.018
N of Valid Cases	69		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.29.			
HL Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.459[a]	2	.003
Likelihood Ratio	11.606	2	.003
Linear-by-Linear Association	5.703	1	.017
N of Valid Cases	90		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.00.			
SB Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.464[a]	2	.793
Likelihood Ratio	.471	2	.790
Linear-by-Linear Association	.017	1	.897
N of Valid Cases	63		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.10.			
ED Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.351[a]	2	.000
Likelihood Ratio	16.067	2	.000
Linear-by-Linear Association	15.154	1	.000
N of Valid Cases	136		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.04.			

In general, age shows a negative correlation with willingness to implement RWH without grants. As one gets older, the likelihood to willingly implement RWH goes down if no grants are given. Younger people were more willing to implement RWH as compared to older people. It has been suggested in a study that the younger people may recognize the time remaining in their lives as long and thus give priority to preparing for future-oriented goals, social goals and maybe expected to be higher on environmental awareness and knowledge (Carstensen *et al*., 1999). Hence even though other research suggests that age is not correlated to environmental concern, in this research there was a strong association between youth and willingness to implement RWH and thus confirms the hypothesis by (Liere and Dunlap, 1980). However, a recent research by (Wiernik *et al*., 2013) suggests that the relationship between age and environmental awareness were negligibly small, nevertheless generalized relationships insinuated that older individuals appeared to be more likely to engage with nature, avoid environmental harm, and conserve raw materials and natural resources. This might explain why Scottish Borders showed no difference between age and willingness to implement RWH compared to Edinburgh, Aberdeenshire and Highland which were the contrary.

7.4 BEHAVIOUR INFLUENCING UPTAKE OF RWH

It was assumed that people collect water from their roof tops and store it to use for gardening and washing of cars without any concerns about the health. As observed from this study, although small, some respondents had some form of RWH devices which they said was used for gardening. However, when asked if they might consider RWH for domestic purposes respondents tend not to like the idea. People might not have an idea that they are harvesting rainwater; therefore, this section explores the beliefs; that is information and or knowledge people have about RWH. This is because for RWH to be used by householders and for an effective policy push, the level of receptivity by user is necessary. Identifying the recipient's level of receptivity or ability is an important starting point to pursuing successful policy and or technology adoption and its successive implementation (Jeffrey and Seaton, 2004; Ward *et al*., 2012).

7.4.1 RWH consideration

The achievement of RWH system implementation depends on the interest, enthusiasm and active support of the users (Islam *et al*., 2011). Therefore, not only were participants accessed in terms of awareness, stakeholders were asked on their general views on RWH to perceive their level of awareness and acceptance. It was observed that stakeholders were highly aware of RWH and majority were in favour of it and or were willing to consider it.

> *I think we would be in favour of it. We would be in favour of it from a sustainable urban drainage point of view. Really it could cut the run-off from housing developments for instance. We did have a discussion actually about whether or not it will make a difference to living, I don't know if it would, and I don't know if you would be able to get enough storage for it to make a big difference to flooding, but clearly it would make a big difference to the urban drainage, the run-off and you know the potential treatments and discharges and so on.*
>
> **Specialist 2, SEPA**

> *I think there is a potential for RWH in Scotland and it's possibly something that hasn't been looked at in any great details at the moment. But because we are a hilly country that does get probably and certain areas of the country gets high than others in rainfall, there is this potential there for that RW to be harvested and used but I don't know how much in relation this has been looked at which is at attitudes, you know building or adapting properties in order to enable them to that successfully, and I know it's not the council that's currently on it, it might end up with the energy of environment and health. So maybe the kind of thing you know, it needs to be promoted more and it needs to be an awareness raising campaign as well.*
>
> **Environmental Health Officer, Hebrides**

> *I mean the thing is that Scottish Water itself is the beneficial of these systems in terms of the logistic capacity and the need for large works but, I think there is a place to book it in the Scotland PLC, to say look as a country where RWH is so much the slight thing to do per household.*
>
> **Sustainable Rural Communities, Scottish Water**

Some stakeholders echoed this. Consideration and recognition of the value of RWH is beginning to filter across the academic-policy boundary in some parts of the world. This has been initiated by recognition of drivers including increasing water demand and increasing risk of flooding (Ward, 2010) and as echoed by the interviewees, it can be observed that there is consideration on the part of stakeholders. Moreover some stakeholders also reiterated on the value and importance of RWH which is in concordance with (Ward, 2010). The value is beginning to get across even though it was perceived that in the UK, implementation of RWH was not straight forward:

I will say it is not an area that we have explored. But it probably ties into the broad policy objective which is to maximize the value of our resources. So, on that basis we are supportive of these kind of technology because obviously it has a knock on effect on the pressures on the main system. So, anything that can reduce the cost for customers, we are interested, and anything which is more sustainable option we are interested. We've been talking today about what to support rural communities where supply issues are more acute and they are in the central belt. So, we were positively disposed towards this kind of technology and interested in finding out about where they can help, where they can be implemented and what the implication is for: the supply and indeed for the planning processes as well that are required. So, it's not been a hot topic particularly but if it is in our area we will support.

I think it could be promoted in Scotland. The most straight forward way of promoting it will be in new builds. I mean water butts have been promoted to some extent and beyond that, I don't know if you are connected to the mains water, there's no incentive to.

Specialist 2, SEPA

When stakeholders were also asked if they will or if they were already supporting RWH, majority where either supporting or will support it if government should come out with policies. As well stakeholders felt there was the need for awareness and education:

I think as an organisation, yes in principle we will probably support that and we will support anything that promote RWH. But again, it is the caveat that without education and awareness it is very difficult to in turn increase people's use of RWH or even take knowledge on the benefits that might bring.

Water Policy Analyst, CABS

In terms of from a water efficiency perspective, as long as the system complies with bylaws in order to protect the public water supply so that the back feeds doesn't go into the public water supply, you know we are supposed to have a RWH in our new office which is one of the environmentally friendly building in Scotland over in steps. So technically we will support the uptake of these kinds of things and we have a little bit of work with another person in Scottish water who is looking at water efficiency measurable part and that is RWH as well.

Policy Adviser, Scottish Water

Stakeholders echoed these views. However even though there has been broad policy statements about RWH in the UK, they have been low on details about implementation and systems (*Ward et al*., 2009). An example is the Code for Sustainable Homes (CSH), first introduced in 2006, and abolished in 2010. The code promoted the use of RWH in England and Wales but was voluntary rather than mandatory. Thus in practice it was merely a series of recommendations which developers can chose to adhere to or not (Ward *et al*., 2009). The code did not cover Scotland. A stakeholder expressed this:

> *I think RWH in itself is a great idea but there are few challenges before we see it starts being rolled out voluntarily in households. And it is going to be a long time I think before we see internal design solutions within properties that do not make part of how the natural household functions.*
>
> **Water Policy Analyst, CABS**

There will however be some challenges even if a policy was set-up. For Scotland, it's not about code or lack of, it is changing the way people think and value water. Notwithstanding, two stakeholders believed RWH should not be implemented in Scotland:

> *It's not something that we do.*
>
> **Operations Team Leader, DWQR**

> *We would resist any attempt to use RWH for drinking water. For others if somebody wanted it, yes. But we would probably advise against it.*
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

The last view was because of bad experience with RWH. The interviewee expressed RWH was done before in Aberdeenshire in a school but the smell was offensive thus his perspective. However, some stakeholders were willing to consider RWH against the non-existence of policies or recommendation in Scotland, they assumed that it might be expensive and thus this will hinder public acceptance:

> *We think it's a good idea. It's expensive, you know to retrofit, so that's one of the issues but certainly when you are thinking about new builds, I don't know a reason why not. There is this thing about public acceptance and some of those stuffs.*
>
> **Director, WICS**

Although RWH is currently experiencing increased interest, stakeholders expressed diverse barriers that impedes its acceptance and implementation in the UK like its cost implications (installation and maintenance), external constraints (supply/demand balance) and inclusion issues (eligibility for financial assistance) (Ward *et al*., 2009). Not to mention, stakeholders again believed the benefits need to be properly outlined before an uptake is possible:

> *For a water resources point of view, I think it clearly has some potential to cut demand and obviously, that will be useful. It's a bit different with PWS, but if you look it from the point of view of the public water supply then anything which cuts demand is obviously going to be a good thing and reduces demand for water. But depending on when the demand is reduced, it might or might not make a difference during a very dry period. It might make a difference to how much water they needed to abstract in terms of their licensing which then has a knock off effect on what's left for the environment.*
>
> **Specialist 2, SEPA**

This is because in the UK, there exist some gaps in social and technical barriers, concerns and knowledge which currently restrict its widespread utilisation (Ward, 2010) especially in Scotland thus stakeholders scepticism. Further to barriers and social concerns, there is also an implementation deficit in RWH systems that exist in terms of legislation which has failed to provide adequate support mechanisms in the UK (Ward *et al*., 2009). As echoed by an interviewee:

