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Public attitudes towards Digital Water Meters for households

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Abstract: In response to droughts, various media campaigns and water saving instructions are released, often however, with only temporary water conservation effects. A promising development is this regard are Digital Water Meters (DWM) that provide near real-time water-use feedback. Despite extensive DWM experience in some water-stressed regions, a profound understanding of the initial attitude towards DWM and message tailoring opportunities are rarely empirically explored. Therefore, we aim to obtain insights into the attitude towards the introduction of DWM and explore opportunities for message tailoring, a topic of extra relevance as we may be on the threshold of a large-scale implementation in many world regions. Messages tailored to (i) normative beliefs and attitudes on drinking water, (ii) water-use activity and (iii) phase of decision-making, seem particularly compatible with DWM. Through a survey (n=1037) in the Netherlands, we observe that 93% of respondents have no objections utility investments in DWM and that 78% would accept a free DWM because of improved leakage detection, lower costs and environmental considerations. Finally, instead of sociodemographic factors, we observed that an attitude-based customer segmentation approach proved an especially useful predictor of respondent's motivation to endorse DWM and forms a promising basis for water conservation message-tailoring strategies.

Keywords: Water Conservation; Customer Segmentation; Pro-Environmental Behaviour; Smart Water Meters; Water-use Feedback

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1. Introduction

Changing precipitation patterns, prolonged droughts and higher temperatures as well as rising water demands due to population growth, irrigations needs and industrial activities, lead to increasing competition for diminishing water resources (Droogers et al. 2012; Wada et al. 2016). People's global water footprint is largely determined by their consumption of, amongst others, meat, energy and manufactured products, the direct use of tap water far less (Hoekstra and Chapagain 2007; Vanham et al. 2019). However, drinking water consumption could put a significant pressure on the regional availability of freshwater resources (Bierkens and Wada 2019). Water utilities are an important entry-point for promoting water conservation and awareness, if only because most people tend to associate mainly their direct tap water consumption with issues of water scarcity (e.g. Russell and Fielding 2010; Willis et al. 2011; Larbey and Weitkamp 2020). To this end, utilities can promote the installation of technical water-saving devices, in some cases increase tariffs or impose water-use restrictions, and at all times initiate public awareness campaigns or focus more on individual customers by applying various tactics to enhance water conservation (Koop et al. 2019). Although a higher average price has resulted in temporary water conservation (e.g. Grafton et al. 2011; Worthington and Hoffman 2008), it can also lead to affordability issues as well as ethical and political sensitivities that in turn have to be addressed through for example volumetric charges and lower minimum tariffs (Pinto 2015). In response to drought crises, a combination of water-use restrictions and awareness campaigns have frequently been applied across the globe. As an immediate effect, roughly 10-25% of water savings can be achieved, primarily because of restrictions on watering lawns and gardens (Kneebone et al. 2018; Michelsen et al. 1999). However, water use often quickly returns to pre-drought levels once the state of emergency has been lifted; i.e., the water saving is not maintained (e.g. Borisova and Useche 2013; Jaeger and Schultz 2017; Syme et al. 2000; Koop et al. 2019). The effectiveness of the more general awareness campaigns are often poorly evaluated and it is particularly difficult to separate the effect of imposed restrictions and awareness raising (Syme et al. 2000). Carefully controlled field experiment conditions are able to observe that more generic knowledge about water or energy conservation tend to provide little incentive for people to change their water consumption habits in the long run (Abrahamse et al. 2005; Kurz et al. 2005; Landon et al. 2018). A promising new and more targeted approach to enhance structural water conservation is now available through the use of water meters, in particular Digital Water Meters (DWM) that provide near real-time water-use feedback (Anda et al. 2013; Steward et al. 2018). Since many households use more water than they are aware of, this strategy of confronting people with their actual water use, a mechanism also referred to as cognitive dissonance, evokes a feeling of discomfort. The difference between the feedback information and how people consider themselves or how people want others to view them, is maintained to provide an incentive to save water (Cialdini et al. 2006; Anda et al. 2013). Such an approach can be largely automated, i.e. is far more efficient, while being equally effective as more expensive face-to-face water conservation interventions (Walther et al. 2011; Tom et al. 2011; Jaeger and Schultz 2017). Various feedback experiments using DWM have resulted in water savings during drought episodes in for example Australia, California or the Mediterranean (e.g. Schultz et al. 2016; Boyle et al. 2013; Liu et al. 2017). Such experiments showed to be especially effective if influencing tactics were applied simultaneously. Two well-known tactics in this regard are comparison with others through social norms (Bernedo et al. 2014; Otaki et al. 2017), as well as message-framing, a tactic which emphasises certain aspects to achieve a desired interpretation by making use of biases in people's information processing like loss-aversion (Zhuang et al. 2018; Katz et al. 2018; Kronrod et al. 2012). Given that in many cases water use tend to return to pre-intervention levels within a few months, many authors emphasize the importance of frequent reminders intervening in or relating to specific water-use behaviours (e.g. Chang, 2013; Middlestadt et al. 2001; Borisova and Useche, 2013; Kurz et al. 2005). Moreover, it has been argued that messages may be more effective if they are aligned with personal motivations, convictions and attitudes towards the recipients drinking water use (Cialdini et al. 2006). Many studies have focussed on the relation of domestic water consumption with socio-economic factors such as income, education, family composition, age, gender, religion and culture (e.g. Beal et al. 2013; Fielding et al. 2012; Laurent and Lee 2018). Segmentation based primarily on people's attitude towards water conservation behaviour is much more limited though it can be as relevant (Brouwer et al. 2019). Hence, this paper aims to explore opportunities for message tailoring, both from a traditional and a modern segmentation approach. In addition, many regions across the globe - including the Netherlands - only recently have started experimenting with DWM. It is rarely empirically explored how people unfamiliar with DWM view this development and what opportunities for message tailoring this may provide. Accordingly, the second aim of this paper is to obtain insights into the public attitude towards the introduction of DWM.

The remainder of this paper is organised as follows: Section 2 provides the methodology. Section 2.1 introduces a modern customer segmentation approach consisting of four perspectives on drinking water that can enable tailored messaging. Section 2.2 elaborates on conducting the large-scale survey regarding public attitudes towards DWM. Section 3 introduces concepts that may be pivotal in enhancing DWM ability to enhance water conservation. As such, section 3.1 provides an overview of mainstream DWM applications. In section 3.2, three forms of tailoring that may be particularly applicable for DWM are identified. Based on online survey results, section 4 characterises attitudes towards water conservation (section 4.1), water efficient household devices (section 4.2) and in particular DWM (section 4.3). The discussion (section 5), starts with discussing the relevance of privacy challenges in DWM applications (section 5.1 and particularly focusses on illustrating a four-step message-tailoring for DWM supported water conservation (section 5.2). We end with the conclusion in section 6.

2. Method

In order to obtain empirically-based insights into the attitude towards the introduction of DWM and explore opportunities for message tailoring, households in the Netherlands have been selected as a case study. With an average tap water consumption of about 120 litres per day, Dutch households are in relation to other industrialised countries relatively water efficient (UNDP 2006). Water availability has not been a major concern for a long time. More recently however, the frequency and length of heatwaves has substantially increased leading to environmental degradation (Rozemeijer et al. 2021) as well as challenges of lower pressure and sometimes discolouration at the tap (Summeren and Blokker 2017; Agudelo-Vera et al. 2020). Moreover, freshwater resources and particularly groundwater resources are under pressure (Stuyfzand and Raat 2010; Lijzen et al. 2014). Accordingly, these development have also led to the cautious introduction of DWM as a means to enhance domestic water conservation. For an enhanced understanding of message tailoring opportunities through DWMs, this study has explored the attitude towards water conservation and DWM themselves through the lenses of both traditional segmentation parameters such as gender and level of education as well as an attitude-based customer segmentation approach, which is introduced in section 2.1. Next, section 2.2 introduces the large-scale survey approach.

2.1. Introduction into customer perspectives on drinking water

Profiling is key in arriving at a message-tailoring framework than can enhance domestic water conservation through the considered use of DWM. Based on the empirical data collected from both a Q-study, encompassing a focus group and more than 30 interviews, Brouwer et al. (2019) distinguish four customer perspectives on drinking water:

(i) the "aware and committed" perspective, characterized by pro-environmental values and collective sustainability ideals;
(ii) the "quality and health concerned" perspective, characterized by a focus on personal preferences and needs, especially regarding personal health;
(iii) the "egalitarian and solidary" perspective, marked by a great sense of solidarity with less-favoured households, low-income countries, and future generations; and
(iv) the "down to earth and confident" perspective, characterised by a great confidence in the responsibility of drinking water utilities, along with a desire not to be bothered about drinking water.

In order to determine the perspective of individual respondents, each perspective was translated into a set of propositions that can be presented in a matrix format, as shown in Table 1 below, accompanied by the question which set of propositions, respectively labelled numbered from A to D, best represents their individual perceptions.

