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What role does behaviour change play in the achievement of climate resilient water management in the UK?

Author: Ijas Muhammed

Student number: 19147760

Supervisor: Dr. Emma Wragg

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Abstract

As the effects of climate change are being already felt across the world, the water will be one of the most affected resources. Therefore, water management should seek all possible solutions to address the challenges it will face with climate change.

In the UK, private water companies provide water and wastewater services for the general public. The strategies adopted in the UK are mostly to ensure water sufficiency, which is to ensure that there is enough supply of water to serve the ever growing population. Water efficiency, which deals with responsible usage of water, seems to be given a lesser priority in the water companies' attempts to address the challenges that they confront. To achieve climate resilient water management, it will be necessary to have equal, if not more, importance attached to water efficiency. This can be achieved by inducing behaviour change among the consumers, not just with water usage, but also waste disposal which has a strong interrelation with the water resources.

A review of literature was carried out to explore the challenges that are faced by the UK's water industry, which was the first objective of this research. The second objective was to investigate the strategies that were adopted in regions which had already experienced such challenges. There has been numerous regions in the world, mostly of developing nature, who have experienced the challenges of water scarcity. A review of literature was conducted to explore the strategies that these regions adopted to address the issue of water and the importance attached to behaviour change as a strategy.

The third and fourth objectives were to explore the strategies that the water companies in the UK have adopted to address the challenges faced by them, and what is the importance attached to behaviour change as a strategy, by taking Thames Water as a case study. In-depth interviews were conducted with 4 key professionals working in water-related sectors to inform the research. A survey questionnaire was also sent to a sample group living in the Thames Water region. Documents published by Thames Water was also investigated to learn about the strategies adopted to address the challenges.

An analysis of the primary data collected and the review of literature was carried out to meet the objectives set out, and it was evident that behaviour change can play an important role in achieving climate resilience in water management. This was stressed on by the interviewees and also the survey response indicated the residents acknowledging their responsibility.

Moreover, the analysis showed that there is a disconnect that exists between people and water. This will have to be taken into serious consideration by the water companies and measures to address this disconnect will ensure that people take fond responsibility for water. However, it was identified that a case study involving a larger number of residents will paint a better picture of the disconnect between people and water and also their thoughts about the role they can play in helping the water sector to achieve climate resilient water management.

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Chapter 1: Introduction

1.1 Background and rationale

Climate change is expected to have one of its most potent impact on water with the rising temperatures hastening the hydrological cycle, thereby affecting water availability and quality, as well as more frequent floods and droughts (GIZ, 2020) (Azhoni, et al., 2018). With the onset of climate change already in place, the pressure on water supplies in many parts of the United Kingdom are expected to rise in the future (Hall, et al., 2020). This increased pressure will place a strain on the water companies in the UK who are responsible for providing a reliable water supply to the customers (Charlton & Arnell, 2011). While significant effort and attention has been focused on actions to mitigate climate change, adapting to the future has been left behind with the uncertain climate future already on the horizon (Muller, 2007). In order to adapt to the uncertain climate future facing them, water companies/authorities are under increasing pressure to tackle the challenges that they will face in the future. This research raises the question whether the authorities and companies in the UK are looking at all adaptation measures which have been adopted in other parts of the world for effective water management.

In the United Kingdom, water companies are well aware of the climate change induced challenges and have adopted measures to both estimate the effects of climate change and address climate change in draft water resources management plans (dWRMPs) (Arnell, 2011). There has been arguments about the institutional context facilitating or constraining the adaptation of water companies to climate change, for example the relatively short time horizon of the Periodic Review headed by Ofwat hindering the long term investment strategies and the funding mechanism placing the total costs of climate change adaptation onto companies and their customers rather than taken on by the public sector (Arnell, 2011). Arnell & Charlton (2009) believes that methodologies have been developed to support adaptation to climate change.

Reservoir options (winter storage, expansion/raising, and new reservoirs) has been included in fourteen dWRMPs so that secure supply of water is maintained and the need for additional resources has been acknowledged by some water companies including Thames Water so as to manage the uncertainty and secure water supply for the future (Charlton & Arnell, 2011). Hundreds of millions has been spent by the water industry in the UK to address the deteriorating groundwater quality and the water companies have worked with the farmers wherever possible to improve land management practices thereby limiting the pollution entering the water bodies (RGS-IBG, 2012). In hindsight, strategies adopted in the UK water

sector seem to be more focused on ensuring water sufficiency than on water efficiency. This research aims to explore the measures taken for water efficiency through behaviour change and how it compares with the behaviour change strategies adopted in the global south and also how much weight it is given within other strategies adopted for water management in the UK.

In the face of these challenges and the imminent threat that climate change poses for the water industry, it is crucial to turn to practices that make the water sector climate proof. These are challenges which many regions in the Global South have already been grappling with resulting in a number of different strategic approaches. One such strategy that has been adopted is Integrated Water Resources Management (IWRM) which provides the tools and approaches for planning for the uncertainties of climate change and has associated benefits in other sectors including food and energy (GIZ, 2020). This approach has been further modified to give greater focus to future changes to the climate and to make the water sector climate proof and the term Climate Resilient Water Management (CRWM) was coined for this approach (ACT, 2018). Within the context of the UK, which experiences uneven distribution of water resources and possible threats posed by climate change which are discussed in the following sections, there is a real need to explore strategies such as CRWM which offer opportunities for achieving water security in the context of climate change. This study considers what lessons have been learnt in the Global South and their applicability to the UK context.

1.2 Statement of the problem

As climate change is expected to have a significant impact on the water cycle, effective management of water resources and its supply is fundamental for climate proofing the water sector's operations. The water companies have responded to this problem by adopting strategies which focus more on water sufficiency, that is to ensure that there is enough water to meet the demands of the users. While water sufficiency is essential, equal importance must be attached to water efficiency measures to ensure that the customers are aware of the challenges faced by the water sector, which will see them taking responsibility for water and be mindful of their actions and their impacts on water networks. Therefore this research aims to explore the role that behaviour change could play in achieving climate resilience in the field of water management.

1.3 Aims and Objectives of the research

1.3.1 Research Question

Is behaviour change the key to the achievement of climate resilient water management in the UK?

1.3.2 Research aim

To investigate the role of behaviour change in the achievement of climate resilient water management in the UK.

1.3.3 Research objectives

1. Investigate the key challenges confronting the water sector in the UK and the impacts of climate change on effective water management.
2. Examine the strategies adopted to achieve climate resilient water management in developing regions globally and the importance attached to behaviour change
3. Identify strategies adopted in the UK to respond to climate change through a case study analysis of Thames Water assessing the significance attached to behaviour change
4. Assessing through a comparative analysis of global strategies with those adopted in the Thames Water case study the importance of behaviour change for the achievement of climate resilient water management in the UK

The introduction is followed by an in-depth review of the literature in section 2. The challenges faced by the water sector and how climate change exacerbates these challenges, how other water authorities have adapted to these challenges around the globe, and the role behaviour change is given in these strategies are explored as part of the literature. Section 3 then discusses the methodology and the research approaches adopted for this study and explains how a research design was adopted to suit the study. This is then followed by section 4 which lays out the research findings and the study ends with conclusions drawn in section 5. The research tools will be listed in the appendix at the end.

Chapter 2: Literature Review

2.1 Introduction

An in depth review of literature was carried out to identify the challenges that are faced by the UK's water industry and the impact climate change could have on the water sector. Furthermore, strategies adopted by authorities and communities to address these challenges were looked at, with greater focus being placed on the global south, where many regions have been dealing with issues of water shortages since decades.

The threat of climate change features large in studies which identify challenges facing the UK water sector but they also highlight how this is likely to interact with other challenges facing the water sector. Ofwat (Ofwat, 2015) has identified the two key challenges that the water companies face to be water scarcity due to the shortage of resources, and maintaining environmental water; and predicted that these challenges will be heightened in the future with the influence of external drivers such as climate change, population growth and rising customer expectations (Ofwat, 2015). The Royal Geographical Society and the Institute of British Geographers (RGS-IBG, 2012) highlighted ten key challenges faced by the stakeholders in the water sector including

- Resource distribution and use
- Catchment approach
- Ecosystem services
- Pollution and water quality
- Land use management
- Public and stakeholder participation
- Behavioural change and water metering
- Energy use and carbon footprints
- An international perspective and virtual water
- Adapting to future pressures

There is also the issue of increasing population (populationmatters, 2019) and the usage trends of these growing population (Mace, 2020) Every person in the UK consumes around 143 litres of water on a daily basis which is considerably higher than the 85 litres per day consumed by a person in the late 1960s (Mace, 2020). A major share of the daily individual water usage is for bathroom related activities with 40% of the consumption while 22% is consumed for drinking purposes and 9% for washing machines (BBC, 2019).

Section two of the literature review explores in more depth the challenges the water authorities in the UK faces and this is followed by section 3 which presents a critical review of different strategies adopted by the authorities globally to mitigate the challenges arising from climate change. Section 4 looks specifically at measures followed to achieve behavioural change across the world as well as in the UK, which helps in shifting towards climate proofing the water sector.

2.2 Challenges being confronted by the water authority

With a direct reliance on the hydrological cycle, the water industry will be directly affected by the changing and highly variable weather patterns associated with climate change (Thorne & Fenner, 2011).

2.2.1 Resource availability

Globally, only around 12% of the total river runoff and groundwater recharge is available for human use and of this, around 40% is already being extracted from rivers, lakes and groundwater for human use (Heathwaite, 2010). Various reports have suggested that climate change might lead to severe water shortages placing a large proportion of the world's population to live under absolute water scarcity (GIZ, 2020).

Water resource distribution in the UK is highly disproportionate with some regions experiencing droughts while other regions have abundant water (Defra, 2008). Although the UK receives abundant rainfall, the distribution of the precipitation is uneven with the majority of the rainfall is received in the less densely populated north and the west (RGS-IBG, 2012). In southern and eastern England, rainfall and available water are comparatively lower than the northern and western parts of the country, but a higher population means that the water use in these regions are higher (Ofwat, 2007) and Defra (Defra, 2008) highlighted the shortage of water availability in the southeast England with a rank of 161 out of the 180 regions in the world in terms of water availability. This shortage in resource availability does not only mean that the water companies in the southeast of England need to find additional sources of water, with some areas already experiencing abstraction more than the environmentally sustainable level (Defra, 2008), but the wastewater has to be treated more before being discharged into the water bodies (RGS-IBG, 2012). Since the standards of wastewater treatment depend on the extent to which the effluents can be diluted upon discharge, lesser stream flows mean the treatment processes has to be intensified to maintain the environmental standards (Muller, 2007).

Climate change is projected to be the major contributor to further reductions in water availability (Charlton & Arnell, 2011). According to Muller (Muller, 2007), increased temperature can eventually cause less water entering the rivers or the underground aquifers,

but if climate change causes intense rainfall, resulting floods will mean larger proportion of the water will flow off the ground or infiltrate into the deeper groundwater. The uncertainty related to climate change is also observed as the most significant supply side uncertainty by some companies although there are other drivers of uncertainty (Charlton & Arnell, 2011). Changes in annual as well as seasonal precipitation along with warmer conditions points to the possibility of parts of the UK shifting towards relatively arid conditions which can have an effect on groundwater recharge, river flows and reservoir yields (Rance & Wade, 2016). Most studies on the availability of groundwater recharge agree that there could be a decrease in recharge of groundwater throughout the 21st century although the changes are projected to be in the range of a 20% decrease and a 30% increase (LWEC & NERC, 2016). According to Whitehead et al (2009), winter precipitation could increase by 10-20% and 15-35% for low-emission and high-emission scenarios respectively but at the same time, summer precipitation could see almost the whole of UK becoming drier with up to 35% and 50% drop in precipitation in the above two scenarios. The rise in winter and decrease in summer precipitations over the past centuries were illustrated by Marsh and Hannaford (Hannaford & Marsh, 2007) and this is shown in **figure 1.** Romanowicz et al (2006) modelled river flow changes under different climate model projections and remarked that by the 2020s there could be reduction in summer flows ranging from 1 and 32 %. This could mean serious shortages of water available for supply during the summer across the country.

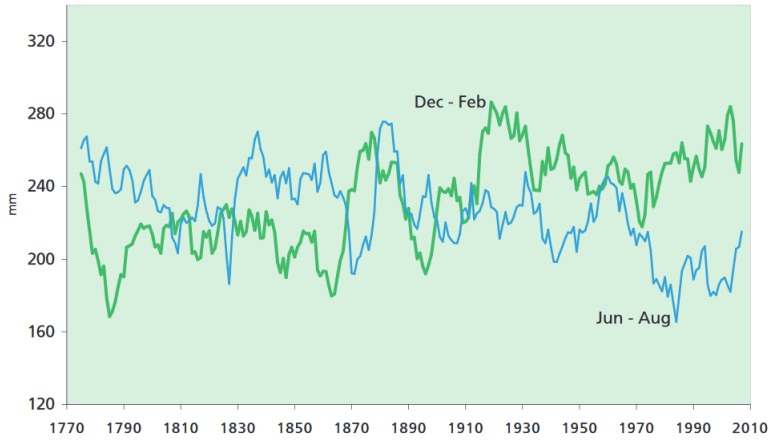

Figure 1: Winter and summer precipitation trends in the UK (Source: (Hannaford & Marsh, 2007)).