> *I can envisage circumstances where we might see that as part of a solution, and maybe we certainly be prepared to consider it. But it would be done as part of a holistic consideration of the issue so we will be bound to listen to our colleagues in DWQR because we would have views about water quality and our environmental colleagues as well. So, and even if there were a policy decision, it would be one that would be based on discussion with other partners as well. We have not got to that point, not really been on the agenda but if it were, that was how we will approach it.*

This confirms research by Ward *et al*., (2009) on barriers impeding installation of RWH. Another research by (Ward *et al*., 2008) on the other hand showed that participants in England showed a positive response to consider RWH. Compared to Scotland, a stakeholder expressed that:

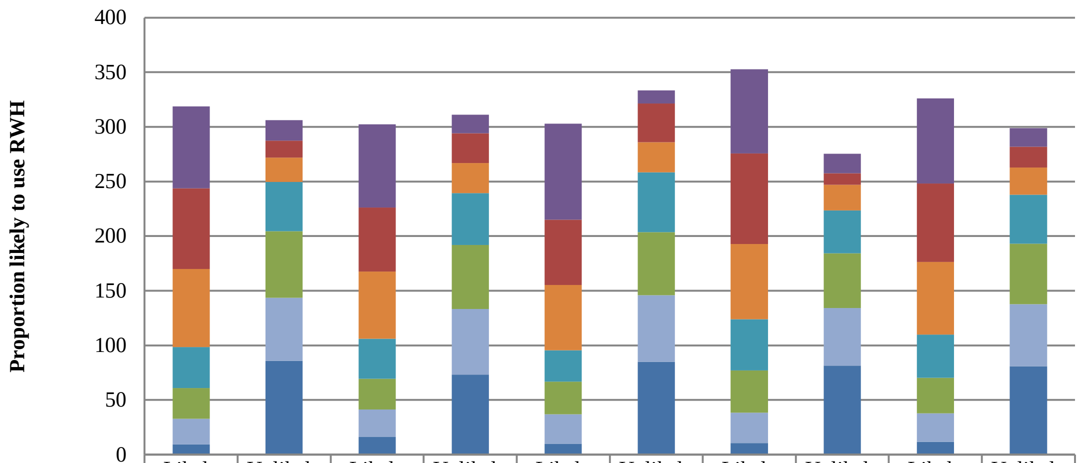
> *The Scottish market isn't the same as English market and I think the main reason for that is that they've got their water bill separate from the council tax bill.*
>
> **Business Development Manager, GRAF UK**

This has been observed in previous chapters as a barrier to RWH implementation in Scotland since it is assumed that water is free in Scotland even though it is paid as part of the council bill tax charges. And as stated by the RWH Association, the economy of a system depends on various factors such as charges for water supply and sewage services which vary greatly between the various UK supply companies, and these charges can significantly affect the potential any RWH system.

7.5 ATTITUDES AND PERCEPTIONS: LIKELIHOOD AND ACCEPTABILITY OF RWH IN SCOTLAND

7.5.1 Likelihood of using RWH

RWH is increasingly being encouraged as an alternative or supplemental approach to household water supply in tropical regions (Thomas & Martinson, 2007) and has been considered as an effective alternative water source for both potable and non-potable uses in a number of countries throughout the world (Ahmed *et al*., 2011). In England and Wales RWH use is becoming increasingly common (Ward *et al*., 2012a), but not Scotland. Therefore, for RWH systems to be adopted in Scotland and widely used, householders' preference for it as an alternate source or supplement should be understood. Overall, a relatively high percentage is likely to use RW for gardening (78%), toilet flushing (71.7%) and car washing (66.4%) (Figure 7.6). Majority of participants were unlikely to use RW for drinking (80.7%), bathing (56.9%) and dish washing (55.6%) (Figure 7.6). In individual study areas, it was relatively similar except the Scottish Borders where 54.8% of participants were unlikely to use for laundry (Figure 7.6).



	AS Likely	AS Unlikely	HL Likely	HL Unlikely	SB Likely	SB Unlikely	ED Likely	ED Unlikely	ALL Likely	ALL Unlikely
Garden	75.0%	18.8%	76.3%	17.1%	88.1%	11.9%	77.0%	17.7%	78.0%	16.9%
Toilet flush	73.8%	15.4%	58.4%	27.3%	59.5%	35.7%	82.9%	10.6%	71.7%	19.2%
Car wash	71.4%	22.2%	61.6%	27.4%	60.0%	27.5%	69.1%	23.6%	66.4%	24.8%
Laundry	37.5%	45.3%	36.8%	47.4%	28.6%	54.8%	46.7%	39.2%	39.7%	44.7%
Dish wash	28.1%	60.9%	28.0%	58.7%	30.0%	57.5%	38.8%	50.0%	32.5%	55.6%
Bath	23.4%	57.8%	25.3%	60.0%	26.8%	61.0%	27.7%	52.9%	26.1%	56.9%
Drink	9.5%	85.7%	16.0%	73.3%	10.0%	85.0%	10.6%	81.3%	11.6%	80.7%

Figure 7.6: The likelihood of using RWH for domestic purposes (If RWH is implemented in your house, how likely will you use it for these purposes?)

The use of RWH systems to supply non-potable water to buildings in urban areas of some developed countries has become popular as well with people accepting it for non-potable uses (Berndtsson, 2004). Although it is not popular in Scotland, most householders were likely to consider RWH for non-potable use as flushing the toilets, gardening and car washing in their homes with a relatively higher proportion in Edinburgh likely to use it for laundry (46.7%) and dish washing (38.8%) (Figure 7.6). Householders showed a strong preference for either “likely” or “unlikely”; therefore, there were relatively a small proportion of participants that were neutral (Table 7.4).

Table 7.4: The likelihood of using RWH for domestic purposes as expressed by participants (If RWH is implemented in your house, how likely you will use it for these purposes?)

ABERDEENSHIRE			
	Unlikely	**Neutral**	**Likely**
Drink	85.7%	4.8%	9.5%
Laundry	45.3%	17.2%	37.5%
Dish wash	60.9%	10.9%	28.1%
Toilet flush	15.4%	10.8%	73.8%
Bath	57.8%	18.8%	23.4%
Garden	18.8%	6.3%	75.0%
Car wash	22.2%	6.3%	71.4%
HIGHLAND			
	Unlikely	**Neutral**	**Likely**
Drink	73.3%	10.7%	16.0%
Laundry	47.4%	15.8%	36.8%
Dish wash	58.7%	13.3%	28.0%
Toilet flush	27.3%	14.3%	58.4%
Bath	60.0%	14.7%	25.3%
Garden	17.1%	6.6%	76.3%
Car wash	27.4%	11.0%	61.6%
SCOTTISH BORDERS			
	Unlikely	**Neutral**	**Likely**
Drink	85.0%	5.0%	10.0%
Laundry	54.8%	16.7%	28.6%
Dish wash	57.5%	12.5%	30.0%
Toilet flush	35.7%	4.8%	59.5%
Bath	61.0%	12.2%	26.8%
Garden	11.9%	0.0%	88.1%
Car wash	27.5%	12.5%	60.0%
EDINBURGH			
	Unlikely	**Neutral**	**Likely**
Drink	81.3%	8.1%	10.6%
Laundry	39.2%	14.2%	46.7%
Dish wash	50.0%	11.2%	38.8%
Hand dish wash	46.3%	15.7%	38.0%
Toilet flush	10.6%	6.5%	82.9%
Bath	52.9%	19.3%	27.7%
Garden	17.7%	5.3%	77.0%
Car wash	23.6%	7.3%	69.1%

Householders were not enthused at all to use it for drinking. For instance, in Scottish Borders, a participant felt:

> *I would not use rainwater harvesting for drinking, dish washing and personal washing because of crow poo…***P35, SB**

But some of the participants expressed:

*I will extremely likely drink RWH if it is made safe, filtered or treated. As at now I am using it for gardening…***P11, SB**

*Do you think harvested rainwater is acceptable for DRINKING? ANSWER: if filtered perfectly acceptable…***P61, AS**

*Private supplies are essential in remote areas but they are often relatively poor quality and so perhaps a system of rainwater harvesting could provide a better quality of water. It all goes through a UV filter anyway so would probably be safe enough…***P8, HL**

*RWH is perfectly acceptable for drinking purpose if treated…***P55, SB**

Not only were some participants willing to use it for drinking purposes, a stakeholder also expressed using RWH and was likely to use it as well:

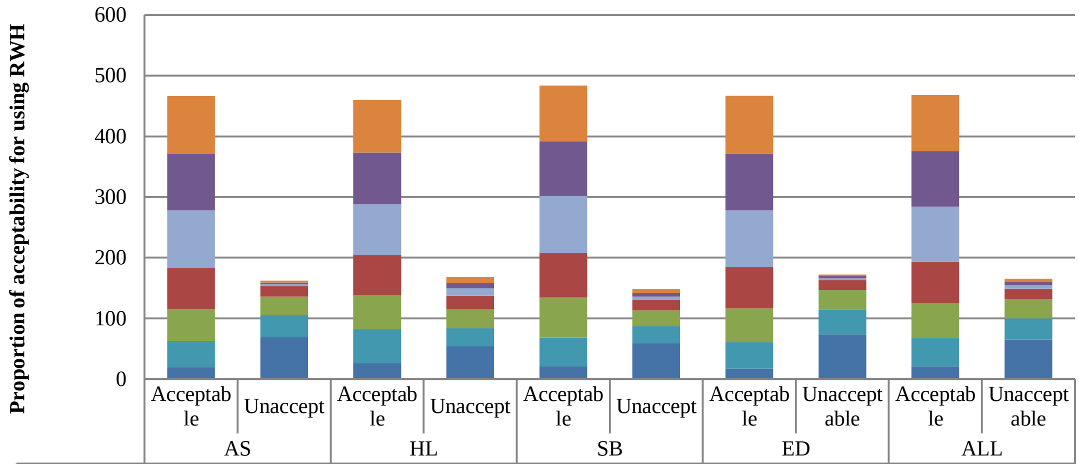
> *I have done it in the past. I've done camping and stuff like that so you know you do collect water. It's the same as you go take water in a barn. You don't think about it.*
> **Water Policy Analyst, CABS**

Therefore in addition for the acceptance of RWH, it is important to consider the way beliefs and attitudes are formed, in order to for it to adequately establish why changing them is important (Ward *et al*., 2012) .

7.5.2 Acceptability of RWH

Consequently, householders were asked if they found RWH to be acceptable for domestic purposes. Exploring beliefs, attitudes and desire to implement RWH in terms of its acceptance for domestic purposes; acceptance is known to be strongly driven by environmental concerns and social responsibility (Mankad and Tapsuwan, 2011). Research on the other hand shows that the beliefs about appropriate applications for alternative water seem to be influenced by cognitive perceptions related to water quality in addition to social responsibility (Gardiner *et al*., 2008; Gardiner, 2009; Marks *et al*., 2003), thus participants were asked if they were likely to use harvested RW for domestic purposes.

Overall householders perceived RW to be acceptable for gardening (92.5%), toilet flushing and car washing (91%), laundry (68.8%), dish washing (56.6%) but unacceptable for drinking (65%) and bathing (47.3%) (Figure 7.7). This order was relatively similar in all the study areas except for Highland. There some participants (55.7%) felt RW was acceptable for bathing (Figure 7.7).

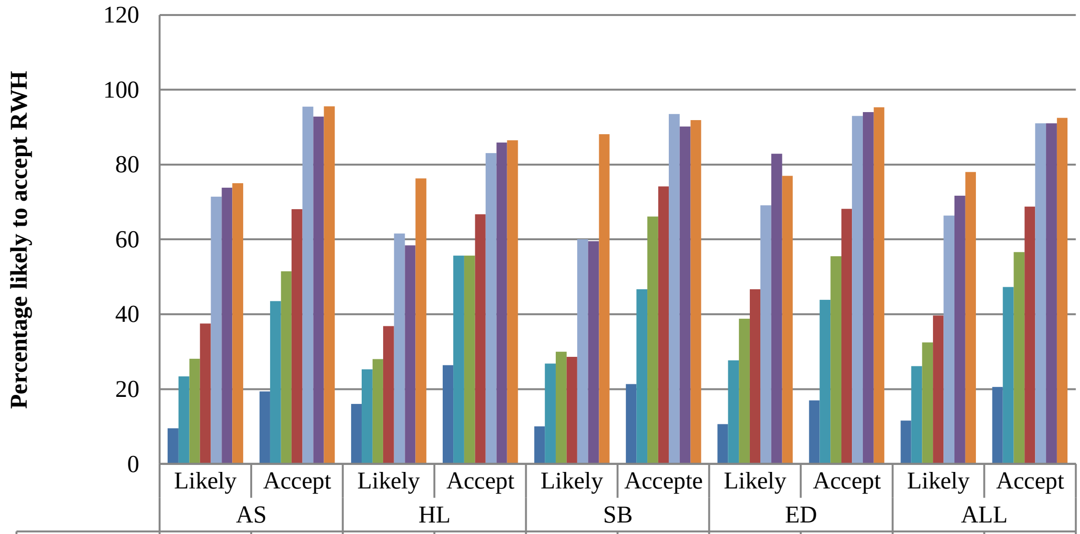


	AS Acceptable	AS Unaccept	HL Acceptable	HL Unaccept	SB Acceptable	SB Unaccept	ED Acceptable	ED Unacceptable	ALL Acceptable	ALL Unacceptable
Garden	95.6%	2.9%	86.5%	10.1%	91.9%	6.5%	95.3%	2.3%	92.5%	5.2%
Toilet flush	92.8%	2.9%	85.9%	8.7%	90.2%	6.6%	94.0%	3.7%	91.0%	5.3%
Car wash	95.5%	3.0%	83.1%	12.4%	93.5%	4.8%	93.0%	3.1%	91.0%	5.8%
Laundry	68.1%	17.4%	66.7%	22.2%	74.2%	17.7%	68.2%	15.9%	68.8%	18.1%
Dish wash	51.5%	30.9%	55.7%	31.8%	66.1%	25.8%	55.5%	32.8%	56.6%	30.9%
Bath	43.5%	36.2%	55.7%	29.5%	46.7%	28.3%	43.9%	40.9%	47.3%	35.0%
Drink	19.4%	68.7%	26.4%	53.8%	21.3%	59.0%	17.0%	73.3%	20.6%	65.0%

Figure 7.7: The acceptability of using RWH for domestic purposes (Do you think harvested rainwater is acceptable for these purposes?)

7.5.3 Perceptions of RWH in Scotland

Comparing likelihood to acceptability (Figures 7.6; 7.7), it was observed that some participants accepted RWH for certain domestic purposes but they were unlikely to use it. Finding RWH acceptable for certain domestic purpose suggests that if barriers were overcome, then willingness might change. Therefore, the difference highlighted between acceptability and likelihood to use RWH is important in relation to RWH implementation policies. Participants found RW to be acceptable for gardening, car washing, toilet flushing, dish washing and laundry but they were only likely to use it for gardening, toilet flushing and car washing only (Figure 7.8). Results were similar in both PWS users and MWS users.



	AS Likely	AS Accept	HL Likely	HL Accept	SB Likely	SB Accepte	ED Likely	ED Accept	ALL Likely	ALL Accept
Drink	9.5%	19.4%	16.0%	26.4%	10.0%	21.3%	10.6%	17.0%	11.6%	20.6%
Bath	23.4%	43.5%	25.3%	55.7%	26.8%	46.7%	27.7%	43.9%	26.1%	47.3%
Dish wash	28.1%	51.5%	28.0%	55.7%	30.0%	66.1%	38.8%	55.5%	32.5%	56.6%
Laundry	37.5%	68.1%	36.8%	66.7%	28.6%	74.2%	46.7%	68.2%	39.7%	68.8%
Car wash	71.4%	95.5%	61.6%	83.1%	60.0%	93.5%	69.1%	93.0%	66.4%	91.0%
Toilet flush	73.8%	92.8%	58.4%	85.9%	59.5%	90.2%	82.9%	94.0%	71.7%	91.0%
Garden	75.0%	95.6%	76.3%	86.5%	88.1%	91.9%	77.0%	95.3%	78.0%	92.5%

Figure 7.8: Likelihood vs acceptability of RWH for domestic purposes (If RWH is implemented in your house, how likely will you use it for these purposes? Do you think harvested rainwater is acceptable for these purposes?)

The observed acceptability for these purposes, according to Ward *et al*., (2008), correlates to participants perceiving these uses to be less risky. Perceived risk according to Ward *et al*., (2008), is assumed when the type of use of rainwater becomes personal as in drinking and bathing thus, they do not find it acceptable. This was confirmed with responses from households:

If filtered perfectly acceptable…**P61, AS**

Acceptable if boiled…**P82, HL**

For drinking it depends on the quality…**P69, HL**

RWH is perfectly acceptable for drinking purpose if treated…**P55, SB**

So, for uses like gardening and toilet flushing where it is perceived not to be personal use, they find it perfectly acceptable. Similarly, studies by Holliman (2007) 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. As confirmed by (Mankad and Tapsuwan, 2011), the most dominant social factor that emerged from a review of community acceptance of alternative water like RWH was the "perception of risk". 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 and or if the water was treated very well:

> *My response regards acceptability for RWH drinking water in relation to cleaning/ purifying techniques not discussed but it got to be better than the lead pipe it's currently sitting*…**P35, ED**

> *Private supplies are essential in remote areas but they are often relatively poor quality and so perhaps a system of RWH could provide a better quality of water. It all goes through a UV filter anyway so would probably be safe enough*…**P8, HL**

> *Depending on how RW is stored, I don't know enough to know if it will be suitable for domestic purposes, gardening and car washing hence my answer being neutral*…**P22, HL**

This further corroborates Ward *et al*., (2008) and Hurlimann (2007), 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:

> *Our water supply is from the burn. It is good water! And yes, I like to wash in it and drink it. Is your question will I be willing to wash in water-butt water? The answer is no, not really. It would be warm in the summer!! Not fresh, have bits in (like crow droppings) - the water is collected from the roofs*…**P35, SB**

Thus, it is not just risk that affects perception of RWH however people feel it is contaminated. According to Sadhu *et al*., (2014), rainwater collected and stored in domestic tanks may also 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*., (2014), 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 some participants found it unacceptable for drinking purposes but were willing to use it for toilet flushing.