Table 1. Matrix question to elicit the drinking water perspectives of respondents.

A	C
I believe in working collectively towards a more sustainable world. Water utilities should do as much as possible to provide tap water in a 'green' and sustainable way. Every individual has a responsibility to save water and use it wisely. People will be encouraged to use water more wisely if they have access to information about	I believe that water is a human right and everyone should have enough to meet their basic needs. Everyone should have access to the same water services; households should not be able to access better services simply by paying for them. I am prepared to save water now in order to help guarantee sufficient water resources for future generations.

their own water consumption.	
B	**D**
I am concerned about my health, and I think that tap water should be as natural as possible. Substances should be removed from my tap water, even if they are in concentrations much lower than would be considered harmful. Water utilities are mainly responsible for providing me with safe tap water, and I shouldn't have to pay for anything beyond that. Sometimes I worry about the quality of my tap water in the future, and its effects on my health.	I value convenience and minimising hassle. I prefer to think about my tap water as little as possible, and I should be able to use as much as I like. Water utilities are responsible for meeting our water needs in the most efficient and affordable way possible. I'm not concerned about the future of water resources; I believe technological progress will solve most problems.

The minimum number of required customer information that is necessary to profile customers (the above given set of propositions that the respondent most agrees with) benefits a large-scale application of this customer profiling exercise. In addition, it does not require any personal and possibly privacy-sensitive information such as ethnicity, income, level of education or other social-economic parameters.

2.2. Large-scale survey

In order to acquire an empirically-based understanding of the attitude towards DWMs and water conservation, a questionnaire (see supplementary information) has been developed and completed by 1037 respondents in the Netherlands between January and February 2020 which was just before the Covid-19 pandemic affected the Netherlands. The survey was executed in collaboration with CG Selecties, an experienced market research agency. As part of the scoping process, CG Selecties implemented age, gender, educational, and regional quotas based on Dutch population census data. Respondents received a small monetary reward to participate. Table 2 provides the respondents' key characteristics which are representative for the overall Dutch population. The questionnaire consists of a total of 26 questions divided over four categories:

1. Introductory questions related to characteristics listed in Table 2.
2. Questions about attitude towards water conservation
3. Questions about attitude towards water-efficient household devices
4. Questions about attitude towards DWM

Table 2. Descriptive statistics for the survey conducted in the Netherlands (n = 1037).

Characteristic	Category	Survey
(I) Age	18 -24	10 %
	25 – 34	17 %
	35 – 44	17 %
	45 -54	17 %
	55 -64	20 %
	65 ≥	19 %
(II) Gender	Women	50 %
	Men	50 %
(III) Education	High	39 %
	Medium	39 %
	Low	22 %
(IV) Perspective	Quality & health concerned	14 %
	Aware & committed	34 %
	Egalitarian & solidary	29 %

	Down to earth & confident	23 %
(V) Home ownership	Home owner	54 %
	Renting, energy and water bills included	39 %
	Renting, separate energy and water bills	7 %

The total sample and each of the six characteristics (listed in Table 2) were tested for normality (using the independent samples Kolmogorov-Smirnov test). In addition, Levene's test was conducted to validate for the assumption of the homogeneity of variance between groups. Two-tailed ANOVA tests with planned contrasts have been conducted to test the null hypothesis that all groups are equal. The statistical analyses were tested at 0.05 level of significance. An individual sub-group is consistently compared with the total of other sub-groups. For example, the answers to a particular question within the age category 18-24 years was compared with all other age categories. Hence, the statistical analysis enables an exploration of which categories have significantly higher or lower scores with respect to various questions. Average scores were being transformed to round numbers that correspond with score categories (for example: 1=fully disagree to 5=fully agree). In addition, effect size (r) was calculated and interpreted according to Cohen (1988, 1992) with r=0.01 as very small effect (vs), r=0.10 as small effect (s), r=0.30 as medium effect (m), and with r=0.50 as large effect (l) (Cohen 1988, 1992; Field 2009). These statistical analysis only provide additional information to better interpret the survey data and are not applied in an experimental design context.

3. Digital meters' potential for water conservation

Before we delve into the specifics of the public attitude towards DWM and explore opportunities that DWM may offer for tailored messaging, we first provide a brief overview of mainstream applications of DWM (section 3.1). In section 3.2, we discuss three forms of tailoring that may be particularly applicable for household DWM application.

3.1. Digital water meters

Water meters have been installed since the first public water systems were established, back in the 1800's (Crainic 2012). Over the past 70 years, water meters have developed from manual red meters to today's DWMs that store and transmit measurements at specific time intervals (Crainic 2012; Britton 2013). In addition, two-way communicating devices have been launched (March 2017). Utilities can send signals back to the meters to reprogramme meter intervals, leakages in service lines can be identified and near real-time water use feedback can be communicated to households (Crainic 2012). DWMs were first implemented to track water use and identify peak demand hours, days or months (March 2017). In Australia (Queensland) DWMs were used in 2006 and 2007 to design water price structures that reduce peak demands (Cole and Stewart 2011). Similar experiments were conducted in Europe. For example, Loftus et al. (2016) describe the start of a digital metering programme in the South East of England that is implemented to develop a new finance system for water utilities. Another application example is Spain, where DWMs are implemented in houses in Alicante since 2011. Their main purpose is to detect leakages and to read water usage more accurate and remotely. In addition, the information from the DWMs in Alicante is used to get a better understanding of consumption patterns and make demand forecasting models (March 2017). DWMs are also used to provide feedback to users with the intention to encourage them to save water. However, the effectiveness of this type of water-use feedback is debated. Fielding et al. (2013) did an experiment in Queensland providing a group of households with consumption information at one moment in time. As a result these households started to consume less water than the control group. However, these effects disappeared after one year. In addition, this study was executed during a drought, therefore people were already conscious about their water use. This situation may not be comparable to households where DWMs are yet to be introduced. DWMs that track the water use of separate devices are developed to give more insight in the sources of water use. By combining high resolution water meters and data loggers, water flow towards end users in households (like taps, showers and washing machines) can be measured (Britton 2013). Recent developments include smart web services such as the e-Learning platform by Kossieris et al. (2014) that provide insight and teaches end-users how to reduce their water use. These smart online systems also increases the collaboration between users and water utilities towards sustainable supply-demand management (Ribeiro et al. 2015). These pose interesting learning opportunities Overall, most water-use feedback trials result in temporary water saving that return to the pre-intervention levels after about a few months, supporting the finding that water-use feedback as a stand-alone intervention tend to be insufficient to enhance water savings in the long run (e.g. Schultz et al., 2016; Boyle et al., 2013; Liu et al., 2017; Koop et al. 2019).

3.2. Digital meters, tailoring & water conservation – Key considerations

There are good reasons to assume that the advent of DWM technology provides substantial benefits over more traditional water awareness campaigns. After all, households often do not turn information into water conservation actions, unless they can understand it in their own context and interpret how this information can be readily applied in their daily water-use patterns (Giurco et al. 2010). And this is precisely the potential that DWMs can offers, i.e. it can provide insight about people's own water use but even more so, it can provide essential tailored feedback that can be used to improve people’s self-efficacy. In its simplest form tailoring can be defined as making or adapting of something to suit a particular purpose. In the context of domestic water conservation, we observe three routes of tailoring that can be considered in conjunction:

1. *Tailored to normative water conservation beliefs and attitudes*: In fields such as social marketing, health behaviour and risk communication, segmentation strategies have long been applied (e.g. Noar et al. 2007). Messages are typically tailored to people's behavioural patterns, motives, beliefs and socio-economic backgrounds with the aim of influencing people’s behaviour. For this purpose, tailoring is often embedded in communication strategies that apply various behaviour influencing tactics including increasing self-efficacy and message framing and in relation to people’s personal characteristics. The segmentation of such characteristics into different profiles can range from merely identifying general groups using simple characteristics up to micro-targeting based on data mining of for example social media activities (Bostrom et al. 2013). However, especially the latter approach requires the collection, (temporary) storage and analysis of large amounts of personal data which tend to raise issues of privacy and a substantial number of people may consider this as intrusive. In addition, data-demanding tailing approaches such as micro targeting can also be expensive and time demanding for the utility. Therefore tailored-messaging approaches preferably use a minimum amount of customer’s information. Traditional segmentation profiles in the field of water and energy conservation tend to derive most support from these socio-economic factors (e.g. Cominola et al. 2018; Loureiro et al. 2007; Sutterlin et al. 2011; Barr et al. 2005; Issock et al. 2017; Abrahamse et al. 2005). However, socio-economic factors such as income, culture and religion, gender or ethnicity may pose unwanted biases and - perhaps more importantly - peoples believes and attitudes could be more distinctive and therefore more meaningful as a segmentation strategy. Although such attitude-based segmentation methodologies have been developed abundantly in the field of pro-environmental behaviour, ranging from energy conservation (McKinsey Company 2013) to sustainable food choices (Funk et al. 2021) and sustainable tourism (Del Chiappa and Lorenzo-Romero 2015), in the field of drinking water this approach is relatively unexplored. Certainly in relation to residential water conservation such attitude-based segmentation approaches for more persuasive water-use feedback seem promising (Liu et al. 2015). For this reason, this paper builds on the work of Brouwer et al. (2019) on attitude-based segmentation, further elaborated on in section 4.
2. *Tailored to water-use activities*: The effectiveness of tailoring strongly depends on the type of behaviour change that is aimed for. Essentially, a more specific definition of the desired behaviour allows for more targeted messages, a better integration of these tailored-messages with other influencing tactics and enables better monitoring of the behaviour change that is aimed for. Accordingly, domestic water conservation includes different behaviour patterns, each with its own motivations, habits and intentions that do not necessarily need to relate to water but rather relate to personal hygiene, comfort, orderliness (of laundry, the dishes or the garden), or simply people’s thoughtless routines. Domestic water use is largely determined by how people use a limited number of household appliances, namely the shower, washing machine, toilets and garden hose. An example

