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**Longitudinal studies
for drinking water
clients: opportunities
and limitations**

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Joint Research Programme

KWR

Bridging Science to Practice

CONCEPT

Colophon



Longitudinal studies for drinking water client research: opportunities and limitations

BTO 2023.066 | August 2023

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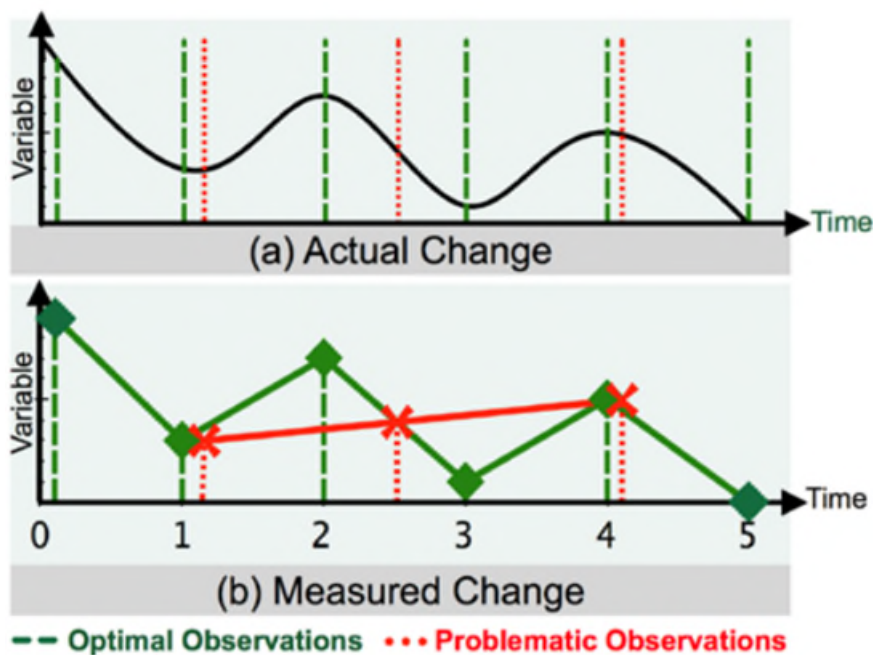
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Managementsamenvatting

'Ideale' vragenlijst voor longitudinaal klantonderzoek helpt drinkwaterbedrijven hun klanten en de evoluerende behoeften van die klanten beter te begrijpen

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Er is een 'ideale' vragenlijst ontwikkeld voor longitudinaal klantonderzoek, als onderdeel van een optimale opzet die helpt bij het starten van longitudinale studies naar de drinkwaterklant. Deze aanpak kan drinkwaterbedrijven helpen hun klantenservice te optimaliseren. De erin beschreven voorwaarden voor longitudinaal onderzoek naar de drinkwaterklant zijn gebaseerd op analyses van vragenlijsten en internationale literatuur en interviews met experts. De optimale vragenlijst geeft ook de mogelijkheid te onderzoeken of en hoe klantperspectieven in de tijd veranderen en kan zo een genuanceerder begrip geven van de attitudes en perceptie van de drinkwaterklant rond risico's, waterbewustzijn, alternatieve waterbronnen, duurzaamheidsaspecten en drinkwatertarieven. Zo kunnen drinkwaterbedrijven hun diensten beter afstemmen op specifieke klantgroepen. Ook kan analyse van longitudinaal onderzoek watergebruikspatronen verhelderen, trends in de watervraag identificeren, de impact van waterbesparende initiatieven beoordelen en nauwkeurigere projecties voor toekomstige waterbehoeften helpen ontwikkelen.



Werkelijke verandering (a) versus gemeten verandering (b). Longitudinaal onderzoek gaat verder waar cross-sectioneel onderzoek ophoudt. Cross-sectioneel onderzoek merkt alleen de gemeten verandering op en kan zo leiden tot metingen die losgekoppeld zijn van werkelijke verandering. Longitudinaal onderzoek meet de werkelijke verandering door de tijd heen, wat leidt tot meer optimale waarnemingen (Kehr & Kowatsch, 2015).

Belang: de drinkwaterklant en de evoluerende behoeften en perspectieven beter begrijpen

Het bestuderen van klanten op één bepaald moment heeft een beperkte waarde in vergelijking met

metingen van dezelfde klanten op meerdere momenten. Observaties over een langere tijdsspanne identificeren makkelijker veranderingen door de tijd heen. Dergelijk longitudinaal onderzoek

helpt zo om een genuanceerder begrip te krijgen van de attitudes en de perceptie van de klant over risico's, waterbewustzijn, alternatieve waterbronnen, duurzaamheidsaspecten en drinkwatertarieven. Ook kunnen longitudinale studies informatie geven over de progressie van klantperspectieven in de loop van de tijd, waardoor drinkwaterbedrijven hun klanten beter begrijpen en hun diensten beter op hen kunnen afstemmen. Er bestaat behoefte aan een goede, consistente aanpak van longitudinaal drinkwateronderzoek.

Aanpak: literatuurstudie, expertinterviews en analyse van vragenlijsten uit klantonderzoek

Er is een analyse gemaakt van de internationale literatuur over longitudinaal onderzoek. Ook zijn acht interviews gehouden met experts op de gebieden longitudinaal onderzoek, KWR klant-gerelateerd onderzoek en ontwikkelingen in de watersector. Er zijn in totaal 27 vragenlijsten van acht verschillende projecten geanalyseerd op samenhang in structuur, context, thematiek en respons.

Resultaten: een 'ideale' vragenlijst voor longitudinaal drinkwater klantonderzoek.

De overwegingen en voorwaarden voor het opzetten van longitudinaal onderzoek zijn beschreven. De methodologische randvoorwaarden omvatten de hoeveelheid participanten, de kosten, middelen, duur van het onderzoek, validiteit, ethiek, data, proefstudies, verwoording van de vragen, en externe invloeden. De samenhang van vragenlijsten van klantonderzoeken tussen 2018 en 2023 is bekeken en vervolgens is een coherente benadering opgesteld voor het ontwerpen van vragenlijsten

voor de periode van 2024 tot 2029. Zo is een optimale opzet geschetst voor longitudinale studies naar de drinkwaterklant, inclusief een 'ideale' vragenlijst voor longitudinaal drinkwaterklantonderzoek. Deze vragenlijst helpt bij het starten van longitudinaal onderzoek in consistentie met eerder en aankomend klant gerelateerd onderzoek. De vragenlijst kan dienen als richtlijn voor het ontwikkelen van toekomstige vragenlijsten voor klant gerelateerd onderzoek.

Toepassing: diensten en service beter afstemmen op specifieke klantgroepen en hun behoeften.

De optimale vragenlijst voor longitudinaal onderzoek geeft de mogelijkheid om te onderzoeken of en hoe klantperspectieven veranderen. Met deze inzichten kunnen drinkwaterbedrijven hun diensten beter afstemmen op specifieke klantgroepen, wat de succesfactor van strategieën vergroot. Ook helpt longitudinaal onderzoek om watergebruikspatronen in stedelijk en landelijk gebied te verhelderen door de vraagpatronen in watergebruik over een langere periode te analyseren. Longitudinale studies voor de drinkwaterklant kunnen trends in de watervraag identificeren, de impact van waterbesparende initiatieven helpen beoordelen en nauwkeurigere projecties voor toekomstige waterbehoeften helpen ontwikkelen.

Rapport

Dit onderzoek is beschreven in het rapport Longitudinal studies for drinking water clients: Opportunities and limitations (BTO 2023.066).

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Keywords

longitudinal studies, drinking water clients



1 Introduction

The Dutch drinking water sector is increasingly facing challenges of growing complexity such as water pollution, demographic growth, salinization due to sea level rise and land subsidence, and ageing assets that require high-investment augmentation (Vewin, 2021). A specific example is the occurrence of increasingly strong heat waves and drought events which lead to high peaks in water demand (Rathnayaka et al., 2015). These peaks in water demand cause abrupt changes in pressure and are eventually accompanied by tap water discoloration (Koop et al., 2019). Peak water demands also require expensive infrastructure enhancement needs and high energy costs to treat, pump and maintain the water supply network (Beal et al., 2016; Koop et al., 2019; Rathnayaka et al., 2015). To meet future water demands, alternative technologies like wastewater reuse, rainwater harvesting or desalination are increasingly deemed essential (European Commission, 2018; Šteflová et al., 2018).

Changes such as tap water discoloration, emergence of water reuse, and increased costs affect drinking water clients and their perceptions regarding these changes (AIVD, 2023; Miller & Jones, 2014). The joint research programme of the Dutch and Flemish water utilities (Bedrijfstakonderzoek or BTO) develops fundamental knowledge required to face these challenges in the next 10 to 20 years. In particular, the scanning and interpretation of new trends and their relevance to the water sector plays an important role in developing sufficient anticipatory capacity to understand emerging challenges. This research is published in short articles known as trend alerts. Although this signalling is instrumental to identify upcoming challenges, a more profound understanding of long-term developments is also needed. Currently, when most research in the water sector addresses emerging issues, such as climate change (Ougahi et al., 2021), sea level rise (Haasnoot et al., 2020), or salinity (Corwin, 2021), it does so at a single point in time, or predicts future trends (Shahvari et al., 2019). Such research helps to understand the living environment at one specific moment, but still says little about emerging challenges.

During the period from 2018 to 2023 the water utilities have gained a more fundamental insight into clients' risk perception, water awareness, and attitude towards alternative water resources, drinking water tariffs and sustainability aspects. Most notably, client perspectives have been developed and applied consistently to enable a more nuanced and articulated interpretation of drinking water clients (Brouwer et al., 2019). The perspectives break with the conventional notion that there is one type of client that is not interested in any additional information from the utilities. Four client perspectives have been distinguished: 1) 'aware and committed', 2) 'down to earth and confident', 3) 'egalitarian and solidary', and 4) 'quality and health concerned' (Brouwer et al., 2019). Clients with an 'aware and committed' perspective are idealistic and possess a strong belief in the power of the collective. They believe that every individual is responsible to help make the world a better place. They are optimistic that a sustainable world is achievable by working together and are willing to put effort into this. Alternatively, clients with a 'down to earth and confident'-perspective want to be unburdened as much as possible. They expect the water utilities to focus on their core task, efficiently ensuring the supply of enough, healthy and good quality drinking water. They fully trust that the water utilities are capable of this and are willing to pay more if necessary. The third client perspective, 'egalitarian and solidary' is not willing to pay more for water services. They not only see water as a basic need, but also emphasize that water is a human right that should be accessible to everyone. This includes people that do not have much money to spend, thus prices should be kept as low as possible. They expect water utilities to put in effort to help other countries achieve accessible and safe drinking water for all. Additionally, they also expect the water utilities to ensure the safe water supply for future generations. Finally, clients with a 'quality and health concerned'-perspective often reason based on their own needs and wishes, with a particular focus on their personal health. They expect the water utilities to take zero risks when it comes to (possibly harmful substances in drinking water. Preferably, they would have pure drinking water without any additional substances.

When considering such topics, looking at clients at one point in time is of limited value when compared to studying the same water client groups over time can help to get a more nuanced understanding of their attitude towards drinking water services. At present, cross-sectional research methods are the most prevalent methods used in water related research. Cross-sectional research is characterised by measuring variables at a single moment in time and inferring conclusions from observations made at that moment and under those circumstances (Kesmodel, 2018). This type of research is helpful in describing the incidence of a particular finding or identifying associations between variables. Longitudinal research is more beneficial in identifying changes through time. It is characterised by repeated observations of the same variable (or individual) over a period of time (Singer & Willett, 2003). It is customary in human development studies, with famous examples of subjects being followed over their entire life (Vaillant, 2002). Longitudinal studies use temporality to observe changes in variables over time, observing patterns and trends of development, turning observable snapshots into a movie.

When studying clients across time, a first disadvantage of longitudinal setups may be costs. While cross-sectional research looks at a group once, longitudinal research takes more preparation and perhaps initial funding. However, it is expected to provide invaluable insights in the long run, with lower incurred costs for additional measurement moments. By measuring at a single moment, research loses insight into the trends that happen within those moments of time. Figure 1.1 illustrates this, by highlighting that measurements may be detached from actual change. This is the fundamental distinction between cross-sectional and longitudinal research designs.

