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How do citizens feel about their water services in the water sector? Evidence from the UK

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Abstract

At present, many studies have used social survey methods to explore UK water citizens' perceptions of the water sector's water services, but there are few more targeted and systematic studies. This paper mainly displays the perceptions of UK water citizens on water services in the water sector in recent years and analyses the main reasons for different perceptions and possible strategies. We conduct extensive research from four aspects that are highly related to water services: water citizens' perceptions of the water supply services and technology application (infrastructure construction) provided by the water sector; the state of communication between the water sector and water citizens and their perceptions of water supply management; water citizens' perceptions of the comprehensive utilisation of water resources in the water sector; water citizens' perceptions of the water prices set by the water sector. These discussions aim to discover citizens' perceptions of the water sector and the effects on the public participation mechanism. These insights help attract the water sector's attention so that the public's opinions can genuinely support water policymakers and provide sure support for the water sector to formulate corresponding solutions.

Keywords: Perceptions, Water supply services, Technology application, Water supply management, Comprehensive utilisation, Water price

Introduction

Globally, by 2050, domestic water use is anticipated to increase by 130% [1]. Faced with rising pressure on the water supply, water companies use a combination of tools to increase water capacity (through water reuse schemes) and decrease demand for water (through motivating customers to change behaviour). Due to the continuous reduction of available freshwater resources, the quality and service level of the water supply is gradually affected [2, 3]. Although some policies have been formulated to alleviate or reduce the potential risks of water supply, it is anticipated that extensive adaptation measures will still be required to reduce water stresses in urban population centres [4]. The review shows that although the amount of adaptation research that can provide decision support has grown exponentially in the past few decades, there is still a deficit in understanding the specific information that decision-makers require and use when making decisions [5, 6]. The facts have proved that the lack of decisive communication methods does the work of reducing water consumption very ineffective [7, 8] and may even lead to an increase in water consumption as individuals seek to protect their "water rights" [9]. In other words, the water sector needs to promptly communicate with water citizenship on time to understand citizens' perceptions of the water sector. This can provide specific guidelines for the water sector to improve the quality of service and increase the satisfaction of water citizenship.

It is essential to recognise that the water sector in the UK represents a policy context where the institutional enmeshing of commodity-like entities such as

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water are often removed from being entirely managed or governed at the local scale due to marketisation, thus making the operational thinking a complex one [10]. In the UK, a mixture of public–private (Scotland, Northern Ireland), private (England), and employee-owned (Wales) companies provide water, wastewater, and stormwater services under-regulated and non-regulated regimes [10, 11]. Over 50 million household and non-household consumers in England and Wales receive good-quality water, sanitation, and drainage services. These services are provided by 32 privately owned companies in England and Wales [12]. The sector can be characterised by its high fixed costs, long-term relationships, and limited competition, as well as the extent of financing required [13]. There are many different ways to conceptualise individuals who might be targeted for engagement initiatives. Other research or practice disciplines use different terms and concepts. These include citizens, individuals with a right to access clean water and related services; the public, any individual or group of individuals; consumers, water users who pay for water and related services; and stakeholders, individuals that have an 'interest' in the issue [14, 15]. It also may include those directly or indirectly affected by the issue or those whose interest is personal, financial, moral, or legal. In this review, the term 'water citizenship' will be used inclusively to refer to the public and citizens.

The public's perceptions of the water sector and the services provided by the water sector will directly affect the sustainability of the water supply and the future development of the entire water supply industry. The current water business operation units or organisations have relatively weak external adequate competition pressure, and there is insufficient internal motivation to improve efficiency and service quality. Despite the participation of the Office of Water Services (Ofwat), Drinking Water Inspectorate (DWI), Environment Agency (EA), Natural Resources Wales (NRW), and the newly established Market Operator Services LTD (MOSL), each of the five agencies have a division of labour, which has dramatically improved the overall water service level. However, the status quo of the pluralised internal system regulation and internal management, service efficiency, and service awareness has caused citizen participation to gradually become the top priority of the water sector's planning and management. In trying to identify water-related problems, it is essential to consider the local conditions of citizens, develop cultural-related solutions, and implement appropriate solutions and appropriate interventions to solve the problem [16]. Therefore, the public's perceptions and practical suggestions are incorporated into the water services of the water sector, and the role, status, and benefits of water citizens are emphasised to improve the level of water services.

Materials and methods

A significant gap in the current literature is the relative lack of long-term research on citizens' perceptions of water services in the water sector from different dimensions and the failure to form a research system on public participation in water services. However, some examples that support widespread changes have been noted. When formulating the water service policy, there are different ways to understand water users. Water users can be regarded as customers who pay for goods through commercial transactions with a certain level of service or as citizens in a political system that recognises water rights [17]. Several studies also emphasise that water user perceptions of water services and water interventions are linked to intervention acceptance and long-term sustainability (e.g. [18, 19]). The UK water sector has established a public participation mechanism to protect the rights of water citizens from different aspects. Ofwat and DWI issue an annual bulletin to allow the public to quickly obtain water quality information and fully protect the public's right to know. Besides, the UK water sector has formed a remarkable legal document for public participation in water services and will also accept complaints from water users against water companies.

