sustainability

MDPI

Article

Public Attitudes towards Digital Water Meters for Households

Steven Hendrik Andreas Koop [1,2,*], Sharon Helena Pascale Clevers [1], Elisabeth Johanna Maria Blokker [1,3] and Stijn Brouwer [1,4]

[1] KWR Water Research Institute, Groningenhaven 7, 3430 BB Nieuwegein, The Netherlands; sharon.clevers@kwrwater.nl (S.H.P.C.); Mirjam.Blokker@kwrwater.nl (E.J.M.B.); stijn.brouwer@kwrwater.nl (S.B.)
[2] Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, The Netherlands
[3] Faculty of Civil Engineering and Geosciences Stevinweg 1, Delft University of Technolgy, 2628 CN Delft, The Netherlands
[4] Department of Sociology, University of Antwerp, Sint-Jacobstraat 2, 2000 Antwerp, Belgium
* Correspondence: stef.koop@kwrwater.nl

Abstract: In response to droughts, various media campaigns and water-saving instructions are released. However, these often only have temporary water conservation effects. A promising development in this regard is Digital Water Meters (DWM), which can 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. This study aims 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 DWM 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 if their utility invests 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 observe that an attitude-based customer segmentation approach is 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

Citation: Koop, S.H.A.; Clevers, S.H.P.; Blokker, E.J.M.; Brouwer, S. Public Attitudes towards Digital Water Meters for Households. *Sustainability* **2021**, *13*, 6440. https://doi.org/10.3390/su13116440

Academic Editors: Francesco Granata, Carla Tricarico and Fabio Di Nunno

Received: 20 April 2021
Accepted: 3 June 2021
Published: 5 June 2021

1. Introduction

Prolonged droughts, higher temperatures and rising water demands, due to population growth, irrigation and industrial activities, lead to increasing competition for diminishing water resources [1,2]. Drinking water consumption can put significant pressure on the regional availability of freshwater [3]. 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 [4,5]. To this end, utilities can promote the installation of technical water-saving devices, 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 [6]. Although higher average prices have resulted in temporary water conservation [7,8], they 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 [9]. In response to drought crises, a combination of water-use restrictions and awareness campaigns have frequently been applied. As an immediate effect, roughly 10–25% of water savings can be achieved, primarily because

of restrictions on watering lawns and gardens [10,11]. However, water use often returns to pre-drought levels once the state of emergency is lifted; i.e., the water-saving is not maintained [12–14]. Moreover, 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 [14]. Controlled field experiments can show that more generic knowledge about water or energy conservation tends to provide little incentive to change domestic water consumption habits in the long run [15–17]. A promising new and more targeted approach to enhance structural water conservation is now available through the use of Digital Water Meters (DWM) that can provide near real-time water-use feedback [18,19]. Since many households use more water than they are aware of, this strategy of confronting people with their actual water use evokes feelings of discomfort that incentivises them to save water [18,20]. Such an approach can be largely automated, while being equally effective as more expensive face-to-face interventions [21,22]. Various feedback experiments using DWM have resulted in water savings during drought episodes in, for example, Australia, California and the Mediterranean [23–25]. These experiments showed to be especially effective if influencing tactics were applied simultaneously. A well-known tactic in this regard is the comparison with others through social norms [26,27]. Additionally, many authors emphasise the importance of frequent reminders intervening in or relating to specific water-use behaviours [12,16,28,29]. Moreover, it has been argued that messages may be more effective if they are aligned with personal motivations, convictions and attitudes towards the recipient's water use [20]. Many studies have focussed on the relation of domestic water consumption with socioeconomic factors, such as income, education, family composition, age, gender, religion and culture [30–32]. Segmentation based primarily on people's attitude towards water conservation behaviour is mostly unexplored though it can be as relevant [33]. By identifying clearly distinguishable groups of users sharing similar characteristics (i.e., segments), messages can be better aligned with the normative beliefs and situation of each individual segment, and as a consequence, be perceived as more reliable and useful. Hence, this paper aims to explore opportunities for DWM-supported message targeting, both from a traditional and a modern segmentation approach. In addition, many countries across the globe 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. Key insights into the public attitude towards DWM, as well as key insights into overcoming the widely observed gap between intention and behaviour [34], may benefit DWM-supported water conservation. Accordingly, the second aim of this paper is to obtain insights into the public attitude towards the introduction of DWM and to translate these lessons into a stepwise introduction of DWM that can maximise long-term water conservation behaviour.