The chances of potentially dangerous supply failures due to climate change in the UK by 2035 are substantial in the absence of adaptation with individual impacts on deployable output (DO) rising up to 60% for some water companies (Charlton & Arnell, 2011).

2.2.2 Water Quality

Although the river water quality in the UK has shown significant improvement over the past decades, geographically spread diffuse pollutants still remains a hurdle for the management of freshwater bodies and rivers (RGS-IBG, 2012). According to this report, more than 50% of the groundwater used for public water supply in the UK is found to be deteriorating in quality (RGS-IBG, 2012). In 2012, the Environment Agency's standard scale assessment of the groundwater resources returned with the result of only 29% of the sources being good or better in quality (RGS-IBG, 2012). As water stress increases, it is inevitable that abstraction rates increases and this leads to increased salinity of groundwater sources (GIZ, 2020).

Climate change is also expected to bring about a temperature rise of up to 4 degree Celsius by 2080 according to a study by Thorne and Fenner (Thorne & Fenner, 2011) and the resultant higher water temperatures and with runoff varying greatly, changes in water quality are expected which can adversely affect human water use. The study assumes that the combined effect of climate change and human resource use will cause further deterioration of water quality and with the increase in global air temperature, river and reservoir water temperatures are also projected to increase which are again likely to adversely affect the water quality as the increased temperatures alone can impact the physical, chemical and biological processes that govern water quality, and these changes to water quality can further be exacerbated with altered spatial distribution and intensity, frequency and duration of precipitation induced changes (Thorne & Fenner, 2011). Lower minimum flows during summers as projected by Romanovicz et al (Romanovicz, et al., 2006), means that lesser volume of water available for dilution of point discharges and this could impact on organic pollutant concentrations as increased biological oxygen demand (BOD) leading to lower dissolved oxygen concentrations in rivers and Whitehead et al (Whitehead, et al., 2009) concluded that in poor quality rivers, low oxygen levels can be exacerbated during summer low-flow conditions. A study on BOD, dissolved oxygen, ammonia and temperature in rivers based on a model sensitivity analysis highlighted that, reduced flows in summer leads to BOD and phosphorous levels to increase while ammonia levels fall leading to higher nitrate concentrations which could lead to the enhanced growth of algal blooms in rivers and reservoirs which will have an impact on dissolved oxygen in the water and hence could affect water supply ((Whitehead, et al., 2009), (Conlan, 2007)). While lesser quantity of water reduces the dilution capacity of the pollutants and sediments receiving waters, an increased flow in the event of intense precipitation and flooding can lead to the deterioration of water quality due to the untreated pollutants entering the water bodies and sea level rise can also contribute to salinization of groundwater (GIZ, 2020).

2.2.3 Wastewater treatment

The extent to which wastewater has to be treated depends on the dilution capacity of the stream which the effluents are discharged into (Muller, 2007). As mentioned before, with the varied resource distribution of water resources in the UK, different levels of treatment has to be achieved at different wastewater treatment plants (WWTPs). For WWTPs located in catchments of low base flow of streams and rivers, discharged effluents must be treated to a higher standard and might require additional treatment facilities, while in regions that receive intense rainfall and related flooding, combined sewer overflows can strain the efficiency of WWTPs located there (Tolkou & Zouboulis, 2015). An anthropogenic challenge posed to WWTPs are the flushing down of solid wastes other than human excreta which is the only waste that the conventional sewer systems are designed to accept. Vidal et al (2020) highlights numerous such products and the challenges they cause to the treatment plants, the sewerage system and the overall water infrastructure. Products mainly consisted of wet wipes and menstrual absorbents followed by cotton buds, condoms, nappies, dental floss, cigarettes, medical wastes etc. (Tolkou & Zouboulis, 2015). This process also impacts water availability as the water in the toilets used for flushing the “unflushables” are often treated to drinking water standards in the UK (Ashley, et al., 2005). These challenges are aggravated by the fact that most WWTPs and sewer systems have been designed based on the historic hydrologic record without considering climate change induced changes to flow conditions (Tolkou & Zouboulis, 2015) and these infrastructures are not designed to receive and process solid wastes flushed in to them and would increase costs for the infrastructure including repair and maintenance costs (Ashley, et al., 2005).

As discussed earlier, climate change will have considerable impact on the water resources and intense precipitation and droughts could become a common theme at different locations. The processes associated with wastewater treatment plans including treatment, distribution and disposal of wastewater will be affected by climate change through multiple avenues including higher volumes of wastewater and stormwater entering the system in regions experiencing intense rainfall and floods whereas higher levels of treatment and reuse becoming necessary in regions with lesser water flow ((Tolkou & Zouboulis, 2015), (Rosenzweig, et al., 2011)). These climatic variability, combined with ever increasing usage and possible flushing of personal hygiene products would mean that in cases of intense rainfall these solid wastes would overflow and enter the water resources thereby possibly exacerbating the pollution of water resources thereby straining the water supply infrastructure.

2.2.4 Energy use and carbon footprint

Water supply and treatment are energy intensive processes with approximately 7 grams of carbon dioxide produced for every litre of drinking water (RGS-IBG, 2012) produced and overall, the UK water industry contributes approximately six percent of the greenhouse gas emissions in the country (Bond, 2021). The activities that leads to the emission of greenhouse gases such as CO2 from a water industry perspective includes abstraction, pumping, treating and heating water as well as pumping and treating wastewater which are all consuming of energy (Waterwise, 2021). The total CO2 emissions from water-related activities in the UK ranges from 2.4 MtCO2 per annum to 27.7 MtCO2 per annum and this includes emissions from water company operations, water supply and wastewater treatment and water use at homes, which is the largest contributor to the overall emissions with a 90% share (Bond, 2021).

With warmer temperatures a likely consequence of climate change, it is very likely that water usage would increase substantially which in turn will have an effect on the carbon footprint of the water related activities as all of the above mentioned processes intensified. For example, ten billion litres of sewage are treated daily across the UK which generates 1.7 million tonnes of GHG emissions (Staddon, 2010) and with higher water usage, more wastewater will have to be treated and this will increase the associated GHG emissions.

With these challenges and an even more uncertain future ahead, practices such as weighing up the local water treatment costs against the physical containment of the pollution at the source or altering local land management practices are being adopted (RGS-IBG, 2012).

2.3 Strategies/approaches has been taken to address the challenges

Water as a resource connects people, places and different sectors of society; it is of both local and global concern and involves public, private and non-profit actors; and it is often capital intensive and is critical for development needs and hence governance of water is crucial (OECD, 2015). Therefore it is necessary to ensure there is an adequate supply of clean water for all.

2.3.1 Resource availability

Water shortages due to climate change has been experienced around the world and governance of water has been adopted as fitting to the environmental, political and administrative setting of each region as there is no one size fits all solution for water management (OECD, 2015). Following are some of the strategies used to overcome the scarcity of water resources:

2.3.1.1 Desalination

One of the strategies used by the regions in water stressed countries is by augmenting water supplies with desalination of seawater to meet the increase in demands as population increases and also to ensure supply for the industrial, tourism and agriculture developments (Quintanilla & Vestergaard, 2014). City of Windhoek in Namibia has adopted desalination as one of the strategies to deal with water scarcity (Ndebele-Murisa, et al., 2020).

Desalination is highly effective and prevents any pollutants from entering thereby protecting the water quality ensuring safe supply (Elsaid, et al., 2020). Over the recent decades, there have been technological advancements in desalination of saltwater and brackish water which has made the process cheaper and energy efficient (GIZ, 2020). This has been utilized in different parts across the world including in Qingdao in China (Wang, et al., 2021) to supplement water availability for industrial and other non-drinking purposes.

2.3.1.2 Supply augmentation

Supply augmentation measures to increase the availability of surface and groundwater are adopted to overcome water scarcity and this includes a variety of options including cloud seeding, transferring surface water between different regions with the help of large infrastructure, smaller infrastructures such as rainwater harvesting and village tanks and reducing and reusing domestic wastewater, sewage and industrial effluents; and reducing groundwater contamination (ACT, 2018). Rainwater management and wastewater reuse have been adopted successfully to reduce vulnerabilities in regions depending on the climate change impacts expected in those specific regions and integrated water storage concepts including groundwater, surface reservoirs, soil moisture etc. helps to replace natural water sources threatened by climate change (GIZ, 2020). In Singapore wastewater was treated intensively to release it to the water sources used for abstracting drinking water (Tortojada & Nambiar, 2019).

Transfer of water between different boundaries of water zones has been in practice in parts of the world. For example, this has been viewed in the basins of Mekong, Nile, Mahanadi and Niger (GIZ, 2020). Water markets are also being promoted in the Southern Africa Development Community (SADC), which is made up of 16 countries of uneven distribution of water resources (Matchaya, et al., 2019). Transferring water from regions with higher resource availability to the more arid regions in SADC, according to Matchaya et al (2019), is also seen as a way for regional integration.

These are viable options for specific regions and can help in overcoming serious water scarce situations.

2.3.2 Wastewater Treatment

The challenges posed by climate change, including the pressure to reduce emissions and the challenge of adapting to a changing climate has begun to be addressed by the wastewater industry (Tolkou & Zouboulis, 2015). New York City has adopted an adaptation process including studying the impacts of sea-level rise on the infrastructure and options including relocation of facilities and enhanced treatment of water quality (Rosenzweig, et al., 2011). Developing innovative monitoring of combined sewer overflows and installing early warning systems for faecal contamination in recreational waters can help the wastewater facilities to proactively approach any contamination due to combined sewer overflows and uncontrolled runoff which is a possibility in high intense rainfall regions (Tolkou & Zouboulis, 2015).

Reusing treated wastewater from WWTPs for non-drinking purposes as well as for agricultural and industrial purposes can improve the WWTPs effluent quality which in turn will have a positive impact on the quality of water abstracted for drinking from the rivers (Becerra-Castro, et al., 2015). Florida in the USA has a very high rate of reusing treated wastewater with 45% of the reuse dedicated for landscape irrigation (Eczaj & Grosser, 2018).

Awareness campaigns to encourage people to deter from flushing non-human waste via the toilet has been carried out in some countries including the UK (Ashley, et al., 2005) and this will help the wastewater processes reduce costs for treatment, maintenance and also contamination of water resources.

2.3.4 Limiting carbon footprint

Water sector is one of the leading users of energy (Rothausen & Conway, 2011). For sustainable water management, efforts for reducing energy use of the water sector should be taken, which will also help in reducing their environmental impacts (Stillwell, et al., 2011). Therefore the need to reduce the carbon footprint of the water sector is acknowledged within the sector.

The water sector in Auckland, New Zealand has a relatively small carbon footprint for their operations as they generate electricity internally from biogas, a product of wastewater treatment process (Lee, et al., 2017). Similarly, internal generation of electricity using biogas from wastewater treatment processes supply almost 40% of the energy demand of WWTPs in Melbourne (Kenway, et al., 2018).

2.3.5 Integrated Water Management

Conventional water management policies and actions have followed a stationary approach which derives future water availability in different seasons from the historically available data but climate change development adds uncertainties to the water availability in the future and this has the potential to increase risks for water management (GIZ, 2020). This led to the

adoption of new strategies to assess the future risks affecting the performance of water management systems (Hallegate, 2009). Sustainable water management is a crucial adaptation strategy to mitigate the impacts of climate change and if implemented successfully, it can have vast positive impacts in other sectors as well and it plays a crucial role in enhancing the climate resilience of societies and ecosystems (GIZ, 2020)**.** Climate resilient water management can help in managing the water resources with viable adaptation strategies in place to face the threat of climate change and can help the water management and governance institutions (ACT, 2018).

In Zambia, Lusaka Water Security Initiative (LuWSI) along with partners have developed an investment and action plan to assess the future risks that the water management sector could face due to the changing climate as up to 2020 the water sector had resorted to deal with any issues as they arose despite the growing demand for water in the city (GIZ, 2020). LuWSI has set an action plan to ensure water security and the steps include preventing groundwater pollution; sustainable extraction of groundwater; maintain river health; manage urban flood risks and provide access to water and sanitation (Ilunga & Cullis, 2020). Adaptive water management, which is helpful in juggling between different water management solutions according to the specific conditions, is a tool to ensure long term robustness of adapting to the climate risks (GIZ, 2020). This has been used in different regions across the world including in Vietnam where adaptation pathway was used to determine the long-term adaptation responses to the flood-risk management system of Can Tho city (Radhakrishnan, et al., 2018). Climate resilient approaches for managing extreme events were also adopted in Assam, Bihar, Odisha, Maharashtra, all in India (ACT, 2018).

IWRM has been also practised in some of the countries in South Asia with the help of Action on Climate Today (ACT), including integrating data from automated weather stations into the hydro-met system in Bihar, India; and water resource assessment for improved climate resilience in Chattisgarh, also in India (ACT, 2018). Public and private actors have adopted numerous similar strategies to meet the challenge of climate change through sustainable long-term infrastructure decisions (GIZ, 2020).