According to the research topic of the paper, all research articles come from Science Net, Scopes Net, JSTOR database and Google Scholar. The keywords are mainly "water supply service or wastewater service", supplemented by "water resource utilisation", "water resource management", "water price", and "technical application" as keywords for advanced search. In addition, it is necessary to screen out articles that are similar to the research topic of "Service Satisfaction with Water Sector". We need to set some other search conditions, and mainly the research area is limited to the UK and articles published in recent years as much as possible. These documents are more representative of the perceptions of modern British citizens on water or wastewater services in the water sector. This study also collected relevant reports and published data issued by water sectors or companies, supplementing information not involved in the literature research.

The identified literature and related reports are used to dig out different research categories using content analysis methods and analyse citizens' perceptions of the services of the water sector according to these categories. The UK Consumer Council for Water (CCW) has launched a survey of citizens' satisfaction with the water sector's services since 2011. With the gradual improvement of surveys and evaluations, water citizens'

perceptions of the water sector have been demonstrated in water services, wastewater treatment services, communication and consultation, and water charges. Besides, some experts and scholars believe that water resources management and technology applications are also observed indicators of water or water service satisfaction [19–22].

Therefore, this research mainly includes four main aspects. The first relates to water citizens' perceptions of water supply services and technology applications in the water sector. It mainly determines the satisfaction of citizens with the service provided by the water sector and the recognition of the technical application in the water sector. The second aspect is the citizens' perceptions of water supply management in the water sector. It mainly establishes the communication status between the citizens and the water sector and the citizens' perceptions of the management methods and policies in the water sector; the third relates to citizens' perceptions of the comprehensive utilisation of water resources in the water sector. It mainly establishes how citizens feel about wastewater treatment and water reuse practices. The final aspect concerns citizens' perceptions of water supply safety and water prices in the water sector. It establishes the citizens' response to the water price setting in the water sector. These discussions aim to discover citizens' perceptions of the water sector and the effects of the water sector in the public participation mechanism and explore the significant impact of citizens' perceptions of the work of the water sector.

Perceptions of water supply services and technology application in the water sector

In the UK, water provided by the water sector is a commodity and a service. In addition to the factors that citizens need to consider water quality and water supply safety, an intuitive feeling of citizens in water use is the service provided by the water sector or company, and the citizens have already paid for it. The most crucial service measure to ensure water quality and water supply safety is technology, which is mainly reflected in the use of infrastructure. Therefore, this part mainly summarises the three aspects of water supply service, water infrastructure, and technical support.

Water supply services

Water supply services mainly include water supply safety, a supply interruption (planned and unplanned), water quality, etc. These services are essentially "public goods". However, because many citizens live in different areas, different water companies that provide services result in different levels of service enjoyed by citizens [23].

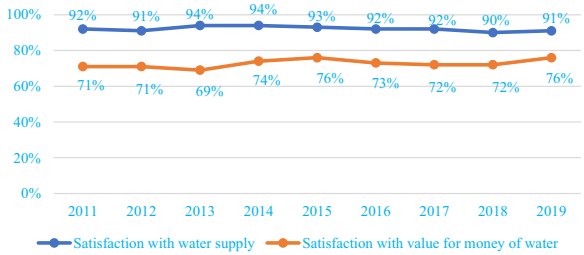

Fig. 1 Overall satisfaction with water and value for money of water (data source from CCW [43]). The rolling 9-year averages are calculated based on the total valid base of weighted data at each time point. The 9-year trends are assessed using the Mann–Kendall method [119, 120]. The Mann–Kendall analysis is applied to exponentially smooth, transformed data rather than the raw data. The data calculation methods in Figs. 2, 3, and 4 also use this method

Perception affects users' views of water services and their ability to discern that water service interventions are beneficial to health. It also affects the payment, acceptance, and willingness to use water services in the long term [24]. Perceptions are variable, subjective, and based on beliefs and lived experiences that cannot be objectively verified or measured. However, perceptions must be considered because they ultimately manifest in fundamental behaviours and actions [25]. In recent years, the British water sector has been continuously reforming to standardise water supply services, improve the quality of water and wastewater, and raise citizens' positive perceptions of water supply services [26]. Many citizens surveyed said that they felt that the water sector's quality of water services was gradually improving. It can be found from the satisfaction reports published by CCW in recent years, as shown in Fig. 1, even though the number of citizens surveyed by the survey report is limited.

Many water users say that if they have no health problem caused by poor water quality, there is little motivation to change drinking water sources or invest in water services [27, 28]. Nevertheless, when users receive some innovative services [29], for example, information services [30], consumption simulation [31], smart measurement [32, 33], intelligent control and delegation, roaming and payment, they will agree with the existing innovative service models for water supply and thought this worked well. Whilst the sector has seen a range of service innovations, there is still some cynicism from non-household customers as to whether its use in the water sector will be beneficial or costly and whether regulation will be reintroduced at some future point [29].