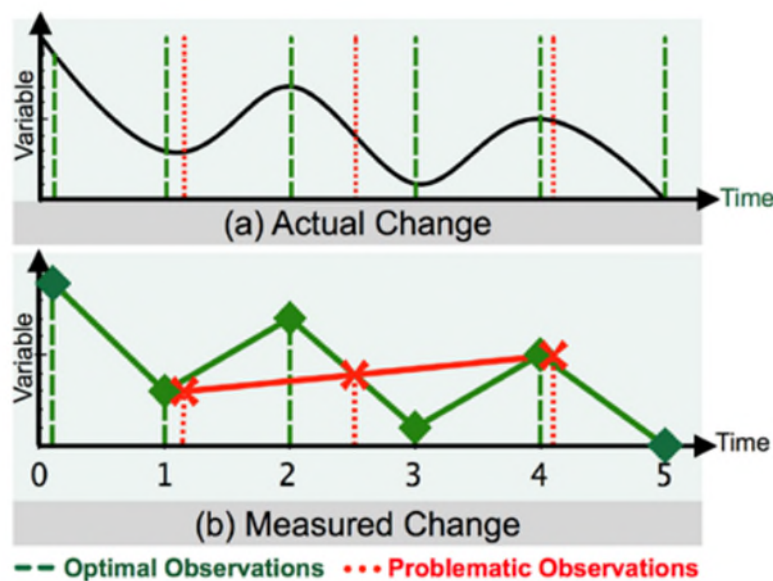


Figure 1.1: (Kehr & Kowatsch, 2015): Actual change (a) versus measured change (b). Illustration of a comparison of actual change to measured change through time, including indication of optimal and problematic observations.

This study aims to explore the added value, feasibility and shaping of longitudinal studies for Dutch and Flemish drinking water client research. To fulfil this general goal this study addresses three key aims:

- I. Assess methodological preconditions and outline optimal design of longitudinal studies for drinking water client research.
- II. Retrospectively assess the cohesion of client-related research data for the period 2018-2023 and provide a coherent approach to design questionnaires for the period 2024-2029.

- III. Develop an optimal longitudinal questionnaire to study drinking water clients, capable of anticipating developments of relevance in the duration of the study.

To meet these aims, the following sections include a first conceptualisation of longitudinal research for the drinking water sector within existing literature (chapter 2). This conceptualisation is followed by the methodology used to explore the added value, feasibility and shaping of longitudinal studies for Dutch and Flemish drinking water clients (chapter 3). These methods are then used to yield the results of this research (chapter 4), inherent discussion points (chapter 5) and conclusion (chapter 6).

2 Conceptualisation

“They both listened silently to the water, which to them was not just water, but the voice of life, the voice of Being, the voice of perpetual Becoming (Hesse, 2002, p. 81).”

Hesse (2002) beautifully captures the nature of water and the self as perpetually changing and becoming. More concretely, as explained by the theory of personal constructivism (Liu & Chen, 2010), learning creates meaning by interpreting experiences. The self is continuously experiencing, thus learning, and thereby changing (becoming). The phenomenon of changing and becoming should be considered when studying a population and its relationship with and behaviour towards water. One way is to combine data collection methods like standardized questionnaires and in-depth interviews. Given that the subject interviewed at one moment in time will inevitably continue experiencing things, and thus change throughout time, additional considerations need to be made regarding temporality and how time affects the individual.

The concept of introducing the human factor of water in research is not new and can better be seen as a reintroduction. Linton (2014) describes it as “hydrosocial renewal” which refers to the fact that water cannot only be described by its physical properties but ought to be seen as the inextricable component of society that it is. It meanders through sectors, shaping agriculture and industry, as well as health and well-being. Consequently, the current challenges the water sector is facing cannot be addressed without recognising society as an integral part of the issue and potential solutions. Therefore, a fitting research design should be capable of capturing temporal changes and patterns as accurately as possible, to gain a comprehensive understanding of the dynamics of the human-water relationship.

As the self is perpetually changing, even more so is society and the challenges it faces (Kehr & Kowatsch, 2015; Koop et al., 2022). Longitudinal research is used as a tool to understand the past, present, and future dynamics of studied populations or variables (Banati & Oyugi, 2019). It is applied in many different sectors, predominantly public health, sociology, education, and economics. The drinking water sector could benefit from using this research design, in the Netherlands, Flanders, and beyond. Longitudinal research can help researchers go beyond stationary measurement snapshots, and understand causal relationships, drivers, determinants and development patterns.

As aforementioned, other sectors have been resorting to longitudinal research for decades, with examples of studies following subjects for their whole lives. These include the Grant study, or Harvard study of adult development, in which a group of 268 Harvard graduates was followed for the past 85 years, debuting in 1938 (Vaillant, 2002). Dr. George Vaillant, the director of the study wrote a book regarding the findings of his longitudinal research. It includes lessons and insights into the lives of the study participants in their 80s and 90s. From this study, researchers were able to distil the predictors of happiness and health as well as a collection of unexpected outcomes (Vaillant, 2002).

Despite such landmark studies in other scientific fields, there are only a few longitudinal studies in the field of water management, especially the drinking water sector. Some longitudinal research has been performed to assess domestic water conservation behaviour (Moore et al., 1994), and water consumption and demand before and after water conservation interventions (Lee et al., 2011; Stewart et al., 2013). Another longitudinal study has been executed to understand the shifts and transitions of institutions responsible for water management in the Netherlands for the past 30 years (van der Brugge et al., 2005). Nonetheless, the potential added value, feasibility, and shaping of longitudinal studies with Dutch and Flemish drinking water client research is still unknown. This study explores this knowledge gap, by defining methodological preconditions and guidelines for longitudinal studies as well as assessing previous qualitative research projects by KWR. To illustrate the potential, the next

three examples describe research topics that could benefit from the inclusion of longitudinal research methods in the water sector are.:

1. *Perception and extent of wastewater reuse*

Wastewater reuse and the public perception of alternative water sources have the potential to be better understood through the moving lens of longitudinal research. The potential of wastewater reuse is receiving increasing attention worldwide. Such efforts can and should be accompanied by a study focussing on the perceptions of wastewater and its reuse. Longitudinal research could study the long-term shifts and trends in public perception of wastewater reuse, which is of inherent relevance to the water sector.

2. *Analysis of trends in bottled water consumption*

Studying bottled water consumption using longitudinal research may give valuable insights into changes in consumption rates. Longitudinal research methods could reveal more factors responsible for these changes than conventional cross-sectional research. For instance, if there would be a hypothetical increase in consumption of bottled water (replacing tap water), longitudinal research could show if there is 1% more people drinking bottled water, or if this 1% change refers to 2% that stopped drinking bottled water and started more drinking tap water while 3% more people started consuming bottled water. These dynamics are not captured in conventional cross-sectional research, as it captures just one frame of the population it studies at a single point in time. Longitudinal research can provide an answer to these questions by observing the same individuals repeatedly over extended periods of time.

3. *The evolution and impacts of the Exposome*

The growing interest in exposome research could benefit from longitudinal research methods. The Exposome refers to the cumulative measurement of environmental exposures from birth onwards (Miller & Jones, 2014). Central to this concept is the rising interest and awareness of the public regarding the potential risk of exposure pathways through drinking water. Such risk perceptions can affect the water sector and utilities by leading clients to demand unnecessary costly treatment steps. The changing risk perceptions of clients and their progression can be studied through the lens of longitudinal research. In doing so, empirically based tangible insights can be collected on the evolution of risk perceptions regarding the Exposome.

3 Methodology

To explore the added value, feasibility and shaping of longitudinal studies for drinking water client research, the following methodological approaches were used: literature study, expert interviews, and an inventory and analysis of previous client research questionnaires conducted by KWR. The applied methods were tailored to the different research aims (Table 3.1 and Figure 3.1). Sections 3.1, 3.2, and 3.3 provide a detailed description of the methodological operationalisation steps for each research aim.

Table 3.1 Detailed operationalisation steps, including two methods tailored to each research aim.

Aim		Operationalisation steps
I	Assess methodological preconditions and outline optimal design of longitudinal studies for drinking water client research	1.1 International literature review to assess methodological preconditions and outline optimal design of longitudinal client studies 1.2 Interview experts across sectors to complement and tailor methodological findings
II	Retrospectively assess the cohesion of client research data for the period 2018-2023 and provide a coherent approach to design questionnaires for the period 2024-2029	2.1 Review previous questionnaires to assess cohesion of KWR client-related research in the period 2018-2023 2.2 Interview KWR experts to contextualise, verify, and complete insights from previous client-related research
III	Develop optimal longitudinal questionnaire to study drinking water clients	3.1 Interview water experts to get insights into topics of relevance for the drinking water sector in the future 3.2 Project findings of previous aims to the period 2024-2029 by (re)formulating questions for consistent measurability over time and anticipation of developments of relevance in the duration of the study

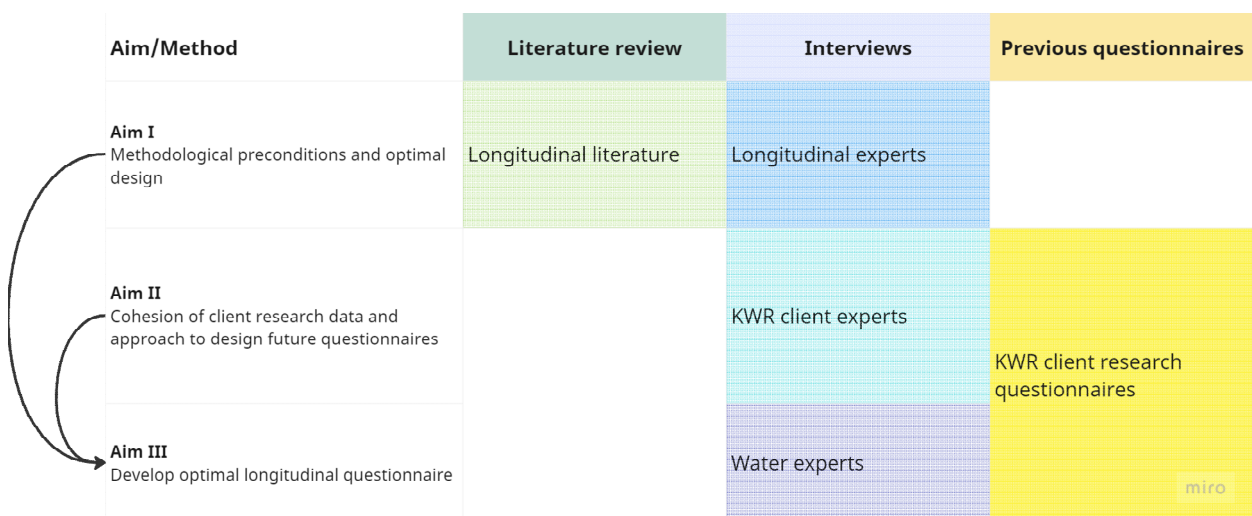


Figure 3.1 Methodological operationalisation of the research aims with research aims (left), research methods (top) and operationalisation steps (middle).

Table 3.2 explains the codes used to refer to the experts interviewed based on their expertise. Some interviewees are experts in several fields, such as client-related research and water management research, or longitudinal research with tailored knowledge to the water sector.

Table 3.2: List of experts interviewed for each relevant field, and their codes based on their field of expertise.

Expert field:	Number of experts	Expert codes
Longitudinal research experts	2	L1, L2
KWR client-related research experts	3	K1, K2, K3
Water experts	3	W1, W2, W3

3.1 Aim I: Assess methodological preconditions and outline optimal design

The first aim of this research was to assess the methodological preconditions of longitudinal research for the drinking water client and to outline the optimal design of such research (aim I). To distil methodological insights to carry out longitudinal research an international literature review was carried out across sectors that most often rely on longitudinal research, such as human development studies, medicine, etc (step 1.1).

During the literature review an important question arose, namely: When is research considered longitudinal? Some authors reflect on whether two measurements in time is an appropriate form of longitudinal research (Collins, 2005). Others reflect on whether retrospective longitudinal research is a reliable form of longitudinal research (Henry et al., 1994). Retrospective longitudinal research does not involve following participants over time, and relies on existing records, or recollections from participants to reconstruct the historical trajectory of the studied variables (Kehr & Kowatsch, 2015). According to Singer and Willett (2003) retrospective longitudinal research defies the definition of longitudinal research, which is primarily meant to follow participants or variables through time. In this research we follow the definition of longitudinal research as proposed by Singer and Willett (2003) and will thus not address retrospective longitudinal research as it challenges the definition of longitudinal research. Additionally, this literature study focused on papers that describe methodological considerations of longitudinal research, or longitudinal studies including an explicit reasoning behind their methodology.

The primary source for finding peer-reviewed articles was Google Scholar. The following keywords were used as search terms: longitudinal research, client, customer, qualitative, quantitative, water, management, attrition, time, guidelines, and participants. Using the reference list of the articles found during the initial Google Scholar search, a 'snowball method' was applied to find additional relevant articles. This approach helped to ensure a comprehensive review of the literature. Key themes and trends in the area of longitudinal research were identified.