When stakeholders were also interviewed, some perceived the water quality to be a concern but discerned RWH implementation in Scotland to be viable although it might add to treatment cost:

The health aspect and quality aspect needs to be thoroughly managed because I think there is quite a few issues with that perspective and that doesn't mean that it shouldn't be considered as a viable source.

Operations Team Leader, DWQR

Now what you will find is that it's a difficult political kind of issue as well so essentially if you put a requirement for a house to start RWH, that's an additional cost which is getting on put on the price of the house and inevitably get passed onto consumers and may reduce the feasibility of standard developments, it may have impact on the number of house buildings and there is always the balance of you know the supply of housing versus the sustainability of housing and essentially affordable housing and RWH systems at the moment probably don't go hand in hand and the building have to be lower cost to get the opportunity for it to be buyable.

Policy Adviser, Scottish Water

It is about what you are using that water for and if you are using RW to flush your toilet, what is the problem? I don't see the problem, yes you guard against contamination that might then add to increase treatment cost and that will be acceptable to us if an increase in treatment cost of say any other particular savings that would work for us. Because we are very keen to preserve and keep cost low for customers through their water supply so that's an absolute given. So, that will be a critical point, but I can't see myself how that would later be a real issue. However, some householders were not in complete agreement to RWH implementation.

Manager, Hydronation

Public health concerns on RWH is not only limited to Scotland, a study in Australia revealed that untreated roof-harvested rainwater samples tested positive for *Salmonella*, *Giardia lamblia*, *Legionella pneumophila*, and *Campylobacter jejuni*, which was a public health hazard to consumers (Ahmed *et al*., 2010). Several studies have also suggested that roof rainwater can be contaminated, and it should not be consumed before treatment other than that it poses as a public health risk (Ahmed *et al*., 2011; Dobrowsky *et al*., 2014; Hatha *et al*., 2013). For this reason, it is important to understand the factors that control rainwater quality and contamination pathways (Gwenzi *et al*., 2015). This according to (Gwenzi *et al*., 2015) is critical for minimization of rainwater contamination and safeguarding public health. More studies on RWH also suggests though there is a contamination concern, it can be overcome by education in order to maximise public acceptance and confidence of RWH systems provided the user is well informed on the significant public health issues around it (Marks *et al*., 2003). Also research shows that if rainwater is collected and stored properly, it can offer an additional high quality resource at household or small community level (Edmunds, 2006). This confirms current research on RWH public health concern were it is suggested that the measures to minimize rainwater contamination and safeguard public health can be done through engineering/technological interventions, public education and housekeeping *(Gwenzi et al.*, 2015).

Additionally, the need for education on RWH for it to be accepted by householders was further confirmed by stakeholders:

> *I think it is very much consumer awareness and engagement type thing which is still to the new standard.*
>
> **Policy Adviser, Scottish Water**

> *The big question is how do you get people to engage with the whole issue; unless you are actually discussing it with them and unless you are making them aware or unless you are leafleting their house or putting an advert on television.*
>
> **Water Policy Analyst, CABS**

Some stakeholders on the other hand were concerned that although RWH can serve as an alternate water supply or as a supplement;

> *I think it potentially has a place in terms of supplementing another water supply, another source of water just like the greywater use so just another supplement for water supply.*
>
> **Operations Team Leader, DWQR**

The issue of maintenance and ensuring it was sustainable would be challenging:

> *I mean one concern is it doesn't become a phase or something temporarily people do. It is looking at what is the difference between something being promoted for a while and everybody gets engaged and then they forget about it? How do you make that a sustainable par? How does it go through being a temporarily popular thing for a while to something that people do from now to like forever? You know and I kind of got a mental picture of a house with every seconds grown pipe coming down, and there's plastic water butt at the bottom of it. Because that will be a more permanent feature or you can make it more a permanent feature if it directly go inside the house and down into the toilet system, that kind of thing. So, I think it is just looking at how do you make these things more permanent rather than just be temporarily and optional.*
>
> **Water Policy Analyst, CABS**

Along these lines, there is the need for a policy that outlines and ensures RWH implementation and its sustainability, but in Scotland such a policy is non-existent.

Even though in the UK over the last few years there have been diverse policies aimed at making water use sustainable through alternate sources like RWH, there has not been any review on a number of codes, regulations, standards and best practice guidance manuals that are relevant to RWH (Ward *et al*., 2012). The need for education is verified through comments from stakeholders:

> *I think people perceive water falling out of the sky to be completely pure and there are potentially quite a lot of health issues surrounding RWH if it is not done properly. So, if it is harvested from the roof there could be faecal contamination, if there is any lead on the roof that could also be an issue. So, I think obviously if security of supply issue, like if it doesn't rain and you don't have any water so either you have a large storage tank which again it's a potential quality issue there, or you certainly did not have an alternate source. So, I think yeah there's a place there but I think it's probably one of the least reliable sources of drinking water, certainly has a number of health issues that needs to be addressed before it is acceptable and supply of water. And we have also found that we have had incidences reported to us from England, that our colleagues in England have found where there is a dual system so the greywater used in the house is RW and it is crossing to the main.*
>
> **Manager, Hydronation**

> *The other thing I found through my work is we are looking at, well I am interested in RW treated, so is the rain safe, is it a wee device that sits in your house and that takes away all your RW, is it for drinking purposes? So, this kind of technology I am interested in for a small remote household and stuff. But it's how do we get that through to people that you know actually this is the right thing to do for the future.*
>
> **Policy Adviser, Scottish Water**

> *No I mean on the face of it I think it is a good idea. I think it is ridiculous that we treat waste water to a very high standard and may it get used for that those sorts of purposes. So, I am for, but, as we have seen from incidences from down south, I think it needs to be managed very carefully so that the two systems can be kept completely set apart and individuals of that supply are aware of the risks of yea they can't just drink the RW supply, it has to be used for the greywater purposes. So, there is a sort of an awareness to handle and sort of plumbing bylaws issue and that needs to be in place, looking for if it is acceptable. In principle, I think it is a good idea.*

> *The people do worry about you know, will the water go stagnant, you know all these issues, practical is smell, practical is storage because of people don't have places to store the water. But we would definitely support you know a move to that, because it's sustainable both from an economic and an environmentally side, it's a sustainable way of moving forward.*
>
> **Director, WICS**

Consequently, education is important in explaining the concept of RWH, its storage and ensuring it is not a public health hazard. Notwithstanding, research in England and

Wales on public attitudes to in-house water recycling suggests that there was a broad willingness to accept in-house water recycling provided that public health was not compromised and furthermore perceptions, rather than factual information, may sometimes be more persuasive when it concerns water reuse (Jeffrey, 2002).

Aside risk perception, the concept of public threat perception is a strong driver for the acceptance in implementation of RWH (Marks, 2004). Public threat perception, according to (Mankad and Tapsuwan, 2011) refers to threats associated with water quality, severe water crisis and personal well-being. This confirms responses from stakeholders who perceived rainwater should be treated before it is acceptable:

> *I think if you are using RWH to consume as in to drink or to use, you have to treat it because the minute it hits the grid it is contaminated. So RWH, yes by all means as long as you have got a filtration or a water purification process then you can use. But for other purposes such as watering your garden or washing your car or flushing your toilet it doesn't need to be drinkable.*
>
> **Water Policy Analyst, CABS**

> *The questions do come about treated water going into the toilets and that kind of stuff; do we need to do it? Problem you have got is it's cultural in this country that they think they can have unlimited water. So, the question or problem is why do I need to it, what is my benefit? Because at the end of the day it is still going to go down the toilet and I flush away.*
>
> **Policy Adviser, Scottish Water**

> *Yea, it is feasible and it does help or lowers with the groundwater supply or the groundwater or the water going back into the ground actually. But, I think it's people's perceptions is the biggest thing and free water as well, we don't pay for it so.*
>
> **Business Development Manager, GRAF UK**

But as observed from the willingness to implement RWH in homes, a minority of householders were willing to implement without grants but if given grants a relatively higher proportion were willing to. Yet, they are likely to use it for toilet flushing, gardening and car washing although they found the water acceptable for laundry, dishwashing and bathing (Figure 7.8).