International academic research on water supply services shows that the general public (water users) will give priority to the quality of drinking water and the reliability of safe supply (e.g. [34–38]). If the water

sector guarantees the reliability of the water supply, quality issues will become the first consideration for water users [37]. This result shows that water quality is inherent to the public discussion of public health [38]. CCW investigation showed that 90% of customers were satisfied with water services (92% in 2017) and 85% with sewerage services (88% in 2017); the satisfaction data of England and Wales in the past 9 years are shown in Fig. 1 [39]. The results show that the overall satisfaction is relatively high, but the satisfaction of wastewater services is lower than that of water supply services. However, awareness of Water Sure and Priority Services has increased since 2011, there have been fallen in awareness in 2017 [40]; this also proves that water users lack differences in water service priorities and preferences [37]. These results may lead to the water sector's inability to use feedback from these services to inform their plans and decisions, especially where regulators and stakeholders may review [41]. However, over time, long-term unreliable water supply services can lead to water users' distrust of water companies [42].

Water infrastructure

The water infrastructure is essentially the embodiment of the technical system, which constitutes the technical structure of the entire water supply system and provides essential functions for water users [44–46]. In Great Britain, the state of the water services infrastructure has been rated B (on a scale of A–E) [47]. The issues concerning poor quality infrastructure and the delivery of infrastructure-related services have continued to elicit high levels of interest [48, 49]. Infrastructure is often thought of as a response to social technology, but it is not just technology. Based on the insights from technical research, the water supply system can be seen as a manifestation of technology, including rules and regulations and cultural norms [50]. Moreover, certain technologies provided by the water sector, such as water meters, allow users to feel their water consumption intuitively, and some families introduce new technologies that will make it more convenient for them to store water in their houses [14]. More and more people are using the Web as an information source. For example, Thames Water provides a large amount of information on joint water equipment and technology on its website; the public has replaced many electrical appliances in their homes after researching this information. Many families also claim that they want more information, not limited to water issues but includes effective water technologies [14].

Technical support

With the gradual application of advanced technology in the water service system, the public's demands for technology are reflected in its application and convenience. For example, the client proposed to the water company the idea of explaining its water supply in a more straightforward, less technical, and more explicit way to better understand the meaning of its water supply. Scottish Water also realised the application to its business plans [51, 52]. When the water sector learned that technological progress could circulate water purified using advanced technology was cleaned and purified to a high level and met strict water quality and health standards [44]. As a result, water users have more positive emotions and less negative emotions towards reclaimed water, as well as increase their perception that recycled water has a lower risk and are more willing to support recycling water plans, including increasing the possibility of voting for such plans [53].

The study also proved that the current technical support provided by the water sector is still insufficient to meet the needs of water users. For example, water users have shown tremendous willingness to change their behaviours to conserve water, but water provision technologies and infrastructure are rarely available to support their efforts [14, 44]. Another convenience is about the water users' perceptions of technical maintenance. Some studies mentioned that customers are not optimistic about the regular maintenance of water infrastructure and local spare parts, and local technical reserves to provide fast and high-quality repairs [54, 55]. However, Water UK has responded to the release of the National Infrastructure Strategy in 2020 and increase investment in infrastructure to continue to provide services to its customers and the environment. Because the water company's efforts have also achieved partial results, pipeline leakage has been reduced by 7% in 2020 and promised to reduce it by half by 2050.

There has been an awareness of the threat to the climate and environment of the changes caused by population growth and the intensified urbanisation process, which have brought tremendous pressure to existing water supply services, water supply systems (infrastructure, technological products), and sustainable development [45, 46]. The ability of the water sector to continuously provide safe (reliable) services is constantly being challenged. Water users, even more, expect the water sector to develop new innovative service strategies, invest in facilities and products that are more in line with customers, and further strengthen the water sector's ability to deal with water resources issues. More importantly, these strategies must also be sustainable in response to the changing environment.

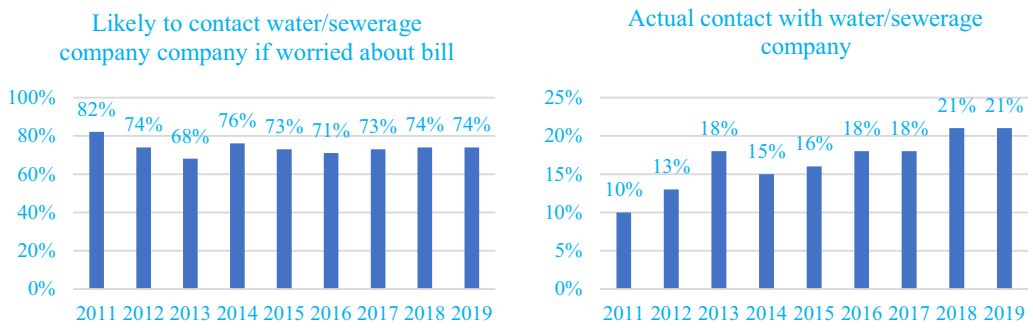

Fig. 2 Likelihood to contact if worried about bill and level of actual contact with water/sewerage company (Data source from CCW [43])

Perceptions of water supply management in the water sector

Water supply management is the behaviour or activity that the water sector implements management in the water supply process. The most critical participants in the entire water supply management process are citizens. Establishing a good communication relationship between the water sector and citizens, sharing water-related information (such as water quality information, billing information, etc.) is very important to improve citizens' satisfaction with services. The water sector must also clarify the water needs of citizens to provide citizens with better water services. In addition, the water sector needs to ensure the necessary emergency management of water supply and can solve the water supply of the citizens in time when encountering sudden water supply problems. This is very important to increase the recognition of the citizens to the water sector. Therefore, this part summarises the three aspects of information communication, water demand management for citizens, and emergency management of the water sector.