To complement the insights derived from literature, semi-structured face-to-face interviews were conducted with two experts in the fields of longitudinal research (L1 and L2) and public management (L2) (step 1.2). The interviewed experts were found through Google Scholar.

At the beginning of the interviews, experts were asked for informed consent on recording and storing of data. After analysis, interviewees were sent the obtained insights for verification and got the opportunity to provide additional information. The interviews conducted helped to overcome potential limitations of the literature review. By interviewing these experts on longitudinal research, up to date insights outside or beyond published results were gained. Experts were able to give a holistic overview of longitudinal research, including

undocumented knowledge, experiences during research and after publication, rules of thumb (from experience), and unpublished outcomes (accounting for publication bias).

3.2 Aim II: Assess cohesion of previous questionnaires and export this to upcoming studies

To retrospectively assess the cohesion of client research data for the period 2018-2023 and provide a coherent approach to design questionnaires for the period 2024-2029 (aim II), previous questionnaires carried out for KWR's client-related research were analysed (step 2.1). In addition, interviews were conducted with KWR experts that were involved in some of these projects (step 2.2).

To assess the cohesion of previous client-related research within KWR (step 2.1), all projects carried out by the theme group Klant were reviewed. For each project it was then identified whether a questionnaire was used. The questionnaires from the distinct projects were then collected for analysis. This analysis consisted of a (1) structural, (2) contextual, (3) response and (4) thematic analysis (Table 3.3). During the cohesion analysis several indicators were considered, which were decided on during a project team discussion. For the structural analysis (1), indicators pertaining to the length of the questionnaire and introduction, confidentiality statement, type of questions (Likert scale, multiple choice, if yes, open, other namely, value between x and y), and detail and placement of socio-demographic data were considered. The contextual analysis (2) studies indicators regarding the contact source, sampling method, respondent type, recruitment strategy, country, purpose of study, respondent type, year of questionnaire, time the questionnaire was open, time asked, and whether there were follow-up interviews. The response analysis (3) considered the number of respondents, whether the study used incentives, and response rates. Lastly, the thematic analysis (4) identified the recurrence of themes across questions of all the questionnaires. Throughout these analyses, similarities between questionnaires were considered and analysed to assess the compatibility and consistency among questionnaires previously used for client-related research at KWR.

Table 3.3 Indicators used for the cohesion analysis across all questionnaires used for client-related research in the period 2018-2023. Indicators were considered in four different categories of analysis, (1) structural, (2) contextual, (3) response, and (4) thematic analysis.

Goal	Indicators
1 Structural analysis	<ul style="list-style-type: none"> a) Introduction length (number of words) b) Length (number of questions) c) Length (total number of words) d) Number of words per question e) Detail of sociodemographic data (number of questions) f) Placement of sociodemographic data g) Confidentiality statement and privacy h) Use of Likert scale? i) Use of multiple-choice questions? j) Use of follow-up questions? k) Room for comments? l) Use of other, namely questions? m) Use of open questions? n) Use of semi open questions? Value between x and y
2 Contextual analysis	<ul style="list-style-type: none"> a) Contact source b) Sampling method c) Respondent type d) Country

	<ul style="list-style-type: none"> e) Purpose of study f) Number of questionnaires g) Type of study h) Year of questionnaire i) Time open j) Time asked k) Follow-up interviews
3 Response analysis	<ul style="list-style-type: none"> a) Number of respondents b) Response rates c) Use of incentive
4 Thematic analysis	<ul style="list-style-type: none"> a) Recurring themes

In addition to the cohesion analysis semi-structured face-to-face interviews were conducted with the KWR experts involved in the projects of the analysed questionnaires (step 2.2). Three experts (K1, K2, K3) were interviewed to get a holistic overview of the analysed projects, verify findings of the cohesion analysis, and obtain unpublished insights into the research carried out, including methodological considerations and insights obtained after publication.

3.3 Aim III: Develop 'ideal' questionnaire for longitudinal study of the drinking water client

To develop an 'ideal' questionnaire for longitudinal drinking water client research (aim III), the findings from aim I and II were used. Thereby this aim builds on the international literature review carried out for aim I, the interviews carried out for both aim I and II, and the cohesion analysis of previous client-related KWR questionnaires carried out for aim II.

In addition, to develop a new longitudinal research questionnaire compatible with previous KWR research and tailored to expected future developments, three experts in the field of water research were interviewed (W1, W2, W3). The expert interview approach served to gain insight into the major trends that will be relevant for client-related water research in the coming decade. The following interview topics were addressed:

- Recent and past developments in the Dutch and Flemish water sector;
- Topics relevant to longitudinal studies in the water sector for the coming decade;
- Outlook for the future of the drinking water sector, longitudinal research and key societal developments.

Finally, based on the interview results, the new ideal questionnaire includes reformulated questions from previous client-related questionnaires and newly formulated questions to suit longitudinal research over the coming years. These are devised to account for hypothesized relevant developments in the duration of the research designed.

4 Results

4.1 Methodological outline of longitudinal research

4.1.1 Value of longitudinal research for Dutch and Flemish drinking water client research

KWR is the research institute for the Dutch and Flemish water utilities with a mission to “Bridge Science to Practice”. The Dutch and Flemish water utilities often combine their wide range of disciplines into transdisciplinary research. The client-related research is one of eight research themes defined by KWR. This client-related research has been carried out since 2018 to gain insight into client needs and expectations regarding various topics related to drinking water. Topics of concern for the water utilities include clients’ risk perception, water awareness, perception of alternative water sources, sustainability aspects, and attitudes towards drinking water tariffs. Client-related research is essential as it helps the water utilities tailor their services to meet the various needs and preferences of their clients. KWR’s research highlights the importance of client engagement and the need for a more nuanced and articulated interpretation of drinking water clients to provide better services. Client-related research could benefit from longitudinal research, as clients, and ultimately their needs and perceptions, are not static in the face of time. The need for a more nuanced and articulated understanding of drinking water clients is emphasised by the uncertainty brought by climate change into existing water systems and infrastructure (Pahl-Wostl, 2007).

The water utilities are facing several challenges such as demographic growth, rising water pollution, salinization, increasingly strong heat waves, drought, and ageing assets that require high-investment augmentation (Vewin, 2021). There is an increasing need for research on the emergence, trends, and consequences of these challenges, and how they affect the interaction between the water utilities and their clients. There is a simultaneous growing interest and need for research on the perception of the public towards the various challenges the drinking water sector faces, and how individuals deal with issues threatening water quantity and quality.

An appropriate lens to understand the interaction between clients, the water sector, and issues such as climate change, ought to look at developments and their effect over time. How one relates to water, a changing climate, drinking water, and their interactions is not static and will shift through time and experiences. To provide adequate and tailored services to the drinking water clients, the water utilities need an in-depth understanding of their client. That is in line with the objectives of KWR for client-related research, which are defined in the six-year for the research theme Klant. In this six-year plan for client-related research for the period 2024-2029, KWR’s pillars of research are health, environment, science and technology, economy, politics, socio-culture, and education.

Longitudinal research is common in the fields of medicine, psychology, and human development studies, among others. In these fields longitudinal research has been used to tackle complex themes such as happiness, ageing (Vaillant, 2002), child development, mental health, and substance use (Lansford et al., 2009). Examples of remarkable findings include the predictors of happiness throughout life (Vaillant, 2002), the long-term health effects of exercising (Reiner et al., 2013) and relating childhood events to substance abuse later in life (Lansford et al., 2009).

In the water sector, longitudinal research has been done to understand the historical development of Dutch water management and according institutional arrangements (van der Brugge et al., 2005), the Dutch-German border water management regime (Renner et al., 2018), to measure domestic water conservation behaviour (Moore et al., 1994), and to gain insight into water consumption before and after specific interventions (Lee et al., 2011;

Stewart et al., 2013). In addition, there is a cornucopia of studies that, through longitudinal research, have looked at the influence of various factors on client satisfaction over time (Bernhardt et al., 2000; Cooil et al., 2007; Goić et al., 2021). Despite the abundance and relevance of client-related longitudinal research in other sectors, these studies are not common in the water sector.

4.1.2 Conditions and considerations to set up Longitudinal research

When setting up longitudinal research, several conditions have to be met, the main being: repeating measurements, with the same respondents, and temporal precedence (i.e. one measurement after the other to determine cause-effect relationships) (Rindfleisch et al., 2008). Additionally, designing longitudinal research elicits a panoply of considerations: participants and attrition (loss of participants over time), time, ethics, validity considerations, data management, and externalities (L1).

Participants and attrition

Longitudinal research that studies people needs to consider several conditions to ensure that the longitudinal study is representative. The foremost consideration relating to participants is whether they will participate in all the measurement moments, to allow for a significant sample for analysis. The phenomenon of participants dropping out of longitudinal studies, by choice or external factors such as death or disease, is called attrition. Loss of participants can affect any research, but this loss is particularly relevant to longitudinal studies. A loss of participants in longitudinal studies means a loss of the time, efforts, materials, and funds invested in the lost participants, as well as harm to the validity of the results (White & Arzi, 2005)

The optimal sample size at the beginning of a longitudinal study depends on the desired sample size at the end of the study. For example, if attrition is expected to be 15%, and a study wants to look at a sample population of 1000 people over a period of 10 years, it needs to start with an initial sample population of 1150 people. Thus, it is important that attrition rates are predicted. All the considerations to be made when setting up a longitudinal study will affect attrition rates, such as the platform used to respond (online or offline, laptop or phone), collection method, length of the questionnaire, desired duration of the study, validity considerations, sampling methods and funding (L1).

Other than accounting for attrition, a longitudinal study needs to account for the representativeness of the sample it resorts to. The most appropriate sampling method depends on resource availability (funding), the objective of the research at hand, and the risk of attrition bias. It is important that the sample that is chosen represents the population studied. However, attrition will inevitably affect this representativeness. Thus precautions need to be taken to ensure that after attrition, the sample obtained is still representative of the studied population. Ultimately, researchers should account for attrition and report its prevalence in their conclusions (Barry, 2005)

Beyond attrition rates, a longitudinal study needs to consider response rates. Previous longitudinal studies on the elderly have had initial response rates ranging from 62% to 93%, and attrition rates ranged from 5% to 50% (Chatfield et al., 2005). Based on this example, if a study wants to look at a sample population of 1000 people, and the response rate is 62%, it needs to contact at least 1613 people. Attrition and response rates are affected by dispersion, where respondents may move off grid, to a different country, or simply change their email address, and be lost in the length of the study (White & Arzi, 2005). Alternatively, making participants feel “special” helps in promoting participation, as is the case in the Netherlands twin register (NTR), where respondents are recruited because they are a twin. The respondents associate being a twin as motivation to participate in the research (L1). Alternatively, to maximise response rates, a video introduction can be used, to appeal to a larger audience (L1).

The duration of the study, the measurements, and their chosen frequency will affect participant dropout (attrition) but will also affect the response given by participants. A study that is too long in duration (years) or that makes use of a very long questionnaire, will likely reduce response rates and increase attrition (L1, L2).

Time

"Neither the life of an individual nor the history of a society can be understood without understanding both."
(Neale, 2015, p.3)

A defining characteristic of longitudinal research is its tight relationship with time. It includes temporality in its design by following the same individuals or variables over a period of time (Singer & Willett, 2003). In doing so, longitudinal research creates a framework to analyse how personal experiences, external factors, and societal shifts contribute to individual development and society. In that regard, individual development may be detached from chronological time, as time perception may differ across individuals (L2). An individual's perception is influenced by time in three distinct dimensions, a chronological dimension (one calendar year has passed), a biological dimension (ageing), and a generational dimension (the cohort one belongs to) (L2). The social component of time as described here can hardly be quantified, but considerations of time are a prerequisite to the start of a longitudinal study (L2).

Longitudinal research is attributed the capacity to capture causality (Menard, 2002). It does so by capturing temporal precedence (Oppewal, 2010). Temporal precedence is the simple notion that one measurement follows the other, which allows for measuring the order in which variables change or occur. By studying the sequence of events or variables over time, researchers can infer causality, assessing whether the cause precedes the effect (Oppewal, 2010). This can be illustrated by a hypothetical example of the effect of participating in a water conservation campaign on household water consumption over time. By measuring water consumption before, during and after the campaign over several years or months, temporal precedence could be used to measure whether there is evidence to support a causal relationship between a decrease in water consumption and participation in the campaign. Alternative factors could change household water consumption patterns, see subheading 'externalities'. A series of considerations and design choices when setting up longitudinal research should thus revolve around time. In the setup phase, it is first relevant to choose a study duration that allows for effectively measuring the variable considered. These considerations regarding the duration of the study and the intervals between measurements depend on the topic and thus variables of interest (Ortega & Iberri-Shea, 2005). This can be illustrated by an example regarding water consumption. Measuring daily water consumption habits or seasonal water consumption patterns will require following water consumption for different durations. Understanding daily fluctuations can likely be done with one year of measurements, whereas understanding seasonal fluctuations in water consumption habits needs to be studied for several years. Furthermore, it is imperative to match measurement intervals with variables (Kehr & Kowatsch, 2015). Using the same example, measuring water consumption weekly is insufficient to understand daily water consumption habits, whereas measuring water consumption every hour is excessive when the goal is to understand seasonal patterns in water consumption. Figure 1.1 illustrates the effects of the number and distribution of measurement moments on research results. Design choices related to time need to be supported by theoretical assumptions in the nature and oscillation of the variables studied.