The remainder of this paper is organised as follows: Section 2 introduces concepts that may be pivotal in enhancing DWM ability to enhance water conservation. Next, the methodological approach regarding the large-scale survey is elaborated in Section 3. Based on online survey results, Section 4 characterises attitudes towards water conservation, water-efficient household devices and DWM. The discussion focuses on privacy challenges and illustrates a four-step message-tailoring approach for DWM supported water conservation. Section 6 provides the conclusions.

2. Digital Meters, Tailoring and Water Conservation—A Short Review

Water meters have developed from manually read meters to today's DWMs that store and transmit measurements at specific time intervals. More recently, two-way communicating devices have been launched, allowing utilities to detect in-house leakages, automate water-use registration, analyse water-use patterns and calibrate diurnal profiles or long-term demand forecasting models, as well as provide near real-time water-use feedback [35,36]. DWMs were first implemented to track water use and identify peak demand hours, days or months [34]. Such information has, in some cases, been used for water tariff structures that mitigate peak demands [37,38]. More recently, high resolution

water meters and data loggers have been used to register water flow velocities. A thorough analysis of this high resolution data enables identifying specific water-use patterns, such as the use of the tap, shower and washing machine [39]. Such technologies also enable smart web services that provide learning opportunities for end-users to reduce their water consumption and spurs collaboration between users and water utilities in order to improve supply-demand management [40,41]. Overall, 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 [42]. And this is precisely the potential that DWMs can offers, i.e., it can provide insight into people's personal 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 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 [43]. Messages are typically tailored to people's behavioural patterns, motives, beliefs and socioeconomic 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 that include increasing self-efficacy and messages framed to align with people's personal characteristics. The segmentation of such characteristics into different profiles can range from merely identifying generic groups using simple characteristics to micro-targeting based on data mining of, for example, social media activities [44]. 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 people may consider this as intrusive. In addition, data-demanding approaches, such as micro-targeting can be expensive. Tailored messaging approaches, therefore, preferably use a minimum amount of customer's information. Traditional segmentation profiles in the field of water and energy conservation derive most support from socioeconomic factors [15,45–49]. Socioeconomic factors, such as income, culture, religion, gender or ethnicity, may pose unwanted biases and—perhaps more importantly—people's beliefs 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 [50] to sustainable food choices [51], and sustainable tourism [52], 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 [53]. For this reason, this paper builds on the work of Brouwer et al. [33] on attitude-based segmentation of customer perspectives on drinking that consists of four segments:
    i. The "aware and committed" perspective, characterised by pro-environmental values and collective sustainability ideals;
    ii. The "quality and health concerned" perspective, characterised 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 great confidence in the responsibility of drinking water utilities, along with a desire not to be bothered about drinking water.
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 tailored messages, 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 various 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 dominated 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 specific water-use activity is provided by Kurz et al. [16]. 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 used the washing machine, dishwasher, toilet and garden hose less frequently and more efficiently and took shorter showers.

3. *Tailored to the phase of behavioural change*: Phases of behavioural change can be conceptualised into a detection, decision and implementation phase [54]. Each phase involves a specific set of leading mechanisms that affect 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 emphasise the negative impact of not saving water (loss frame). Such an approach is only effective if people are also provided with effective means to address these impacts [55,56]. If this is not the case, people are likely to avoid any further information on the topic [57]. 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 act [54]. Many studies about healthy behaviour indicate that gain-framed messages that emphasise 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 [54]. Accordingly, gain-framed messages that emphasise the feasibility of water conservation may be preferred at this point. Finally, once people have decided to act, they enter the implementation phase and become more sensitive to messages that provide them with information about implementing water conservation behaviour in their lifestyle. In this connection, it is worth noting that, time and again, a substantial gap between behavioural intentions and actual behaviour has been observed [58,59]. Typically, humans 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 [1,57]. For example, if someone hoses the garden 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 [60]. It this phase of decision-making, DWMs can be particularly beneficial.

3. 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 were selected as a case study (analysed through a survey, including 1037 respondents). Dutch households are relatively water efficient compared to other industrialised countries [61]. More recently, however, the frequency and length of heatwaves have substantially increased, leading to environmental degradation [62], lower pressure, sometimes discolouration at the tap [63,64], and freshwater resources—particularly groundwater resources—are under pressure [65],. These developments are paving the way for the small-scale introduction of DWM as a means to enhance domestic water conservation. This study 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 3.1. Next, Section 3.2 introduces the large-scale survey approach.