Communication of water-related information

Public support is more than just public awareness or interest in a policy issue. It involves the public taking a positive attitude to communicate and take action, and responses could be exemplified as 'Of course we should do that!' [56]. Public participation is a paradigm that shows trust. According to the research results, it is the main factor affecting the water recycling plant of the water sector [57]. This strategy is a face-to-face communication method that focuses on participating in the opinions of experts and leaders and interacting with the water sector [58].

There is a legal obligation on the water sector in the UK to promote efficient water use, and pressure on water resources means that water companies need to encourage changes in water consumption behaviours. However, there is a lack of information about how UK water companies communicate with the public [59]. A report showing that the percentage of total water company spending used on water resources and efficient communications in the UK (0.2%) was much lower than in the EU (1%), the US (1%), or Australia (6%) [60], this also shows that the UK's expenditure on customer communication and water efficiency marketing needs to be improved. It is necessary to move towards actively interacting with customers, mainly focusing on achieving large-scale water reduction. Studies have confirmed that interviewees recognised the need for an ongoing conversation about water in the UK and identified many practices that could support a change in public water consumption, for example, once a water company communicates with water users about drought issues in time, water citizens will always consciously do something to reduce water consumption [59, 61]. Interviewees also believe that the water consumers within groups (e.g. Consumer Association) may be more amenable to communication with the water sector about water risks, arguing that those with a greater connection to water could act as trusted messengers for water risk messages.

However, most water users are only likely to contact the water company or related sector when they are worried about the bill. The CCW's report in 2020 shows that fewer customers say they are likely to contact their water and sewerage company if worried about their bill over the last 9 years in England and Wales. However, when customers do contact, they are increasingly likely to be satisfied [43]; the trend in the past 9 years is shown in Fig. 2. From the data in the figure, in England and Wales, there may be contact with water or sewage companies for billing issues, but the average level of actual contact each year is only about 1/5; there is a connection between water citizens and the water sector needs to be strengthened to obtain more water use information.

The percentage of consumers concerned about billing problems and contact water or sewage treatment companies has decreased, indicating that water utilities have improved their water billing services.

Water demand management for citizens

Water users need to keep in touch with the water sector and share information to understand the different situations they may encounter to get more strategic guidance to support the adoption of specific response mechanisms [62]. Only those water users who contact the water sector or company can be satisfied with their treatment, including quality of information, knowledge/professionalism, resolution and kept informed [40]. As the research results of Larbey and Weitkamp [59] show that many water users want to have continuous communication with the water sector because "Once you stop doing this (short-term), the expected behaviour or expected awareness will disappear." Some other interviewees said they are ignorant of water resources most of the time and hope to communicate throughout the year on water-related issues [59], which can be more aware of water information. As far as water-saving and information feedback are concerned, we can do better and better by knowing more information.

In the desired field, the water sector's supply and demand management is an attempt to reduce water consumption and an attempt to reduce safety and reliability risks and enhance customer service [63]. It is introduced in the introduction that the UK's water sector consists of multiple agencies and companies, a complex system. This complexity may hinder sustainable water management [64]; through research, it is found that the water sector still expects to create conditions to support specific water demand management models. However, the water users interviewed criticised the demand management activities of the water sector and believed that these ideal methods obscure specific ways to improve water efficiency daily [63]. The water sector should focus its management on technological transformation and water-saving proposals [61]. During the interview, Bunney [65] found that people think that finances and resources are limited, and they expect managers to provide the same level of service with fewer resources.

Emergency management of water sector

Regarding citizens' satisfaction with the water sector's emergency management of water resources, Bunney's ([65]], p. 268) survey results show that most respondents "agree" (50%) and "strongly agree" (41%) that local authorities have the responsibility to prepare for emergency management in possible emergencies. The water sector is increasingly using social media to provide customers with relevant basic service information. However, the public realised that the upload of instant information was complex for the water sector to manage, and there was not enough time for participants to understand the emergency and determine how to respond to the emergency ([65], p. 254). For example, from late February to early March 2018, the United Kingdom experienced a long-term low-temperature effect termed the "Beast from the East" by the British media, affecting many parts. During this period, the Web Standards Project (WSP) in the UK actively advised customers on the potential consequences of freezing pipelines in their homes. However, as the temperature rose, WSP was faced with a series of pipe ruptures that have disrupted the centralised water supply of more than 200,000 customers [66]. At least 36,000 people did not have a centralised water supply for more than 24 h, sometimes even more than 5 days 40. Since then, the water sector has made great efforts in emergency management, such as establishing an integrated social network before an emergency, increasing social capital, and providing many advantages for the community and responder organisations [67–70]. Those have helped the water sector maintain emergency management in emergencies to achieve the desired goals.