2.3.5 Governance and public participation

For successful implementation of water management, it is crucial that there are policies, standards, legal and financial instruments as well as processes that are in place to support the smooth operation of such programmes and it is essential that there is coordination in the water sector as well as among different sectors to achieve the benefits of integrated water management (ACT, 2018). As mentioned above, a water-energy-food (WEF) nexus approach is adopted widely because it avoids undesired improvements in the efficient use of the natural resources sustainably and also avoids conflicts among the different sectors (GIZ, 2020).

Natural resources were managed with a top-down approach where the decisions concerning and affecting the allocation and usage of resources were taken by bureaucrats and technical experts with little involvement from the community or the affected stakeholders ((Blaikie, 2006), (Dewan & Buisson, 2014), (Wester, 2003)). This approach has more often than not compromised the needs of deprived communities and also did not take into account the local knowledge when it came to the management of resources, Community based natural resources management (CBNRM) has been promoted as a measure to sustainably manage natural resources since the mid-1980s (Dewan & Buisson, 2014). This practice was formed from the assumption that communities, based on their social structure and common interests, could manage their natural resources in an efficient, equitable and sustainable way (Blaikie, 2006).

One of the countries that adopted CBNRM was Bangladesh with the help of donors such as Swedish International Development Agency (Sida) and the Embassy of the Kingdom of Netherlands (EKN) (Dewan & Buisson, 2014). They introduced and financed participatory projects which were designed to organise excluded and marginalised groups to take part in water resource management in the coastal regions of Bangladesh (Dewan & Buisson, 2014). Public consultation was used for addressing and informing the concerns and opinions of the society in the Mekong river basin, which included 4 countries (Cambodia, Lao PDR, Thailand and Vietnam), and it grew in importance and stature and the general public were able to criticise and contribute to adaptiveness in water management policies (Lebel, et al., 2010). Public involvement in the discussions of a water basin development was also witnessed in the Philippines, with the Bohol-Cebu Water Supply Programme (Fisher & Urich, 2000). Although the body tasked by international donors of the project to supply water to the region did not encourage active participation of the affected stakeholders, other institutions such as the church, NGOs and a newspaper ensured that stakeholders affected by the project were informed and represented in the decision making processes of the water supply project (Fisher & Urich, 2000). Similarly, Mexico and South Africa placed public participation at the forefront of water resources management, with improvised water laws established in the 1990s (Wester, 2003). The process of participation in Mexico and South Africa did not give powers or representation to every affected stakeholder instantly, although like in the Philippines, they were tweaked around and improved over time (Wester, 2003).

In Africa, knowledge and experience of a city in successfully tackling water management issues are transferred to other cities to improve their performance. This has been witnessed in how Lusaka in Zambia took out lessons from Durban's (South Africa) water management measures (Ndebele-Murisa, et al., 2020).

2.3.6 Demand Management

South Africa is one of the countries that has experienced severe water shortages and in 2018, a prolonged drought lead to the announcement of Day Zero in Cape Town (Enqvist & Ziervogel, 2019). The government of South Africa has adopted a number of strategies to tackle the water shortage including repairing leakages in the water infrastructure and introduction of water management devices (WMDs), so as to reduce water wastage during times of supply shortages (City of Cape Town, 2007). The mostly used strategy by the authorities in Cape Town was demand management, which was utilised to bring down water consumption to nearly half (Said-Moorhouse & Mezzofiore, 2018). Demand management tools included curbing overall demand, reduction in leakage and also repairing them and block tariff which discouraged high water consumption (Rodina, 2019). The crisis in Cape Town exposed the importance of demand management, which is taken for granted in the water management realms (Rodina, 2019).

The City of Windhoek utilized strategies of water rationing and awareness campaigns to induce behavioural changes among the public to address issues of droughts and water shortage (Ndebele-Murisa, et al., 2020). In Pakistan, ACT conducted a study to assess the data on water demand and how this could change along with socio-economic change, population growth and climate change and this was used to draw up strategies for managing the water resources to meet the demands in the future (ACT, 2018). Other measures such as pricing mechanisms to disincentivize excessive groundwater abstraction were also in use in Asia (ACT, 2018).

However, demand management has its limitations particularly the burden it places on the consumers and hence it was highlighted that despite the challenges, incorporating uncertainty, unpredictability and variability into the water management policies must be made a priority (Rodina, 2019).

2.4 What has been done to achieve behavioural change?

It has been accepted that urban water management has to move beyond the traditional approaches as it has contributed to the degradation of waterways, cause wastage of water resources and does not reflect the environmental values of the society anymore (Niemczynowicz, 1999). One of the ways the water industry can achieve climate resilient water management is to induce behavioural change among the customers (RGS-IBG, 2012). While demand management can be classified as a measure of water conservation, behaviour change is inclined more towards water efficiency (Gearey, 2014). She concluded briefly that demand management measures are more focused on securing the water resource while behavioural change as a water efficiency measure requires a change in water use and

promotes active and mindful participation from the individuals which can then be scaled up to the wider community.

In South Africa, with the threat of day zero looming, behavioural change was one of the most crucial strategies used to relieve the stress on the water resources and push the day zero further away (Sagris, et al., 2018). The City of Cape Town introduced voluntary water restrictions in January 2016 after low rainfall in 2015 (Kaiser & Macleod, 2018). By 2018, measures to control water demand escalated and measures such as increased tariffs and penalties for high volume users, an extensive communication campaign and installation of Water Management Devices (WMDs) were adopted which helped, in controversial circumstances, to reduce water consumption (Enqvist & Ziervogel, 2019). Water metering has been used to good effect to raise awareness among customers on the amount of water that they use and this has brought down consumption in countries like Australia and USA where water shortages are a recurring phenomenon (Borle, et al., 2016). Pricing of water has also been effective in bringing down water consumption in Namibia, although the effectiveness of block tariff was found to be over-estimate (Magnusson, 2004).

A project carried out in a major university campus in Mexico encouraged the students to change their behaviour in water usage and managed to bring down consumption of potable water by around 50%, while improving the quality of water and treating wastewater more efficiently (Nickum, et al., 2020). However, they noted that bringing out these changes takes a lot of time and effort, especially in the beginning stages of its implementation.

As a result of awareness campaigns, potable water consumption has been on a decline in China, Botswana and South Africa (Moglia, et al., 2018). A framework for water conservation was proposed by Moglia et al (2018) highlighting the actions and interventions that could be taken.

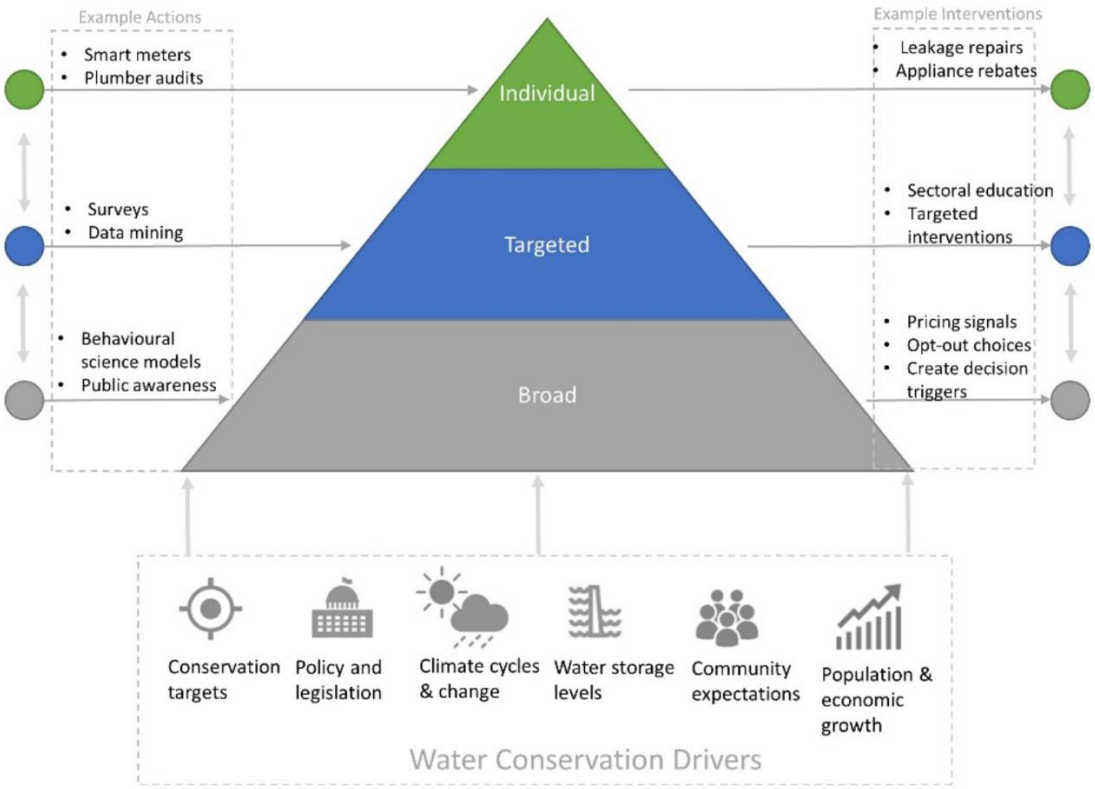

Figure 2: Water conservation drivers and levels of intervention (Source: (Moglia, et al., 2018)).

Bhor and Ponkshe (2018) suggested that the use of sanitary waste incinerators in India can be a viable and safe option to dispose of sanitary wastes sustainably rather than having to flush them or dumping in landfills.

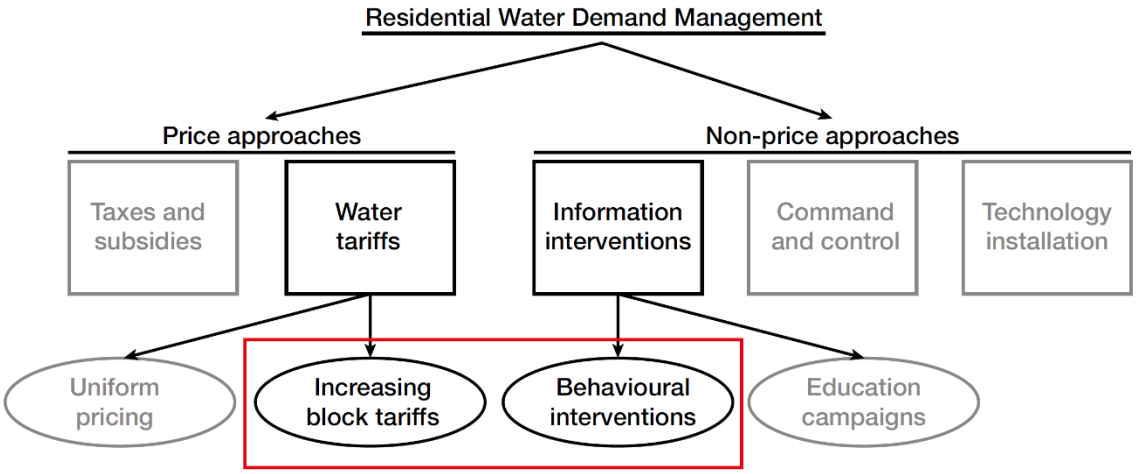

Figure 3: Demand management measures for residential water use (Source: (Lu, et al., 2018))

2.5 Literature review findings

Climate change is a serious challenge facing the water sector. The uncertainties surrounding climate change projections means it is difficult for water authorities to be prepared for the future with exact measures. However, the UK water sector could look at the strategies that have been adopted in different parts of the world. This could be used as a template to address the challenges posed by climate change. Some of the strategies adopted has been highlighted in the review of the literature done for this paper.

Supply Augmentation

Supply augmentation has been adopted in some water stressed regions, however it seems to be an expensive and a not-so sustainable way to address the shortage of water availability. Measures such as desalination, rainwater harvesting, intensive treatment of wastewater have been adopted in countries like Singapore.

Integrated Water Resource Management

Some countries including Zambia, Vietnam, India and Pakistan have started to integrate climate change into their resource management programs and have a wider scope for dealing with multiple aspects of resource management including handling extreme events. As this approach tries to deal with climate change projections, care should be taken to ensure the best data is used for preparations to ensure avoiding mal-adaptations.

Subsidiarity

Countries such as Bangladesh, Mexico and South Africa have focused their attention on governance processes and have adopted the principle of subsidiarity to devolve responsibility for water management to local communities. Incorporating the consumers in the management of water resources would help the water sector to carry out water management in a consumer-friendly nature incorporating the community's knowledge about their resources and how they intend to utilise them.

Collaboration

Countries such as Zambia and South Africa share knowledge and best practices to address water scarcity issues. This helps to learn from an array of strategies adopted in a region facing similar water scarcity issues and tailor those strategies to fit to the adopting region. Countries sharing the same water resources have come together to manage these resources fairly and effectively as witnessed in Cambodia, Vietnam, Lao PR and Thailand. This kind of collaboration is necessary to ensure that every community depending on a resource is served fairly and their knowledge about the resource is put to good use.