Ethics

Ethical considerations are necessary to ensure that research takes ground in principles of respect, justice, and the avoidance of harm, both to participants and researchers (Neale, 2013). It is common in the field of medical research to submit a proposal to the ethical committee at the beginning of a research project. Despite this not being a requirement in the field of water management, ethical considerations need to be made prior to the start of client-related longitudinal research in the water sector. Given participants will be involved, it is important to

first obtain informed consent. This is to ensure that participants agree to the use of their answers for research purposes. Participation should be voluntary, and thus participants need to be given the right to not answer (L1).

Using and disseminating findings to contribute to scientific knowledge and inform policies and practices should be done in a manner that causes no harm or stigmatization to the respondents. These ethical considerations along with ethical considerations specific to the research objectives need to be made prior to data collection. These considerations allow researchers to conduct longitudinal studies in a responsible and respectful manner, fostering trust between researchers and participants while producing valuable and reproducible insights.

Validity

The internal validity of a study refers to its ability to accurately reveal a cause-and-effect relationship between variables. An example of a study with poor internal validity is one that would find a strong positive correlation between ice cream sales and the number of drowning incidents. Ice cream does not cause one to drown, but there are confounding variables such as weather conditions, swimming ability, and beach or pool access that have a direct influence on drowning incidents. Internal validity considerations are of utmost importance for most research setups, but even more so for longitudinal studies. Especially, since attrition poses a threat to the internal validity of longitudinal studies (White & Arzi, 2005). An example of poor internal validity related to attrition from longitudinal research in science education is a seeming improvement in the performance of a group of students through time, whereas results are simply inflated after weaker students dropped out.

Considerations of internal validity include the sample size, as a sample that is too small risks to be biased and thus not representative of the population it studies. Another relevant validity consideration is the maintenance of the same participants in the sample group. It is important to ensure that in the case of a repeated questionnaire, it is indeed the same respondent that fills in the questionnaire. In some cases, it happens that a spouse, or another family member, fills out the questionnaire instead of the person who first did (L1). This phenomenon is especially relevant in online formats. This can be partially bypassed (or identified) by posing socio-demographic questions, such as gender, age, name, at every measuring moment.

The timing and frequency of measurements can also affect the internal validity of a longitudinal study. Inadequate planning regarding the timing and frequency of data collection waves can lead to insufficient or inaccurate data that fails to accurately portray the dynamic changes happening in the real world (figure 1.1). Thereby compromising the internal validity of a study (Kehr & Kowatsch, 2015).

External validity refers to the applicability of findings to a larger population or real-world settings. It differs from internal validity because it refers to the ability to generalize findings to other contexts, instead of referring to the reliability of the actual findings of the study itself. However, it seems logical that if the internal validity is poor, so will the external validity. However, a high internal validity does not necessarily ensure a high external validity. External validity of longitudinal studies is threatened by attrition, sample representativeness (or bias), and the chosen setting and context. As attrition occurs, the characteristics of the sample change, creating a bias (Barry, 2005). To assess if a study's external validity is compromised, it is vital to look at the characteristics of participants who drop out. If the dropouts are similar among themselves but different from those who continue participating in the study, it sets off a decline of the study's external validity. Additional considerations should be made to assess whether sample bias or context changes have occurred that may have compromised the external validity of the study.

Data

"It all has to be kept" (White & Arzi, p.146, 2005).

Ensuring external and internal validity goes hand in hand with data collection. To ensure external validity, a longitudinal study needs to consider and meet certain criteria. To ensure reproducibility of the research setup in other conditions, it needs to store all the data it produces. This highlights the importance of appropriate data storage in longitudinal studies. Since measurements are repeated in longitudinal research, management of gathered data is a crucial consideration.

Data collected on the same individuals measured at different times have to be easily aligned. This is especially challenging for qualitative data collection methods (White & Arzi, 2005). Raw data cannot be discarded after analysis, as later different methods of analysis may become available, or different questions are raised. It is also necessary to label data in a way that is easily accessible yet protected. Some longitudinal studies may make use of standardized questionnaires for data analysis (quantitative data collection method), others may resort to interviews (qualitative data collection method). The choice will depend on the specific research objectives at hand. However, data collection and treatment are significantly different between the two. Quantitative research is employed to test hypotheses derived from theory, often aiming for generalizability across populations and contexts (Creswell, 2009). Qualitative research is used for exploring, generating hypotheses, and understanding problems in detail. Quantitative methods allow for more ease of analysis, whereas qualitative methods, such as interviews, pose a lot more effort in their collection and analysis. They take longer than a questionnaire, and when analysing per example the third interview with the same participant, researchers must consider the answers to the previous two for the interpretation of the new insights (White & Arzi, 2005).

Regarding the validity of the study, data collection is the way to bypass, or at least account for the effects of attrition on the validity of the study. To rule out the bias of attrition longitudinal studies should gather the following data (Barry, 2005):

- Sample size at each data collection moment
- Samples lost between measurements
- Reasons for sample loss
- Statistical comparison of dropouts and remainder of sample on:
 - Demographic data
 - Pre-test responses
 - Variables considered in the study

Additional considerations to be made regarding data collection are the occurrence of the Hawthorne effect and the social desirability bias. The Hawthorne effect is a bias in data where respondents alter their behaviour due to their awareness of being observed or studied. This can affect the validity of the collected data (McCambridge et al., 2014). The social desirability bias describes respondents reporting positive change to meet a subconscious need to report positive outcomes, or satisfy the researcher (Vilar et al., 2020). Both the Hawthorne effect and the social desirability bias can be minimised by making use of standardized questionnaires, instead of interviews. This is because questionnaires allow for a more anonymous approach, reducing the direct influence of the researcher on participants' responses. Participants may feel less pressured to conform or provide socially desirable answers when completing questionnaires privately. Indicating in the introduction to the questionnaire that there are no right or wrong answers, and that the answers will remain anonymous may help reduce the Hawthorne effect among respondents (K1).

Piloting

It is important to pilot the intended longitudinal research consideration prior to beginning data collection. This ensures the success and validity of a longitudinal study. A pilot study serves to test and refine the research design, procedures, and measurements before committing to a full-scale longitudinal study. Piloting helps to identify and address potential logistical, methodological, and ethical challenges while allowing to assess and adjust the

feasibility of data collection methods (surveys, interviews, or observations). It helps in determining the appropriate frequency and timing of data collection waves, as well as the duration of the study. Pilots can also provide valuable insights into the practical aspects of participant recruitment, engagement, and retention, allowing researchers to refine their strategies and mitigate potential attrition issues. By pretesting these elements, research can gather valuable feedback from participants and experts, allowing to make necessary adjustments and improve the accuracy of longitudinal studies (L1).

Externalities

It is of utmost importance to keep track of events that occur between measurement moments of a longitudinal study. These external events are expected to affect the respondents and thereby their response. The longer the duration of a study, the more likely it is for additional influences to arise (White & Arzi, 2005). As an example, the occurrence of a drought can create a temporary heightened sense of urgency and awareness about water conservation among the public. This temporarily increased awareness may lead to a higher participation in water-saving behaviours, such as reducing outdoor water usage or implementing water-efficient practices. As a result, the study may observe a higher level of water conservation behaviours during the drought period compared to non-drought periods, and thereby infer wrong conclusions. In this scenario, drought is a confounding variable that should be accounted for. Therefore, it is essential to collect data on participants' exposure to external factors, such as drought or awareness campaigns, to control for their influence on the studied variables during the analysis.

A less prevalent but potentially relevant factor depending on the duration of the study is maturation which occurs when a study tracks changes in the studied variables, which are due to respondents getting older rather than a causal relationship between studied variables (White & Arzi, 2005).

4.1.3 Outline of longitudinal research design to follow client perspectives

This section provides a design for a hypothetical longitudinal study, building upon the conditions and considerations as described in paragraphs 4.1.1 and 4.1.2. It uses the client perspectives defined by Brouwer et al. (2019) as an illustrative case. The client perspectives emerged from the notion that clients are not one homogenous group just expecting to receive water at the lowest costs, which was the traditional view. Rather, they all expect different things from the water utilities. Four groups of clients were identified, called the client perspectives, namely (1) 'aware and committed', (2) 'down to earth and confident', (3) 'egalitarian and solidary' and (4) 'quality and health concerned'. A short description of the different client perspectives is shown in Table 4.1.

Table 4.1: Concise descriptions of the four different client perspectives, for a full description of the client perspectives refer to: (Brouwer et al., 2019).

'Aware & committed'	Clients with pro-environmental values and a strong commitment to sustainability.
'Down to earth & confident'	Clients who trust drinking water companies and prefer not to worry about drinking water.
'Egalitarian & solidary'	Clients who feel a strong sense of solidarity with disadvantaged households, developing countries, and future generations.
'Quality & health concerned'	Clients primarily focused on their personal preferences and health when it comes to drinking water.

Brouwer et al. (2019) first performed a Q-study in 2015 to identify the different client perspectives. Following, two quantitative surveys were conducted in 2015 and 2018. In the Q-study the different client perspectives in the

Netherlands were identified by combining both quantitative and qualitative data collection methods. Despite eliciting the existence of the four client perspectives, the Q-study did not show the prevalence of the different

Updating client perspectives prior to a longitudinal study

Before the launch of such a hypothesized longitudinal study, there should be a cross sectional study at KWR to redefine the client perspectives described above. Given the perspectives were developed in 2019, it is relevant to assess whether these still reflect the water clients as accurately as when they were developed. This revision of the client perspectives will serve as a starting point for a longitudinal study following the adapted client perspectives.

To do so, KWR should carry out a new qualitative study to identify if new client perspectives emerged, or if the current ones changed. A longitudinal study should not change its questions and formulation to ensure its validity. Hence, this research is a prerequisite to the beginning of the longitudinal study to follow the client perspectives.

client perspectives. This was achieved using the two rounds of questionnaires. The four client perspectives are now used to understand the different types of clients of the water utilities. In addition, they are applied to tailor communication efforts to the different clients. In this way, the water utilities can better appeal to clients to change their behaviour based on their perspectives and motivations.

The relevance of a longitudinal research design to follow the client perspectives can be explained when considering that in the design of the study by Brouwer et al. (2019) two quantitative surveys were already carried out. When comparing results from the two surveys, the authors found that the geographical division of the perspectives was stable over time.

Longitudinal studies can take these findings further by following the same participants repeatedly over a longer time. Interesting questions when conducting longitudinal studies to follow the client perspectives are: How fluid are the client perspectives over time? How do the clients change perspectives and why? It is useful to follow the clients and their perspectives over time to get an empirical understanding of how the client perspectives evolve among and within individuals. As such, a hypothetical longitudinal study to follow the client perspectives would use the lens of the four client perspectives. Consistency is particularly important for longitudinal research. To compare data collected at different time points, the data collection instruments at the different moments must stay constant. This means that changing questions in longitudinal studies over the years will render them useless (L1). This trade-off is used to introduce the hypothetical research as described below.

This research plans to follow the four client perspectives in the face of time and relevant developments. This will give insights regarding factors that affect the client perspectives throughout a long period of time.

To address the need for consistency but also flexibility, this hypothetical research design will make simultaneous use of quantitative and qualitative data collection methods. Longitudinal measurements of quantitative data will serve to track shifts in perspectives through time, and cross-sectional qualitative measurements will serve to help understand what triggers these changes. This will be done on a smaller subsample of the longitudinal study. A qualitative understanding of the quantitative answers is crucial to get a nuanced and empirically based understanding of the reasoning, motivation, and developments at hand, which may fall outside the scope of the quantitative questionnaires.

A foremost consideration to develop this hypothetical study is the choice of an appropriate sample. For that, researchers need to ensure that the initial sample is representative of the population they aim to study. Factors to consider are, for example age, gender, socioeconomic status, and language. To understand and follow the four

client perspectives in the Dutch and Flemish population, simple random sampling in the two groups is an appropriate way to get a representative sample of the population, while minimising attrition bias. Nonetheless it should be noted that clients with certain perspectives may be less prone to participate in the study, and thereby may be underrepresented. For this research, a simple random sampling is thought to be an appropriate strategy to get a grip of the numerical distribution of the perspectives through time and developments.