After reviewing documents, most studies show little or no communication between water citizens and water sectors (e.g. [10, 59, 61]). Some water citizens say that there are limited communication and information, and they need lengthier and more detailed communication to deepen their understanding of water resources. The water sector is also continuously strengthening communication practices [39, 40]. The perception of water supply and demand management in the water sector is not ideal, and water citizens pay more attention to improving water use efficiency and using fewer resources to obtain better services. The water sector still needs to provide further information sharing and clarification regarding water resources security and macro-management. In water resources emergency management, citizens depend on the water sector, but the ability to deal with emergencies still requires further strengthening.

Perceptions of the comprehensive utilisation of water resources in the water sector

Comprehensive utilisation of water resources is currently essential for alleviating water shortages in many countries or regions. The key to the comprehensive utilisation of water resources is citizens' perceptions of the reuse of reclaimed water. Citizens' satisfaction with wastewater treatment determines their acceptance of reclaimed water. In addition, seawater desalination and utilisation, rainwater harvesting, and reuse are crucial factors that reflect citizens' perceptions of water or wastewater

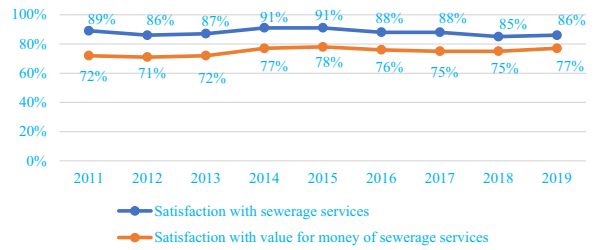

Fig. 3 Overall satisfaction with water services and value for money of sewerage services (data source from CCW [43])

services in the water sector. This part mainly summarises three aspects of comprehensive utilisation of water resources: Seawater desalination and utilisation, rainwater harvesting, and water reuse.

Wastewater treatment satisfaction

The evidence base of water citizens' preference for wastewater services is relatively small, which has also been confirmed in the research, and there is not much difference in the focus of customers' investment in water and wastewater services [71, 72]. However, the continuous increase in water demand and difficult-to-control pollutants (such as pollutants from agricultural and urban diffusion sources) have made the currently less optimistic ecosystem problems more complicated [73–76]. It has been pointed out that water and wastewater treatment should be further improved and optimised in smaller scattered locations and a few extensive centralised facilities [77, 78].

In the UK, the CCW publishes annually the results of a survey of customers' views on different "water issues" to monitor and motivate the relevant water service sectors. Since 2015, water users' satisfaction with sewerage services has declined, but from the overall data analysis results, the satisfaction rate exceeds 85%. Consumers' satisfaction with the value of sewerage services is lower than their overall satisfaction with them because consumers have paid a specific fee for wastewater services, which may cause some people to have lower satisfaction. However, the results of the past 9 years have shown a gradual upward trend, which also confirms that the water sector has invested more energy and funds in service satisfaction and achieved results [43], see Fig. 3. The increase in satisfaction is driven more by the privatisation system of the water sector, which makes water companies and the water sector more motivated to treat wastewater before it is discharged [79–81]. Many water users are willing to pay the corresponding water fees, providing specific financial support for the water sector for sewage treatment because this is closely related to their lives.

The wastewater treatment process is regulated by law,[1] which establishes the standards and environmental standards that must be met. Due to factors such as the stricter environmental regulations, the encroachment of residential areas by wastewater treatment plants, generally higher environmental standards, and the increasing expectations of the public of the duties of private water companies, the number of public complaints about wastewater odour has dramatically increased [82]. However, the water sector has adopted many measures in wastewater treatment services, such as the use of advanced technology (e.g. [83, 84]), A membrane bioreactor [85], Constructed wetlands [86]. However, judging from the current state of public satisfaction with wastewater treatment [43], the water sector still needs to improve wastewater treatment facilities, technical means, and management decisions.

Seawater desalination and utilisation and rainwater harvesting

UK water companies must consult with the public on their water resources plans. The water industry is highly aware of the importance of public awareness of new water sources such as desalination and recycling [87]. However, there are many challenges in seawater desalination and utilisation promotion, mainly whether there are satisfactory services in the desalination and utilisation of seawater, and citizens' opinions will restrict the construction and use of some facilities [88]. Escobar (2010) learned from some investigations and studies, including those in the United Kingdom [89], desalinated water after seawater treatment is considered less risky, and the acceptance level of reclaimed water is lower than that of desalinated water. Escobar also believes that for desalinated water to gain public recognition faster, suppliers must monitor their desalination process and measure the quality of the desalinated water continuously [90]. Dolnicar et al. [91], Fewkes [92] and Warner et al. [93] researched citizens' acceptance and perception of Rainwater Harvesting (RWH); when some participants were asked about rainwater harvesting, they did not realise or were not informed by the relevant authorities whether their houses were partly provided by RWH, "When we moved in, we did not know that the house was installed with RWH systems. However, there are still participants who use the RWH system and have positive experiences in using them and have reported negative experiences [94]; for example, no economic savings were observed.