Demand Management

Managing demand to reduce the stress on water resources has been the chosen method to address water scarcity in different parts of the world. Although its implementation comes with layers of challenges, including the burden it places on the consumers and the poor and marginalised facing larger exclusion than the more privileged households; it helped cities like Cape Town to tackle serious water scarcity issues. However, it must be considered that these challenges were posed due to the radical measures that had to be adopted to cope with an imminent threat, and if planned demand management measures had been in place much earlier, it would have helped the authorities to deal with the threat much more conveniently to the consumers. This could be achieved by inducing behaviour change among consumers with campaigns and education about the importance of water conservation as well as responsible disposal of waste into the sewer system. This could be challenging as the consumers might be reluctant to adapt to changing lifestyles for possible future changes in climate which would seem uncertain to the majority of the consumers. However, in a society with good education and concern for the environment, campaigns and education would go a long way in overcoming these challenges.

The UK Water industry could learn from these efforts taken in other parts of the world and be better prepared to address the uncertain climate future ahead.

Chapter 3: Methodology

3.1 Introduction

In this chapter, after the introduction, different research approaches would be looked into and justify why a certain method is chosen for this study. This will be followed by the research design and the data collection methods in the subsequent sections. The following section will discuss the empirical research process drawing a timeline of the processes involved in the research. The final section will explain the limitations of the research and the ethical issues that were encountered while doing the research.

3.2 Research approach

Research is the process in which data is collected, analysed and interpreted in order to understand a specific question or phenomenon (Leedy, 2015). The choice of methods adopted for any research depends on the nature of the research problem (Noor, 2008). The methods adopted for this research depended on the type and availability of information that was required. The two approaches to collect data for a research are by qualitative and quantitative methods (Williams, 2007). The major distinguishing factor between quantitative and qualitative methods is that while qualitative researchers look to measure empirical data to bolster their findings from the study, qualitative researchers employ an approach of interpretivism to understand the perspectives of the subjects of the study (Bryman, 2012).

Fundamental differences between quantitative and qualitative research strategies

	Quantitative	Qualitative
Principal orientation to the role of theory in relation to research	Deductive; testing of theory	Inductive; generation of theory
Epistemological orientation	Natural science model, in particular positivism	Interpretivism
Ontological orientation	Objectivism	Constructionism

Fig 4: Fundamental differences between quantitative and qualitative research strategies (Source: (Bryman, 2012)).

As highlighted in figure 3, quantitative method follows an ontological position of objectivism which asserts that social actors do not influence a social phenomenon and their meanings and that they simply exist naturally (Bryman, 2012). Qualitative research, on the other hand, follows an interpretivism approach, which focuses on the influence of social actors on social phenomena (Bryman, 2012). Interpretivism is of the view that "*subject matter of the social sciences – people and their institutions – is fundamentally different from that of the natural sciences"* (Bryman, 2012, p28).

As the focus of this study is to explore a relatively new social phenomenon, i.e the response to climate change in the water sector, a qualitative approach was selected as it enables to explore it in more depth and also allow for new themes to emerge from the research.

3.3 Research design

Research design is a "*structure that guides the execution of a research method and the analysis of the subsequent data"* (Bryman, 2012, p45). He outlined 5 research designs:

- Experimental design
- Cross-sectional design
- Case study design
- Longitudinal design
- Comparative design

A design is selected for a research to fit the priority given to the range of dimensions of the research process including

- Expressing the causal connection between variables
- Generalizing the data collected from the group forming part of the investigation to a larger group
- Understanding behaviour and its specific meaning in the specific social context
- Having a temporal appreciation of social phenomena and their connections (Bryman, 2012, p46).

Experimental design is adopted where the research is used to set a yardstick against which non-experimental research are assessed (Bryman, 2012). Cross-sectional design is chosen when there are more than one case to be studied to understand variations at a given time, while a longitudinal design is somewhat an extended form of a cross-sectional design with more time and cost involved in its application (Bryman, 2012). Comparative design is the one in which two contrasting cases are studied using more or less identical research methods; and a case study design is adopted when a particular community, organization, person etc. are studied to understand its complexity and particular nature (Bryman, 2012).

As this paper focuses on one organization to understand how it deals with the challenges faced, a case study design is adopted for this research. Thames Water and its jurisdictions were selected as it was deemed to be more convenient to gather data and get in touch with professionals as the base of the study was set in Thames Water's jurisdiction.

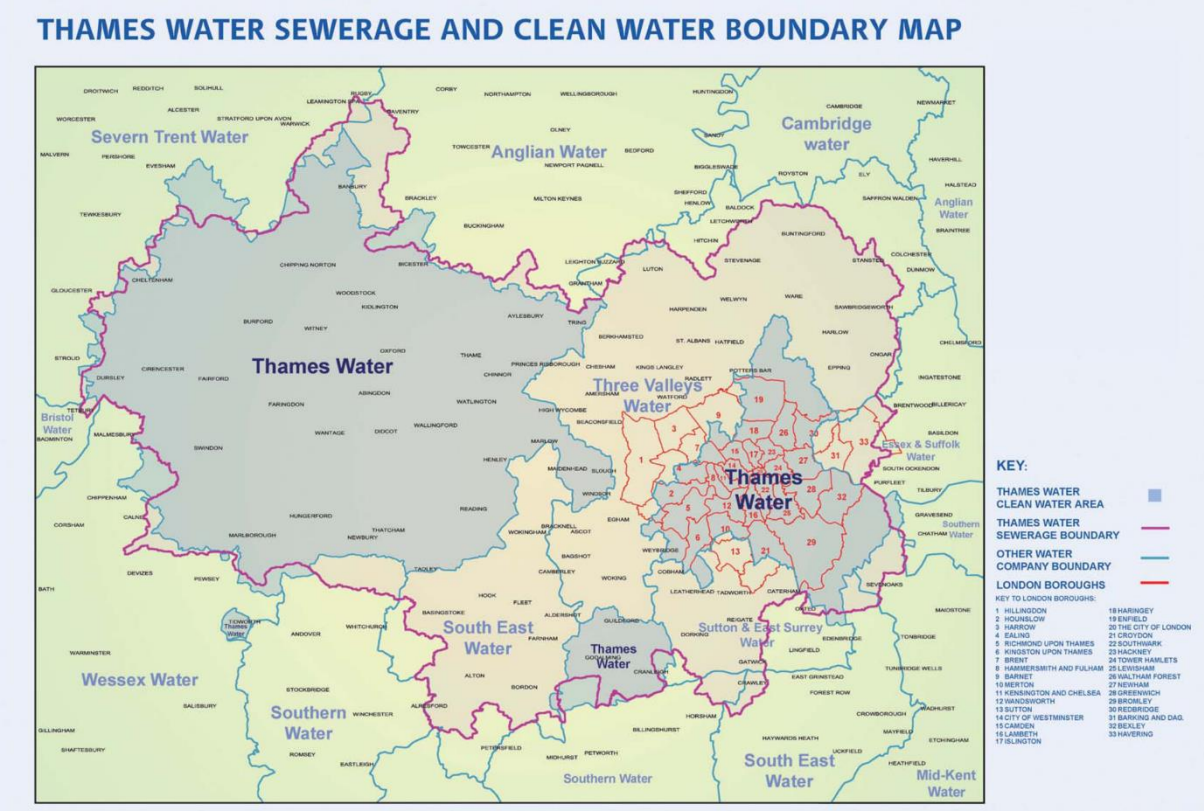

Figure 5: Boundary of Thames Water's services (Source: Thames Water, 2022)

3.4 Data Collection Methods

Once the research design and research approaches were finalised, methods to collect data were identified. For this study, data has been collected mainly from primary sources in the form of semi-structured interviews with relevant professionals in the water sector and also through a survey designed to understand the awareness and knowledge of the general households regarding climate change and water management.

The interviews were designed to understand the professionals' view of the threat of climate change for the water resources and what role they saw for the households to play to achieve climate resilience in water management. The interview schedule has been provided in Appendix A.

The survey included a questionnaire to gather information on the views of the residents living in the Thames Water region about the threat climate change could pose to the water resources and what they thought could be done to avert these challenges. The survey was sent out to people from different social and financial backgrounds to get a broader view from the residents. The questionnaire used has been provided in Appendix B.

Documents published by Thames Water and WaterUK were obtained via google search and these documents were inspected to explore the strategies that are being adopted to address the challenges that confront the water sector.

3.5 The empirical research process

The initial steps of the research included setting out clear aims and objectives of the research. This was followed by reviewing the existing literature to learn the challenges that were faced by the water sector and how these challenges were addressed in different parts of the world. The next step after gaining a broad understanding of the challenges and adaptation/mitigation measures adopted were to gather data from the case study region.

For this, several professionals and activists from the water sector were identified and contacted to arrange interviews online. This stage of the research was challenging as it was difficult to identify the right personnel for conducting interviews, and also once the participants were identified, it was difficult to get in touch with them and arrange a suitable time for the interviews as most of these participants were professionals with a really busy schedule. Once the participants agreed to take part in the interviews, participant information forms and interview schedules were shared with them as per requests, and meetings were arranged on Zoom. The meetings were recorded with the participants' acknowledgement, for convenience and future reference.

The survey questionnaire was shared with contacts and also with the interview participants who were requested to share it with their contacts, so that it reached a wider audience. However, the response rate for the questionnaire was not to the level desired.

Chapter 4 – Research Findings

4.1 Introduction

The primary aim of this research was to investigate the importance attached to household behaviour change by the UK water companies to achieve climate resilient water management. This was done with a case study analysis of Thames Water. The case study analysis used a mixed method approach collecting data from interviews conducted with key informants, survey questionnaire among residents in the Thames Water area and secondary sources on Thames Water. These activities were aimed to address the topics related to the five research objectives, which were shaped from the literature review. This chapter begins with an overview of the interviewees who took part in the research and participants in the survey and how secondary data on Thames Water were obtained. This is followed by the findings from the interviews, the survey and secondary sources. This is structured to address the research objectives. The first objective considers the challenges faced by the water sector in the UK, the second looks at the strategies adopted to mitigate or adapt to the challenges and the third is to understand the role household behaviour change could play in achieving resilience to these challenges.

4.2 Background to the study

Interviews were conducted with four key informants. These participants were professionals working in various roles in water or related sector in the UK including Thames Water. This included a social research manager (Respondent 1) at a not-for-profit NGO in the UK who is the leading advocates of water efficiency in the country, a hydrologist (Respondent 2), a climate change specialist (Respondent 3) at Thames Water, and a water specialist (Respondent 4) at an international organization dealing with water and wastewater utilities. The participants in the survey were people living in the Thames Water region and were from different social and economic backgrounds. The survey received 24 responses, mostly from people working in professional occupations, and the majority of the respondents were white British. Nearly a quarter of the respondents were aged above 50 closely followed by people aged between 26-30 and 31-40. As such, the survey cannot be used as a representative sample of any sorts, but does identify themes for further research with a larger representative sample.

Documents produced by Thames Water were also referred to investigate the established themes and strategies in the water industry.

4.3 Challenges faced by the UK water sector (Research objective 1)

The key informants were asked in the interview about the challenges faced by the UK's water industry and how climate change would exacerbate these challenges. Understandably, the responses varied with each respondent, however had some commonalities when it came to variability in resource availability, ageing infrastructure, financing and wastewater treatment.

4.3.1: Resource availability

The reducing availability of water resources was highlighted as a major issue by all the key informants. They also saw climate change causing even more distress, causing variations in rainfall patterns and temperature rises. The impact of climate change on water resources was also highlighted among the most pressing issues in the future by the respondents of the survey.

"We are having wetter winters and drier summers. For my household that would mean I will have water running down my roof during the winter, and during the summer I would need more water for drinking and cleaning as it would be warm" (Respondent 2)

"The UK's water industry faces many challenges, and one of the more significant one is the limited availability of water to meet the demands of an ever growing population. Although population growth is a concern, it is not the only factor. Climate change induced weather patterns is also largely responsible for this water scarcity problem. " (Respondent 1)

In Thames Water's climate change adaptability report (2020), they highlight the impact climate change will have on water availability.

"Changing weather patterns will affect the amount of water we have to use, reducing London's available supplies by around 180 million litres a day by 2085 (Thames Water (a), 2020)***"***

The respondents also mentioned the challenges of changing water use patterns, floods and droughts and population growth as serious challenges faced by the water sector, at various points in the interviews. The challenge of irresponsible flushing of unflushables by the largely unaware public were also pointed out by the respondents.

"Consumers dumping items that are not supposed to enter the sewer system is an overall challenge" (Respondent 4)

One respondent mentioned the changing water use patterns, floods and droughts due to a changing climate and population growth as challenges facing effective water management.

The survey response also saw water scarcity as a serious issue affected by climate change. It was ranked the second most important factor after temperature rise. Out of the 24 respondents, 21 ranked water scarcity as either the most significant or the second most significant challenge posed by climate change. Twelve of the respondents also saw declining water quality among the top 2 challenges posed by climate change.