But I think people need to understand that rain coming off your roof at some point we need to look at, is that a public body, is that a corporate responsibility to take that away or it's the householders' responsibility to manage that. So, that I think it's the question. Whose responsibility is RW to exit that from your property? Is that a kind of an optional nice if you are meant to support the environment, you stick a water butt or is it the responsibility to put a water butt under your drainage pipes? So, I think there are some really big questions to be asked there that is whose responsibility is it to remove RW from our property? Because until now still people don't think about it, they just think that ah well the local authority does that, it just goes away and there is the drainage point over there I don't think about that. Whereas I think if from a policy point of view we are going to say people should harvest RW are we then putting a legal responsibility on a homeowner to see now you have to do it or are we saying you can do it if you want to but we really like you to do it but you don't have to if you don't want to so I think again it's looking at where is the incentive. Do you apply hard measures through legislation or do you apply softer measures through incentivization.

Water Policy Analyst, CABS

This was expressed by a stakeholder when asked what they perceived of RW. But another interviewee expressed that how people perceive RWH will make it challenging for RWH to be adopted in Scotland:

There's a perception thing and it will take time in terms of the effluent recycling and water reuse with regards to that. When people go deep down they will tell you the issues of the complex of you know the whole perception thing, it's quite a difficult challenge to take on when you've got quite a lot of industry kind of interested as well. So, for example, it would be acceptable for particular industries like agricultural industries for them to tell their prop customers that how their runoff is going to be used at the gate using water from. And then the other factor is as soon as you get into a global market, you know for example, whisky distilleries won't accept its crops grown with recovered sludge and things like because of the perception of the global market. It's marked as a clean product and certain cultures from different parts where whisky is popular overseas will not accept the fact that they have been using that particular effluent in growing that or growing using recovered sludge and things like that. So, all these things are kind of interrelated, it means that no one should underestimate the challenges of changing perceptions in that area.

On the other hand, just like households, a stakeholder perceived RWH to be good:

RWH is one of the facts that we should be more sustainably using resources. And I think RWH as a principle in itself is a really good thing.

I think it's looking at RWH would be helpful to some degree of taking pressure of public networks such as drainage and part of sewage and part of potential flooding. I think from my mind point set it will be good to get people to think more about how they can use RW and how they can use it sustainably on their property.

Water Policy Analyst, CABS

Whereas others perceived it not to be safe and would not encourage it in Scotland:

> *A number of issues and the difficult to resolve and ensure that it is safe. I think from my perspective and a policy point of view we would only promote as mains water supply being a safe reliable source of drinking water. And I mean where in some parts of Scotland where that isn't an option at all, I think we probably would not and we will be looking for secure source of water that is probably treated to not a risk to health and that will probably be a river source, borehole ideally. Ideally, I think RWH will probably be last choice considering a number of health issues and reliability issues.*
>
> **Operations Team Leader, DWQR**

> *I think that we would rather put money into Scottish waters improvement into their system rather than put it towards RWH, because you get a better end results.*
>
> **Technical Officer Infrastructure Service, Aberdeenshire Council**

Stakeholders might have perceived water to be unsafe because as suggested by other researchers, the risk of using RW increases as the use becomes personal; a lower level of acceptance is given to uses that require a high level of personal contact. With the rain, this acceptance is increased as the level of personal contact decreases (Gardiner, 2010; Ward *et al*., 2013; Seidl *et al*., 2010; Domènech and Sauri, 2010), thus householders and stakeholders may have perceived RWH will be contaminated or unpleasant. Further studies also shows that emotions like disgust and yuck factor also limits the value of RWH thus people not accepting it (Russell and Lux, 2009). Alongside, most RWH systems available in the UK, in England are promoted as being fed from roof-tops and suitable for WC flushing and garden use with a few a slight mention for laundry purposes (Ward *et al*., 2013). Thusly, this could be attributed to why householders perceived it not to be appropriate, acceptable, and unsafe for personal contact kind of use.

7.6 GREY WATER AND RWH

During the interviews, it was noticed that stakeholders were mixing the concept of RWH and grey water:

> *I think it is feasible and I can see where developers might be interested in that. Yea we certainly know there is value in the greywater market if you like. I can definitely see the potential there, yes and in both urban and rural setting. I do see, as I mentioned a particular interest in the rural dimensions because that is maybe where a supply issues are more acute. I can see it as a viable solution in both environments.*
>
> **Manager, Hydronation**

I think it has probably got a place, and certainly for greywater use, but I think it needs to be done very carefully.

Operations Team Leader, DWQR

A couple of instance is where RWH is being used; you know appearing in plumbing applications. But again, it is being used for greywater purposes rather than actually if it gets being used for flushing the toilets and things. Can be promoted in Scotland? It is, but I don't know who will do that promotion.

Environmental Health Officer, Hebrides

According to RWH systems; "…*there is a lot of confusion and misconceptions regarding the various types of water recycling systems. For instance, a rainwater harvesting system is typically thought of as the same thing as a greywater system. This is simply not true. Sometimes, the use of harvesting rainwater to flush toilets is confused with greywater terminology but RWH application is much simpler and is an easily installed rainwater system component*". This reinforces the perception that awareness of RWH in Scotland was limited considering a stakeholder also refereed that RWH was:

It is probably fine for greywater use for flushing toilets and stuff like that. But I don't know if I will be happy with it being used for drinking water.

Environmental Health Officer, Hebrides

7.7 CONCLUSION

The main purpose of this chapter was to meet to explore the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH (Objective 4). Awareness of RWH was limited in Scotland. Minority of participants had any form of RWH system in their homes and there was a vast difference between PWS and MWS users in terms of RWH awareness. More than half of the participants on MWS were aware of RWH but few had any form of RWH in their homes as compared to those on PWS. Less than half were aware or had any form of RWH in their homes because of lack of knowledge and uncertainty of implementing RWH.

When householders were asked if they were willing to implement RWH (prior to being asked in association with grants), only a minority were willing to do so. Their reason was attributed to:

- The design of their buildings which they perceived was not feasible for RWH implementation (flats).
- They were not landlords so could not make that decision (housing tenure).
- Abundant water resources in Scotland.
- Storage was perceived to be challenging.

Stakeholders on the other hand perceived that the main barriers were:

- Water charges.
- Social and technical barriers.
- It will be expensive which will hinder public acceptance if no financial incentives are given.
- Awareness and benefits of RWH were the observed to impede the adaptation of RWH in Scotland.

PWS users were more likely to implement RWH if no form of grants were given. It was observed from responses from Edinburgh and Highland that they were more unlikely to implement RWH if no form of grants were given.

Women were more likely to implement RWH without grants as compared to men and the age of a participant also negatively correlated with RWH implementation. Participants in the age category 16-54 years (younger people) were most likely to implement RWH without grants as compared to those who were 55 years and above (older people). In Scottish Borders, however, older people were more likely to implement RWH if no form of grants were given. Results were similar in both MWS and PWS users with relation to age and RWH implementation without grants.

Stakeholders perceived there was a potential for RWH in Scotland. They believed RWH was good for water efficiency measures in Scotland and it will also cut down on the demand for water. When they were asked if they will support RWH in Scotland they suggested:

- They will support it if government comes out with policies that support RWH.
- If RWH will comply with bylaws to protect public water supply.

They also suggested for it to work, there needs to be some form of promotion by starting it in new builds. Not only that, they perceived for it to be successful in Scotland, there is the need to create awareness and educate inhabitants of Scotland. Yet they felt it will be challenging. Although some stakeholders supported RWH, some were against it and attributed it to previous bad experience with RWH. Therefore, some felt the benefits for RWH should be properly outlined and understood before it can be implemented.

Although householders and stakeholders found RW acceptable for gardening, toilet flushing, car washing and laundry, they were unlikely to use it for laundry. They also found RW unacceptable for drinking. This was the same for both PWS users and MWS users. The perception of RWH observed from both stakeholders and households was that: it was unsafe, contaminated and risky. Both stakeholders and residents surveyed perceived the plentiful water in Scotland did not demand for RWH. Lack of evidenced studies of the success of RWH in Scotland compared to England shows low acceptability responses from householders. Residents in Scotland were more likely to use RWH for lower risk domestic activities like flushing the toilet, gardening and car washing. Furthermore, it was observed that RWH was being mistaken for grey water by some stakeholders this could be attributed to the low acceptable level as well. The confusion between greywater systems and RWH may explain the low acceptability levels. So, some stakeholders suggested education and policies as a way to boost RWH installation in Scotland.