3.1. Introduction into Customer Perspectives on Drinking Water

In order to better characterise differences in attitudes towards DWMs, respondents are first classified according to a customer segmentation approach that focuses on their perspective on drinking water. In doing so, we applied the segmentation and classification approach proposed by Brouwer et al. [33]. The motivation for using this framework is threefold: Firstly, it was specifically designed in the context of the current study (i.e., the Netherlands); secondly, it has proven its value in several follow-up studies [66], and thirdly, methodological practicality, as it gives an easy method for determining the perspective of individual respondents. To this latter end, as shown in Table 1, each perspective was translated into a set of propositions and was presented in a matrix format, accompanied by the question of which set of propositions (labelled 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 their own water consumption.	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.
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 it 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 minimal required customer information that is necessary to profile customers benefits a large-scale application of this customer profiling approach. 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.

3.2. Large-Scale Survey

In order to acquire an empirically-based understanding of the attitude towards DWMs and water conservation, a questionnaire (see supplementary information) was conducted in an online format. To this end, a representative sample (n = 1037) for the Netherlands was recruited through the panel of CG Selecties, an experienced market research agency, who also organised and coordinated the data collection. The survey was completed between January and February 2020, which was just before the Covid-19 pandemic affected the Netherlands. 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 from participate. Table 2 provides the respondents' key characteristics. The questionnaire consists of a total of 26 questions divided over four categories:

1. Introductory questions related to key characteristics. Results are 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. Key characteristics of the survey's respondents (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 and health concerned	14
	Aware and committed	34
	Egalitarian and solidary	29
	Down to earth and confident	23
(V) Homeownership	Homeowner	54
	Renting, energy and water bills included	39
	Renting, separate energy and water bills	7

The total sample and each of the five characteristics (listed in Table 2) were tested for normality (by checking for skewness and kurtosis using Q-Q plots and—given the relatively high sample size—normality was also checked using the independent samples Kolmogorov-Smirnov test). In addition, Levene's test was conducted to validate the assumption of the homogeneity of variance between groups. Two-tailed ANOVA tests with planned contrasts were conducted to test the null hypothesis that responses are equal for all groups. The statistical analyses were tested at a 0.05 level of significance where the t-value expresses the difference relative to the sample variation (as a ratio of the standard error). 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 were 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 to determine the level of difference in answers of each sub-group. The effect size was interpreted according to Cohen [67,68] 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) [67–69]. These statistical analyses only provide additional information to better interpret the survey data and are not applied in an experimental design context.

4. Attitudes towards Digital Water Meters—Survey Results

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 $p < 0.05$) are further described to characterise respondents' attitudes.

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 years", 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 provides interesting observations from a segmentation perspective. Most respondents, and in particular, high educated respondents ($p < 0.001$), particularly 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 ($p < 0.001$) and women ($p < 0.001$), disagreed or fully disagreed with the statement that the current focus on climate change has been greatly exaggerated (statement 3). This may suggest that most respondents recognise the risk of climate change and the importance of water conservation, and regard the latter also as an individual responsibility. That is, provided 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 recognised 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 nor disagree with the statements—"I do as much as a can to use as little water as possible" and "I want to (further) reduce my water consumption" (statements 6 and 7). The latter result is especially interesting when focusing on the differences between different segments, although the segmentation based on gender and educational background show relative moderate differences. More specifically, highly educated respondents showed to have a neutral attitude towards this statement ($p < 0.001$), whereas low educated people show to have a slightly negative attitude ($p < 0.001$) towards further reducing their water consumption (statement 7). Accordingly, high educated respondents tended to be somewhat more interested in receiving more information about how to save water and water-efficient household devices ($p < 0.01$; statements 8 and 9).

Table 3. Statements about water conversation in relation to gender, level of education and perspective on drinking water. Statements 1–4 and 6–10 are scored from 1 = fully disagree to 5 = fully agree. Statement 5 is scored form 1 = much worry to 5 = no worry. Results of an independent *t*-test (for gender) and two-tailed ANOVA are shown that tests the null hypothesis that responses are equal for all respondent categories (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$). Effect size is indicated as very small (vs), small (s) or medium (m).