of tailoring messages to a water-use activity is provided by Kurz et al. (2005). They observed that providing leaflets that included water and energy conservation information had little effect after six months. However, attunement labels that were installed at specific household appliances (including showers, washing machines, clothes dryers, dishwashers, toilets, and outdoor taps) and provided similar information as the leaflet but specified for the appliance in question resulted in a water saving of 23%. Arguably, the attunement labels constantly reminded people to change water-use patterns at the right time, with the right tailored information without requiring additional efforts of the participants (i.e., little need to exercise self-control). In this way, participants took shorter showers, less frequently and more water efficiently used the washing machine, clothes drier, dishwasher, toilet and garden hose.

3. *Tailored to the phase of behavioural change*: Phases of behavioural change can be conceptualised into a detection, decision and implementation phase (Pelletier and Sharp 2008). Each phase involves a specific set of leading processes that affects the way people process information and accordingly how messages can best be framed. In the detection phase, messages aimed at drawing people's attention to water conservation as well as exemplifying the personal relevance may be effective. In this phase, people may be more sensitive to messages that moderately emphasize the negative impact of not saving water (loss frame). Importantly, appeals that elevate feelings of concern (i.e. fear appeal) are only effective if they also provide people with effective means to reduce their concerns (Feng 2016; De Hoog et al. 2007). If this is not the case, people are likely to avoid any further information on the topic. Accordingly, loss-framed messages that also hint to solutions can be effective in convincing people that water is scarce and that they can do something about it (Das et al. 2003). Once people have detected water conservation as a problem, they reach the decision phase where they become more sensitive to messages that help them decide if and how to take action (Pelletier and Sharp 2008). Accordingly, many studies about healthy behaviour indicate that gain-framed messages that emphasize the feasibility of the intended behaviour (e.g. healthy diets) are likely to be persuasive since they are more congruent with people's developed intention to eliminate risks of water scarcity (Pelletier and Sharp 2008). Finally, once people have decided to act, they enter the implementation phase and become more sensitive to messages that provide them with information about how to implement water conservation behaviour in their lifestyle. In this connection it is worth noting that time and again a substantial gap between behaviour-intentions and actual behaviour has been observed. Typically, people lack the mental energy to develop an action plan and stick to it. The formulations of implementation intentions that link goal-oriented responses of where, when and how to act in various critical situations help people to implement their intended behaviour. Such goal-oriented responses can be evoked through simple reminders, cues and messages framed in terms of goals and implementation intentions that people themselves have formulated (Gollwitzer 1999; Sheeran et al. 2005). For example, if one hoses the gardens two days in a row, a message can appear reminding someone of their intention to save water by only watering the garden once every three days. The intention or motivation to save water is an essential pre-condition for this strategy. In case people stick to their implementation intention, repeated positive feedback may be a strong incentive to strengthen the newly formed behaviour pattern (Walton and Hume 2011).

4. Attitudes towards digital water meters – a survey

In this section, we empirically assess people's attitude towards water conservation (section 4.1) and water-efficient household appliances (section 4.2) before we arrive at a characterisation of people's attitude towards DWM (section 4.3). Significant differences in response (i.e., at least $p < .05$) are further described in order to characterise respondents' attitudes. In this characterisation, classical segmentation on parameters such as gender, age, education and income are considered as well as modern customer perspectives on drinking water (see section 2.1 for an explanation).

4.1. Characterising attitudes on water conservation

Overall, Table 3 shows that respondents firmly disagreed with statement 1 "There is enough water in my country, we do not need to reduce water consumption in the next 25", statement 2 "There is no point in saving water if not everyone participates" and statement 3 "Current focus on climate change has been greatly exaggerated". These responses suggest that people believe that the need for water conservation may not be pressing at present, but is important in the mid-and long-term. A closer look at gender and level of education in Table 3 provide interesting observations from a segmentation perspective. Most respondents and in particular high educated respondents ($p < .001$)

also disagreed with statement 2. A similar pattern can be observed when considering climate change and pro-environmental behaviour as a whole. Most respondents and in particular high educated respondents (p < .001) and woman (p < .001) disagreed or fully disagreed with that the current focus on climate change has been greatly exaggerated (statement 3). This may suggest that most respondents recognize the risk of climate change and the importance of water conservation, and regard the latter also as an individual responsibility. That is, provided that that this responsibility does not interfere with people's current lifestyle. At least, that is what the data suggest related to statement 4 "I want to have a fully sustainable lifestyle, even if I have to compromise on comfort". In short, although water scarcity and climate change are generally recognized as important issues, it seems that most people are not necessarily willing to substantially change their lifestyle and compromise on their levels of comfort (like taking shorter showers). Similarly, although respondents are on average somewhat concerned about tap water availability (statement 5), most of them did not agree or disagree with the statements "I do my best to use as little water as possible" and "I want to (further) reduce my water consumption" (statements 6 &7). The latter result becomes more interesting when focusing on the differences between different segments, although the segmentation based on gender and educational background shows relative moderate differences. More specifically, highly educated respondents showed to have a neutral attitude towards this statement (p < .001) whereas low educated people show to have a slightly negative attitude (p < .001) towards further reducing their water consumption (statement 7). Accordingly, high educated respondents tended to be interested in more information about how to save water and water efficient household devices (p < .01; statements 8 & 9).

Table 3. Statements about water conversation in relation to gender and level of education. Statement 1 is scored from 1=no worry to 5=much worry, and statements 2-10 are scored from 1=fully disagree to 5=fully agree.

Statement	Total	Gender		Education			Perspectives			
		Women	Man	High	Medium	Low	Quality & health concerned	Aware & committed	Egalitarian & solidary	Down to earth & confident
1. There is enough water in my country, we do not need to reduce water consumption in the next 25 years[1]	3.84	3.94	3.74	3.92	3.79	3.79	3.79	4.00* t = 1.98 (vs)	4.00** t = 2.94 (vs)	3.42*** t = -4.20 (s)
2. There is no point in saving water if not everyone participates[1]	3.50	3.58	3.43	3.63** t = 2.61 (vs)	3.45	3.38	3.29	3.71*** t = 4.16 (s)	3.59* t = 2.03 (vs)	3.21*** t = -3.78 (s)
3. Current focus on climate change has been greatly exaggerated[1]	3.47	3.62*** t = 3.34 (s)	3.32	3.75*** t = 6.20 (s)	3.31	3.12*** t = -4.10 (s)	3.22	3.89*** t = 8.50 (s)	3.48* t = 2.20 (vs)	2.85*** t = -7.59 (s)
4. I want to live as sustainably as possible, even if I have to compromise on comfort	1.93	1.94	1.92	1.97	1.87	1.96	1.91	2.25*** t = 7.71 (s)	2.05** t = 3.09 (s)	1.33*** t = -10.03 (m)
5. Worried about tap water availability	2.79	2.78	2.81	2.78	2.78	2.84	2.72*** t = -4.30 (s)	2.81	2.76	2.84*** t = 8.26 (s)
6. I do my best to use as little water as possible	2.77	2.78	2.76	2.74	2.76	2.85	2.77	2.86** t = 2.62 (vs)	2.89*** t = 3.28 (s)	2.50*** t = -4.96 (s)
7. I want to (further) reduce my domestic water consumption	2.59	2.61	2.56	2.69*** t = 3.94 (s)	2.56	2.45** t = -2.64 (vs)	2.58	2.85*** t = 7.28 (s)	2.57	2.23*** t = -5.64 (s)
8. I want more information about how to save water at home	2.41	2.40	2.42	2.48	2.42	2.27	2.36	2.63*** t = 6.03 (s)	2.46	2.05*** t = -5.33 (s)
9. I would like to have more information about water efficient household devices[1]	2.35	2.35	2.34	2.42** t = 3.04 (vs)	2.34	2.23* t = -2.29 (vs)	2.42	2.57*** t = 4.19 (s)	2.34	1.99*** t = -5.05 (s)

* p < .05; ** p < .01; *** p < .001. [1] Statements 3, 5 and 9 are inversed.