Chapter 8- CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

This research explored the feasibility of rainwater harvesting (RWH) in a Scottish context. It is the first study of its kind in Scotland; one of a handful of Northern European countries which are water rich. In doing so the research has revealed empirical evidence on residents and stakeholders' attitudes to and perceptions of RWH and climate change. Resident questionnaires and interviews of stakeholders explored the social drivers for RWH adaptation, the feasibility of community water development scheme in Scotland. Householders' perceptions of climate change and its effects on their source of water supply were also explored. This understanding of climate change was required to facilitate:

1. the development of a strategic framework that the Scottish Government can use to support the use of rainwater as an adaption strategy to climate change against flooding;
2. a move towards an alternative water supply to areas that use PWS in times of drought; and
3. aid in achieving one of its hydronation agenda.

RWH is not a new concept in water resources management and many countries have widely promoted RWH to meet increasing water demand, mitigate the risk of flooding, droughts and also reduce erosion and non-point pollution in urban environment (Fewkes, 2012; Gould and Nissen-Petersen, 1999; Julius *et al*., 2013; Roebuck and Ashley, 2007). The barriers to the implementation and acceptability of RWH have been investigated across the UK nations except for Scotland.

8.2 CONTRIBUTION TO KNOWLEDGE

This research has contributed to the knowledge gap on RWH and receptivity of households towards this technology and the attitudes to and perceptions of climate change in UK. It has done this by looking specifically at a Scottish context as much of the existing research is in England and Wales. Ward *et al*., (2008, 2010, 2012, 2013);

Parsons *et al*., 2010; and Fewkes (2012), have conducted substantial research on RWH systems (feasibility, adaptation, and acceptance) in England. They suggested RWH can be implemented when financial incentives are given to households and the perceived risk of using RWH increases when the type of use became personal as in physical contact with the water. If Scotland is to tackle climate change even though it has enough water resources, the government needs to look at the importance of RWH as has been done in Wales (Nash, 2015). In relation to that, this research used questionnaire survey modified from Ward *et al*., (2013) to access the attitudes, perceptions, and behaviour towards RWH and climate change in Scotland through residents and stakeholders.

By analysing responses from the questionnaire, this research has contributed to international knowledge on RWH acceptability, attitudes, and perception. Empirical evidence from this study revealed that residents were enthusiastic to implement RWH if some form of financial incentives were given. Residents surveyed preferred grants from their Local Authority to implement RWH and were unlikely to use it for personal use since they felt it was not safe. Contributions from this study are new since nothing has been done in Scotland and this research focuses solely on Scotland. This makes this study important due to the different climatic context of Scotland as compared to other regions that have embraced RWH. For instance, in areas like Australia, Japan, and Germany where rainwater has widely been harvested, the reason for harvesting were entirely different. In Japan for instance, RWH was introduced for the reduction of flood risk (Ward, 2008) whereas in Australia it was introduced as an alternate water supply.

This research contributing to literature on RWH in a Scottish context has also opened a way for more research on RWH implementation and adaptation in Scotland. Geographically and needs wise, Scotland is different and may have a use for RWH, example as a flooding mitigation solution. Through interviews with stakeholders, it was revealed that there is a place for RWH in Scotland if households were properly educated on its implementation and benefits. This has suggested the need for an in-depth study and a framework for its implementation in Scotland. However, by examining the Welsh Government’s approach on surface water rebate for properties, this project has produced conclusions regarding how government could research into new regulations and incentives that foster the use of RWH.

This study has further contributed to the knowledge gap on the feasibility of implementing RWH in Scotland. In Scotland, this research has shown that RWH is feasible in the sense that there are no technical barriers as to why RWH cannot be implemented. In comparison to other countries using RWH, Scotland has:

a. An abundance of water;
b. Financial resources (outlays) for RWH implementation through grants or tax rebates;
c. Infrastructure (the basic physical and organizational structures and facilities) to support RWH; and
d. Safe system for producing good quality water, thus they can make RWH safe and less risky as observed in other countries.

There is, therefore, no technical reason RWH cannot be part of the Hydronation agenda. The only impediments that are observed are related to structure, culture, who will pay and who will maintain the system. But this can be overcome with an effective policy on RWH implementation.

On climate change, this study makes a key contribution to literature on the awareness of climate change but in a Scottish context. This study agrees with several researchers that have concluded that climate change is not high on people's agenda. Although in Scotland the awareness of climate change was not high on people's agenda, it was found that the "wording" of climate had an impact on people understanding the effects of climate. People related better to a phenomenon where they perceived to feel the direct impact on their water resources. For instance, a drastic change in weather which results in situations like hurricanes, flooding and drought. They perceived climate change as a distant phenomenon likely not to affect Scotland.

Although participants only perceived the positive impacts of climate change and not the negative impacts, they were willing to reduce the impact of climate change when the wording was turned and or changed to mean floods, droughts, water pollution, and more energy which they could relate to more. This was in agreement with other literature where it has been suggested that an increase in temperature may contribute to an important role in people's beliefs about climate change (Krosnick *et al*., 2006; Ratter *et al*., 2012; Weber and Stern, 2011). Therefore, although climate change is perceived not to be high on people's agenda, this study has found that weather impacts are high and if “climate change” was changed to “weather impacts”, then it will be high on the public’s agenda. This study has thus brought in insights on changing the word “climate change” to something people can relate to more.

By drawing on responses from residents and stakeholders, Scotland is perceived to have abundant water resources and it is assumed if climate change should happen it will be minimal or have no effect. However, major weather impact is perceived to have an impact on water resources in Scotland by residents. Thence this research has suggested water efficiency measures to be put in place if a value is to be put on water in Scotland. And in the context of climate change, this research presses home the need for an action to be taken by the Scottish Government mitigating the effect climate change may have on water resources through adoption of RWH.

Adaptation plans to mitigate impact of climate on source of water supply for private water users is underexplored in Scotland. This research has highlighted the need for future plans and practical adaptation actions to ensure PWS resources in rural communities are safe from the impacts climate change might have on them through contamination, drying up and pollution. This makes this research important for the Scottish Government in its bid to tackle climate change. RWH can be adopted for new buildings as has been done in Wales. Scotland and Wales share common characteristics and if RWH has been feasible in Wales to combat flood (Nash, 2015), the Scottish Government can take a cue from Wales. In terms of climate, Wales is relatively similar to Scotland and both have little population with dispersed settlements and a lot of rural to semi-rural areas.

In Scotland, most rural communities use private water supply (PWS). Even though the effect of climate change is very difficult to model, this study has shown that some PWS dry up in summer or freeze in winter. Thus, this research emphasizes the need for public education and engagement of rural and peri-urban communities on the effects of both positive and negative impacts of climate change since participants were willing to reduce the impact of climate change if they will be affected directly. This enforces a need to review existing policies, plans and framework which incorporates public engagement in both theory and practical on climate change action plans to ensure PWS users are safe and prepared to adapt to climate change impact for water neutrality to be feasible. This study thus suggests that such a policy document or framework can be from Scottish Water, Scottish Environment Protection Agency, or the Water Industry Commission Scotland. The policy should involve an active public engagement which focuses on water service resilience with the public understanding water resource planning (understand sensitivity to climate change), water resource supply and quality.

8.3 KEY FINDINGS AND HOW THEY WERE ACHIEVED

The key findings focus on RWH being widely practised in many developed countries which were on par with Scotland in terms of water abundance. However, residents surveyed in Scotland felt RWH would not to be financially beneficial due to Scotland's abundant water resources and were unwilling to practise it unless given some form of grants. But stakeholders felt it will be challenging for it to be accepted in Scotland even if given grants since the risks involved were likely to affect people's perception and attitudes. A minority of stakeholders were confusing RWH with greywater and felt it was not feasible as a climate change mitigation solution in Scotland. A greater number of residents surveyed were aware of climate change in terms of the media, friends, and community but felt it would not negatively affect water resources in Scotland. Residents however could relate more to flooding, droughts, water pollution and catastrophic weather events as compared to using the word "climate change".

The key findings were arrived by answering the four objectives introduced in Chapter 1 using a mixed method approach in the form of a questionnaire survey to households and semi-structured interviews with stakeholders. The objectives were to:

Objective 1: Explore and understand the theories and practices of rainwater harvesting in the world

To achieve Objective 1, Chapter 1 set forth an introduction which was followed by literature review in Chapter 2 exploring the international use and adoption of RWH and climate change. This revealed that RWH was widely practised in many developed countries like Germany, Australia, Japan, New Zealand, Singapore and USA (Brown *et al*., 2005; EA, 2003; UNEP, n.d.; Chilton *et al*., 1999; Hills *et al*., 2001; Zaizen *et al*., 2000). In Germany which is on par (in terms of development) with Scotland and not considered a water-poor country, RWH has been used by households since the 1980s and about 50,000 professional rainwater plants are installed yearly in new one-family houses (Nolde, 2007). Research showed that RWH has been beneficial around the world by reducing flooding (Fricano and Grass, 2014). Due to this and climate change impacts on water resources, RWH is now receiving increased recognition as a as an adaptation or mitigation solution (Mwenge Kahinda *et al*., 2010; Pandey *et al*., 2003; Vohland and Barry, 2009).