[1] https://www.gov.uk/permits-you-need-for-septic-tanks (General Binding Rules exist in the UK to regulate sewage treatment systems. However, treated wastewater legislation is different in England, Scotland, Wales and Northern Ireland).

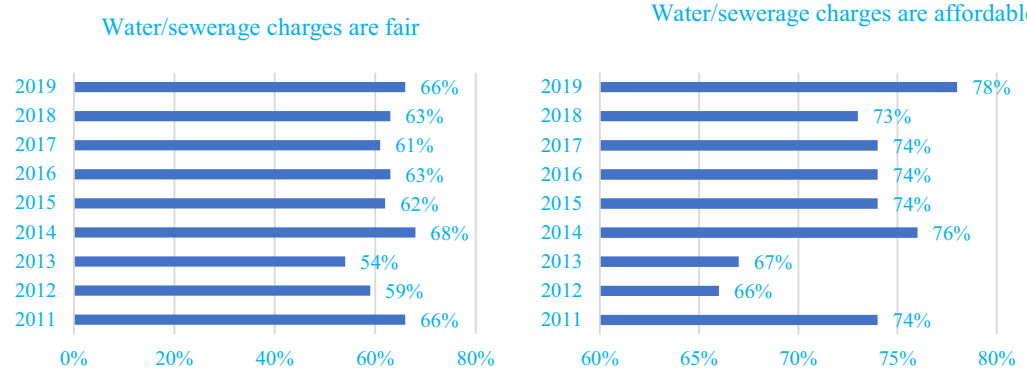

Fig. 4 Fairness and affordability of water/sewerage charges (data source from CCW [43])

Some people also hope that more consideration will be given to promoting and installing systems that combine multiple uses (such as WC and outdoor uses). The water sector still needs to provide more innovation and support [95–97]. The more significant interaction between system end-users (including home users) and product developers will also increase effectiveness.

Water reuse

Regarding the literature research on water reuse, this study refers to the literature analysis conducted by Smith [57], which showcases post-millennium evidence and thinking around public responses to water reuse (only refer to the opinions of the UK public on water reuse). Due to the negative response from the public, increasingly projects have failed or been abandoned [98]. Compared with other alternative water supplies (e.g. rainwater harvesting [99]), people often think that the water provided by water reuse programmes is less palatable. Some recorded cases show that water reuse projects were directly reduced or shelved due to public opposition [100]. Similar investigations show contradictory findings. For example, in an opinion survey on household water recycling in the UK [101], water users were reluctant to use reclaimed water alone for garden watering because the chemicals in reclaimed water can harm their plants. On the other hand, because the system's installation costs money and requires a lot of working time, it may not be possible to use the system alone. However, other studies have shown that a willingness by people to reuse water. For example, Jeffrey [102] investigated the internal recycling attitude of 300 participants in England and Wales by focusing on the universal recycling system (water reuse in showers and bathtubs). The results show that if organisations have established reusable standards that are trustworthy, the public will express their willingness to recycle and use them.

According to the above research conclusions, the attitude of most water users to water reuse is that they worry about water quality problems and need to instal and use reclaimed water recovery systems and are unwilling to drink or use reclaimed water to irrigate plants. The key to solving these problems is that the water reuse plan implemented by the water sector and the service facilities provided needs to be further improved and strengthened to improve the quality of reclaimed water continuously. Water citizens can use the treated water with confidence and trust the water sector emotionally as much as possible. Simultaneously, in promoting and using reclaimed water, the water sectors need to provide more relevant information and increase communication to increase the possibility of water users accepting recycled water.

Perceptions of water prices in the water sector

According to CCW's 2019–2020 annual report, in 2019, 66% of customers in England and Wales agreed that the fees they paid were fair, and more customers agree that their charges are affordable than fair. The positive perceptions of water consumers in England and Wales on the fairness and affordability of water/sewage charges in the past 9 years are shown in Fig. 4 [43]. Overall, water consumers do not have a high degree of recognition of the fairness of water charges (around 60%). Still, the trend in recent years has been gradually increasing, indicating that the water sector has also done so in terms of water charges to meet consumer demand worked hard. Simultaneously, with the continuous development of the economy and the improvement of living standards, consumers have a higher and higher proportion of positive perceptions about being able to afford water bills, reaching the highest value in history in 2019.

From the perspective of many researchers, Liu distributed 93 valid questionnaires in the centre of Loughborough Church. The results showed that 2% think water

bills are more expensive, 55% think water bills are set reasonable, and 43% think water bills are cheap. 61% of people use water meters to calculate water cost, but the remaining 14% are unclear about calculating water cost [101]. Due to the limited knowledge of customers about water charges, the extent to which most customers can participate in discussions about investment plans and their implications for customer bills is also limited [103]. Some customers claim that they "have a say in all issues that affect their bills" ([104], p. 10), especially water prices as the main expenditure on their bills. Many water users believe that the water sector needs to meet the actual needs of customers and the reasonableness of pricing, but they do not oppose mandatory measurement or variable price structures [105].