Beyond gender and level of education, attitudes towards water conservation have been explored based on customer perspectives on drinking water (Table 3). Respondents profiled as "aware & committed" significantly more often indicate that they do their best to use as little water as possible ($p < .01$) and (further) want to reduce their water consumption ($p < .001$; statements 6 & 7). Accordingly, they more often disagree with statement 2 that there is no point in saving water if not everyone participates ($p < .001$) and that there is no need to reduce water consumption in the next 25 years because there is enough water in their country ($p < .05$; statement 1). These finding are in line with some central element of this profile, in which sustainable behaviour with respect to nature and humans is highly valued (Brouwer et al. 2019). On the other end, respondents profiling as "quality & health concerned" and in particular respondents profiled as "down to earth & confident" show less willingness to save water. Down to earth & confident respondents tend to disagree with statement 6 "I do my best to use as little water as possible" ($p < .001$) and they generally do not want to (further) reduce their water consumption (statement 7; $p < .001$). Accordingly, they agree with statement 1 that we do not need to reduce water consumption in the next 25 years since we have enough water in our country ($p < .001$). This attitude may very well relate to a strong belief in technological progress this perspective has (Brouwer et al. 2019). While on average respondents disagreed with the statement that there is no point in saving water if not everyone participates (statement 2), down to earth & confident respondents replied neutrally ($p < .001$). Accordingly, down to earth & confident respondents had little worry about water availability ($p < .001$; statement 5). Finally, respondents profiled as "egalitarian & solidary" showed the highest agreement with statement 1 "there is enough water in my country, we do not need to reduce water consumption in the next 25 years" ($p < .01$). They also consider themselves as responsible for addressing water scarcity issues as they significantly disagreed with statement 2 "there is no point in saving water if not everyone participates" ($p < .05$). The finding that these respondents demonstrate responsibility for the water availability in the future indicates solidarity for future generation and is therefore completely in line with expectations (Brouwer et al. 2019). Respondents profiling as "egalitarian & solidary" also more often indicate that they try to do their best to use as little water as possible (statement 6; $p < .001$). Again, a similar pattern can be observed when considering climate change and pro-environmental behaviour as a whole. Respondents profiled as "aware & committed" and "egalitarian & solidary", significantly more disagreed with statement 3 "the current focus on climate change has been greatly exaggerated" ($p < .001$ and $p < .05$ respectively). On the contrary, respondents profiled as "quality & heath concerned" and "down to earth & confident" ($p < .001$) replied neutral to this statement. Although most respondents think that focus on climate change is not aggregated, most of them are not willing to compromise on their levels of comfort in order to live more sustainably (statement 4). In particular, down to earth & confident respondents fully disagreed ($p < .001$). Though scoring above average, the "aware & committed" ($p < .001$) and the "egalitarian & solidary" ($p < .001$) profiled respondents, still disagreed with compromising on comfort. Most respondents have little interest to receive more information about water-efficient household appliances. Indeed, on average respondents disagreed to the statement 8 "I want more information about how to save water at home". Highly educated respondents however tend to be more interested in receiving further information about water saving household devices ($p < .001$; statement 9). "Down to earth & confident" respondents replied particularly negative to receiving more information ($p < .001$) while "aware & committed" respondents replied more positively ($p < .001$). It is likely that respondents would apply much more positive to receiving more information about how to save water this is tailored to their own water consumption patterns. Although gender and in particular level of education are to some level related to respondent's interest and willingness to reduce their water consumption, customer perspectives on drinking water show to be more strongly related. In other words, these customer perspectives corresponded with more pronounced differences in attitudes towards water conservation.

4.2. Characterising owners of water-efficient household appliances

Beyond merely attitudes towards water conservation, an important question is who already owns water-efficient household appliances and for which reasons (Table 4 and Table 5). In our survey, 50.1% of the respondents indicate to have a water-saving shower head and 56% indicate to have a water-efficient washing machine. Home owners have significantly ($p < .001$) more often (64%) a water-efficient washing machine. On the contrary, only 40.8% of the respondents that rent and have to pay separately for water and energy, have a water-efficient washing machine ($p < .01$). Only 18% of the respondents have a water saver at their kitchen sink. "Aware & committed" respondents have the most water-efficient devices already installed. In fact, 57% of them have a water-saving shower head which is significantly more than other customer groups ($p < .01$). Interestingly, when asked about the motivation to obtain water-efficient devices most people, and in particular women ($p < .001$), more often tend to choose environmental motives over financial ones. In particular "aware & committed" ($p < .001$) and "egalitarian & solidary" respondents ($p < .001$) choose environmental motives over financial ones. In contrast, the "down to earth & confident" respondents significantly ($p < .001$) more often chose the financial over the environmental motivation.

Table 4. Percentage of respondents indicating to have a (i) water saving shower head, (ii) water saver at kitchen sink and water-efficient washing machine.

		Water saving shower head	Water saver at kitchen sink	Water-efficient washing machine
	Total	51	18	56
Gender	**Women**	47	15	57
	Men	54	21	56
Education	**High**	49	17	54
	Medium	53	20	58
	Low	49	16	57
Perspective	**Quality & health concerned**	49	17	55
	Aware & committed	57** t = 2.61 (vs)	19	57
	Egalitarian & solidary	49	19	60
	Down to earth & confident	46	16	51
Rent/owner	**Home owner**	55* t = 2.16 (vs)	18	64*** t = 5.13 (s)
	Rent incl. water & energy bill	45	18	49
	Rent excl. water & energy bill	49	18	41** t = -2.64 (vs)

* p < .05; ** p < .01; *** p < .001.

Table 5. Motivations to have water saving household appliances (n=636) split into environmental and financial motivations. Scores range from 1 to 4 points, with 4 = very important motivation, 3 = important motivation, 2 = not important motivation, 1 = totally not important motivation.

		Environmental motive	Financial motive
	Total	2.32	2.26
Gender	**Women**	2.41*** t = 4.03 (s)	2.31* t = -2.04 (vs)
	Men	2.23	2.21
Education	**High**	2.35	2.24
	Medium	2.29	2.28
	Low	2.33	2.23
Perspective	**Quality & health concerned**	2.30	2.33
	Aware & committed	2.45*** t = 4.75 (s)	2.23
	Egalitarian & solidary	2.38*** t = 2.63 (vs)	2.27
	Down to earth & confident	2.01*** t = -6.18 (s)	2.22
Rent/owner	**Home owner**	2.30	2.22
	Rent incl. water & energy bill	2.36	2.34
	Rent excl. water & energy bill	2.17	2.13

* p < .05; ** p < .01; *** p < .001.

4.3. Characterising attitudes towards digital water meters

If the DWMs are offered for free, 78% of the respondents state that they are likely to accept them. About 15% of the respondents are likely to refuse this offer, and 7% is neutral. As presented in statement 1 of Table 5, this results in an (average probability score of 7.16 on a 1-to-10 scale). "Aware and committed" respondents would accept the offer (82%) significantly more often ($p < .001$) while "down to earth and confident" respondents are somewhat less likely to accept it (71%; $p < .01$). Also high educated respondents would accept the offer more often (82%; $p < .05$). Furthermore, almost all respondents (93%) did not disagree with their water utility investing in DWM (statement 2). Women ($p < .01$) and high educated respondents ($p < 0.05$) are slightly more positive to this idea. "Aware & committed" respondents tend to agree more often with the idea that water utilities invest in DWM ($p < .001$). On the contrary, "down to earth & confident" and "egalitarian & solidary" respondents more often disagreed. The latter, mainly because of affordability considerations and not so much because they do not see the benefits of investing in DWM. With respect to interest in receiving information about DWM devices (statement 3), the "down to earth & confident" respondents replied negative ($p < .001$). Home owners have strong opinions to either accept or refuse a DWM, which suggest that home-ownership results in more opinionated responses towards the installation of DWM.

Despite the overall acceptance for installing DWM, our data suggest that most respondents consider the advantages of a DWM not that important (see statements 4.1 to 4.7). Their attitude can therefore be described as 'There is no harm in accepting a free DWM'. Nevertheless, 53% of respondents considered lower costs, 34% environmental arguments and 33% leakage detection as very important advantages (note that Table 6 reports percentage of respondents considering advantages important and very important). On the other end, arguments such a better understanding of water-use patterns (23%) or receiving water-saving tips (20%) were less frequently mentioned advantages. Notably, the advantage of not having to provide meter readings to the water utility (because this is done automatically by the DWM) was the least mentioned as very important motivator (19%). Interestingly, home owners have slightly more objections to a free offer of a DWM ($p < .05$; statement 4.1). The environmental argument was significantly more mentioned by women ($p < .001$). The environmental arguments also showed significant and relevant differences between customer profiles. The "aware & committed" considered this as the primary advantage and on average indicated it as important ($p < .001$). The "quality and health concerned" and "egalitarian and solidary" respondents also selected the environment as their primary advantage (though somewhat less important) whereas the "down to earth and confident" respondents considered this as one of the least important advantage and rated this motivation as not important ($p < .001$). They also indicated that receiving water saving tips was the least important argument to accept the free offer of a DWM ($p < .001$).