The initial sample needs to accommodate for attrition to ensure that at the end of the study, there are enough respondents to allow for statistical analysis of the results. While it is impossible to predict attrition, it is possible to account for a worst-case scenario, based on previous works. As seen in Chatfield et al. (2005), studies on the elderly had attrition rates of up to 50% and initial response rates as low as 62%. Thus, if the study aims to follow client perspectives among the Dutch and Flemish population, a sample of 4000 respondents (1200 in Flanders and 2800 in the Netherlands, proportional to the population sizes) at the end of the study seems appropriate. Based on the findings of Chatfield et al. (2005) to end with 4000 respondents after ten years, a longitudinal study would need to contact around 13000 respondents on its first round.

For the cross-sectional qualitative interviews to be conducted, a smaller group of respondents would suffice. These respondents should be selected to represent the socio-demographic characteristics of the larger longitudinal sample. For these interviews, smaller groups of 20 respondents would be enough to get nuanced insights into the reasoning, motivation, and developments at hand, falling outside the scope of the quantitative questionnaires. The interviews will not be conducted with all the respondents in a longitudinal matter, as conducting 13 000 interviews would require great funding, time, and effort, therefore make it unfeasible.

In the context of KWR, a longitudinal study following the client perspectives should run for ten years, taking measurements every year. A period of ten years was chosen given that currently client-related research projects are completed in one or two years as part of the six-year BTO research programme. To capture societal developments of relevance, it is expected that a ten-year period will capture enough change to be able to infer causality. This period is also related to the speed of change, infrastructural changes tend to happen in decades, whereas perception and political affiliation change faster (L2). Additionally, policy goals are set in the order of magnitude of decades, such as the water and land use policy in the Netherlands which aims to reduce water use by 20% by 2035 (K3). However, it should be noted that ten years remains an arbitrary number.

Quantitative data will be collected at every measurement moment, to assess the prevalence and shifts of the client perspectives. Respondents will be asked the same questions every two years. Answers will be given using a Likert scale. In addition, some questions will consist of a list of statements that the respondents will be asked to sort by importance/relevance (i.e., most important statement first, least important last). Finally, as a small qualitative measurement at the end of the questionnaire, respondents will be asked to give three words they associate with developments that have occurred since the last measurement moment. These will later be used to create a word cloud representing the most prevalent words and concepts brought up by respondents of each of the four client perspectives. This quantitative data will be complemented by interviews at every measurement round, with a subsample of different respondents. This methodology allows respondents to explain their answers, while remaining consistent throughout the years. Since these interviews are complementary, they do not affect the validity of the longitudinal data. The added value of interviews is to get qualitative insight into the reasoning of the respondents regarding their given answers. These interviews following quantitative questionnaires will also allow to scan for trends in society, which will add to a nuanced understanding of the results

The questionnaires will be sent out and collected online, in a format that allows answering on a mobile device, to minimise attrition (L1). Socio-demographic data will also be collected at every measurement moment, to ensure that it is the same respondent at every measurement moment. In addition, this allows to later search for correlations between socio-demographic factors and perspective shifts. The chosen variables to measure will

depend on the previous questionnaires used to quantify the client perspectives, as well as the updated Q-study, and will be delved upon in section 4.3.

Additionally, sociodemographic measurements will be carried out to check whether changes in perspective are relatable to socio-demographic factors, such as:

- Age
- Gender
- Education level
- Perceived social status
- Geographic location
- Income
- Religion
- Cultural background
- Ethnicity/race
- Political preferences
- Health
- Perceived wealth (scale)
- Occupation

Additional considerations expected to influence respondents' answers are education and employment status, followed by the respondent's situation on the housing market. These should thereby be closely monitored in an optimal longitudinal study (L2).

By keeping track of potential confounding variables throughout the study, such as externalities, internal validity can be ensured. Additionally, a plan to handle missing data and attrition will be made. To rule out the bias of attrition the data suggested by Barry (2005) will be collected (see 4.1.2 "Data").

To account for externalities that might affect respondents' answers, the online longitudinal questionnaire can make use of an open question where respondents can indicate whether they perceive if an external event/experience has influenced their answers to the questionnaire. Later, these responses can be analysed to look for common factors or events among responses. Insights from KWR's own trend alerts should also be used to relate external changes to research outcomes.

In the case of a study following client perspectives of Dutch and Flemish water clients for 10 years with measuring moments every year, there are several ethical considerations to be made prior to start of the research. The first is to obtain informed consent, which refers to the process of providing participants with relevant information about the research so that they can make an informed decision about whether to participate or not. Informed consent should be documented (signed), transparent, and inform or ask the participants for (L1, K1):

- Explanation of the study
- Voluntary participation
- Risks and benefits of participating
- Confidentiality and privacy
- Data collection and follow-up procedures
- Contact information and questions

To ensure the integrity and safety of the respondents and research setup, researchers should ensure an inclusive and diverse, yet representative sample of the population studied. Researchers should also consider and adhere to academic integrity principles prior to dissemination of results. The results should accurately represent the data collected. Lastly, researchers should facilitate communication with, and feedback from respondents throughout the study. Participants should be able to withdraw from the study without negative consequences.

To minimize attrition, it may be beneficial to reward participants at every measurement moment. This is especially relevant given the 10-year duration of the study. A yearly newsletter, as a way of staying in contact with the respondents, may also aid in reducing attrition (L1).

Additionally, to test the proposed study, it is essential to conduct a pilot. A pilot could consist of two measurement moments with 50 respondents over two years. Such a pilot would make use of the final design, questionnaire and interviews and use the chosen contact type (email, online questionnaire). In this way, it would give insight into the feasibility of the setup chosen. This pilot can avoid the unnecessary costs and efforts of setting up the whole research, only to find out it is flawed.

4.2 Cohesion analysis of previous research

This section builds creates a retrospective assessment of the cohesion of client-related research questionnaires for the period 2018-2023. In addition, it provides a coherent approach to design questionnaires for the period 2024-2029. This is not considered a longitudinal analysis, given that these questionnaires were not conducted among the same respondents at multiple times. Nonetheless the analysis will serve to align future client-related studies in a longitudinal vein. It does so, by assessing to what extent there already is cohesion among previously conducted questionnaires. Using this information, future studies can be performed in coherence with previous research. In addition, it ensures improved cohesion among future studies.

First, all projects carried out by the theme group Klant (client-related research) were collected, as can be seen in Table 4.2. Following, the projects with questionnaires were selected. Some projects had multiple questionnaires, so in total 27 questionnaires from eight different projects were collected. Most projects had a single questionnaire (sometimes translated into the Flemish context). One project, "Gedragbeïnvloeding in de praktijk", had several measurement rounds and thus used nine different questionnaires. For these reasons the following analysis will firstly consider individual questionnaires, followed by an analysis at the project level.

Table 4.2: Overview of the analysed projects, including the project number, project name, year the project was carried out, and the number of questionnaires the projects used.

Project number	Project name	Year	Number of questionnaires
BTO 2018.083	Klantperspectieven	2018	1
BTO 2019.023	Risicoperceptie	2019	1
BTO 2020.034	Bewustzijn Kraanwater	2020	2
BTO 2020.013	De klantperspectieven toolbox	2020	3
BTO 2020.051	Citizen science en lood - Institutionaliserings	2020	1
BTO 2021.024	De hardheid van water	2021	8
BTO 2023.045	De Klant als nabehandelaar	2021	2
BTO 2022.015	Gedragbeïnvloeding in de praktijk	2022	9

Several steps were taken in the questionnaire analysis, which were qualified into an intra- and inter-analysis. The intra-analysis is respective to the analysis of the questionnaires individually. The inter-analysis refers to the comparison of the questionnaires, to look for similarities and differences among them.

4.2.1 Structural analysis

The first step of the intra-analysis looks at the structure of the different questionnaires. For this first step, several factors were considered including the length of the questionnaire, the type of questions used, and the placement and detail of questions related to sociodemographic data (Table 4.3).

The *length* of the 27 questionnaires was studied by looking at the introduction length (number of words), the number of questions, and the number of words of the whole questionnaire. The questionnaires created by KWR in the period 2018-2023 for client-related research feature a brief introduction of on average 82 words. These questionnaires are on average 1400 words, consist of 23 questions, with an of average 61 words per question.

The *question types* used in 27 the questionnaires always include multiple choice questions. 25 out of the 27 questionnaires make use of a Likert scale. 26 questionnaires include questions with the possibility to give an alternative answer (“other, namely”). 10 questionnaires use follow-up questions, whereby one question leads to the next (e.g., ‘Do you shower every week? If so...’). Of the 27 questionnaires, 12 have a comment section after completion of the questionnaire. There respondents are given the option to give comments. However, no questionnaires made use of truly open questions. 13 questionnaires make use of semi-open questions, where the respondents can choose a value in a given range. 19 of the 27 questionnaires have questions related to *socio-demographic data*. Of these 19 questionnaires, eight have the socio-demographic related questions at the end, seven questionnaires have them at the beginning, and four have them both at the beginning and the end. The socio-demographic related part of the questionnaires is between three to 17 questions long with an average of seven questions.

Table 4.3: Results of intra- and inter- structural analysis of 27 questionnaires. For each indicator the minimum, maximum, average and median value are defined. For non-numeric indicators, the number (#) of occurrence was counted.

Structural analysis				
Indicator	Minimum – maximum		Average	Median
Introduction length (# of words)	23-284		82	65
Length (# questions)	4-51		23	19
Length (total # of words)	300-3800		1400	1302
Words per question	29-107		61	58
Detail of sociodemographic data (# of questions)	3-17		7	5,5
Placement of sociodemographic data	Beginning	Beginning + end	End	None
# of questionnaires with sociodemographic data at	6	4	8	9
Indicator		Yes	No	
Confidentiality statement and privacy		15	12	
Likert scale?		25	2	
Multiple choice questions?		27	0	
Follow-up questions?		10	17	
Comments?		12	15	
Other, namely questions?		26	1	
Open questions?		0	27	
Semi open questions? Value between x and y		13	14	

Insights can also be derived from a completely project-based analysis, where one questionnaire per project is analysed. The registration questionnaire for all studies was chosen. The registration questionnaire, which is the first the respondents are exposed to, includes the least project-specific bias, and the most elements characteristic of questionnaires, such as a complete privacy and confidentiality statement, and complete socio-demographic sections. Thus, this is the questionnaire that has the most elements of comparison with questionnaires from projects with just one questionnaire. The summarised findings of the project based structural analysis can be found in Annex 1. The key structural differences which can be seen in the project-based as opposed to the questionnaire-based analysis is that the average introduction length is longer (120 as opposed to 82 words) and the questionnaires are on average longer (29 as opposed to 23 questions, and 1943 as opposed to 1400 words). In addition, the questions are also slightly longer (65 as opposed to 63 words per question). The questionnaire-based analysis concluded that nine of the 27 questionnaires did not make use of a sociodemographic data section, whereas in the project-based structural analysis all eight questionnaires did. In addition, the project-based structural analysis shows a higher share (seven out of eight, as opposed to 15 out of 27) of questionnaires that make use of a confidentiality and privacy statement.

4.2.2 Contextual analysis

For the contextual analysis several indicators were measured (Table 4.4). For some of the indicators this contextual analysis was carried out at the project level instead of the questionnaires level to avoid over-representation by some of the projects which make use of several questionnaires in the same context.

As a *contact source*, four of the total of eight projects used a recruitment agency (such as Norstat) or online panel to distribute their questionnaires. These recruitment agencies had the role of executing the *sampling method* and finding a representative sample for the study in question. Other projects used social media (Facebook), or the contact list of the water utilities, and had a *sampling method* to email a randomly chosen share of the clients represented by that water utility. Only one project physically left questionnaire invitations in houses of the neighbourhood it was studying, as a sampling strategy.

In terms of *respondent type*, all the projects studied drinking water clients, although in different regions. Four of the projects take place in the Netherlands, one project takes place in Belgium, and three projects studied drinking water clients from the Netherlands and Belgium simultaneously.

In the projects with several questionnaires, not all questionnaires present a privacy and confidentiality statement, or a socio-demographics section. This is because multiple questionnaires are sent to the same people, making these questions redundant. Out of 27 questionnaires, 10 ask their respondents for 10 minutes of their time, 15 questionnaires do not give an indication of *how long answering will take*, one single questionnaire asks respondents for four minutes of their time, and one other questionnaire asks the respondents for 10 to 15 minutes of their time. The questionnaires were open for a minimum of 10 days, an average of 20 days, and maximum of 30 days. The questionnaires considered in the analysis were carried out between the *years* of 2018 and 2023. Four out of the eight projects used *follow-up interviews* with the respondents of their questionnaire to deepen the analysis of the obtained quantitative results.