Statement	Total	Gender	Education			Perspectives			
		Women–Man	High	Medium	Low	Quality and Health Concerned	Aware and Committed	Egalitarian and Solidary	Down to Earth and Confident
1. There is enough water in my country, we do not need to reduce water consumption in the next 25 years	1.16	1.06–1.26	1.08	1.21	1.21	1.21	1.00 * t = 1.98 (vs)	1.00 ** t = 2.94 (vs)	1.58 *** t = –4.20 (s)
2. There is no point in saving water if not everyone participates	1.50	1.42–1.57	1.37 ** t = 2.61 (vs)	1.55	1.62	1.71	1.29 *** t = 4.16 (s)	1.41 * t = 2.03 (vs)	1.79 *** t = –3.78 (s)
3. Current focus on climate change has been greatly exaggerated	1.53	1.38–1.68 *** t = −3.34 (s)	1.25 *** t = 6.20 (s)	1.69	1.88 *** t = −4.10 (s)	1.78	1.11 *** t = 8.50 (s)	1.52 * t = 2.20 (vs)	2.15 *** 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 as much as I can 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	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)

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 and committed" significantly more often indicate that they do as much as they can to use as little water as possible ($p < 0.01$) and (further) want to reduce their water consumption ($p < 0.001$; statements 6 and 7). Accordingly, they more often disagree with statement 2 that there is no point in saving water if not everyone participates ($p < 0.001$) and that there is no need to reduce water consumption in the next 25 years because there is enough water in their country ($p < 0.05$; statement 1). These findings are in line with some central element of this profile, in which sustainable behaviour with respect to nature and humans is highly valued [33]. On the other end, respondents profiling as "quality and health concerned" and in particular respondents profiled as "down to earth and confident" show less willingness to save water. Down to earth and confident respondents tend to disagree with statement 6—"I do as much as I can to use as little water as possible" ($p < 0.001$), and they generally do not want to (further) reduce their water consumption (statement 7; $p < 0.001$). Accordingly, they agree with statement 1 that we do not need to reduce water consumption in the next 25 years ($p < 0.001$). This attitude may very well relate to a strong belief in technological progress this perspective has [33]. 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 and confident respondents replied neutrally ($p < 0.001$). Accordingly, down to earth and confident respondents had little worry about water availability ($p < 0.001$; statement 5). Finally, respondents profiled as "egalitarian and 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" ($p < 0.01$). 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" ($p < 0.05$). 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 [33]. Respondents profiling as "egalitarian and solidary" also more often indicate that they try to do as much as they can to use as little water as possible (statement 6; $p < 0.001$). Again, a similar pattern can be observed when considering climate change and pro-environmental behaviour as a whole. Respondents profiled as "aware and committed" and "egalitarian and solidary", significantly more disagreed with statement 3—"the current focus on climate change has been greatly exaggerated" ($p < 0.001$ and $p < 0.05$, respectively). On the contrary, respondents profiled as "quality and heath concerned" and "down to earth and confident" ($p < 0.001$) replied neutrally 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 and confident respondents fully disagreed ($p < 0.001$). Though scoring above average, the "aware and committed" ($p < 0.001$) and the "egalitarian and solidary" ($p < 0.001$) 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 with 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 ($p < 0.001$; statement 9). "Down to earth and confident" respondents replied particularly negative to receiving more information ($p < 0.001$), while "aware and committed" respondents replied more positively ($p < 0.001$). It is likely that respondents would reply much more positive to receiving more information about how to save water if this is tailored to their own water consumption patterns. Although gender and in a 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 attitudes towards water conservation, an important question is who already owns water-efficient household appliances and for which reasons (Tables 4 and 5). In our survey, 50.1% of the respondents indicate to have a water-saving showerhead, and 56% indicate a water-efficient washing machine. Homeowners have significantly ($p < 0.001$) more often (64%) a water-efficient washing machine. On the contrary, only 41% of the respondents that rent and have to pay separately for water and energy, have a water-efficient washing machine ($p < 0.01$). Only 18% of the respondents have a water saver at their kitchen sink. "Aware and committed" respondents have the most water-efficient devices already installed. In fact, 57% of them have a water-saving showerhead which is significantly more than other customer groups ($p < 0.01$). Interestingly, when asked about the motivation to obtain water-efficient devices, most people, and in particular women ($p < 0.001$), more often tend to choose environmental motives over financial ones. In particular, "aware and committed" ($p < 0.001$) and "egalitarian and solidary" respondents ($p < 0.001$) choose environmental motives over financial ones. In contrast, the "down to earth and confident" respondents significantly ($p < 0.001$) more often chose the financial over the environmental motivation.