As mentioned about 15% of the respondents are likely to refuse a free offer of the DWM. Arguments for refusing a free DWM (statements 5.1 to 5.5) mostly relate to a doubt about the reliability of the water meter (mentioned by 22% amongst the respondents that would refuse and mentioned by 3% of all respondents). This disadvantage is significantly more mentioned by "down to earth and confident" customers ($p < .05$). This result is somewhat unexpected, given that a strong belief in technological progress and convenience are important characteristic of this perspective (Brouwer et al. 2019). Speculatively, this may suggest that respondents with the "down to earth & confident" perspective regard the provision of DWM beyond the core task of drinking water utilities, an assumption that seems to be supported by the finding that these respondents are relatively reserved with the idea of drinking water utilities investing in DWM. Also respondents with lower education level, more frequently questioned the reliability of the DWM ($p < .05$). The second most selected argument to refuse the free offer of a digital meter was the worry that data would get in the hands of the wrong people (17% amongst refusers and 2% for all respondents). Interestingly, "egalitarian & solidary" respondents had significantly more worries about this matter ($p < .05$). Lack of information was only for 10% an argument for refusing the offer. Accordingly, most respondents were indifferent to receiving more information about DWM. In this respect highly educated respondents tend to be more interested in receiving further information ($p < .001$).

When asked whether the respondents are willing to pay for the DWM (statement 6), 68% replied with no, 7% replied with an unconditional yes and 25% replied with yes but only if the water utility makes an interesting offer (20%) or if I can have the option to choose whether they share their data with the water utility or not (6%). Respondents that own a digital energy meters were significantly ($p < 001$) more likely to accept a free offer for a DWM. 88% of them would accept it whereas only 69% of the people that did not own a digital energy meter would accept the free offer. Familiarity with a digital energy meter therefore makes a difference in favour of also installing a DWM.

Table 6. *Public attitudes towards DWM.* Statement 1 is the probability of accepting free DWM ranges from 1=unlikely to 10 = very likely. Statements 2 and 3 range from 1=fully disagree to 5=fully agree. The advantages (4) are in percentages replying it as important or very important. The percentage of respondents mentioning each disadvantages (5) is provided for all 1037 respondents and in between breakages are the responses of the 155 DWM refusers. Statement 6 shows the percentage willing to pay for DWM.

			Gender		Education			Perspective				Rent/owner		
Statements		**Total**	**Women**	**Men**	**High**	**Medium**	**Low**	**Quality & health concerned**	**Aware & committed**	**Egalitarian & solidary**	**Down to earth & confident**	**Home owner**	**Rent incl. energy & water bill**	**Rent excl. energy & water bill**
1 Probability of accepting free DWM		7.16	7.11	7.21	7.39* t = 2.07 (vs)	7.03	7.00	6.99	7.59*** t = 3.72 (s)	7.21	6.57** t = -3.06 (vs)	7.07	7.32	6.99
2 It is a good idea that my water utility invests in DWM		2.86	2.95** t = 2.72 (vs)	2.78	2.95* t = 1.98 (vs)	2.79	2.85	2.74	3.04*** t = 4.47 (s)	2.94* t = -2.06 (vs)	2.59*** t = -4.24 (s)	2.89	2.87	2.97
3 I want more information about DWM benefits		2.30	2.34	2.41	2.43** t = 3.06 (vs)	2.25	2.16* t = -2.03 (vs)	2.29	2.48	2.30	2.04*** t = -3.68 (s)	2.36	2.33	2.26
4 Advantages free DWM	**4.1 No objections - Many benefits**	56	58	54	62	55	48	50	62	59	48	54* t = -2.01 (vs)	60	59
	4.2 No more reporting	40	40	40	44	40	34	37	41	44	37	37	44	45
	4.3 Understanding of own water use	49	51	47	53	49	43	45	54	52	41	45	54	51
	4.4 Lower costs	53	56	49	58	52	46	48	59	56	44	50	57	51
	4.5 Leakage detection	54	57	50	58	53	47	48	59	57	45	51	57	54
	4.6 Good for the environment	53	57*** t = 3.64 (s)	49	58	52	45	48	61*** t = 4.28 (s)	57* t = 2.12 (vs)	40*** t = -6.87 (s)	50	58	51
	4.7 Receiving tips for water conservation	49	51	46	51	48	44	41	56	51	39*** t = -2.71 (vs)	45	53	51
5 Disadvantages free DWM	**5.1 No benefits**	9 *(59)*	7 *(52)*	10 *(66)*	9 *(64)*	10 *(56)*	8 *(60)*	8 *(67)*	7 *(63)*	7 *(47)*	14 *(65)** t = -2.57 (vs)	10 *(66)** t = -2.02	7 *(55)*	5 *(36)*

											(vs)		
5.2 Lack of information	1 *(10)*	1 *(4)** t = 2.37 (vs)	2 *(15)*	2 *(12)*	2 *(10)*	1 *(7)*	1 *(11)*	1 *(8)*	2 *(12)*	2 *(10)*	2 *(10)*	1 *(10)*	1 *(9)*
5.3 No personal data to water utility	2 *(15)*	2 *(11)*	3 *(19)*	2 *(15)*	2 *(19)*	1 *(7)** t = 2.03 (vs)	3 *(22)*	1 *(10)** t = 2.00 (vs)	2 *(12)*	4 *(20)*	2 *(12)*	3 *(25)** t = -2.51 (vs)	0 *(0)**** t = 4.80 (s)
5.4 No personal date to malicious actors	2 *(17)*	2 *(18)*	2 *(15)*	2 *(21)*	3 *(12)*	1 *(21)*	2 *(17)*	1 *(10)** t = 2.01 (vs)	4 *(30)** t = -1.97 (vs)	0 *(10)*	2 *(15)*	3 *(23)** t = -1.99 (vs)	0 *(0)**** t = 5.00 (s)
5.5 Doubt reliability of DWM	3 *(22)*	3 *(19)*	4 *(25)*	3 *(15)*	2 *(32)*** t = 3.17 (s)	3 *(10)** t = -2.44 (vs)	3 *(22)*	2 *(17)*	3 *(20)*	6 *(27)** t = -1.98 (vs)	3 *(21)*	4 *(27)** t = -1.96 (vs)	0 *(0)**** t = 5.86 (s)
6 Willingness to pay for DWM	39	39	38	42	38	32	43	45* t = 1.98 (vs)	37	26** t = -2.92 (vs)	40	41	39

* p < .05; ** p < .01; *** p < .001.

5. Discussion

Various studies indicate that salient real-time water-use feedback through DWM in itself can enhance water short-term savings, but that this technique is inadequate to improve water conservation in the long term (e.g. Nguyen et al. 2018; Boyle et al. 2013). In this paper, we identified three forms of tailoring that can support more persuasive DWM water-use feedback messages: messages tailored to (i) to people's set of normative beliefs, motives and attitude towards water conservation, (ii) water-use activities and (iii) phase of decision-making. Next, we empirically-explored the attitude towards DWM amongst households that are not yet familiar with them. Section 5.2 will outline a four-step approach to account for the key findings of this study to be adopted in research and practice. However section 5.1 first briefly reflects on privacy aspects associated with DWMs.

5.1. Privacy

In our survey, privacy concerns about the DWMs where observed to be of low concern for most respondents. To the opinion of the authors this is, however, no reason to disregard this issue. Indeed, the deployment of DWM is sensitive to privacy risk if data protection rights are not well accounted for (Rubio et al. 2017). One of these concerns is determination of personal behaviour patterns by external companies or the government. This can lead to companies using the behavioural information in specific campaigns or governments taxing specific uses (Espinosa and Lavrijssen 2018). Another privacy concern is target home invasions. After all, the data indicates when people are not at home (Salomons et al. 2020). Our survey results show that only 6% of the respondents that would refuse a DWM do that because they are afraid the data will be misused by third parties. However, such number can easily change over time depending on privacy issues that may occur in society. In relation to DWMs there are three important factors to take into account (TNO 2012):

1. Data granularity, the amount of measurements in a time unit. When the granularity is high, information about people's behaviour is exposed.
2. Data actuality, more recent information gives information about recent behaviour.
3. Data quantity, when more data is available better behavioural patterns can be found.

DWMs give access to detailed information about a households' water-use patterns with time-intervals of only a few seconds or minutes. When personal behaviour (daily routines) can become available to third persons, privacy can be at stake. In the energy sector, more extensive research and experience regarding digital meters has been acquired (Zabkowski and Gajowniczek 2013). From these experiences several preconditions to preserve the privacy of end users can be identified. Utilities not only need to save their data in a highly protected environment, but employees who can access this data also need to sign a privacy declaration first (Zabkowski and Gajowniczek 2013). In addition, explicit agreement from every household in a building with DWMs is necessary (Espinosa and Lavrijssen 2018). This is especially important when several households live in a rental building with one (external) owner. For utilities it is valuable to gain frequent (e.g. hourly) data and save this for several years to do behavioural research studies. This might be more data than necessary for leakage detection and feedback to customers. Therefore, it is important that households agree with the period of time that data will be stored and the measurement frequency (Espinosa and Lavrijssen 2018).