Table 4.4: Results of intra- and inter- analysis for 27 questionnaires of 8 projects. Indicators of contextual analysis were studied in questionnaires used for client-related research at KWR in the period 2018-2023.

	Contextual analysis
Contact source	Recruitment agency, social media, or water utilities contact list
Sampling method	Simple random or area sampling
Respondent type	Drinking water clients
Purpose of study	Project specific
Number of questionnaires	1, sometimes adapted to BG. 2 projects have 8-9

Type of study	Project specific			
Year of questionnaire	2018-2022			
Follow-up interview	4/8 projects			
Time asked (in questionnaires)	No time asked	4 minutes	10 minutes	10-15 minutes
	15	1	10	1
Time open	Minimum – maximum		Average	Median
	10-30		20	19,5
Country	Netherlands		Belgium	Netherlands and Belgium
	4		1	3

4.2.3 Thematic analysis

After studying the themes delved upon by the eight different projects, overlap was found. The lens of this analysis is set on the projects and not the questionnaires, since questionnaires from the same project all focus on the same topic. This would result in an overrepresentation of themes addressed in projects with multiple questionnaires. The prevalence of themes was assessed by looking at all the questionnaires of the different projects, and accounting for overlapping topics across questionnaires of the same project. When a topic appeared twice in different questionnaires of different projects, this was noted. A list of the most prevalent themes was created (i.e., themes that are addressed in five out of eight projects at least). This thematic analysis will at a later stage be used to develop recurrent questions which should be present in future questionnaires trying to study the drinking water client.

The first and foremost overlapping theme among the projects is the prevalence of the *client perspectives*. They were addressed at least once in every different project. This was done by means of four statement lists, one corresponding to each of the perspectives, asking respondents to choose the statement list they identified with the most. Another topic that was addressed in questionnaires of all eight projects is the client's relationship with their water utility. Additionally, despite the different objectives of the projects, seven of the eight client-related research projects and inherent questionnaires for the period of 2018 to 2023 include questions pertaining to the clients' *perception of tap water quality*. In the same vein, six of the eight projects questioned their respondents on their perception towards *pollutants in tap water* and on their *view of the price of water*. In addition, five of the eight client-related research projects question the clients' *consumption of bottled water*. Finally, in five of eight projects the questionnaires addressed the *client's water conservation behaviour*. These thematic insights are summarised in Annex 2, which reviewed all the questionnaires to create an overview of the prevalence of themes across projects.

4.2.4 Response analysis

Given the differences in data collection methods and contexts of the different questionnaires, no statistically significant insights could be derived from metrics such as the number of (in)valid responses, people reached, and response rates. This is because of discrepancies between the projects, like using a recruitment agency which does not specify such data or using different platforms to reach respondents.

Ideally, all the questionnaires and their responses would be in a consistent format that would allow to correlate questionnaire characteristics to response rates. This would act as a system of measurement for success of the developed questionnaires and collected answers. For the studied questionnaires this was not the case, since several projects did not report their response rates or number of respondents reached. The main obtainable insights are depicted below (Table 4.5). Though they should not be used in further analysis, given that they do not include data from all the questionnaires/projects, and thereby serve only as a simple indication of what could be analysed if all necessary data was available.

Table 4.5: Results of intra- and inter- response analysis. Indicators pertaining to response analysis were studied for questionnaires used for client-related research at KWR in the period 2018-2023.

Response analysis				
Indicator	Minimum	Average	Median	Maximum
Number of respondents	63	1221	1035	4010
Response rates	6,5%	16,6%	86%	9%
Incentive (occurrence in projects)	Incentive		No incentive	
	6/8 projects		2/8 projects	

4.2.5 Expected developments of relevance for client research

The relationship between water utilities and their clients is influenced by various factors emerging from the water sector and society. Understanding and monitoring these factors and their development is crucial for conducting an effective longitudinal study on the drinking water client. By conducting interviews with four experts (W1, W2, W3, and L2), valuable insights have been gathered regarding the anticipated changes and challenges in the near future. The factors here outlined, including water scarcity, institutional trust, demographic changes, conflicting interests, and socio-cultural and psychological influences, provide key considerations that future longitudinal studies could keep track of. It is unfeasible and unnecessary for a single study to keep track of all these developments, and thereby choices of the most relevant and measurable indicators should be made, which will depend on the research objectives of the project considered.

There are many factors expected to influence the relationship between water utilities and their clients. The first major predicted event that is expected to affect the water utilities and their clients is a decrease in water quantity (water scarcity) and quality of water sources, which is exacerbated by climate change (W1, W2, W3). This relates to a decrease in river flow, changing rainfall patterns and all the issues deriving from scarcer water sources (W1, W2). Such a decrease in water quality and quantity affects the ability of the water utilities to meet high water demands in increasingly long and intense drought periods (W1, W2).

A general decrease in institutional trust, which has already been identified (AIVD, 2023), is expected to influence the relationship between clients and water utility (W3). This decrease in institutional trust may be accompanied by a decrease in willingness to save drinking water, a decrease of trust in the quality of drinking water (W3), and a decrease of trust in the capacity of water authorities to adequately treat wastewater (W1, W2). This is especially an issue because increasing awareness and willingness to save drinking water will be essential in tackling water scarcity in the coming years (W3). In addition, a decrease in institutional trust is expected to decrease acceptance of alternative water sources (W1, W2). Overall, shifts in institutional trust have a great impact on the relationship between the water utilities and their clients, and should be monitored (W3).

Another expected development that may impact the relationship between the water utilities and their clients is the rate of urbanization which is still on the rise (W3). People living in urban areas have different water demands than their rural counterparts. As such, a growing urban population will present new challenges (W3). The average age of the population is getting higher, which is likely going to impact socio-economic dynamics and raise new challenges regarding the interaction between water utilities and their clients (W3). Related to an increased urbanization rate and socio-demographic growth, an increasing need of space for industry, housing, and agricultural interests conflict with the availability (or lack) of space for drinking water sources. This makes it virtually impossible for water utilities to explore new areas for drinking water exploration. On the other hand, increasing the capacity of existing locations is difficult due to legislation protecting nature areas and the groundwater-dependent ecosystems surrounding them (W3).

On an individual level, the personal experiences of clients are expected to impact the stance of respondents towards drinking water quality and water utilities (L2). Examples include, (mental) health issues and political perception. Political perceptions could be influenced by the emerging political discussion regarding the role of the water utilities (W1). Other socio-cultural developments such as migration trends (W2) and subsequent inclusion issues (L2), as well as propensity to extremism ought to be tracked to measure their influence on the drinking water clients and their relationship with their water utility (L2). These considerations can be accompanied by an analysis of the level of social capital and relationships, which will in turn reflect on how supported respondents feel (L2).

The factors here outlined, including trust, demographic changes, water scarcity, conflicting interests, and socio-cultural and psychological influences, provide key considerations that future longitudinal studies could keep track of. It is unfeasible and unnecessary for a single study to keep track of all these developments, and thereby choices of the most relevant and measurable indicators should be made, which will depend on the research objectives of the project considered.

4.3 Ideal questionnaire

Building on the results discussed in paragraph 4.1 and 4.2, an ideal questionnaire to study drinking water clients is developed. The ideal questionnaire ensures collecting multiple dimensions of data, enabling a more holistic understanding of the clients. One basis questionnaire allows for consistency and comparability across projects, even if these projects have different objectives or sampling methods. The ideal questionnaire empowers KWR researchers and the water utilities to identify areas for improvement, tailor interventions to meet clients' evolving needs, and improve the quality of drinking water services. 4.3.1 discusses the ideal questionnaire outline to study the drinking water client. 4.1.2 proposes an example of the application of this ideal questionnaire layout based on the longitudinal study of the client perspectives.

4.3.1 Layout of ideal questionnaire

The ideal questionnaire introduces elements of longitudinal research to maximise consistency and comparability across client-related research projects. This will allow for better insights into the client, based on a joint analysis of previous and future client-related research.

Based on the analyses discussed in paragraph 4.2, the layout for the ideal questionnaire is as follows:

1. Introduction (80-120 words)
2. Socio-demographic-related questions (6 questions)
3. Recurring questions (10 questions)
4. Project specific questions (14 questions)
5. Conclusion (60-80 words)
6. Comment section

The introduction of the ideal questionnaire should be one that attracts respondents to participate. It should contain a privacy and confidentiality statement. In addition, it should give respondents an indication of how long filling in the questionnaire will last. This helps to minimise participant dropout and enhance response rates. To ensure the questionnaire is attractive to respondents while maintaining consistency with previous KWR client-related research, the introduction should be short, around 100 words, ranging from 80-120 words.

The introduction is followed by the socio-demographic related questions. This section aims to collect data such as names, gender, addresses, and level of education. In line with previous client-related research, the socio-demographics part of the questionnaire should consist of approximately 6 questions. To improve response rates

it should be mentioned again at this socio-demographics section that the data will be anonymised and treated confidentially, as was done in most of the previous client-related research questionnaires at KWR (K1).

In the thematic analysis carried out in chapter 4.2.2., several recurring questionnaire topics were identified. Thus, it is recommended for these topics to be featured in every future KWR client-related questionnaire. This allows for added consistency and comparability across the questionnaires and across time.

These questions address topics such as *the client perspectives, the clients' perception of drinking water quality and water pollutants, the clients' consumption of bottled water, the clients' relationship with their water utility, the client's perception towards the water prices, and the clients' water conservation behaviours*. These are materialised into seven questions, one pertaining to each of the themes above. Including them will allow for comparison of the seven key themes across time in an almost longitudinal manner. Almost longitudinal here refers to the fact that the findings will be comparable and consistent, despite not using the same respondents every time. It is thus not officially considered longitudinal. Nonetheless, such an approach applied to large groups of respondents over the years is expected to yield unique, valuable insights.

To further ensure consistency and comparability among new research and with previous client-related research, project specific questions should also adhere to certain guidelines. Project specific questions differ based on the inherent aims of the project, but a few recommendations could be distilled from the analyses applied in this study. The project specific questions should be around 60 words each. The method of answering should be a Likert scale, multiple-choice, and follow-up option (if so then...). Open questions should be avoided, especially in questionnaires with larger respondent groups. Additionally, a focus group, where interviews are conducted in conversation with a subsample of the respondents is recommended. This allows for more insightful qualitative data collection. Such qualitative data will provide an in-depth, contextual understanding of the research questions at hand, while also allowing for analysis of unexpected outcomes.

The closing of the ideal questionnaire should thank the respondents for their time and cooperation, while giving respondents the possibility to contact the involved researchers for feedback or questions. In a closing note, the questionnaire should also allow the respondents to give feedback in a comments section, where respondents can share any additional thoughts in an open textbox.

Given the likelihood that the ideal questionnaire will be distributed and completed online, several data-related considerations should be taken into account for optimal results. A first consideration is to formulate clear and concise questions and answers. In addition, the respondents should be given the possibility to indicate "I do not know", or "I abstain from answering". The number of responses in these two categories give insight in the quality and/or potential sensitivity of the questions at hand. Additionally, incorporating metadata, such as the date and time of response, or how long respondents took to answer, enables tracking changes over time and identifying trends in client behaviour towards the questionnaire. Other meta data that can provide valuable insights are the geographical location of respondents, the referral source (how respondents found the questionnaire), completion time (whole questionnaire), response time (per question), the dropout rate, and response rates. So, these data should be collected for every future KWR client-related questionnaire. Lastly, researchers must ensure safe data privacy and security measures, as it is essential to protect the confidentiality of respondents' information.

Lastly, any questionnaire, even the ideal questionnaire designed in this study, benefits from a piloting phase, where it can be iteratively refined. By testing the questionnaire on a small sample of participants, researchers can evaluate the clarity and relevance of the questions, identify ambiguities or confusing questions, and assess the overall flow and length of the survey. Piloting helps uncover discrepancies between researchers' intentions and respondents' interpretations, ensuring accurate questioning. Additionally, a pilot study provides an opportunity to gather feedback from participants regarding the questionnaire's comprehensibility and relevance.

4.3.2 Format of ideal questionnaire

Introduction (~80 words)

Welcome to this year's questionnaire on tap water. This questionnaire is designed to gain insight into your (...) regarding tap water. Completing this questionnaire will take about **10 minutes**. All information you enter in this questionnaire will at all times be confidential and anonymous. Thank you in advance for your participation.

(Project details)

The following few questions are designed for the research and will not be used for commercial purposes.

Sociodemographic questions (~6 questions)

1) What is your gender?

- Male
- Female
- I do not want to say

2) What is your age?