Table 4. Percentage of respondents indicating to have a (i) water-saving showerhead, (ii) water saver at the kitchen sink and water-efficient washing machine. Results of an independent *t*-test (for gender) and two-tailed ANOVA are shown that tests the null hypothesis that responses are equal for all respondent categories (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$). Effect size is indicated as very small (vs), small (s) or medium (m).

	Total	**Water-Saving Showerhead (%)**	**Water-Saver at Kitchen Sink (%)**	**Water-Efficient Washing Machine (%)**
		51	**18**	**56**
Gender	Women–Men	47–54	15–21	57–56
Education	High	49	17	54
	Medium	53	20	58
	Low	49	16	57
Perspective	Quality and health concerned	49	17	55
	Aware and committed	57 ** t = 2.61 (vs)	19	57
	Egalitarian and solidary	49	19	60
	Down to earth and confident	46	16	51
Rent/owner	Homeowner	55 * t = 2.16 (vs)	18	64 *** t = 5.13 (s)
	Rent incl. water and energy bill	45	18	49
	Rent excl. water and energy bill	49	18	41 ** t = −2.64 (vs)

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 6, 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 ($p < 0.001$), while "down to earth and confident" respondents are somewhat less likely to accept it (71%; $p < 0.01$). Moreover, high educated respondents would accept the offer more often (82%; $p < 0.05$). Furthermore, almost all respondents (93%) did not disagree with their water utility investing in DWM (statement 2). Women ($p < 0.01$) and high educated respondents ($p < 0.05$) are slightly more positive to this idea. "Aware and committed" respondents tend to agree more often with the idea that water utilities invest in DWM ($p < 0.001$). On the contrary, "down to earth and confident" and "egalitarian and 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 and confident" respondents replied negative ($p < 0.001$). Homeowners 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.

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. Results of an independent *t*-test (for gender) and two-tailed ANOVA are shown that tests the null hypothesis that responses are equal for all respondent categories (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$). Effect size is indicated as very small (vs), small (s) or medium (m).

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

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 the percentage of respondents considering advantages important and very important). On the other end, arguments, such as 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 a very important motivator (19%). Interestingly, homeowners have slightly more objections to a free offer of a DWM ($p < 0.05$; statement 4.1). The environmental argument was significantly more mentioned by women ($p < 0.001$). The environmental arguments also showed significant and relevant differences between customer profiles. The "aware and committed" considered this as the primary advantage, and on average, indicated it as important ($p < 0.001$). 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 advantages and rated this motivation as not important ($p < 0.001$). They also indicated that receiving water-saving tips was the least important argument to accept the free offer of a DWM ($p < 0.001$).

Table 6. Public attitudes towards DWM. Statement 1 ranges from 1 = unlikely to 10 = very likely. Statements 2 and 3 range from 1 = fully disagree to 5 = fully agree. The advantages, disadvantages and statement 6 are provided in percentages of respondents considering them important or very important. The number between breakages represent the responses of the 155 DWM refusers. Results of an independent *t*-test (for gender) and two-tailed ANOVA are shown that tests the null hypothesis that responses are equal for all respondent categories (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$). Effect size is indicated as very small (vs), small (s) or medium (m).

Statements		Total	Gender	Education			Perspective			Rent/Owner		
			Women Men	High	Medium	Low	Quality and Health Concerned	Aware and Committed	Egalitarian and Solidary	Down to Earth and Confident	Home Owner	Rent incl. Energy and Water Bill	Rent Excl. Energy and 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 2.78 ** t = −2.72 (vs)	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 49 *** t = −3.64 (s)	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 (vs)	7 (55)	5 (36)
	5.2 Lack of information	1 (10)	1 (4) 2 (15) * t = −2.37 (vs)	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

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 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 ($p < 0.05$). This result is somewhat unexpected, given that a strong belief in technological progress and convenience are an important characteristic of this perspective [33]. Speculatively, this may suggest that respondents with the "down to earth and 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. Moreover, respondents with lower education level, more frequently questioned the reliability of the DWM ($p < 0.05$). The second most selected argument for refuse the free offer of a DWM is the worry that data would get in the hands of the wrong people (17% amongst refusers and 2% for all respondents). Interestingly, "egalitarian and solidary" respondents had significantly more worries about this matter ($p < 0.05$). Lack of information was only for 10% an argument for refusing the offer. Accordingly, most respondents are indifferent to receiving more information about DWM. In this respect, highly educated respondents tend to be more interested in receiving further information ($p < 0.001$).