5.2. Message-tailoring for DWM supported water conservation – a four-step approach

As substantiated in this paper, messages tailored to water-use activities - particularly the most water consuming activities of showering, watering the garden, cloth washing and dishwashing – can provide a strong incentive to reduce water consumption because they constantly remind people to change water-use patterns at the right time, with the right tailored information and without requiring additional efforts (Kurz et al. 2005). Therefore, a more integrated approach may be explored for DWM that track the water use of separate household devices. Such meters are more expensive but also pose more opportunities to enhance water conservation. Four steps are outlined that specifically accounting for decision-making phase, water-use activities and a person's perspective on drinking water:

- *Step I: Evoke water conservation awareness:* Many world regions such as the Netherlands are just starting to introduce DWMs in households to enhance water conservation. Therefore most individuals are not familiar with DWM. Accordingly, many people might not be well-acquainted with water scarcity issues, have little knowledge on how much water they use and how to reduce their water consumption (Brouwer et al. 2021). It is essential to account for this when a utility invests in DWM for domestic water conservation. In the context of limited prior knowledge and (in many cases) limited problem awareness, people tend to be more receptive to moderately loss-framed messages such as "*If we do not reduce our water consumption, prices will go up and our environment is harmed*". Importantly, messages that also hint to solutions may trigger people's interest in the topic. These messages are likely particularly effective if the ease of water conservation is emphasized by simple tips and advice. Primary aim of these messages is that people are introduced to the issue and some level of awareness is evoked which will be helpful in step 2. Communications at this stage can vary from posters, folders, radio or social media. Water utilities may also want to focus on specific areas were they have observed water over-demand that may have led to issues related to loss of pressure or tap water discolouration. In these places DWM supported water conservation is most advantageous.
- *Step II: Emphasizing feasibility of water savings with digital meter:* After triggering people's water conservation awareness, the DWM can be introduced as a more advanced way of supporting people in water conservation at home. People should get the feeling that new water saving behaviour patterns are rather easy to carry out with the support of a DWM. Like with water conservation itself, it should be emphasized that getting and using DWM does not require much time or effort. An offer to a DWM may be given using a default tactic. In addition, timing is also of essence. Offering a DWM during heatwaves or more generally during summer can be advantageous since people are more reminded of the impacts of drought via personal experiences or in the news. A utility could also give people a few weeks reflection period to consider the DWM offer. Such a strategy would help to select only people who have developed a more intrinsic motivation to reduce their water consumption.

- *Step III: Anticipating people's perspective on drinking water:* Once people have decided to endorse the DWM, it is helpful to understand how this decision relates to the existing values and conviction in order to support them in implementing in implementing water conservation behaviour. The data of this study suggests that such a normative based segmentation is a more telling indication of people's attitudes towards water conservation and DWM than more classical segmentation parameters such as gender or education. Through the answer on a single question (Table 1) people can relatively simply be profiled according to one of four perspectives on drinking water. In this way, no additional data mining is necessary, nor the transfer of additional personal data or socio-economic characteristics. The results show that respondents classifying as "aware & committed" are more likely to install a free DWM and is most interested in water-use feedback through in-home displays, because of their internal motivation to live more sustainably. Given the characteristics of this perspective, messages tailored to enhance their self-efficacy to live sustainable and that relate to their concerns about environmental degradation are likely most effective. "Down to earth & confident" respondents on the other hand, are less likely to install a free DWM and consider environmental reasons as one of the least important arguments. They would install a DWM primarily because it can lower costs and detect leakages. Accordingly, the installation of a DWM seems interesting for them but tailored messages focussed on changing behaviour (i.e., shorter showers) seem less effective. Arguably, the potential cost savings (related to the conservation of water and energy used for heating the water) can make a convincing argument for this group. In addition, the cost benefits of water-saving devices can be most appealing, in particular, it has to be emphasised that these devices do not result in a loss of comfort or require additional efforts. "Egalitarian & solidary" respondents are sensitive to similar message tailoring as "aware & committed" respondents. However, they focus more on the principle that water has to be affordable for all. For this reason, it seems safe to assume that messages focussed on the reduced societal costs of prevented environmental degradation and infrastructure augmentation are more persuasive for this group. Accordingly, emphasizing the need to reduce water consumption in order to ensure continued service delivery for everyone including future generations may appeal to them. Finally, for "quality & health" concerned respondents are hardly persuaded by messages tailored to environmental, solidarity or financial values. They are primarily concerned about their health. Their interests in DWM or water conservation is slightly below average. Tailored messages for this group could be focussed on the possible mental health benefits of taking low-temperature (and therefore shorter) showers (Buijze et al. 2018).
- *Step IV: Tailored reminders of implementation intentions*: A water conservation intention can be considered a prerequisite for DWM adoption. However, as most people know, good intentions - such as New Year Resolutions like going to the gym, stop smoking or adopting healthier diets - by no means guarantee sustained behaviour change. This intention-behaviour consistency gap is well-known in literature (Sheeran and Webb 2016) and it is this gap that can be addressed with the support of DWM. Based on a water-saving intention, a goal can be formulated which is often nothing more than a translation of noncommittal desires into a commitment that mentally obligates someone to realise the goal. However, people's knowledge of their own water-use patterns tend to be rather low. Often an overall water use - for example 120 litres/person/day in the Netherlands - can be provided which often tends to form an unintended anchor for formulating a water conservation goal. A simple example of such an anchored goal is: reduce my water consumption from 120 litres a day to 100 litres a day. Although goal-specificity and goal-proximity are an important attribute to goal implementation, the lack of prior knowledge of someone's water-use patterns hamper the setting of attainable and specific goals. Interestingly, DWM can provide this prior knowledge that is invaluable in goal setting and as a consequence can greatly contribute to water use reductions. Based on a

water consumptions related to (i) showering, (ii) watering the garden and (iii) dishwasher and washing machine, more specific goals can be formulated that directly relate to specific behaviour. Since users have a behaviour intention, the formulation of promotion-framed goal that focusses on positive outcomes instead of framed as avoiding negative outcomes can be supported as well to enhance goal attainment. In order to fulfil such (for most people) rather complex water-saving goals, it is important to specify when, where and how to respond in a range of foreseeable situations in a way that lead to goal attainment. This is known as implementation intentions (Gollwitzer 1999). By formulating a set of implementation intentions (i.e., When situation x arises, I will perform response y), anticipated critical situation are linked to goal-directed responses. In this way, various situational decisions that require a lot of willpower or mental energy are not required. In fact, after numerous of similar situations such goal-oriented actions may even occur without much thought and become more automatic and effortless. DWM and implementation intentions can reinforce each other in the pursuit of water conservation behaviour.

6. Conclusion

The goal of this study is to obtain insights into the attitude towards the introduction of Digital Water Mater (DWM) and explore opportunities for message tailoring. We conclude that messages tailored to (i) to people's set of normative beliefs, motives and attitude towards water conservation, (ii) water-use activities and (iii) phase of decision-making, are particularly promising in enhancing water conservation behaviour. In this context, DWMs that track the water use of separate household devices provide ample opportunity to support people in fulfilling their water conservation intentions. Through a large-scale survey in the Netherlands, we observe that 93% of respondents have no objections if their utility invests in DWM and 78% would accept a free DWM because of improved leakage detection, lower costs and environmental considerations. Interestingly, not having to report meter readings was the least considered advantage. In addition, people that already owned a digital energy meters are more likely to accept a free DWM offer. Beyond socio-economic segmentation approaches, we observed that an attitude-based segmentation may be more promising approach to appeal to a person's motivation to endorse DWM and forms a promising basis for message-tailoring strategies. As such, frequent tailored water-use feedback seem most feasible for respondents classifying as "aware & committed" perspective on drinking water (emphasizing joint sustainability efforts) or "egalitarian & solidary" perspective on drinking water (emphasizing equality for disadvantaged people now and in the future). The other two perspectives that are focused on comfort (down to earth & confident) and health and water quality (quality & health concerned) are primarily interested in DWM for leakage detection and cost reductions. Finally, the deployment of more advanced DWMs that that track the water use of separate household devices may also require a more advanced strategy to support the water conservation intention of households in regions most affected by droughts or drinking water supply issues. On the basis of our work, we propose to this end an advanced strategy can be summarised in four steps:

I. Evoke water conservation awareness
II. Emphasizing feasibility of water savings with digital meter
III. Anticipating people's perspective on drinking water
IV. Tailored reminders of implementation intentions