- 0-99
- I do not want to say

3-6) Project specific sociodemographic questions (~4 questions)

Recurring questions (~10 questions)

Please read the following groups of statements carefully

Statement list A

- I believe in working together for a more sustainable world Drinking water companies should produce water in a 'green' and sustainable way.
- Reusing water in and around the house or via a second pipe network seems like a good idea.
- Every individual has their own responsibility to use water sustainably and economically deal with water.
- Information and insight for individual citizens leads to awareness and thus possibly more sustainable water consumption

Statement list B

- I am concerned about my health.
- Tap water should be as natural as possible.
- Substances, even in concentrations much lower than where there are harmful effects, should be removed from my tap water.
- I do not consider it desirable that (social) efforts of drinking water companies, other than the supplying safe water, should be passed on to me as a consumer.
- Sometimes I worry about quality of my water in the future, and its effects on my health.

Statement list C

- It is my belief that water is the absolute basics and should be the same for everyone

- It is undesirable that households should be able to purchase better quality water, or a better service could be purchased.
- To ensure the supply of sufficient tap water in the future, I am willing to use my water.
- Drinking water companies also have a role in providing water in developing countries.

Statement list D

- For me, convenience and no hassle are important.
- Drinking water companies should stick to their core mission: ensuring sufficient, healthy tap water from high quality in the most efficient way possible.
- About my tap water, I would prefer to think as little as possible.
- I do not worry about my tap water: even in the I do not foresee any insurmountable problems in the future due to technological progress.

7) Which of the above group of statements best reflects how you feel about tap water?

- The statements A
- The statements B
- The statements C
- The statements D

8) What rating do you give the quality of your tap water? 1-10

1 represents very poor, and a 10 represents excellent

9) What rating do you give for the service of your drinking water company?

1 represents very poor, and a 10 represents excellent

10) What rating do you give for the value for money of your tap water?

1 represents very poor, and a 10 represents excellent

11) Do you use bottled water at home?

1 represents never, 10 represents daily

12) To what extent do you agree with the following statements about the tap water at your home?

- a) The tap water is odourless
- b) The tap water is clear
- c) Tap water tastes good
- d) Tap water is soft
- e) Tap water is healthy
- f) I try to save tap water at home
- g) I would like to save more tap water at home

- Totally agree
- Agree
- Neutral
- Disagree
- Totally disagree
- Do not know

13-17) (Add around 4 further recurring questions relevant to the project and based on insights of section 4.2.4.)

Project specific questions

18-30) Project specific questions (~12 questions)

Conclusion

Finally, we invite you to write down whatever else comes to mind now about the topics addressed in this questionnaire. All your additions and/or comments are greatly appreciated.

- No comments/additions

-...

This was the end of the questionnaire, thank you for filling it out! If you have any questions, you can contact us at (...). We hope to hear from you in the next questionnaire!

Best regards, KWR.

4.3.3 Longitudinal research questionnaire to follow the client perspectives

The ideal questionnaire for longitudinal research is one that meets all the requirements as listed in the section above but meets other criteria as well. The purpose of this section is to outline the essential components of an ideal longitudinal questionnaire that effectively follows client perspectives over time. The questionnaire serves as a valuable tool for longitudinal research, enabling the assessment of changes in client perspectives, the evaluation of long-term intervention effects, and the identification of trends and patterns in client perspectives.

The structure and format of the questionnaire are crucial considerations. It is important to use consistent measures across measurement points to ensure comparability (L1). Clear instructions and response options are necessary to minimize response bias and increase the questionnaire's overall quality, while reducing dropout and attrition rates. In the same vein, it is important to design the questionnaire in a user-friendly and engaging manner to encourage participation and reduce attrition rates. This can be enhanced by using clear and concise language, but also visual aids, such as rating scales or pictorial representations, to enhance comprehension and participant engagement (L1). To promote participant engagement, it is also important to tailor the questionnaire to the specific context of the research and respondents involved. This should be done by incorporating items that capture relevant aspects of the client's experiences within the geographical and societal context of the research.

Piloting is especially relevant for a longitudinal questionnaire, and should be thoroughly done, while having close contacts with the respondents of the pilot survey. This proximity allows to get an in-depth understanding of the potential weaknesses of the questionnaire designed, and to address them before launching a costly multiple-year questionnaire, which should not be changed once it is released.

Section 4.1.3. gives an outline which can be used to create a research questionnaire to follow the client perspectives as described in Brouwer et al. (2019). Annex 3 applies the insights of the previous sections to design a layout of the ideal questionnaire to follow the client perspectives in a longitudinal manner.

5 Discussion

Although longitudinal research is common in sectors like medicine, psychology, and client satisfaction, it is uncommon in the water sector. By exploring longitudinal studies conducted in other sectors, this research identified opportunities to apply similar research methodologies in the drinking water sector. More specifically to apply longitudinal research to gain insights into client-related studies within the context of the drinking water utilities in the Netherlands and Belgium.

Longitudinal research allows for a nuanced and articulated interpretation of the behaviour of the drinking water client. This helps in examining the progression of client perceptions over time in response to factors affecting drinking water services like climate change, water pollution, and decreasing institutional trust. More than simply tracking these factors, longitudinal studies contribute to understanding the complex dynamics and causal relationships between these factors, drinking water utilities, and drinking water clients.

Important considerations for the feasibility of longitudinal studies include cost, resources, and participant engagement. Longitudinal research may incur large costs given the long temporal nature of its design. Engaging a large group of respondents for a period of 10 years presents significant challenges, amongst which financial ones. Despite this, it is hypothesized that while cross-sectional research setups may have a lower initial cost, longitudinal research setups take more preparation and perhaps initial funding, but are expected to provide invaluable insights in time, with lower incurred costs for additional measurement moments. As such, conducting one longitudinal study over ten years or ten cross-sectional studies every year will come at a similar cost in the context of KWR. However, the insights that could be obtained from longitudinal research are of unique added value.

One of the most significant potential challenges to longitudinal research is participant engagement. Several considerations should be made to ensure representativeness of sample population at both the beginning and end of the study, to account for attrition. Another important factor to consider is the effect of attrition on internal and external validity. Efforts to minimise attrition are of utmost importance when considering that each lost participant represents a monetary loss, but also a threat to the validity of the research at hand. Alternatively, there is also discussion and uprising research around the use of incentives and their influence on the sample group (L2). The type of incentive affects the representativeness of the sample obtained. An incentive consisting of a donation to an NGO, or a monetary gift to respondents seems to result in different compositions of sample groups, altruistic or selfish respondents respectively (L2).

The retrospective assessment of previous client-related research at KWR for the period of 2018 to 2023 yielded great insight into the methods used so far. In addition, it also served to shed light on the factors that should be considered when designing an ideal questionnaire for client-related research. Overall, it would be beneficial for research performed in this theme group to instil consistency among research in a longitudinal manner. If the studies are aligned and have overlapping questions, great insights will be derived from previous and future client-related research, even outside longitudinal setups.

When conducting the retrospective assessment of previous client-related research the structural and contextual analysis were straightforward, and the information was readily available. However, the response analysis was not. For all the projects making use of a selection agency to find respondents and collect data, no data could be retrieved on response rates. For other projects that did report a response rate, the context in which respondents were reached was so different that these response rates were not comparable (7,5% and 85,5%). Similarly, the relationship between people reached and response rates could also have been used as a metric for the attractiveness of the questionnaire studied. Additionally, almost no data could be gathered on the number of people reached across projects. Similarly relevant conclusions could be drawn from secondary data (such as

response time, device information, time of response, etc), if the necessary data had been available. Overall, these indicators should be tracked in future client-related research to allow for analysis of success factors among questionnaires. Furthermore, a set of recurring questions was developed that can help track future expected developments in the water sector, as well as the relationship of the drinking water client to these topics and their water utility. None of the questionnaires made use of open questions given the large sample sizes. The analysis of such a large volume of qualitative data made that impossible. Nonetheless, such qualitative questions can gather unique insight into the respondents' answers. With the rise of artificial intelligence powered text analysis tools, this may be an option for future research.

Another crucial consideration for research regarding the drinking water client (whether longitudinal or not) is wording (K3). The choice of descriptors of the variables studied are expected to have a great impact on respondents and their answers. Thereby, future research should make justified descriptor choices, to allow for an unbiased response and analysis of client-related research (K3). This influence is especially complex when considering that it affects respondents differently based on their past and even generation (L2). In a similar vein, design choices of a longitudinal study with drinking water clients are crucial, especially those pertaining to psychological factors that may influence the answer given by respondents. Firstly, the simple act of observing respondents can alter their behaviour, this is known as the Hawthorne effect (McCambridge et al., 2014).

Additionally, measuring can have an effect on perceived change, as respondents may subconsciously report positive change to satisfy the researcher, called the social desirability bias (Vilar et al., 2020). The influence of the research on the respondents may transcend these effects, and manifest in a different way. For example, if respondents expect to be interviewed on a topic multiple times, they might try to learn more about the topic. This differs from the previous effects, as it does not mean respondents will report change to seem socially acceptable, but simply that their knowledge on and interest in the topic has increased because of partaking in the research. While it is challenging and perhaps not possible to totally illuminate these biases, research may attempt to mitigate them by reinforcing participant anonymity, establishing trust with participants, and making use of mixed methods (such as quantitative and qualitative data collection methods).

To allow for measuring causality through longitudinal studies, an appropriate research design needs to account for external influences. This is crucial in longitudinal research to ensure that observed changes can be attributed to the variables of interest. As such, an appropriate research design needs to identify and capture relevant external factors that may impact the variables being studied. This can include socio-economic conditions, environmental factors, policy changes, media coverage, or other contextual variables that could potentially confound the observed changes.

Alternatively, the proposed study on client perspectives cannot be worked out in detail yet, as such, the considerations and values given should be considered as informed guidelines, and not be seen as a final design. More considerations, and design choices are needed which should be made in a team meeting at KWR, where the details can be worked out, based on the considerations this research elicited. In a similar vein, recommendations can be made for future research at KWR, and beyond, regarding client-related and longitudinal research. Further knowledge on the client perspectives is of inherent relevance, as well as how these change through time. As such, after being updated, it is recommended to follow the client perspectives in a longitudinal manner, to try to grasp what individual, societal, and biophysical factors are most influential on client perspectives, and inherent attitudes.

This research is relevant beyond the water management field, as there is a collection of subjects that can benefit from a better understanding of the drivers of changes in perspective, attitudes, and actions. Likewise, further research on the added value, feasibility and shaping of longitudinal studies can be carried out for other disciplines within water management, but also other sectors where longitudinal research is not yet present. Other research (within or beyond KWR) that could benefit from including longitudinal research in its programs are per example Water governance and policy evaluation. In this topic, researchers can resort to longitudinal studies to assess the

effectiveness and outcomes of water governance and new policies in the water sector over time. Additionally, longitudinal studies can be used in KWR to assess water use and demand patterns, by looking at water use patterns in urban and rural areas and collecting data over an extended period, researchers can identify trends in water demand, assess the impact of water-saving initiatives, and develop more accurate projections for future water needs.

These discussion points are not meant to demoralise researchers wanting to delve into longitudinal research, but to raise interest towards this vastly underused research method, as most of the challenges presented above, also represent opportunities for further research.

6 Conclusion

The aim of this study was to explore the added value, feasibility, and shaping of longitudinal studies for drinking water client research. This aim was met by (I) assessing the methodological preconditions and outline an optimal design of longitudinal studies for the drinking water client, (II) retrospectively assessing the cohesion of client research data for the period of 2018 to 2023 and providing a coherent approach to design questionnaires for the period of 2024 to 2029, and (III) developing an optimal longitudinal questionnaire to study drinking water clients. To achieve this, a literature study was conducted, eight experts were interviewed, and an analysis of previous KWR client research questionnaires was carried out.

Completing these aims showed great added value and potential for longitudinal research to understand the drinking water client in a manner that cannot be achieved through cross-sectional research setups. However, longitudinal research comes with a set of prerequisite conditions and considerations prior to its setup. These include considerations of time, participant engagement, data management, and externalities. Additional considerations include factors affecting the water client and their utilities, such as decreasing institutional trust, socio-demographic changes, water scarcity, conflicting interests, and socio-cultural and psychological influences. While these factors pose challenges to setup longitudinal research, they also present opportunities. By accounting for these, researchers in the water sector and beyond, can setup a longitudinal study capable of providing unique findings.

The cohesion analysis of KWR's previous client related research underscored the added value, feasibility and shaping of longitudinal studies with drinking water clients. Consistency was found across questionnaires, particularly on a structural basis. Further analyses on a contextual, thematic, and response level served to develop an ideal longitudinal questionnaire. This questionnaire is ideal as it helps in starting longitudinal research in a manner that ensures consistency between previous and upcoming client-related research and acts as a guideline to develop future questionnaires for client-related research. Thus, whereas a longitudinal research setup would be of utmost value to the drinking water (client related research) sector, adding the considerations explored in this research to current client-related research will nonetheless ensure consistency and comparability amongst research.