Using high water prices to reduce demand directly is the most common price intervention in the EU [106], despite public opposition [107]. Increasing Block Tariffs (IBT) is the policy proposed by the water sector to achieve price setting. Various research has been conducted on citizens' perceptions of IBT. For example, Gardner [108] surveyed the opinions of UK households on water prices and water consumption. Survey results showed that only 15% of respondents were willing to check the water price and believed that the water sector needs to understand further the household's understanding of water prices and water use. Most respondents avoided answering questions about IBT and overestimated water prices because of it. From a consumer's point of perception, IBT may cause price confusion, indicating that it is unlikely to work in theory, although this does not rule out the possibility of IBT effectively reducing consumption [109]. It is also necessary to improve the performance of IBT and reduce the possible adverse effects of IBT on unknowing families.

When communicating with water users, the water sector should directly target their users' understanding of tariff structure and consumption, rather than indirectly through bills [108, 109]; many users have expressed doubts about the bill. When water users see a high bill, they may voluntarily give up the cost of services improvement, though others may be willing to pay a certain annual fee as the cost of the water sector to improve the quality of service [110, 111]. In addition to bills, water citizens want a clearer understanding of water prices and payment of water fees, and more information on water price regulation needs to be disclosed [112–114]. In England and Wales, the water sector is regulated under the RPI − X + K (Retail Prices Index − X, where K is based on capital investment requirements) price cap method [115]. As an economical regulatory agency, Ofwat is responsible for setting the price limit for each company every 5 years. When setting urban water prices, water users believe that assessing determinants is very important for the regulatory agency [116].

Considering the multi-objective environment, the design of water prices is a complex issue, and it is expected to pursue social, political, economic, and environmental goals while simultaneously being easy to implement and transparent to consumers [107]. The water sector, water supply companies, and water users have different expectations of water prices. A single water price tool cannot meet all goals. When considering the current citizens' perceptions of water prices, the water sector should improve the water price mechanism as far as possible based on the needs of multiple parties and the actual situation. Those would enable the water price to positively impact water saving, water supply and distribution efficiency [112] and ensure that citizens can save water within the acceptable water price range.

Discussion

There has been considerable study from different perspectives into the broad research field of citizens' perceptions of the water sector. As mentioned earlier, although many aspects overlap, the focus of research varies from different perspectives. The literature under review is divided into four sections. The first mainly revolves around the perceptions of water supply services and technology. Since water supply services and infrastructure are the basic guarantees for water citizens, many researchers pay particular attention. The second section is the citizens' perceptions of the communication and management of the water sector. Timely communication and effective water resources management play an essential role in improving work efficiency and promoting the future development of water affairs, thus attracting increasing attention from the water sector and scholars. The focus of the third section is on wastewater treatment and water recycling. The analysis in this area relies mainly on a few influential review articles [57, 117]. The fourth section is a discussion of water price. Water price is a direct manifestation of water consumption by water citizens. It mainly establishes the related content of water price setting and water price supervision. Table 1 summarises the main research results of the four parts and the shortcomings of the current research.

Conclusions

This study reviewed the literature related to water citizens' perceptions of water services and the water sector in the UK, mainly from the perspective of service and technology, communication and management, wastewater treatment and water recycling, and water prices. From the research results, the measures taken by the water sector have greatly improved citizens' satisfaction,

Table 1 Main research results, discussions, and shortcomings of current research

Dimension	Main research results and discussion	Shortcomings of current research
Water supply services and technology application	Although studies mainly consider citizens' perceptions of water supply services and technology investment in the water sector, which are more relevant to their lives, findings vary considerably. Different citizens are satisfied or dissatisfied with the services and infrastructure of the water sector. The survey results show that citizens' satisfaction is higher, relating to the research area and the research object. The current technical support provided by the water sector is still insufficient to meet the needs of water users. The British Water Company also recognises this and is willing to increase investment in infrastructure Citizens, even more, expect the water sector to develop new innovative service strategies, invest in facilities and products that are more in line with customers, and further strengthen the water sector's ability to deal with water resources issues. More importantly, these strategies must also be sustainable in response to the changing environment	Existing research does not reflect that the water sector's service and infrastructure construction work differ from place to place Whether the economic level, citizen income, or some other external environment, these will affect the improvement of water service quality and the application of technology
Water supply management	Most studies on the communication between water authorities and water citizens show less communication and lower efficiency between water citizens and water authorities. Most water users are only likely to contact the water company or related sector when they are worried about the bill. Some citizens mentioned that the water information they know is limited, and more time and expanded communication are needed to deepen their understanding of water resources. At present, the water sector is constantly strengthening information communication with citizens, such as building a communication and information sharing platform, but this requires the water sector and citizens to work together to achieve sound intercommunication Many citizens have unsatisfactory perceptions regarding the research on water supply and demand management in the water sector. Water citizens pay attention to improving water use efficiency and using fewer resources to obtain better services. In terms of water resources safety and emergency management, it is believed that the water sector still needs to improve rapid information transmission and active response	Existing research has not explored what the main communication barriers between citizens and the water sector are The coordination mechanism between water demand management and water supply management and how to improve citizens' service satisfaction requires further exploration

Table 1 (continued)