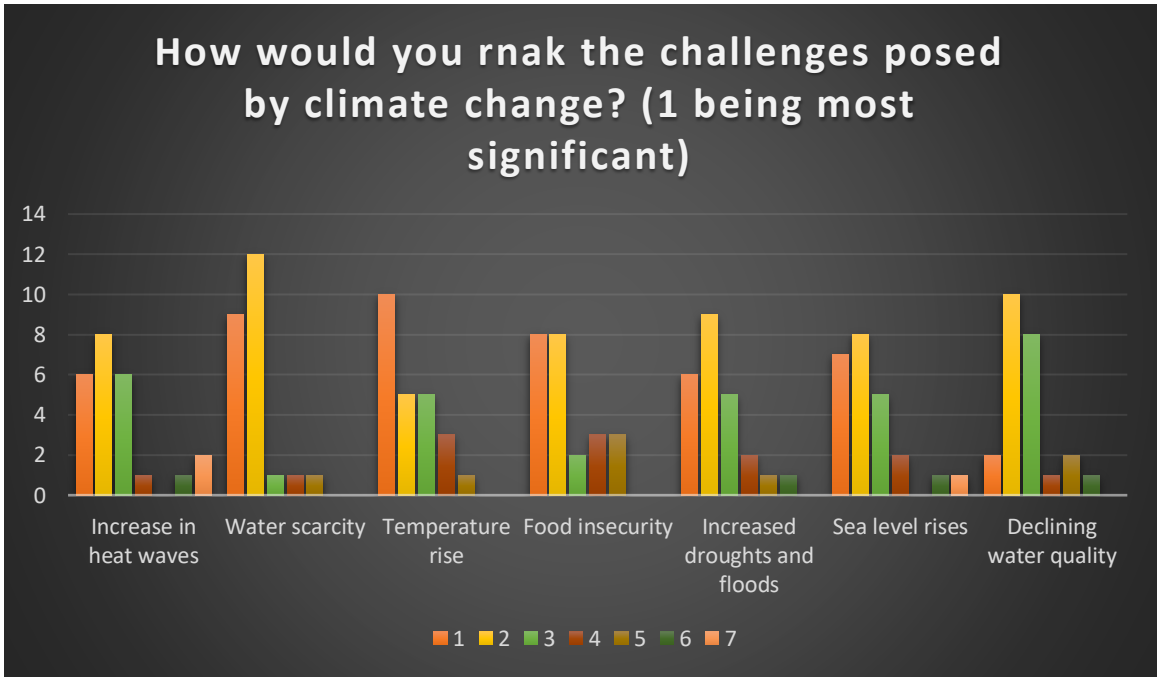

Figure 6: Survey response to the question: “how would you rank the challenges posed by climate change?”

4.3.2: Ageing infrastructure and financing

3 of the 4 key informants mentioned about the ageing infrastructure in the water sector and the difficulty to finance their maintenance and adaptation measures. They also talked about the difficulty in repairing these infrastructure as they are mostly under the ground and has huge financial ramifications when they have to be repaired. Unpredictable weather patterns causing “flash floods” and irresponsible flushing of unflushables were mentioned as a reason for the issues concerning wastewater infrastructures. One respondent said:

“The infrastructure is really old and the challenge of replacing infrastructure or maintaining it” This is compounded by climate change as more flooding events which compromises the infrastructure more often. Replacing infrastructure is very costly particularly in the UK”

The survey also painted a similar theme around people's perception around the efficiency of infrastructure. Ageing infrastructure was given high significance among the challenges faced by the water sector, along with climate change, availability of water and wastage.

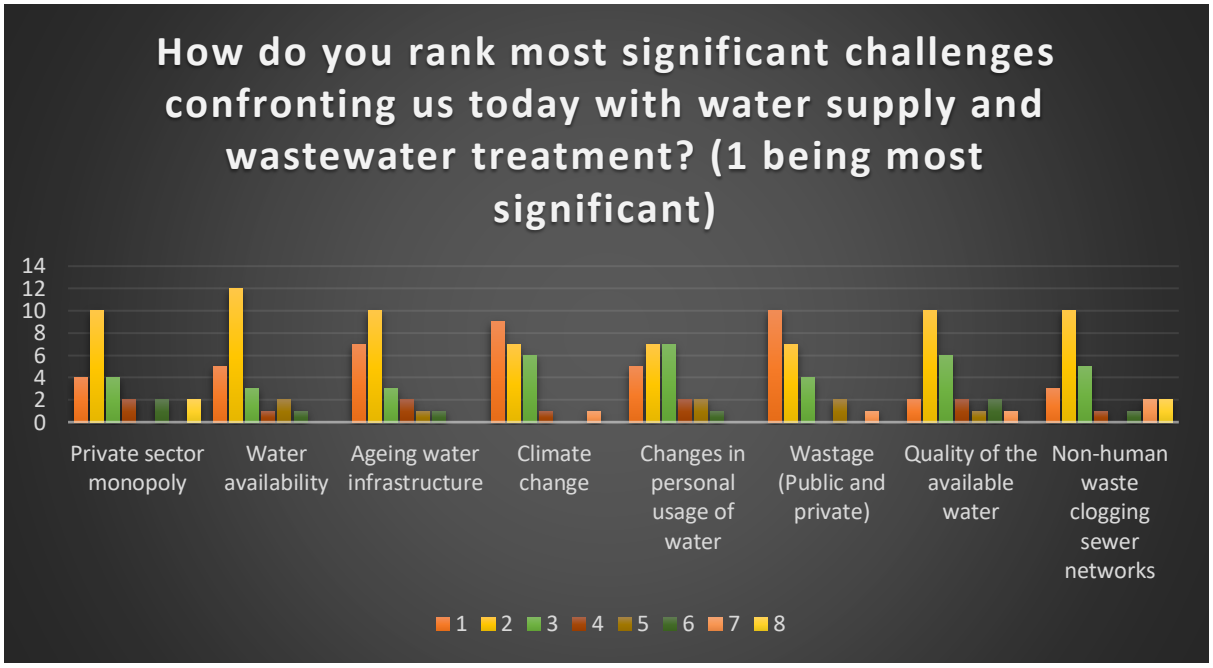

Figure 7: Survey response to the question: "how do you rank the most significant challenges confronting us today with water supply and wastewater treatment?"

This highlights a key difference from the challenges experienced in the developing regions of the world where the infrastructure network is still largely lacking and faces massive under-investments.

The sources for financing infrastructure was a concern for the key informants. They talked about making water really affordable as it is a human right and this leads to the challenge of maintenance and upgrading of infrastructure a financial burden. From the survey, increasing funds for improving the infrastructure was ranked the second most important step to address the challenges, after reducing wastage. This response shows that the participants of the survey were concerned about the efficiency of the infrastructure that delivers the most essential commodity for life. Who should take the burden? This was the response from the climate change specialist from Thames Water:

"For every £1.20 spent for producing and supplying water, the customer only pays £1, this means we borrow money for our operations. Today's customers shouldn't be financing the infrastructure for future consumers and that's why we borrow"

4.3.3: Disconnect between people and water

Another theme that arose from the interviews was the perception that water is undervalued to make it affordable which has other issues that come along. People care less about water as a resource and they do not take responsibility for their actions. This disconnect between people and water was highlighted during the interviews.

"Water has been made so invisible that the people think that it is the role of the water companies to just provide water and they do not actively think about the process of producing water and the process involved in getting water from the sea to the tap." (Respondent 1)

"I am actually surprised on how little we know as a water user where out water comes from. I am a hydrologist and I should know that, but nobody has actually told me." (Respondent 2)

This lack of awareness among people about the processes involved in the water and where it is sourced from is likely to contribute to how people value water as it is done in other parts of the world where water is considered precious. One respondent thought the reason for this could be that water is not perceived in prices unlike other services such as energy. The awareness around energy, the respondent said, is much more than that around water and it showed that *"there is a disparity on how water is treated in comparison with other life essential commodities".*

4.3.4: Carbon footprint

Energy and water has a strong inter-relationship as discovered from the literature. This was also highlighted in the interviews where the carbon footprint of the water industry was causing a concern for the participants. One of the respondents' first response to the question around the challenges faced by the water industry was the carbon footprint of the water sector. The energy used for production, supply and the eventual heating of water at homes and businesses were mentioned and respondents also pointed to the fact that increased demands and changing patterns of usage plays a part in the carbon footprint of the water sector.

"The problem in itself does complicate the issue of climate change, as we have climate change going on but then we have the water industry activities contributing more to that problem" (Respondent 1)

However, the respondent from Thames Water was not in total agreement to the figure of 6% share the water industry has in the UK's emissions footprint. He argued that it is around 1-3%, but this could be discounting the energy used for heating at homes and businesses. He went

on to add that it must be considered that *"it is because we are delivering water and wastewater services without which life would be impossible."*

4.3.5: Discussion

The findings from the research around the challenges confronted by the water industry touched on the key aspects discovered from the literature. Variability and scarcity of water resources across the UK as well as water quality issues was highlighted by Heathwaite (2010), Defra (2008), RGS-IBG (2012), GIZ (2020) etc. and this was supported by the responses received both from the interviews as well as the survey. Erratic weather patterns, floods, droughts, wetter winters and drier summers were all mentioned by the respondents and how these posed serious challenges to the water sector and the need for a strategic plan to be put in place to address these challenges. Respondents were also concerned about the ageing infrastructure which they deemed difficult to be maintained, both from a technical and a financial point of view. These infrastructural challenges, both for water supply and also wastewater treatment, were mentioned by Tolkou (2015) and Ashley (2005) in the literature.

Carbon footprint of the water sector was investigated in the literature (Bond, 2021) and this was also a theme in interview responses. However, these figures were challenged by the respondent representing Thames Water. It could have been misinterpreted as the whole of the 6% share were resulting from the activities of the water companies.

A key issue which emerged from the interviews related to the attitudes of consumers towards water and the lack of 'value' attached to water resources. The lack of awareness among the people around water and their activities impacting the water resources received comparatively less attention in the literature. This may reflect greater awareness and experience of water poverty in developing regions although insufficient literature was available to confirm this. However this theme emerged frequently during the interviews with the key informants. This is suggestive of the importance that the water sector could see in the role people could play in moving towards a responsible public, who are aware of their actions and its impacts on the environment. The question ahead is whether the water companies acknowledge this potential among people and take serious steps ahead to involve the public more in the discussions and plans for efficient management of the water resources and infrastructures.

4.4 Strategies adopted by the water companies in the UK (Research objective 3&4)

To explore the strategies that are being adopted by the UK's water companies and the significance attached to behaviour change, the study examined the approach taken by Thames Water. This analysis was based on review of policy documents produced by Thames Water as well as insights provided by respondent 3 from Thames Water and relevant comments from other respondents. This section presents the findings followed by a discussion which aims to critically evaluate Thames Water's strategies through a comparison with key strategies adopted in developing regions as identified in the literature review. This aims to address research objective 4. This focuses on the following strategies that emerged from the interviews.

4.4.1: Resource availability- Identifying additional resources

To overcome the shortage of the availability of the resources, multiple strategies are being looked at by Thames Water. This includes bringing in water from other water resource zones, direct reuse of wastewater after intense treatment and enhancing winter storage. These strategies are listed out in the water resources management plans that Thames Water releases every five years to explain their plans to the regulators and customers. The priority given to identifying additional resources was highlighted in the interview with Respondent 3.

"We are looking at bringing water in from Wales. This will be look into in the next plan, but the question is will Wales have enough water in the future."

"Another option is to build a reservoir. Capture water during wetter winters and release the water into Thames to enhance the river and also to take water into another place where it could be used for drinking water. This is climate adaptation"

Finding additional sources of water seems to be given a high priority. Another respondent mentioned that the challenge of climate change could be exploited for the better by trapping water during the possible excess rainfall during winters to augment storage and be used for supply during the drier summers. However, the respondents from the survey did not consider this as the top priority as they did with reducing wastage, changing personal behaviour or increasing funds for infrastructure.