To foster the adoption of RWH technology in these countries, regulations, policies and incentives that foster the use of RWH have been increasingly developed (Domènech and Saurí, 2011). For example, in Flanders, new buildings with a roof area more than 100 m^2 are required to install RWH attenuation systems (Environment Agency UK, 2008) and in the USA, RWH is mandatory in new buildings of Tucson (Arizona) and Santa Fe County (New Mexico) (Domènech and Saurí, 2011). In Germany for instance, households harvesting rainwater are exempt to pay stormwater taxes (Hermann and Schmida, 1999). This shows that with policies and incentives in place, there has been an uptake of RWH in these developed countries even perceived to have abundant water resources like Scotland.

With regards to the UK, there has been limited research on RWH and in individual regions the most recent studies on RWH systems were in South-West of England. As of 2010 in England, the government was not offering any financial incentives to householders or developers to install RWH systems (Parsons *et al*., 2010). However recent studies showed that 87% of the residential developers surveyed would increase RWH in UK (England) if incentives were available *(Parsons et al*., 2010). It was thus revealed that in England RWH has a place as an alternative technology to increasing water demand, reducing water charges and a perceived adaptability and resilience to flooding in the face of climate change and population growth.

Conversely, RWH implementation or incentives or policies that will aid in adoption of RWH was underexplored in Scotland.

Objective 2: Understanding the perceptions of Scottish inhabitants on climate change and the likely impacts of climate change on water supply in Scotland

The uncertainties regarding how climate change may impact on Scottish water resources were also explored to meet Objective 2. Participants' perceptions about climate change from the survey were similar across PWS and MWS users (Figure 7.1). Key to the findings of Chapter 5, a greater number of households were aware of climate change in terms of the media, friends, and community but felt it was not happening. Linking literature review to this study, it confirmed with research in 2003 by DEFRA that only 1% of the English public have not heard of climate change (DEFRA, 2003), however, self-reported knowledge is erratic. Reiterating to findings of other studies, residents from the survey felt climate change was good by giving them abundant water resources. This further corroborates climate change awareness comparison research in USA (Kempton, 1997) and England (Norton and Leaman, 2004) where the public were aware of climate change issues but they did not possess an equivalent level of understanding in regards to the causes of and solutions to climate change. It was discovered the "wording of climate change" was misunderstood by participants from the survey. They attributed climate change as not a new thing of which private companies and government institutions were relying on to make profits through complex policies. This response in Scotland further emulates identical findings in the USA (Kempton, 1997) where respondents' general awareness of climate change did not match with a comprehensive understanding of causes, consequences and solutions of climate change.

Residents felt weather could impact on their water supply rather than climate change and could relate more with the weather impacts on their water supply. The Scottish residents from this study's perception corroborate a recent survey in England (2015) where two-thirds of people sampled were prepared to link floods and climate change (in their own judgements). A majority of the public in England viewed the 2013/2014 floods as having been caused in part by climate change (Wadey *et al*., 2014). This further confirms that the public's response to climate change is often determined by the state of the weather (USA Climate Change Science program, 2008). Although they did not believe in climate change, most residents were willing to reduce the impact of climate change if it will affect their source of water supply.

By the depth of understanding of climate-change issues is suggested to depend on individual characteristics such as educational level, age, and gender; gender and age was analysed. It was discovered that gender and age was independent of climate change awareness in Scotland as suggested by some researchers.

Stakeholders said RWH as one of the climate change mitigation solution was not feasible in Scotland; it was assumed to be insufficient to reduce flooding. However, most stakeholders agreed that for it to be adopted, it should be promoted using incentives. If not, it was nearly impossible although they perceived the impacts of climate change on Scottish water to be minimal.

Objective 3: Exploring the factors affecting RWH implementation (understanding people's motivations in the context of what is needed to enable people to consider RWH through finance, maintenance, and ease of using the system) and stakeholders view

To achieve Objective 3, in Chapter 6, residents' motivation to accept RWH was explored through water conservation using RWH, finance, maintenance, and the ease of using the system. Comparing research in England where extensive research has been undertaken on RWH to responses of the survey in Scotland, Scottish respondents had a low level of awareness about RWH, with little technical knowledge or understanding of the environmental and social benefits relating to RWH. Similar to England and other countries (Chapter 2), social concerns (financial incentives and technical adaptations) to RWH implementation were among the major barriers to households embracing the technology.

The awareness of the possibility of water being impacted with drought was found to be limited since it was assumed Scotland has unlimited water resources. Due to that few people (47%) had water saving devices at home. Although RWH concept is not well developed in Scotland, a relatively high percentage (66.3%) believed it was important to conserve water through alternatives like RWH. The few that perceived water conservation (through RWH) was unimportant were a result of:

a. A lack of knowledge on RWH;
b. The assumption that there are abundant water resources in Scotland; and,
c. That the assumption that the cost of water was free.

It was observed linking water efficiency with hot water was quite challenging because those that perceived their domestic water use had an influence on their energy bill were less than 50%.

Residents felt RWH not to be financially beneficial whereas research in England, RWH was thought to be economically beneficial since water is recognized to be expensive (Fitch and Price, 2002). Because of that, residents were unwilling to implement RWH unless given some form of grant which was in conformity with other research where people need to be incentivised before they are willing to implement RWH (Hermann and Schmida, 1999; Domènech and Saurí, 2011). Despite new regulations and incentives that foster the use of rainwater have increasingly been developed worldwide by governments at both the local and regional levels, stakeholders felt strongly that it will be challenging for local authorities to finance RWH in Scotland. An easier way suggested by them was to campaign it like the way it has been dome for energy efficiency.

Comparing participants on MWS and PWS, it can be seen from the results of this study that participants on PWS were more concerned about having constant water supply whereas those on the MWS were willing to accept RWH in their homes if it will reduce their water bill. Conversely, the preference for a communal system was not established since some PWS users did not have closer neighbours.

Objective 4: Exploring the risk involved in using RWH (attitudes towards risk which influences the perception of RWH) and factors that affects behaviour uptake of RWH

The research found that the attitudes, behaviours, and perceptions towards RWH in terms of risk were similar for PWS and MWS. There were mixed views from survey respondents on behaviour, attitude, and perceptions of RWH implementation in Scotland which was explored in Chapter 7. Survey respondents said factors which were likely to affect their perception and attitudes towards RWH included:

a. water charges;
b. the risk of water being contaminated or being ill if one consumes rainwater;
c. abundant water resources;
d. storage of rainwater;

e. smelly water;
f. crow droppings; and
g. designs of buildings.

Both residents and stakeholders found rainwater acceptable for some domestic purposes, however, they were unlikely to use it for drinking and bathing. This contradicts research in Australia, India, Bangladesh, and Germany where RWH is used for drinking and other domestic purposes (Friedler *et al*., 2006; Mohad. Shawahid *et al*., 2007; Hurlimann (2006; 2007); Friedler, 2008). The perception of RWH observed in Scotland was; it was unsafe, contaminated, and risky for a nation which had abundant water resources. In England, which is perceived to have less water resources compared to Scotland, studies show a higher acceptability level for using RWH for domestic purposes as compared to Scotland (Nash, 2010). In Scotland, households were more likely to use it for lower risk purposes such as flushing the toilet, gardening and car washing. Furthermore, it was observed that RWH was being mistaken for grey water by some stakeholders and this could be attributed to the attitude of low acceptance level as well.

Stakeholders thought there was a potential to change the perception of RWH for it to be widely accepted in Scotland. They believed for residents to have a good perception of RWH, it should be promoted as a water efficiency measures. Some were willing to support this if:

a) The government comes out with policies that support RWH;
b) It will comply with bylaws to protect public water supply; and
c) It would be promoted in new builds.

The research, though not intended to have, also demonstrated that the non-treatment of some households of their PWS was a public health issue. This was explored in Chapter 4. However, lack of evidence about diseases in local areas and the immunity perceived by inhabitants makes it difficult to convince them to treat their PWS. While most residents were confident their water was pure and disease free, the factual basis for their opinions is uncertain and or questionable.

8.4 RESEARCH ACTIONS AND IMPACTS

As mentioned in Chapter 3, the author's research background is not of social science and as part of the action research element, this project employed social perceptions as a critical influencing factor regarding the acceptability or non-acceptability of RWH. This was achieved through beliefs, desires, and intentions (Figure 8.1) combined with the VBN model (Figure 1.3).