References

Abrahamse, W.; Steg, L.; Vlek, C.; Rothengatter, T. A review of intervention stuies aimed at household energy conservation. *J Envion Psychol* **2005,** *25*, 273-291

Agudelo-Vera, C.; Avvedimento, S.; Boxall, J.; Creaco, E.; de Kater, H.; Di Nardo, A.; Djukic, A.; Douterelo, I.; Fish, K. E.; Iglesias Rey, P. L.; Jacimovic, N.; Jacobs, H. E.; Kapelan, Z.; Martinez Solano, J.; Montoya Pachongo, C.; Piller, O.; Quintiliani, C.; Rucka,

J.; Tuhovcak, L.; Blokker, M. Drinking Water Temperature around the Globe: Understanding, Policies, Challenges and Opportunities. *Water* **2020**, 12(4), 1049.
Anda, M.; Brennan, J.; Paskett, E. Combining smart metering infrastructure and a behavioural change program for residential water efficiency: results of a trial in the southern suburbs of Perth, Western Australia. *Water J Aust Water Assoc* **2013,** *40*,66-72
Barr, S.; Gilg, A.W.; Ford, N. The household energy gap: Examining the divide between habitual- and purchase-related conservation behaviour. *Energy Policy* **2005,** *33*,1425-1444
Beal, C.D., Stewart, R.A., Fielding, K. A novel mixed method smart metering approach to reconciling defferences between perceived and actual residential end use water consumption. *J Clean Prod* **2013,** *60*,116-128
Bernedo, M.; Ferraro, P.; Price, M. The persistent impacts of norm-based messaging and their implications for water conservation. *J Consum Policy* **2014**, *37*,437-452
Bierkens, M.F.P.; Wada, Y. Non-renewable groundwater use and groundwater depletion: a review. *Environ. Res.* **2019**, *14*, 063002
Borisova, T.; Useche, P. Exploring the effects of extension workshops on household water-use behaviour. *HortTechnology* **2013**, *23*, 668-67
Bostrom, A.; Böhm, G.; O'Connor, RE. Targeting and tailoring climate change communications. *Wiley Interdisciplinary Reviews: Climate Change*, **2013**, *4*, 447-455
Boyle, T.; Giurco, P.; Liu, A.; Moy, C.; White, S.; Stewart, R. Intelligent metering for urban water: a review. *Water* **2013**, *5*:1052-1081
Britton, T.C.; Steward, R.A.; O'Halloran, K.R. Smart metering: enabler for rapid and effective post meter leakage identification and water loss management. *Journal of Cleaner Production* **2013**, *54*, 166-176
Brouwer, S.; Pieron, M.; Sjerps, R.; Etty, T. Perspectives beyond the meter: a Q-study of Modern segmentation of drinking water customers. *Water Policy* **2019**, *21*, 1224-1238
Brouwer, S.; Van Aalderen, N.; Koop, S.H.A. Assessing tap water awareness: the development of an empirically-based framework. *PLOS One* **2021** (unpublished; manuscript in preparation)
Buijze, G.A.; Sierevelt, I.N.; van der Heijden, B.C.J.M.; Dijkgraaf, M.G.; Frings-Dresen, M.H.W. Correction: The Effect of Cold Showering on Health and Work: A Randomized Controlled Trial. *PLOS ONE* **2018,** *13*, e0201978
Chang, G. Factors influencing water conservation behaviour among urban residents in China's arid areas. *Water Pol.* **2013**, *15*, 691-704.
Cialdini, R.B.; Demaine, L.J.; Sagarin, B.J.; Barrett, D.W.; Rhoads, K.; Winter, P. Managing social norms for persuasive impact. *Soc Influ* **2006,** *1*, 3-15
Cohen, J. Statistical power analysis for the behavioural sciences. 2nd ed. Academic Press, New York, United States, 1988
Cohen J. A power primer. Psychological bulletin. 1992, Jul;112(1):155-9. doi: 10.1037//0033-2909.112.1.155
Cole, G.; Steward, R.A. Smart meter enabled disaggregation of urban peak water demand: precursor to effective urban water planning. *Urban Water Journal* **2011**, *10*:3, 174-194
Cominola, A.; Spang, E.S.; Giuliani, M.; Castelletti, A.; Lund, J.R.; Loge, F.J. Segmentation analysis of residential water-electricity demand for customized demand-side management programs. *Journal of Cleaner Production* **2018**, *172*, 1607-1619
Crainic, M. *A short history of residential water meters part III Improvements of water meters*, Proceedings of the Installations for Buildings and Ambiental Comfort Conference XXI- edition Timisoara, Romania, 2012.
Das, E.H.J.; de Wit, J.B.F.; Stroebe, W. Fear appeals motivate acceptance of action recommendations. *Personality and Social Psychology Bulletin* **2003**, *29*, 650–664
De Hoog, N.; Stroebe, W.; de Wit, J.B.F. The impact of vulnerability to and severity of health risk on processing and acceptance of fear-arousing communications: A meta-analysis. *Review of General Psychology* **2007**, *11*, 258–285
Del Chiappa, G., Lorenzo-Romero, C. Environmental issues to profile the consumers' attitude: A latent segmentation approach. *Environmental Engineering and Management* **2015**, *10*, 2449-2457
Droogers, P.; Immerzeek, W.W.; Terink, W.; Hoogeveen, J.; Bierkens, M.F.P.; van Beek, L.P.H.; Debele, B. Water resources trends in Middle East and North Africa towards 2050. *Hydrol Aerth Syst Sci*, **2012** *16*, 3101-3114
Espinosa, B.; Lavrijssen, S. Exploring the regulatory challenges of a possible rollout of smart water meters in the Netherlands. *Competition and Regulation in Network Industries* **2018,** *19(3-4)*, 159–179
Feng, M.F. Impact of fear appeals on pro-environmental behavior and crucial determinants. *International Journal of Advertising* **2016**, *35*, 74-92
Field, A. *Discovering statistics using SPSS*. 3rd ed: SAGE Publications Ltd , 2009
Fielding, K.S.; Russell, S.; Spinks, A.; Mankad, A. Determinants of household water conservation: the role of demographic, infrastructure, behaviour, and psychosocial variables. *Water Resour Res* **2012,** *48*, W10510
Fielding, K.S.; Spinks, A.; Russell, S.; McRea, R.; Stewart, R.; Gardner, J. An experimental test of voluntary strategies to promote urban water demand management. *Journal of Environmental Management*, **2013,** *114*, 343-351.
Funk, A.; Sütterlin, B.; Siegrist, M. Consumer segmentation based on Stated environmentally-friendly behavior in the food domain. *Sustainable Production and Consumption* **2021** *25*, 173-186
Giurco, D.P.; White, S.B.; Stewart, R.A. Smart Metering and Water End-Use Data: Conservation Benefits and Privacy Risks. *Water* **2010**, *2*, 461-467
Gollwitzer, P.M. Implementation intentions: Strong effects of simple plans. *American Psychologist* **1999**, *54*, 493–503
Grafton, R.Q.; Ward, M.B.; To, H.; Kompas, T. Determinants of residential water consumption: evidence and analysis from a 10-country household survey. *Water Resourc Res* **2011,** *47*, W08537
Hoekstra, A.Y.; Chapagain, A.K. Water footprints of nations: water use by people as a function of their consumption pattern, *Water Resources Management* **2007**, *21*, 35-48

Issock, P.B.I.; Mpinganjira, M.; Duh, H. Segmenting and profiling South African households' electricity conservation behavior. *Social marketing Quarterly* **2017,** *23*, 249-265

Jaeger, C.M.; Schultz, P.W. Coupling social norms and commitments: testing the under detected nature of social influence. *J Environ Psychol* **2017,** *51*, 199-208

Katz, D.; Kronrod, A.; Grinstein, A.; Nisan, U. Still waters run deep: comparing assertive and suggestive language in water conservation campaigns. *Water* **2018,** *10*, 275

Kneebone, S.; Fielding, K.; Smith, L. It's what you do and where you do it: perceived similarity in household water saving behaviours. *J Eviron Psychol* **2018,** *55*:1-10

Koop, S.H.A.; Van Dorssen, A.J.; Brouwer, S. Enhancing domestic water conservation behavior: A review of empirical studies on influencing tactics. *Journal of Environmental Management* **2019**, *247*:867-876

Kossieris, P.; Panayiotakis, A.; Tzouka, K.; Gerakopoulou, P.; Rozos, E.; Makropoulos, C. An eLearning Approach for Improving Household Water Efficiency. *Procedia Engineering* **2014**, 89, 1113–1119

Kurz, T.; Donaghue, N.; Walker, I. Utilizing a social-ecological framework to promote water and energy conservation: a field experiment. *J Appl Soc Psychol* **2005**, *35*, 1281-1300

Kronrod, A.; Grinstein, A.; Wathieu, L. Go green! Should environmental messages be so assertive? *J Mark* **2012**, *76*, 95-102

Landon, A.C.; Woodward, R.T.; Kyle, G.T.; Kaiser, R.A. Evaluating the efficacy of an information-based residential outdoor water conservation program. *J Clean Prod* **2018**, *195*, 56-65

Larbey, R.; Weitkamp, E. Water scarcity communication in the UK: learning from water company communications following the 2018 heatwave. *Water scarcity communication* **2020,** *8*, 578423

Laurent, Al.; Lee, J. Nudging greywater acceptability in a Muslim country: comparisons of different greywater reuse framings in Qatar. *Environ Sci Poilcy* **2018,** *89*, 93-99

Lijzen, P.A.; Otte, P.; Dreume, M. Towards sustainable management of groundwater: Policy developments in The Netherlands. *Science of The Total Environment* **2014**, *485–486*, 804-80

Liu, A.; Giurco, D.; Mukheibir, P. Motivating metrics for household water-use feedback. *Resources, Conservation and Recycling* **2015,** *103*, 29-46

Liu, A.; Giurco, D.; Mukheibir, P. Advancing household water-use feedback to inform customer behaviour for sustainable Urban Water. *Water Sci Technol* **2017**

Loftus, A.; March, H.; Nash, F. Water Infrastructure and the Making of Financial Subjects in the South East of England. *Water Altern.* **2016**, *9*, 319–335.