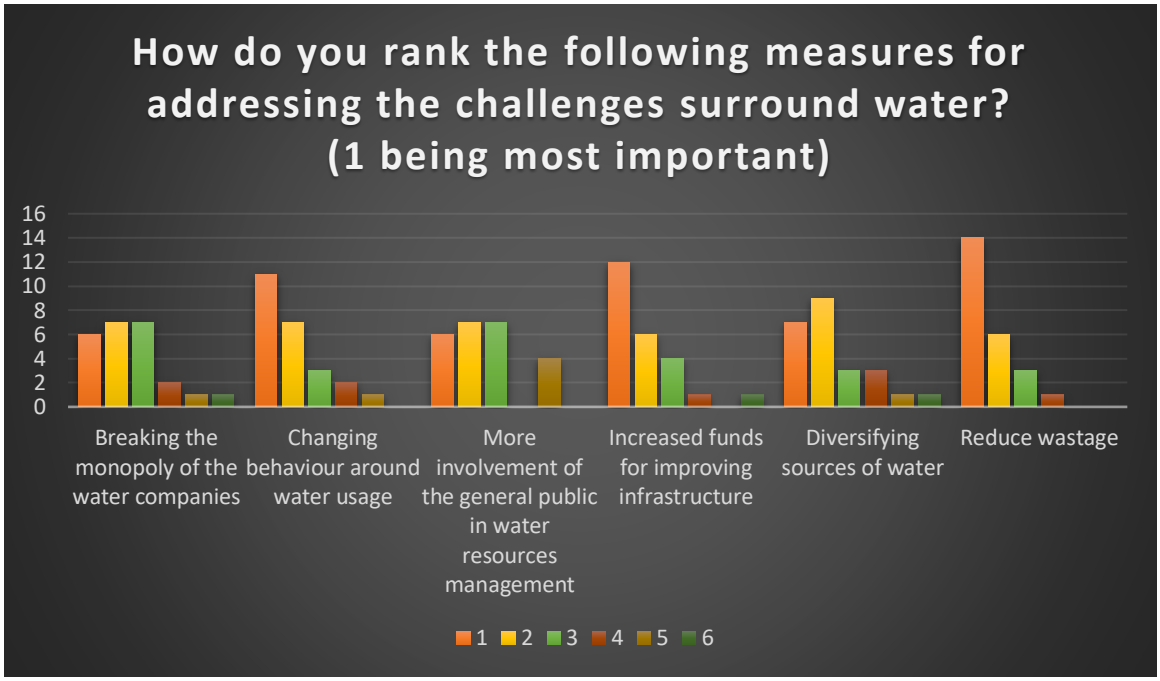

Figure 8: Survey response for the question: "How do you rank the following measures for addressing the challenges surrounding water?

The relatively lesser importance attached to the option of finding additional sources of water, in some ways contradictory to the efforts of the water companies including Thames Water, could be read together with the disconnect between the people and water that was mentioned as a challenge by the key informants during the interviews.

4.4.2: Developing climate resilient strategies - Carbon footprint and collaboration across the sector

Some of the efforts taken by the water sector to mitigate climate change effects were talked positively about by the key informants. The route map for achieving net-zero with regards to the emissions from the operations of the water companies was commended by respondent 4. The respondent added:

"The water companies sees the net-zero route map as an important step in achieving climate adaptation"

The route map was also highlighted by respondent 1, although pointed that to achieve this commitment it should be taken in a holistic approach taking into consideration all the problems that are being faced.

This is also evident in the route map produced by Water UK, an association of all the water companies in the UK including Thames Water. The route map aims to achieve the goal of net-zero by 2030 (WaterUK, 2020). This document detail the pathways to be adopted by the water sector to fulfil their commitment to net-zero and these are shown in figure 6. The strategies adopted include reducing current GHG emissions, using renewably sourced energy and

exporting energy and fuels to the wider UK system, restoration of peatlands and grasslands, and also demand management measures (WaterUK, 2020).

Pathway	Overall pathway description	Key focus for decarbonisation	Hierarchy focus areas (Figure 4-2)
Demand led	This pathway will assume that all possible energy efficiency and demand/per capita consumption (PCC) reduction potential is applied. Technologies for reducing emissions, renewables and then offset of emissions are applied at lower scale. Social influences for sustainable consumption will be key. Regulators assumed to be fully engaged and well prepared to understand trade-offs before PR24 – no increases in emissions due to regulatory influences in PR24.	Pathway focuses on managing demand for water and wastewater services by accelerating and going beyond existing 2030 commitments (e.g. leakage, PCC).	Reduce and renewables
Technology led	This pathway will assume that technological innovations are accelerated (costs rapidly reduced and policies in place) for investing more rapidly in renewables, sustainable transport systems and process technologies for capturing and managing more rapidly process emissions (pre and post 2030). This pathway will consider further acceleration from government via financial stimulus to accelerate and create new supply chains. In this option Ofwat is assumed to be proactively supporting the sector by supporting investment in decarbonisation technologies. The sector is also expected to take advantage of other government funding not passed through to customers.	Pathway focuses on accelerating technological innovations targeted at decarbonising largest emissions contribution areas.	Reduce and renewables
Removals led	This pathway will assume that there has been very slow progress in adopting additional reduction and renewables, in combination with increasing regulatory quality standards for the sector. Natural sequestration solutions (insets, offsets and purchased offsets) play a big part. This is very likely to result in higher cost post 2030.	Pathway focuses on accelerating activities which improve the natural sequestration capacity of the sector, within the companies own land and the wider UK territory.	Offset

Figure 9: Summary of pathway descriptions and main areas of focus to achieve net-zero (Source: WaterUK, 2020)

The respondent from Thames Water claimed that these strategies have already been put to work at Thames Water already. The respondent said:

"Adaptation is one thing, but reducing our contribution is also important. 23% of our energy need are met from biogas produced in the process of wastewater treatment. And the rest is from renewables."

Respondent 3 also acknowledged that demand reduction would mean lesser operational emissions.

The respondents talked positively of the efforts made by the water sector to come together to achieve their common goals. These included the goal of net-zero and transfer of resources between water resource zones. The respondent said:

"An interesting thing about the UK water industry is that they are acting together to address climate change, like in the case of net-zero. They do this in partnership and collaboration among themselves which is not so common in other parts of the world."

4.4.3: A focus on leakage

Another major issue highlighted during the interviews and the survey was the problem of leakage and wastage. This has been considered by Thames Water and they have made plans to reduce leakage by at least 50% by 2050 compared to the 2018 baseline (Thames Water (b), 2020).

"Leakage is a big issue. We have plans to reduce leakages by 2025 and by 2050, there will be very little leakage when compared to 2018." (Respondent 3)

The survey response also indicated the residents' knowledge about the leakage as it indicated that reducing wastage, both public and private, was the most significant measure that could be adopted to address the challenges faced by the water sector (figure 6). This urge to reduce leakage has been reflected in Thames Water's business plan which aims to achieve a 15% reduction in leakage by 2025 (Thames Water (b), 2020, p7).

4.4.4: Preparedness for climate change

Adapting to climate change is crucial for a smoother operation of the water sector in the future. The key informants, understandably, were concerned about the impacts of climate change on the water sector and argued that it was about time that all the stakeholders, especially the water companies, start taking adaptive measures so that the water sector will be well prepared for the future.

***"We are in a vicious cycle where we are trying to solve problems but end up creating more problems, so we will need a strategic plan and overhaul to break the cycle really"* (Respondent 1)**

This is really crucial going forward as maladaptation could cause more damage and exacerbate the challenges in the future. The respondent went on to add that addressing climate change cannot be fulfilled without addressing the issue of water.

"Climate is water!" (Respondent 1)

Thames Water has detailed on how they take climate change into account in appendix U of their WRMP. The impact that various scenarios of climate change could have on water supply and demand balance until the end of the century are listed out and the separate water zones are classified with low, medium and high vulnerability (Thames Water (c), 2020). The eventual effect on deployable output is then calculated and prioritised for action according to their vulnerability level. These calculations are evaluated to prepare response measures which would be required during an event of considerable water shortage. These include

Respondent 3 claimed that wastewater treatment had a separate plan set up for it considering climate change impacts. This was found in Thames Water's climate change adaptation report. The goals and achievements made so far are listed in this document. These include disconnecting land from mains drainage using sustainable drainage systems, preventing untreated sewage entering rivers, completing a Drainage and Wastewater Management Plan (DWMP) etc. (Thames Water (a), 2020).

However, climate change adaptation raises the issue of uncertainty surrounding climate change. This was pointed out by the respondents in the interviews.

"One of the key things with climate change really is that we don't actually know exactly what effect it is going to be or how severe or accurate it is going to be. You're only assuming" (Respondent 2)

"Although the plans are developed incorporating climate change, investments shouldn't go wasteful and uncertainty around climate change should be taken into consideration." (Respondent 3)

The uncertainty around climate change is acknowledged in Thames Water's calculations and they have sought advice and peer review from experts. It was decided to take the full variability of the calculated impacts into account (Thames Water (c), 2020).

4.4.5: Developing climate resilient strategies – the role of public consultation

Public consultation have been carried out for the preparation of assessment manage period (AMP) from 2020-2025. AMP is the business plan that the water company produces which details their plans to ensure an efficient service to their consumers at a specified fare. One million customers were consulted to understand their needs and 67% of the participants were happy with the packages prepared, including a reduction of £5 from average annual water bill (Thames Water (b), 2020). Respondent 3 claimed:

"We have consulted one million consumers as part of preparing the plans. That is not a small number."

The other key informants also acknowledged the steps taken by the water companies in general.

"Now we see the water companies making people to come and have a role to play and take responsibility for water and for the problems as well." (Respondent 1)

However, respondent 2 was not aware of any public consultations that Thames Water had been carrying out. The respondent said:

"I know they hold stakeholder consultations, but I don't know about any public consultation going on. I know about a public consultation going on for a new reservoir, but not for any general plans"

The response from the survey also indicated that the residents do not see themselves playing an important role to address the challenges faced by the water sector (Figure 6). The public consultation seems to be designed to get the public's approval of the company's business plan. The reduction in average annual bill satisfies the customers' needs, and this would again widen the disconnect between the people and water as the theme emerged from the interviews highlighted. Respondent 3 also claimed that the customers were willing to pay more to avoid any restraints.

4.4.6: Demand management through behaviour change

The key informants argued that demand management has a significant role if the water sector wants to achieve climate resilience. The importance of behaviour change for water management was a more pressing issue with Respondents 1, 2 & 4 than with Respondent 3. Respondent 3 claimed that demand management is just one of the solutions among a pool of solutions to address climate change.

Thames water sees demand management as one of the strategies to be implemented to improve water efficiency measures. Respondent 3 claimed that Thames Water provides water efficiency devices on the website and these chances are only exploited by the customers who are aware of such opportunities. Smart water metering is also being considered as an option to influence water demand, as a price signal would provide an incentive for the consumers to reduce consumption.

"We are doing some really good work in terms of policy, to make sure that we are reducing water demand. Smart water metering is causing increased pressure in the policy corridors to ensure water metering programs around the country."
(Respondent 1)

However, the emphasis placed on water efficiency seems to be lower than that placed on water sufficiency.

"Even if customers reduced demand, there is always more customers to be served."
(Respondent 3)

This suggests that the Respondent attached lesser importance to demand management that to other strategies adopted by Thames Water. Thames Water's strategies to achieve behaviour change will be discussed in detail in the next section of this study.

4.4.7: Discussion

The strategies that have been adopted by Thames Water has some similarities that had been explored as part of the literature review, while some differences were also seen. The efforts to diversify and augment the sources for water supply taken by Thames Water resembles the water markets adopted in Southern Africa which was highlighted by Matchaya et al (2019). However, the financial viability and sustainability of such a transfer would have to be studied in a more detailed research.

Reducing their carbon footprint is given a high priority in Thames Water's policies and they have taken up some key measures in regard to this. The key informants also acknowledged these efforts. Leakage reduction was a key measure identified by the survey respondents to address the challenges confronting the water sector, and Thames Water have plans for reducing leakages by a significant amount by 2050. Leakage reduction strategies adopted in the developing countries' water sector was not explored much in the literature but came out in more prominence in the discussions with the key informants and its perceived importance was also indicated in the survey response.

Thames Water sees climate change as one of the biggest challenges that it faces and have been preparing for an uncertain climate future by taking into consideration every possible variability in weather patterns. They have approached experts for advice and peer reviewing their plans for the future. Assessing the possibility of variable climate patterns were adopted in many developing regions of the world facing water stress, and these were pointed out in the literature by ACT (2018), GIZ (2020) and Ilunga et al (2020). However, the UK would probably be better placed with the financial and institutional capabilities available to be well prepared for an uncertain future.

Giving people the responsibility of their water resources was a strategy adopted in some parts of the world to varying levels of success, and these were mentioned in the literature by Blaikie (2006), Wester (2003), Dewan & Buisson (2014) etc. Thames Water have started incorporating their customers into the discussions surrounding water and encouraging them to take responsibilities for the resource and their actions. This was lauded by the key informants involved in the research. However, the survey painted a slightly different picture as the respondents did not see themselves playing a big role in water management activities. This can be attributed to the perceived disconnect between water and the people that was largely part of the discussions and the water companies including Thames Water would want to address this issue more seriously.

4.5: Importance attached with household behaviour change as a strategy: A comparison between the UK and water authorities around the globe (Research objective 3&4)

This section aims to explore in detail the importance attached to household behaviour change as a strategy adopted by the water companies in the UK, including Thames Water, and see how it compares to the behavioural change strategies adopted in other parts of the world. As identified from the literature, household behaviour has huge implications on both water supply and wastewater networks. While efficient use of water can not only reduce the stress on water resources, it can also help in achieving other targets including the carbon footprint of the water sector. Responsible disposal of waste and preventing non-human wastes from entering the sewer networks will help in better service and maintenance of the wastewater infrastructure, which is old and not designed for receiving types of waste other than decomposable ones.

The key informants were mostly vocal about the role that behaviour change could play in achieving climate resilient water management. Respondent 1 put it eloquently:

"Behaviour change could be a game changer for water demand and people will be heavily relied upon for its success."