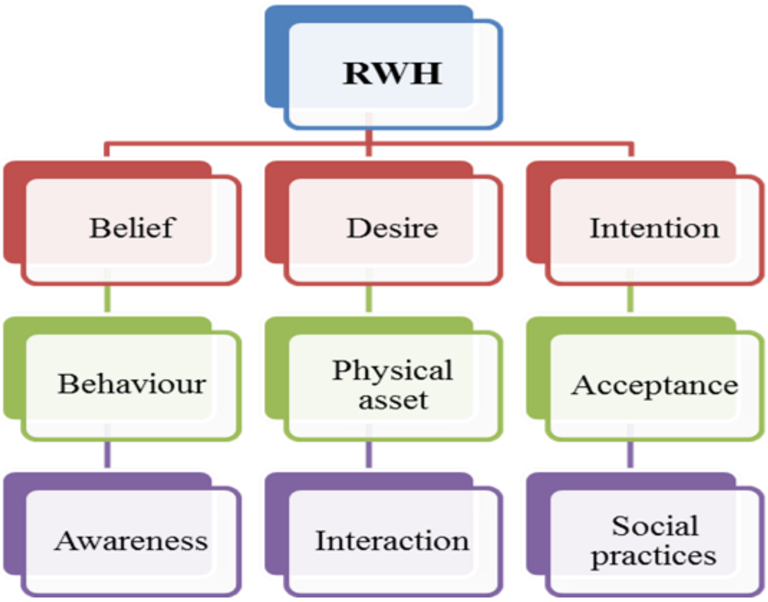


Figure 8.1: A diagram depicting how Chapters 6 and 7 were explored in this study

During the interviews with stakeholders, they expressed interest in the findings of this research. In relation to impact of this research and in conjunction with the recommendations in Section 8.5, it is further suggested that to communicate this research, these have been recommended:

a. Some part of the study will be published in a journal, oral presentations will be given at conferences and informal discussion with stakeholders in Scotland;
b. There should be more campaigning together with government policies;
c. There should be updated building regulations to include RWH;
d. Scottish Water messaging and running adverts to promote RWH;
e. School projects to promote RWH; and
f. There should be a national strategy by the Hydronation for water efficiency which includes RWH which now does not exist in Scotland.

Since stakeholders are interested in the findings of this research, there stands a possibility that the Scottish Government or Scottish Water will start considering RWH as one of the climate change mitigation solution as has been done in Wales.

Considering the Scottish Government is committed to making Scotland a Hydro Nation, to maximise the economic benefits of water, this research has given insights into the feasibility of RWH in Scotland. Even though Scotland has abundant water resources, this research has shown that Scotland can maximise the economic benefit of their abundant water resources within a sound ecological context by reducing energy use (using RWH for non-potable use reducing pumping), improving efficiency (as a form of water recycling) and creating a low carbon water nation (less pumping less GHG) to achieve the Hydro Nation's agenda.

This research though not intended to, created awareness of climate change, the amount of energy used in homes and water conservation when the questionnaires were sent; some residents felt they have been educated and it has created awareness of their water use and their views on climate change and its impact so they will be more conscious of their impact on the environment.

8.5 RECOMMENDATIONS

8.5.1 For the Scottish Government

These findings could be of interest to Scottish Government's Hydronations agenda in their bid to be water efficient as a nation. Coupled with the lack of knowledge and technical know-how to the design and installation of RWH, the following recommendations have been determined:

1. The government should consider 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 to promote wide adoption of RWH.
2. This research has shown that the way water is paid for in Scotland can be changed. It is recommended that the water bill should not be collected as part of

the Council Tax bill but should be collected separately. This will make people more aware of their water usage and be more willing to adopt RWH.

3. A national standard for installation and maintenance should be established.
4. Government in Scotland should consider the introduction of new regulations and incentives that foster the use of rainwater by considering the cost of RWH installation and the feasibility installation of RWH systems so that a policy for mandatory implementation of RWH systems in the homes may be designed.
5. Local Authorities should also create incentives and encourage RWH as most participants have been shown to be interested if grants are given at the local level.
6. Most participants felt their building design could not accommodate RWH therefore buildings should be designed in a way that supports RWH. The government could start with new builds instead of retrofitting.
7. The government should generate data demonstrating the benefits of RWH in Scotland.

8.5.2 For Scottish Water

RWH can be promoted by Scottish Water as a water supplement to reduce dependence on the drinking water supply in their bid to reduce water cost. This study recommends Scottish Water to:

1. Take the lead in promoting and sensitizing the public on RWH system innovation, their benefits in terms of flood control and how the water can be filtered to good quality for potable uses to make it more appealing to a wider range of householder needs.
2. Implement regulations on water efficiency if a value is to be put on water in Scotland by compulsorily installing water meters in homes.

8.5.3 For Research or Academic

As observed from literature, receptivity towards RWH was high in England and in other countries (Spain, USA, Australia, China, and most developing countries) was as a result of water scarcity. Taking into consideration the different climatic regions in Scotland, these recommendations have been suggested:

1. There need to be a localised study due to the different climatic regions in Scotland to understand the wants, needs and conditions of different areas in Scotland for RWH to be feasible.
2. Research in servicing, maintenance, building regulations (housing tenure and types); new builds versus retrofitted builds are highly needed to motivate the uptake of RWH in Scotland.
3. Further research is needed since the income of participants was not taken into consideration so it is difficult to conclude on financial incentives.
4. Since stakeholders thought RWH was not enough as a climate change mitigation solution, research is needed to analyse if RWH has a potential to avoid flooding in Scotland as adopted by Wales and Japan. Therefore, it is suggested for an integrated research approach with RWH: avoiding floods and droughts as a climate change mitigation solution.

8.5.4 For local authorities with private water supply (PWS)

On the use of PWS, this research not intended to, but discovered that PWS users were not treating their PWS because they perceived to have become immune to any pathogens it contains. It was believed by PWS users that it was healthy and not a risk to public health but rather the water was tastier and disease free. The following recommendations have been suggested:

1. Scottish Water can identify such communities and engage them on the possible effects on non-treated water supply for them, their family, and visitors.
2. An enhanced dissemination of information about residents PWS coupled with public health outreach activities is very necessary and important. Environmental Health Officers from Local Authorities should provide support and input for public education programs, particularly those related to private water testing, research into diseases associated with drinking untreated PWS and help should be offered to PWS users to manage their PWS in terms of monitoring and quality (increased monitoring, treatment, and quality).
3. It was discovered that some PWS dry out in the summer thus the effect of climate change impact on PWS could be greater. Although community preference and individual preference was not established, for PWS users, it is recommended for some form of community engagement to address PWS issues.

8.6 RESEARCH LIMITATIONS

The study has offered an insight into Scottish residents' attitudes towards rainwater harvesting and the impacts climate change have on Scottish water resources and was conducted in an urban to semi-rural environment through sampling households. As a direct consequence of this methodology, the study encountered several limitations, which need to be considered. The foremost of which is the representativeness of the sample. A total of 378 people answered the questions from 4 different areas in Scotland out of the 32 councils in Scotland. Since each council in Scotland has different geography, sample of the residents that answered the questions were based on their personal circumstances and climatic conditions. Thus, analysis was based solely on the 4 councils (which were mostly rural) that the questionnaires were sent to and not representative of all Scotland.

A challenge of any survey research is finding and recruiting participants from the target group in the population to answer the questions. This challenge was compounded by using a postal questionnaire survey with a pre-paid reply envelope. To reduce error, responses from the paper survey were manually inputted online using lime survey. The writings of some of the participants were illegible and may have resulted in important comments from participants being omitted in this research.

Some transcripts from interviews with stakeholders were not included in the analysis due to noise interference and inaudible words because of the accent of some participants. These comments were taken out during analysis thus losing some important information.

Finally, while the postal survey was the preferred way by residents in selected study areas to respond, some members of the target population may have not participated because of their discomfort with questionnaires. So out of a total of 1,000 questionnaires that was sent out, 378 were returned. Despite these difficulties, data was obtained and was analysed by collating responses and calculating percentages. The final comments (Appendix VII) from participant from the text-boxes provided in the questionnaire were then used to expand the quantitative analysis.

While the survey provides this study with quantitative data offering insight to attitudes, behaviour and perceptions towards climate change and rainwater harvesting in Scotland, it did not produce the kind of data needed to create a full picture of all of Scotland. If this research was to be repeated, councils on MWS would have been increased since only one council on the mains was used. This led to the results being slightly slanted towards a certain group of people (mostly rural). Furthermore, questionnaires would have been sent to new builds or households intending to buy a house to analyse their preference for RWH. But what is important is that it has served as a basis or the beginning of more research into localised councils in Scotland. Furthermore, it is hoped that this survey will serve as a place to begin an explicit discussion concerning rainwater harvesting implementation in Scotland.

To conclude, this research has shown that RWH has been known to be economically financially beneficial in England where water is perceived to be expensive. However, in Scotland it will be difficult to implement since water is assumed to be free and it is relatively cheap. The use of water meters in England makes people aware and conscious of their water use and is more willing to adopt alternative use like RWH. In Scotland, where there is a water meter fitted, Scottish Water sends such households a monthly or a quarterly bill which normally consists of a fixed charge, plus a charge for water used, measured by the meter, and an estimated charge for waste water. So even though RWH is environmentally beneficial, unless it is financially rewarding to households, they might not willingly implement it since it might be extra burden.

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