Loureiro, D.; Coelho, S.T.; MacHado, P.; Santos, A.; Alegre, H.; Covas, D. Profiling residential water consumption, Proceedings of the 8th Annual Water Distribution Systems Analysis Symposium 2006; Cincinnati, OH; United States; 27 August 2006 through 30 August 2006

March, H.; Morote, A.F.; Rico, A.M.; Saurí, D. Household Smart Water Metering in Spain: Insights from the Experience of Remote Meter Reading in Alicante. *Sustainability*, **2017**, *9*, 582

McKinsey Company. Using a consumer-segmentation approach to make energy-efficiency gains in the residential market. Electric Power/Natural Gas (Americas). Available online: https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/epng/pdfs/using_a_consumer_segmentation_approach_to_make_ee_gains.pdf (archived on 30-03-2021).

Michelsen, A.A.; McGuckin, J.T.; Stump, D. Non-price water conservation programs as a demand management tool. *J Am Water Resour Assoc* **1999**, *35*, 593-602

Middlestadt, S.; Grieser, M.; Hernández, O.; Tubaishat, K.; Sanchack, J.; Southwell, B.; Schwartz, R.;. Turning minds on and faucets off: water conservation education in Jordanian schools. *J. Environ. Educ.* **2001**, *32*, 37-45.

Nguyen, K.A.; Stewart, R.A.; Zhang, H.; Sahin, O.; Siriwardene, N. Re-engineering traditional urban water management practices with smart metering and informatics. *Environ. Model. Softw* **2018**, *101*, 256–267

Noar, S.M.; Benac, C.N.; Harris, M.S. Does tailoring matter? Meta-analytic review of tailored print health behaviour change interventions. *Psychol Bull*, **2007**, *133*, 673–93

Otaki, Y.; Ueda, K.; Sakura, O. Effects of feedback about community water consumption on residential water conservation. *J Clean Prod* **2017**, *143*, 719-730

Pelletier, L.G.; Sharp, E. Persuasive Communication and Proenvironmental Behaviours: How Message Tailoring and Message Framing Can Improve the Integration of Behaviours Through Self-Determined Motivation. *Canadian Psychology* **2008**, *3*, 210–217

Pinto, C. Tariff structures for water and sanitation urban households: a primer. *Water Policy* **2015**, 17, 1108-1126. doi:10.2166/wp.2015.188

Ribeiro, R.; Loureiro, D.; Barateiro, J.; Smith, J.; Rebelo, M.; Kossieris, P.; Gerakopoulou, P.; Makropoulos, C.; Vieira, P.; Mansfield, L. Framework for Technical Evaluation of Decision Support Systems Based on Water Smart Metering: The iWIDGET Case, *Procedia Engineering* **2015**, 119, 1348-1355

Rozemeijer, J.; Noordhuis, R.; Ouwerkerk, K.; Dionisio Pires, M.; Blauw, A.; Hooijboer, A.; van Oldenborgh, G.J. Climate variability effets on eutrophication of groundwater, lakes, rivers, and coastal waters in the Netherlands. *Science of the Total Environment* **2021**, *771*,145366

Rubio, J.E.; Alcarez, C.; Lopez, J. Recommender system for privacy-preserving solutions in smart metering. Pervasive and Mobile Computing **2017**, 41, 205-218

Russell, S.; Fielding, K. Water demand management research: A psychological perspective. *Water Resources Research* **2010**, 46, 5

Salomons, E.; Housh, M.; Sela, L. Hedging for Privacy in Smart Water Meters. *Water Resources Research* **2020**, 56
Schultz, P.W.; Messina, A.; Tronu, G.; Limas, E.F.; Gupta, R.; Estrada, M. Feedback and the moderating role of personal norms: a field experiment to reduce residential water consumption. *Environ Behav* **2016** *48*, 686-710
Sheeran, P.; Webb, T.L.; Gollwitzer, P.M. The interplay between goal intentions and implementation intentions. *Personality and Social Psychology Bulletin* **2005**, *31*, 87–98
Sheeran, P.; Webb, T.L. The intention-behavior Gap. *Social and Personality Psychology Compass* **2016**, *10.9*, 503-518
Stewart, R.A.; Nguyen, K.; Beal, C.; Zhang, H.; Sahin, O.; Bertone, E.; Vieira, A.S.; Castelletti, A.; Cominola, A.; Giuliani, M.; Giurco, D.; Blumenstein, M.; Turner, A.; Liu, A.; Kenway, S.; Savić, D.A.; Makropoulos, C.; Kossieris, P. Integrated intelligent water-energy metering systems and informatics: Visioning a digital multi-utility service provider. *Environmental Modelling and Software* **2018**, 105.
Summeren van, J.; Blokker, M. Modeling particle transport and discoloration risk in drinking water distribution networks. *Drink. Water Eng. Sci.* **2017**, 10(2), 99-107, doi:10.5194/dwes-10-99-2017.
Sutterlin, B.; Brunner, T.A.; Siegrist, M. Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioral characteristisc. *Energy Policy* **2011**, *39*, 8137-8152
Stuyfzand ,P.J.; Raat, K.J. Benefits and hurdles of using brackish groundwater as a drinking water source in the Netherlands. *Hydrogeology Journal* **2010**, *18*, 117–130
Syme, G.J.; Nancarrow, B.E.; Seligman, C. The evaluation of information campaigns to promote voluntary household water conservation. *Eval Rev* **2000**, *24*, 539-578
TNO. Risicoanalyse Slimme Meter Keten; Privacy en Security in het nieuwe marktmodel TNO rapport nr. R10633, 2012
Tom, G.; Tauchus, G.; Williams, J.; Tong, S. The role of communicative feedback in successful water conservation programs. *Appl Envion Educ Commun Int J* **2011**, *10*, 80-90
UNDP. United Nations Development Program: Human development report 2006 beyond scarcity: power, poverty and the global water crisis. 2006
Vanham, D.; Medarac, H.; Schyns, J.F.; Hogeboom, R.J.; Davide, M. The consumptive water footprint of the European Union energy sector. *Environmental Research Letters* **2019**, *14*:104016s
Wada, Y.; Florke, M.; Hanasaki, N.; Eisner, S.; Fischer, G.; Tramberend, S.; Satoh, Y.; van Vliet, M.T.H.; Yillia, P.; Ringler, C.; Burek, P.; Wiberg, D. Modeling global water use for the 21st century: the water futures and solutions (WFaS) initiative and its approaches. *Geosci Model Dev* **2016**, *9*, 175-222
Walther, J.B.; Liang, Y.; De Andrea, D.; Tong, S.T.; Carr, C.; Spottswood, E.; Amichai-Hamburger, Y. The effect of feedback on identity shift in computer-mediated communication. *Media Psychol* **2011**, *14*, 1-26
Walton, A.; Hum, M. Creating positive habits in water conservation: the case of the Queensland Water Commission and the Target 140 campaign. *International Journal of Nonprofit and Voluntary Sector Marketing* **2011**, *16*, 3
Willis, R.M.; Stewart, R.A.; Panuwatwanich, K.; Williams, P.R.; Hollingsworth, A.L. Quantifying the influence of environmental and water conservation attitudes on household end use water consumption. *Journal of environmental management* **2011**, *8*, 1996-2009.
Worthington, A.; Hoffman, M. An empirical survey of residential water demand modelling. *J Econ Surv* **2008**, *22*, 842-871
Zabkowski, T.; Gajowniczek, K. Smart metering and data privacy issues. *Information Systems in Management* **2013**, *2(3)*, 239-249
Zhuang, J.; Lapinski, M.K.; Peng, W. Crafting messages to promote water conservation: using time-framed messages to boost conservation actions in the United States and China. *J Appl Soc Psychol* **2018**, *48*, 248-256