4.5.1: Water efficiency

The key informants were of the same opinion that household behaviour change can begin with efficient use of water. Despite the semi-structured nature of the interviews, education relating to water, awareness campaigns and shared responsibility for the public were all mentioned by the participants in the interviews. Following are some of the responses:

"We can drive down demand in so many ways, but we should address that behaviour change has an important role in the pack of strategies to address climate change." (Respondent 1)

"Consumers must be made aware of the water consumption activities that they take part in and should be asked the question if it is necessary them to be actually doing it." (Respondent 4)

"Reducing overall demand reduces the pressure on the resources." (Respondent 3)

The survey response also indicated that the residents feel they could play an important role in achieving resilience in water management. The options that received the highest priority for the question on how households can contribute to address the challenges, were all related to behaviour change in one way or another. The most important step they believed households could play was recycling grey water for gardening purposes, followed by rainwater harvesting and changes in personal behaviour around water use. The response that was ranked the least

significant, by the most respondents, was the one which said that households cannot play a role in addressing the challenges. The survey response is promising, although it should be considered that it is a very small sample and a larger research could perhaps bring a clearer picture of the thoughts of a wider public.

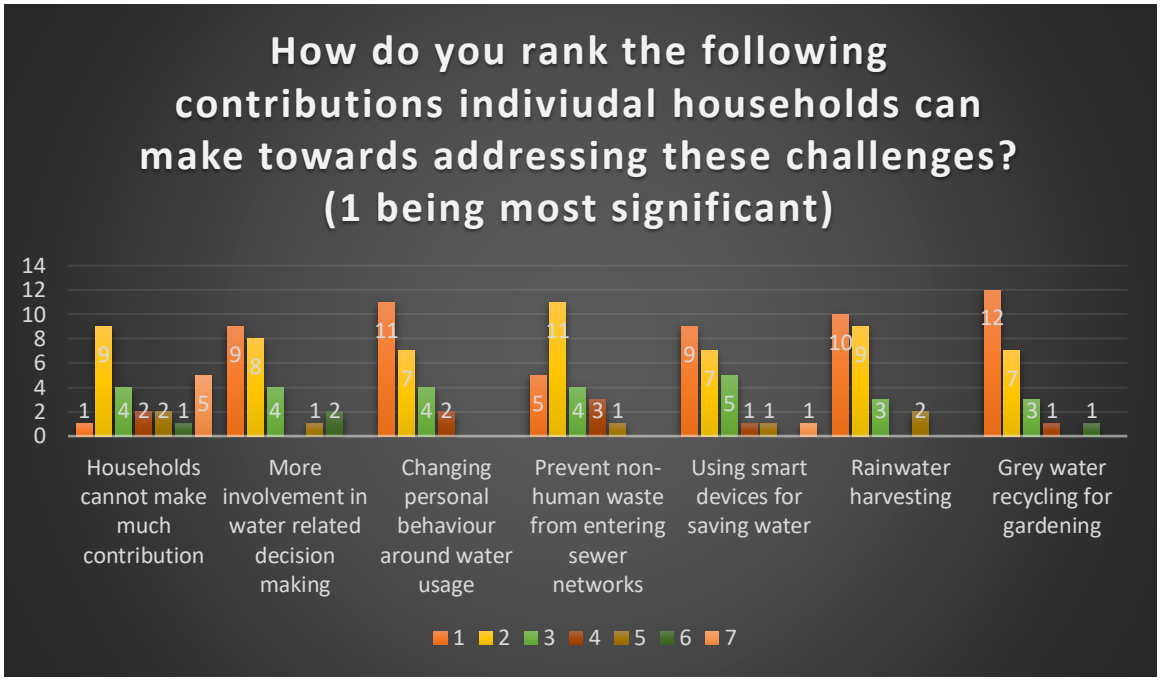

Figure 10: Survey response on the role households could play in addressing the challenges confronting water sector.

Interestingly, having more involvement in water related decision making also received a high priority among the survey responses.

To achieve and maintain change in behaviour among the people, the key informants thought education was crucial. Educating people about their activities related to water, the processes involved in the production and supply of water were mentioned as a step towards people taking increased responsibility and adapting to behavioural change measures.

"We should innovate behaviour interventions. Move further from just having awareness campaigns and giving information and retrofitting devices at homes. Use science to drive the actions that we take to help the public, user behaviour intervention tactics, making sure people are taking fond responsibility of water." (Respondent 1)

"Educating the consumers of the role they can play by improving efficient use of water is a good place to start." (Respondent 2)

Thames Water have claimed to be promoting water efficiency messages to consumers. In its climate adaptability report, Thames Water acknowledges the challenges faced, and mentions that they are "pushing ourselves to spread the word about water, encouraging our customers to save water and educating future generations about the importance of the water cycle" (Thames Water (b), 2020, p6). In their business plan for 2020-25, Thames Water aims to improve water efficiency with steps such as helping customers to reduce their water consumption by 4%, installing more smart water meters, visiting homes and businesses to offer advice and support, incentivise builders to install toilets that use non-drinking water (Thames Water (b), 2020). Respondent 1 acknowledged the water companies' efforts to educate their customers on water efficiency.

"It is good to see water companies going to homes and talking to people on why they need to be using less water and in a more conservative way. The conversations convey to the consumer that if they don't do it now there will be bigger burdens including financial ones in the future." (Respondent 1)

However, the question of whether this messages reach the customers in the Thames Water region is a question yet to be answered. As a knowledgeable resident in the Thames Water region, respondent 2 was not aware of any water efficiency measures that the company has been adopting.

"I don't think there's enough drive to promote efficient uses of water. I mean I never get any literature through my door or through my email or anything telling me to save water." (Respondent 2)

When asked about the unawareness of the residents living in the region and whether Thames Water were doing enough to promote water efficiency, respondent 3 said:

"Is it a perception that the people are not informed or is it a reality? Customers only want to know when they want to know. There are instructions every time the bill goes out and there are campaigns during periods of lower rainfall."

This shows that there might still be more work needed to be done to achieve water saving targets. This was pressed on by the key informants in the interviews.

"If the water companies do not take up demand side measures immediately, it will be really difficult for them to achieve climate resilience. If people are told to use less water in the event of water shortage and they do use less water, this means that the concentration of pollutants in wastewater go higher and this will place the water companies at risk of not complying to regulations of discharge concentrations." (Respondent 4)

"We are also trying to increase the pressure around public education to drive behaviour change because it is not just sufficient to retrofit water systems and hoping that it will achieve the water saving targets of the industry." (Respondent 1)

The challenges related to raising awareness among the people were also touched on by the respondents. The issue of channelling finance towards educating the public was mentioned as it is difficult for its success to be evidenced unlike technological interventions. The survey response also highlighted the lack of awareness among the public as the most significant obstacle in addressing the challenges for the water sector, followed by the lack of visible rewards for water conservation.

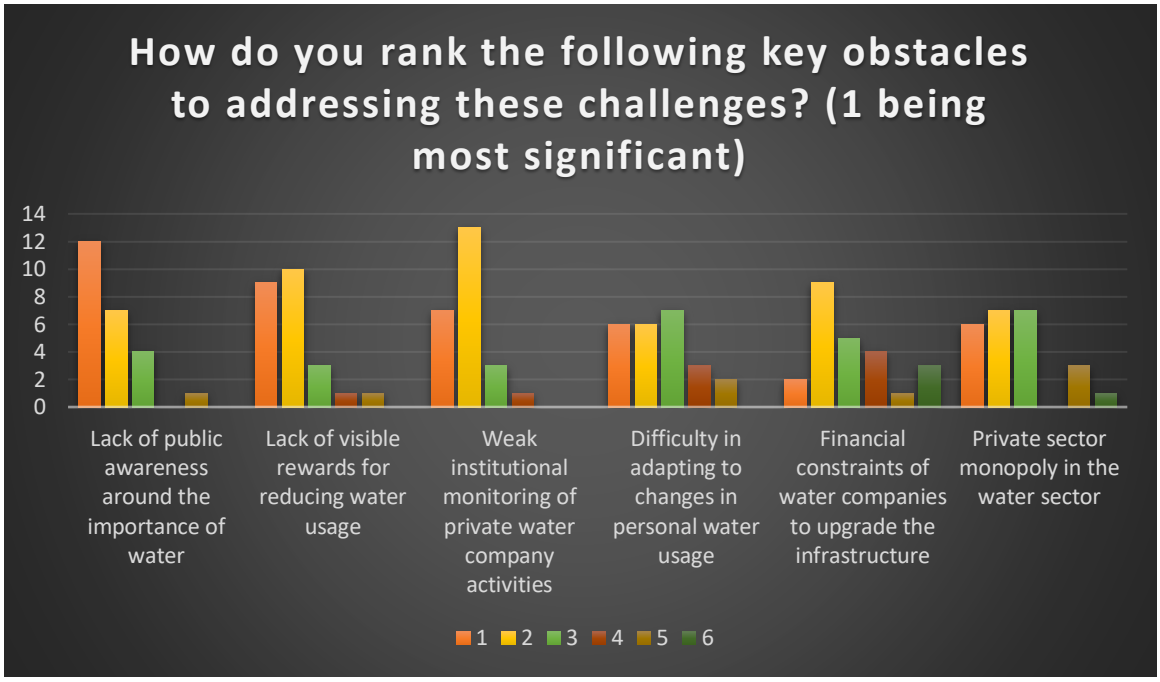

Figure 11: Survey response on the key obstacles for addressing the challenges faced by the water sector.

4.5.2: Responsible waste disposal

The issue of unflushables blocking the sewers was raised by the key informants and the survey respondents were also aware of this issue to an extent. The key informants thought this challenge has to be addressed along with the issue of demand management. Some of the responses from the interviews were:

"Educating consumers about the challenges attached to irresponsible flushing and the items they can flush will be really helpful for the water companies. However it is

not just the consumers; manufacturers are irresponsible when they label unflushable products as flushables and consumers who are not well informed assume they are flushables and flush them down to the sewers." (Respondent 4)

"When we send plumbers to people's homes, and they do not find a bin in the toilet, the plumbers are encouraged to ask how other wastes are disposed as it is fairly obvious that they are not going to run down a flight of stairs to the kitchen to bin waste materials." (Respondent 1)

"On the back of all this, I wouldn't wash down any fat oil down a normal drain, but for the other households, I'm not sure." (Respondent 2)

The overall theme that emerged from these discussions was that the key informants identified the problem of untreatable wastes ending up in the sewer system and urging for action to be taken in order to mitigate the associated challenges.

The survey response also saw the residents of the region believing that refraining from washing down non-human wastes would help in addressing the challenges posed to the water industry (figure 8, option 4). 16 of the 24 respondents placed this as the top two actions that households can take up.

Thames Water has a campaign to raise awareness regarding the challenge of unflushables, called 'bin-it don't block-it' (Thames Water (a), 2020). Among its targets are to reduce internal sewer flooding by 20% of which these wastes are a cause. The water industry have also been involved in dialogue with manufacturers of hygiene products and encouraged them to improve their products to meet the fine to flush standards. This was mentioned by respondent 3. The respondent also mentioned about the campaigns carried out to improve awareness among customers.

A behavioural change campaign was undertaken in Scotland to convince the customers to bin the sanitary waste items based on a study by Ashley et.al (Ashley, et al., 2005) and around tens of thousands of the population were involved in the campaign and up to 90% reported behaviour change (Brown, et al., 2006). However, despite the success owing to decent funding and years of research, this campaign titled "think before you flush" was swapped for the UK's blanket approach of "bag-it-and-bin-it" programme although this is a much discredited one in discouraging the population from flushing non-human wastes via the WC (Brown, et al., 2006). Campaigns to promote the usage of reusable menstrual cups have gained momentum (Radnor, 2017) and if more customers tend to use the reusable products, this would eventually help in lesser "unflushables" entering the sewage system thereby mitigating the effects on treatment infrastructure.

4.5.3: Discussion

Measures adopted to achieve water efficiency targets by Thames Water seem to be well defined on paper. However, its efficiency has to be questioned, especially when a concerned authority mentions “customers only want to know when they want to know”. Efforts to achieve water saving targets will have to be scaled up as the key informants’ think demand management measures are crucial for achieving climate resilience.

The measures including campaigns, metering and installation of smart devices mirrors the efforts adopted in South Africa, Mexico and China were found in the literature (Enqvist, 2019), (Borle, 2016), (Nickum et al, 2020). These steps can also be seen in the strategies being looked into by Thames Water.

Learning from the best practices adopted to achieve behaviour change would be helpful for the water industry to implement efficient strategies. This was mentioned by respondent 4 during the interview when talking about innovations needed in adopting strategies.

Reducing water use has multi-faceted benefits as per respondents. These include reduced stress on the water resources, reduction in the carbon footprint of the water sector, social integrity and also people taking responsibility for water. The survey response was interesting as it indicated the households’ acknowledgement of their part in demand management measures. However, this was a small sample of respondents and further research will give a better picture of the wider public’s perception of the role they can have in achieving water saving targets.