Dimension	Main research results and discussion	Shortcomings of current research
Comprehensive utilisation of water resources	Wastewater treatment and water recycling are essential ways to protect the environment and save water resources. Many studies have shown that water citizens appreciate the environmental and conservation measures taken by the water sector, such as using advanced technology (e.g. [83, 84]) and investing significant resources in wastewater treatment services. However, judging from the public's satisfaction with wastewater treatment, the water sector should continually improve its facilities, technical means, and management decisions The attitude of most water users to water reuse is that they worry about water quality problems and need to instal and use reclaimed water recovery systems and are unwilling to drink or use reclaimed water to irrigate plants. The key to solving these problems is improving the water reuse plan implemented by the water sector and the service facilities provided to improve reclaimed water quality continuously. When promoting and using reclaimed water, the water sector needs to provide more relevant information, increase communication with water citizens to build trust, strengthen supervision to enhance water citizens' perception of water quality, and improve the possibility of water citizens accepting recycled water	Water reuse is affected by environmental factors and personal factors of citizens. Therefore, future research can focus more on disgusting factors that affect citizen acceptance, cognitive-emotional factors, and how these factors affect acceptance
Water prices	The CCW survey results in the past 9 years show that citizens are not satisfied with the fairness and affordability of water or sewage charges, but the satisfaction is on the rise, which means that the water sector has done something to satisfy consumers in terms of water charges. Many studies have confirmed that citizens have a low level of awareness of water prices and calculations. They hope to understand water prices, payment status, and water price supervision information. In addition, when setting water prices, the water sector must meet the actual needs of customers and set reasonable prices The setting of water price needs to consider many factors. In addition to some factors that the management can control, there are many factors outside their control, the external economic environment, the ability of water users to pay, and changes in household water consumption [118]. Therefore, it is necessary to comprehensively conduct market research and ensure information disclosure when setting water prices in the water sector. The difference in water prices may be caused by the quality of services provided by service operators and the unequal amount of investment in infrastructure. Judging from the existing literature, water citizens do not consider these factors and are more concerned about their bills. They hope that the water sector will improve the water price mechanism as much as possible, and the water price implementation process can be more transparent to increase citizens' willingness to pay for water fees	While considering citizens' satisfaction with water prices, formulate reasonable water price pricing mechanisms and implementation strategies The logical relationship between the setting of water prices and the water problems facing them needs to be further explored What is the main reason for the difference in water prices? Is it related to the different services or infrastructure investments provided in different regions?

as can be seen from the CCW's annual report "Household customers' perceptions of their water and sewerage services" released by CCW in recent years. However, these data only show generalisations rather than reveal the citizens' perceptions in specific aspects or analyse citizens' perceptions from different angles. The current information related to water or wastewater services cannot change the perceptions of most citizens. There is still much room for improvement in the services provided by the water sector.

The accumulation of research in the past few decades has provided academics with some potential research directions and concerns regarding the water services provided by citizens to the water sector. Nevertheless, it is still necessary to further analyse different levels and regions regarding water supply services, infrastructure construction, wastewater treatment and water recycling, and water prices. It is also essential to pay attention to the possible impacts of the external water work environment and operating mechanisms. In recent years, the perceptions of British citizens have provided significant help to the water sector policy formulation and supervision and evaluation work. The water sector must develop research results on water or wastewater service satisfaction from different perspectives and attract widespread attention so that citizens' perceptions can genuinely support water affairs decision-makers. Those will further improve the service quality of the water sector, continuously increase water citizens' satisfaction with the water sector, promote the harmonious development of the water industry in the true sense, and achieve sustainable development of water resources.

This paper has certain limitations when reviewing different dimensions. When sorting out the focus of research in different dimensions, it is found that the focus of additional research in the same dimension is also inconsistent. For example, regarding the perceptions of wastewater treatment in the water sector, some documents discuss wastewater treatment and water reuse, and some documents discuss wastewater treatment and water management. The same theories have different classifications under different research perspectives, which requires further analysis in future research. In addition, all the evidence sources of the paper come from the United Kingdom, which acquires research data have certain limitations. Whether the perception of water or wastewater services is divided into four dimensions is comprehensive, and whether the research content reflects the forward-looking nature, these need to be further explored based on evidence on a global scale.

Abbreviations

CCW: Consumer Council for Water; DWI: Drinking Water Inspectorate; EA: Environment Agency; EEA: European Environment Agency; EU: European Union; IBT: Increasing Block Tariffs; ICE: Institution of Civil Engineers; JSTOR: Journal Storage; MOSL: Market Operator Services LTD; NRW: Natural Resources Wales; OECD: Organisation for Economic Cooperation and Development; Ofwat: Office of Water Services; RPI: Retail Prices Index; RWH: Rainwater Harvesting; UK: United Kingdom; WC: Water closet; WSP: Web Standards Project.

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Authors' contributions

KT constructed the overall structure of the review and was responsible for the writing of the manuscript. ZC collected and sorted out some documents, and analysed the data obtained, and was the main contributor to writing the manuscript. She also substantively revised the manuscript. HW polished the English language and expression of the manuscript and put forward essential revisions. All authors read and approved the final manuscript.

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