In conclusion, by bridging the gap between theoretical insights and practical applications, this research equips drinking water sector researchers with the tools to better understand the drinking water client, and their evolving needs. Longitudinal studies for drinking water client research can play a crucial role in advancing understanding of the drinking water client. By employing comprehensive research designs and considering factors like participant engagement, validity, and external influences, longitudinal studies can generate invaluable insights for the drinking water sector. This research contributes to the field by providing methodological guidelines and a deeper understanding of client-related research, thereby paving the way for future advancements in the field of drinking water research and related client behaviour.

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8 Annex

Annex 1: The prevalence of themes across projects

Table 5: The prevalence of themes across projects. All 8 considered projects and their 28 questionnaires were explored to create this overview.

<i>Theme</i>	<i>Prevalence</i>
<i>Client perspectives</i>	8/8
<i>Perception of tap water quality</i>	7/8
<i>Perception of pollutants in tap water</i>	6/8
<i>Bottled water consumption</i>	5/8
<i>Relationship with utility</i>	8/8
<i>Price of water</i>	6/8
<i>Water conservation behaviour</i>	5/8

Annex 2: Project based analysis

Structural analysis				
Indicator	Minimum	Average	Median	Maximum
Introduction length	54	120	100,5	284
Length (nb questions)	14	29	30	45
Length (total nb words)	794	1943	1775	3800
Words per question	47	65	62	107
Placement of sociodemographic data	Beginning 3	Beginning + end 3	End 2	None 0
Detail of sociodemographic data (nb questions)	4	8	6,5	17
Indicator			Yes	No
Confidentiality statement and privacy			7	1
Likert scale?			7	1
Multiple choice questions?			8	0
Follow-up questions?			5	3
Comments?			4	4
Other, namely questions?			8	0
Open questions?			0	8
Semi open questions? Value between x and y			5	3

Response analysis				
Indicator	Minimum	Average	Median	Maximum
Time asked	10	17	14,5	30
Response rates (half of the projects)	7,5%	10,1%	10%	13%
Number of respondents	82	1388	1013	4010
Incentive	6/8 projects		No incentive	2/8 projects
Time asked (occurrence)	No time asked 2/8	4 mins 1/8	10 mins 4/8	10-15 mins 1/8

Annex 3: Ideal longitudinal questionnaire to follow the client perspectives

Section 4.1.3. gives an outline which can be used to create a research questionnaire to follow the client perspectives as described in Brouwer et al. (2019). This section applies the insights of the previous sections to design a layout of the ideal questionnaire to follow the client perspectives in a longitudinal manner:

Introduction (~80 words)

Welcome to this year's questionnaire on tap water. This questionnaire is designed to gain insight into your perception, wishes and needs regarding tap water. Completing this questionnaire will take about **10 minutes**. All information you enter in this questionnaire will always be confidential and anonymous. Thank you in advance for your participation.

(Project details)

The following few questions are designed for the research and will not be used for commercial purposes.

Sociodemographic questions (~6 questions)

1) What is your gender?

- Male
- Female
- I do not want to say

2) What is your age?

- 0-99
- I do not want to say

(3-6 Project specific sociodemographic questions 4 questions)

Recurring questions (10 questions)

7) What rating do you give the quality of your tap water? 1-10

1 represents very poor, and a 10 represents excellent

8) What rating do you give for the service of your drinking water company?

1 represents very poor, and a 10 represents excellent

9) What rating do you give for the value for money of your tap water?

1 represents very poor, and a 10 represents excellent

10) Do you use bottled water at home?

1 represents never, 10 represents daily

11) To what extent do you agree with the following statements about the tap water at your home?

- a) The tap water is odourless
- b) The tap water is clear
- c) The tap water tastes good
- d) The tap water is soft
- e) The tap water is healthy
- f) I try to save tap water at home
- g) I would like to save more tap water at home

- Totally agree
- Agree
- Neutral
- Disagree
- Totally disagree
- Do not know

12) *(Add further recurring questions based on insights of section 4.2.4.)*

Client perspectives questions (Or other project specific questions, question 17 should be included in all future questionnaires)(4 questions)

Please read the following groups of statements carefully

Statement list A

- I believe in working together for a more sustainable world Drinking water companies should produce water in a 'green' and sustainable way.
- Reusing water in and around the house or via a second pipe network seems like a good idea.
- Every individual has their own responsibility to use water sustainably and economically deal with water.
- Information and insight for individual citizens leads to awareness and thus possibly more sustainable water consumption

Statement list B

- I am concerned about my health.
- Tap water should be as natural as possible.
- Substances, even in concentrations much lower than where there are harmful effects, should be removed from my tap water.
- I do not consider it desirable that (social) efforts of drinking water companies, other than the supplying safe water, should be passed on to me as a consumer.
- Sometimes I worry about quality of my water in the future, and its effects on my health.

Statement list C

- It is my belief that water is the absolute basics and should be the same for everyone
- It is undesirable that households should be able to purchase better quality water or a better service could be purchased.
- To ensure the supply of sufficient tap water in the future, I am willing to use my water.
- Drinking water companies also have a role in providing water in developing countries.

Statement list D

- For me, convenience and no hassle is important.
- Drinking water companies should stick to their core mission: ensuring sufficient, healthy tap water from high quality in the most efficient way possible.
- About my tap water, I would prefer to think as little as possible.
- I do not worry about my tap water: even in the I do not foresee any insurmountable problems in the future due to technological progress.

17) Which of the above group of statements best reflects how you feel about tap water?

- The statements A
- The statements B
- The statements C
- The statements D

18) Which of the above group of statements reflects the least how you feel about tap water?

- The statements A
- The statements B
- The statements C
- The statements D

19) You indicate that the statements from group best reflect how you think about tap water. Can you indicate how well these statements reflect how you think about tap water?

- Completely
- Fairly good
- Fairly

20) You indicate that the statements from group reflect reasonably or fairly well how you think about tap water. Which of the 3 remaining groups of statements (in addition to your first choice) best reflects how you think about tap water?

- ...
- None

21-30 Further project specific questions (~... questions)

Conclusion

Finally, we invite you to write down whatever else comes to mind now about the topics addressed in this questionnaire. All your additions and/or comments are greatly appreciated.

- No comments/additions
- ...

This was the end of the questionnaire, thank you for filling it out! If you have any questions you can contact us at We hope to hear from you in the next questionnaire!

Best regards, KWR.

Annex 4: Ideale longitudinale vragenlijst om de klantperspectieven te volgen

Subhoofdstuk 4.1.3. geeft een schets die kan worden gebruikt om een onderzoeksvragenlijst te maken om de klantperspectieven te volgen zoals beschreven in Brouwer et al. (2019). Deze sectie past de inzichten van de vorige secties toe om een lay-out van de ideale vragenlijst te ontwerpen om de klantperspectieven op een longitudinale manier te volgen:

Inleiding (~80 woorden)

Welkom bij de vragenlijst van dit jaar over kraanwater. Deze vragenlijst is bedoeld om inzicht te krijgen in uw perceptie, wensen en behoeften met betrekking tot leidingwater. Het invullen van deze vragenlijst duurt ongeveer 10 minuten. Alle informatie die u invult in deze vragenlijst is altijd vertrouwelijk en anoniem. Alvast bedankt voor uw deelname.

(Details van het project)

De volgende paar vragen zijn bedoeld voor het onderzoek en zullen niet worden gebruikt voor commerciële doeleinden.

Soci demografische vragen (~6 vragen)

1) Wat is uw geslacht?

- Mannelijk
- Vrouwelijk
- Wil ik niet zeggen

2) Wat is uw leeftijd?

- 0-99
- Wil ik niet zeggen

(3-6 Project specifieke Soci demografische vragen 4 vragen)

Terugkerende vragen (10 vragen)

7) Welk cijfer geeft u aan de kwaliteit van je kraanwater? 1-10

1 staat voor zeer slecht en een 10 staat voor uitstekend

8) Welk cijfer geeft u voor de service van uw drinkwaterbedrijf?

1 staat voor zeer slecht en een 10 staat voor uitstekend

9) Welke beoordeling geeft u voor de prijs-kwaliteitverhouding van uw kraanwater?

1 staat voor zeer slecht en een 10 staat voor uitstekend

10) Gebruikt u thuis flessenwater?

1 staat voor nooit, 10 staat voor dagelijks

11) In hoeverre bent u het eens met de volgende stellingen over het leidingwater bij u thuis?

- a) Het leidingwater is geurloos
- b) Het kraanwater is helder
- c) Het kraanwater smaakt goed
- d) Het kraanwater is zacht
- e) Het kraanwater is gezond
- f) Ik probeer thuis kraanwater te sparen
- g) Ik wil graag meer kraanwater thuis besparen

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens
- Weet niet

12) *(Voeg verdere terugkerende vragen toe op basis van inzichten in paragraaf 4.2.4.)*

Vragen over klantperspectieven (of andere project specifieke vragen, vraag 17 moet in alle toekomstige vragenlijsten worden opgenomen) (4 vragen)

Lees de volgende groepen verklaringen zorgvuldig door

Stellingen A

- Ik geloof in gezamenlijk werken aan een duurzamere wereld.
- Drinkwaterbedrijven zouden water op een 'groene' en duurzame manier moeten produceren.
- Waterhergebruik in en om het huis of via een tweede leidingnet lijkt mij een goed idee.
- Ieder individu heeft zijn eigen verantwoordelijkheid om duurzaam en zuinig met water om te gaan.
- Informatie en inzicht voor individuele burgers leidt tot bewustwording en daarmee mogelijk duurzamer waterverbruik.

Stellingen B

- Ik ben bezorgd over mijn gezondheid.
- Kraanwater zou zo natuurlijk mogelijk moeten zijn.
- Stoffen, ook in concentraties die veel lager zijn dan waarbij er schadelijke effecten zijn, zouden uit mijn leidingwater moeten worden verwijderd.
- Ik vind het niet wenselijk dat (maatschappelijke) inspanningen van drinkwaterbedrijven, anders dan het leveren van veilig water, aan mij als consument worden doorberekend.
- Soms maak ik me zorgen over de kwaliteit van mijn water in de toekomst en de effecten ervan op mijn gezondheid.

Stellingen C

- Het is mijn overtuiging dat water de absolute basis is en voor iedereen gelijk moet zijn.
- Het is onwenselijk dat huishoudens water tegen extra betaling een betere kwaliteit water of een betere service zouden kunnen inkopen.
- Om de voorziening van voldoende kraanwater in de toekomst te garanderen, ben ik bereid zuinig om te gaan met mijn water.
- Drinkwaterbedrijven hebben ook een taak in de voorziening van water in ontwikkelingslanden.

Stellingen D

- Voor mij is gemak en geen gedoe belangrijk.

- Drinkwaterbedrijven zouden zich moeten beperken tot hun kerntaak: het zorgen voor voldoende, gezond leidingwater van hoge kwaliteit op een zo efficiënt mogelijke manier.
- Over mijn kraanwater wil ik het liefst zo min mogelijk na hoeven denken.
- Ik maak me geen zorgen over mijn kraanwater: ook in de toekomst voorzie ik door technologische vooruitgang geen onoverkomelijke problemen.

17) Welke van de bovenstaande groep uitspraken weerspiegelt het beste hoe u denkt over kraanwater?

- De stellingen A
- De stellingen B
- De stellingen C
- De stellingen D

18) Welke van de bovenstaande groep uitspraken weerspiegelt het minst hoe u zich voelt over kraanwater?

- De stellingen A
- De stellingen B
- De stellingen C
- De stellingen D

19) U geeft aan dat de uitspraken van groep X het beste weergeven hoe u over kraanwater denkt. Kunt u aangeven hoe goed deze uitspraken weergeven hoe u over kraanwater denkt?

- Volledig
- Redelijk goed
- Tamelijk

20) U geeft aan dat de verklaringen van groep X redelijk goed of tamelijk weergeven hoe u over kraanwater denkt. Welke van de 3 resterende groepen stellingen (naast u eerste keuze) geeft het beste weer hoe u over kraanwater denkt?

- ...
- -Geen

21-30 Verdere project specifieke vragen (~... vragen)

Conclusie

Tot slot nodigen we u uit om op te schrijven wat er nog meer in u opkomt over de onderwerpen die in deze vragenlijst aan bod zijn gekomen. Al uw aanvullingen en/of opmerkingen worden zeer op prijs gesteld.

- Geen opmerkingen/aanvullingen
- ...

Dit was het einde van de vragenlijst, bedankt voor het invullen! Als u vragen heeft, kunt u contact met ons opnemen via We hopen van je te horen in de volgende vragenlijst!

Met vriendelijke groet, KWR.