Impact of irresponsible waste disposal was explored in the literature and the opinions of the key informants mirrored those challenges mentioned in the literature. Educating people about their actions was the strategy the interviewees thought w theas the best way to address this issue. The “bin-it don’t block-it” campaign run by the water companies including Thames Water aims to address this issue. The survey response also indicated that people think this activity has a serious implication and they seem to give a fair acknowledgement of the importance of refraining from such activities.

Adoption of reusable options for hygiene products were explored while reviewing the literature. Whereas in the case of the UK, the water companies tend to focus on convincing manufacturers to produce biodegradable alternatives. However, reusable alternatives have been promoted by voluntary campaigns and seem to be gaining momentum. Similar attempts to promote the usage of reusable hygiene products were witnessed in India as highlighted by

A combined strategy of reusable and bio-degradable options will help in this regard.

Chapter 5: Conclusion

5.1: Introduction

This study set out to explore the question of what role can behaviour change play in achieving climate resilience in the water supply and wastewater services in the UK, by adopting a case study approach on Thames Water.

The study started by exploring the challenges that are currently faced by Thames Water in terms of water supply and wastewater services and how these challenges could be exacerbated by climate change. The strategies adopted in other countries or regions in the world, mostly developing in nature, with the experience of managing the impacts of climate change on water resources, were investigated to explore the range of strategies that were used to address the challenges these countries were faced with. The importance attached with behaviour change was also explored in brief to see the potential it had among the pool of strategies adopted. A problem statement was hence formulated to understand the emphasis that the UK water industry has placed on behaviour change to address the challenges that it faces, by taking Thames Water as a case study. The aim of the study was to evaluate the approach of Thames Water through a comparison with approaches taken in other regions in the world that have experience of managing the impacts of climate change on water resources. Four research objectives were set out to form a framework for the study designed to answer the following questions:

1) What are the challenges that the water industry in the UK are facing.

2) What strategies have been adopted to achieve climate resilient water management in developing regions globally and the importance attached to behaviour change.

3) What strategies are being adopted by the water companies in the UK and how do these compare with the strategies adopted in the developing regions.

4) What is the importance attached with household behaviour change as a strategy by the water companies in the UK?

In this chapter, a summary of the key findings will be presented with systematic interrelations. Preliminary recommendations will be provided for possible interventions. Finally, this chapter will conclude with a brief summary of further research avenues.

5.2: Summary of key findings

Challenges faced by the water industry

The findings from the research supported the themes that emerged from the literature. The challenges of water scarcity ((Defra, 2008), (Ofwat, 2007)), population growth (populationmatters, 2019), water quality ((Thorne & Fenner, 2011), (Whitehead, 2009)), climate change and associated uncertainties ((Charlton, 2011), (LWEC, 2016)), wastewater treatment ((Muller, 2007), (Tolkou, 2015)) and carbon footprint (Bond,2021) were all mentioned in the literature and were picked up by the responses received from the key informants as well as from the survey. These were also observed in the documents published by Thames Water.

Another key finding from the research on the challenges facing the water sector which was less evident in the literature was the lack of connection between water and people. Respondents remarked that water being made available at cheap prices, has caused a lack of value for water by the consumers, who are largely unaware of the sources of their water and the process involved in water supply and wastewater treatment services. The respondent saw this as the reason as to why the people do not take responsibility for their actions when it comes to water. This perceived disconnect suggested the lack of emphasis placed on the role that people could have in addressing a problem that they are very much a part of and will face consequences for if no action is taken. The survey response also supported the thoughts of key respondents in terms of the challenges they thought were faced by the water sector, and also showcased the perceived lack of connection that the key informants claimed there existed.

Strategies adopted by the water companies in the UK

While exploring the documents published by Thames Water and also during the interviews, findings gathered showed some similarities in the efforts taken up by Thames Water were visible with the strategies that were adopted in other parts of the world that were discussed in the literature. Transfer of water (Matchaya et al, 2019), (GIZ, 2020) were in practice in Africa and Asia and this is one of the strategies that Thames Water are focusing on, with high priority. However, desalination of sea water to enhance water availability does not seem to be an option considered by Thames Water although this was found to be used in some regions while exploring the literature. Considering the energy footprint of desalination activities, this is a strategy that doesn't warrant priority unless water scarcity becomes extreme.

Water companies are working collaboratively to overcome the issue of water shortages in certain locations by transfer of water from more water-affluent regions. Thames Water is discussing the possibility of transferring water from Wales in the future. Collaboration was also

witnessed in the preparation of a route map to achieve net-zero emissions in the water sector by 2030.

Thames Water have taken climate change into serious consideration and has studied the possible variations it could cause to the deployable output and hence supply operations. This has set the basis for response measures and these were detailed in appendix U of their WRMP. Similar projections are also made for the wastewater operations to ensure resilience to possible impacts of climate change. Similar strategies were adopted by ACT (2018) while dealing in water stressed regions in Asia which has helped in managing the water resources through the impacts of climate change. This has been seen at various stages in regions like Lusaka (Ilunga, 2020) and Pakistan (ACT, 2018).

A notable feature of Thames Water's response was a clear strategy for reducing its carbon footprint through the use of energy generated from biogas and renewables for its operations. Reducing the carbon footprint of the water sector is an important step and this has been aimed and achieved in different parts of the world including Australia and New Zealand according to Lee et al (2017). These efforts were recognized by the other key informants who also mentioned that this should be implemented by considering all the other challenges that are being faced.

Thames Water have tried to bridge the gap between the people and water by consulting consumers while developing their business plans and have also carried out campaigns and other measures to spread the message of water efficiency. However, more work needs to be done in this regard as testified by the key respondents. The survey respondents too believed that households could contribute to achieving climate resilience by changing personal usage of water and responsible waste disposal practices. The survey response also saw the respondents indicating that they could be more involved in the decisions relating to water management. This is a challenging strategy, as evidence from Mexico and South Africa suggests (Wester, 2003), but has the potential to be a catalyst for climate resilience in water management (Fisher, 2000). This will require improvements in policies and funding for public education surrounding water management. Although the success of these practices are harder to evidence than conventional technological interventions as suggested by Respondent 1, the devolution of responsibility of water to the public can ensure a bottom-up approach towards water management. This will play an important part in water management as witnessed in the Mekong river basin (Lebel et al, 2010).

Behaviour change strategies adopted by Thames Water

From the findings, two key themes were attached to behaviour change strategies: water efficiency and responsible waste disposal. The key informants stressed on the importance of

behaviour change as a strategy for achieving climate resilience. The respondents argued for the need to break the vicious cycle of maladaptation and believed that behaviour change could prove to be a solution for a number of problems that had people at the centre.

While exploring Thames Water's documents for behaviour change measures, it was found that these strategies were mostly restrained to providing water efficiency devices to the customers, of which a big portion is believed to be unaware. This was confirmed by Respondent 3. The other key respondents suggested that it is the need for the best interests of all that behaviour change be given an equal priority. The need to educate the public about their actions was demanded by the key informants so as to devolve the responsibility of water to the consumers as well. The success of behavioural change interventions are well evidenced from the Cape Town example (Rodina, 2019) where a collective effort from the authorities and public helped in avoiding the threat of day-zero. Windhoek in China also took measures to address issues of droughts and water shortage through behavioural change measures (Ndebele-Murisa, 2020).

However, the measures adopted in these regions were quite radical as the situation demanded. Adopting behaviour change measures and maintaining them in the society in advance will help to avoid the threat of such serious magnitudes altogether. As the key respondents highlighted, if the water companies do not take up demand management strategies, it will be hard to achieve climate resilience in the water sector.

5.3: Preliminary recommendations

Thames Water, along with other water companies may want to address the perceived disconnect that exists between water and people. This could be achieved through better education and interactive activities which will make sure that the consumers are aware of the sources of water, the processes involved in getting water to their homes or businesses, and also the impact their actions has on the water infrastructure and resources. This will help in people taking up responsibility and as a society, could engage in a more positive way thereby helping the water sector in achieving climate resilience. As evidence from Cape Town suggests, the power of people's coordination and efforts should not be under-estimated if the water sector aims to achieve climate resilience.

Educating the consumers regarding their household water usage will greatly reduce the stress on the water resources and infrastructure. Reduced usage will also mean that the water companies will be able to provide their services efficiently to a population that is expected to grow in numbers, without having to find additional sources of water. This will go a long way in protecting our environment.

5.4: Limitations of the research

The study is aimed at exploring the current state of water management and to understand the preparedness of the water companies for a future with changing climate and the role households could play in achieving resilience in water management. Due to the qualitative nature and a small sample size of the respondents and the organization chosen, this study serves as a foundation for further research into this topic, in a limited capacity.

Although the results obtained from this study will be indicative of the problems faced by the water industry and also the adaptation measures adopted, uncertainty relating to climate change and the small sample of respondents mean that these are not conclusive findings.

Thames Water and its jurisdictions were chosen for the study for narrowing the scope of the research, and with a limited number of respondents, the conclusions of this study only represent the experiences of a small fraction of individuals in a diverse water industry of the United Kingdom. It is possible that other water companies have different experiences and strategies for dealing with climate change threats and this could have resulted in different findings.

Further quantitative study would be necessary to understand the measures taken in the UK's water sector to achieve behaviour change among households.

5.5: Areas for further research

This research has identified some areas for further research. Firstly, an important area for further research is to explore the perceived disconnect between water and people in further detail, with a larger sample of people. This will help in identifying the reasons for the lack of connection if it exists and how these can be addressed. Another area that needs further research is the range of behaviour change strategies that can be exploited to achieve the water saving targets and climate resilience. Although there is a lot written in the literature about behaviour change, an optimum framework for behaviour change strategies will be useful with the threat of climate change and water scarcity looming large.

7. Appendices

Appendix A: Sample interview schedule

Introduction: Study background and rationale

Climate change will have serious impacts on the water sector as has been experienced in some parts of the world like South Africa. Droughts experienced in the UK are also an example.

While looking at the strategies adopted by the water companies in the UK to address the threat of climate change, it was found to be more lenient towards supply side measures, with demand side measures not given much lesser priority. These included transfer of water, and finding new sources of water, which are not sustainable practices as we move forward.

The role that household behaviour change can have in the pool of strategies need to be explored and find out what impact it can have on achieving climate resilience in water management.

Research question:

What role can household behaviour change play in achieving climate resilient water management?

Topic 1: Challenges faced by the UK's water industry

Questions:

1) What do you think are the challenges that are being faced by the UK's water industry?

Probes: Varied resource availability, carbon footprint, non-human wastes in the sewers.

2) How do you think climate change will exacerbate these challenges?

Probes: Drier summers, lesser availability of water for discharge dilution.

Topic 2: Strategies adopted by Thames Water

Question:

1) What do you know about the strategies Thames Water (or any water company in the UK) has been adopting to address these challenges?

Probes: Water transfer, infrastructure investment, net-zero targets, water conservation.

2) How do you think Thames Water developed these strategies?

Probes: Expert opinions, public consultation, case study

3) What do you think are the greatest barriers for implementing these strategies?

Probes: Infrastructure challenges, lack of awareness among the public, uncertainty.

Topic 3: Role of household behaviour change in achieving climate resilience

Question:

1) How important do you think is household behaviour change for addressing these challenges?

Probes: Consumption, share in carbon footprint, waste disposal.

Appendix B: Survey Questionnaire

Questions and response options:

1) How would you rank the challenges posed by climate change? (1 being most significant)

a) Increase in heat-waves.

b) Water scarcity.

c) Temperature rise.

d) Food insecurity.

e) Increased droughts and floods.

f) Sea level rises.

g) Declining water quality.

2) How do you rank most significant challenges confronting us today with water supply and wastewater treatment? (1 being most significant)

a) Private sector monopoly.

b) Water availability.

c) Ageing water infrastructure.

d) Climate change.

e) Changes in personal usage of water.

f) Wastage (Public and private).

g) Quality of the available water.

h) Non-human wastes clogging sewer networks.

3) How do you rank the following measures for addressing the challenges surrounding water? (1 being most important)

a) Breaking the monopoly of the water companies.

b) Changing behaviour around water usage.

c) More involvement of the general public in water resources management.

d) Increased funds for improving infrastructure.

e) Diversifying sources of water.

f) Reduce wastage.

4) How do you rank the following contributions individual households can make towards addressing these challenges? (1 being most significant)

a) Households cannot make much contribution.

b) More involvement in water related decision making.

c) Changing personal behaviour around water usage.

d) Prevent non-human waste entering sewer networks.

e) Using smart devices for saving water.

f) Rainwater harvesting.

g) Grey water recycling for gardening.

5) How do you rank the following key obstacles to addressing these challenges? (1 being most significant)

a) Lack of public awareness around the importance of water.

b) Lack of visible rewards for reducing water usage.

c) Weak institutional monitoring of private water company activities.

d) Difficulty in adapting to changes in personal water usage.

e) Financial constraints of water companies to upgrade the infrastructure.

f) Private sector monopoly in the water sector.

6) How do you think climate change and water shortages are linked?

Rate from a scale of 1 to 5, where 1 is very low and 5 is very high.

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