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. Respondents that own digital energy meters were significantly ($p < 0.001$) 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.

5. Discussion

Various studies indicate that salient real-time water-use feedback through DWM can enhance short-term water savings, but that this technique is inadequate to improve water conservation in the long term [24,70]. In order to achieve long-term water conservation behaviour, this paper identified three forms of tailoring that can support more persuasive DWM water-use feedback messages and explored the attitude towards DWM amongst households that are not yet familiar with them. Section 5.2 outlines a four-step approach to account for the key findings of this study to be adopted in research and practice. Section 5.1 first briefly reflects on privacy considerations associated with DWMs.

5.1. Privacy

In our survey, privacy issues regarding the DWMs were 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 risks if data protection rights are not well accounted for [71]. One of these concerns is the determination of personal behaviour patterns by private companies or governmental bodies. This can lead to companies using the behavioural information in specific campaigns or governments taxing specific uses [72]. Another privacy concern is target home invasions. After all, the data indicates when people are not at home [73]. Our survey results show that only 6% of the respondents that would refuse a DWM do so because they are afraid the data will be misused by third parties. However, such a 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 consider [74]:

1. Data granularity, the number of measurements in a time unit. When the granularity is high, information about people's water behaviour is exposed.
2. Data actuality, more recent information gives more insight in 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 an hour or 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 have been acquired [75]. 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 [75]. In addition, explicit agreement from every household in a building with DWMs is necessary [72]. 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 both the period of time that data will be stored and the measurement frequency [72].

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 and clothes washing—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 [16]. Therefore, a more integrated approach may be explored for DWM that track the water use of separate household devices. Such meters are more expensive to purchase, but also pose more opportunities to enhance water conservation. Four steps are outlined that specifically account for the decision-making phase, water-use activities and a person's perspective on drinking water:

- *Step I: Evoke water conservation awareness:* Many countries, such as the Netherlands, are just starting to introduce DWMs in households to enhance water conservation. Therefore, most individuals are not familiar with DWM. Furthermore, 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 [76]. 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) a low 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 at solutions may trigger people's interest in the topic. These messages are likely particularly effective if the ease of water conservation is emphasised by simple tips and advice. In addition, the use of images of water stress in the household's vicinity facilitates a closer linkage of the issue with people's daily life. Such an approach may yield more attention and can invoke a willingness to act. The 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 II. Communication at this stage can vary from posters, folders, radio or social media. Water utilities may also want to focus on specific areas where 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: Emphasise the feasibility of water savings with a 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 feel that new water-saving behaviour patterns are rather easy to carry out with the support of a DWM. Like water conservation itself, it should be emphasised that getting and using DWM does not require much time or effort. Timing is also of the 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: Anticipate 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 to support them in implementing water conservation behaviour. The data of this study suggest 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 to 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 socioeconomic characteristics. The results show that respondents classifying as "aware and committed" are more 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 sustainably and tailored to align with their concerns about environmental degradation are likely most effective. "Down to earth and confident" respondents, on the other hand, 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, tailored messages focused on changing behaviour (i.e., shorter showers) seem less effective for this group, whereas the potential cost savings (related to the conservation of water and energy used for heating the water) arguably, can make a convincing argument. In addition to these DWM specifics, the cost benefits of other water-saving devices can be most appealing, as long as it is emphasised that these devices do not result in a loss of comfort or require additional efforts. "Egalitarian and solidary" respondents are sensitive to similar message tailoring as "aware and committed" respondents. However, they focus more on the principle that water has to be affordable for all, including future generations. For this reason, it seems safe to assume that messages focused on the reduced societal costs of prevented environmental degradation and infrastructure augmentation, as well as the need to reduce water consumption to ensure water availability for now and the future are more persuasive for this group. Finally, it must be noted that "quality and health" concerned respondents are hardly persuaded by messages tailored to environmental, solidarity or financial values. They are primarily concerned about their health. Tailored messages for this group could, for instance be focused on the possible mental health benefits of taking low-temperature (and therefore shorter) showers [77].
- *Step IV: Tailor 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 [34], and 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 tends to be rather low. Often an overall water use—for example, 120 L/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 to 100 L a day. Although goal-specificity and goal-proximity are important attributes to goal implementation, the lack of prior knowledge of someone's water-use patterns hampers the setting of attainable and specific goals. Interestingly, DWM can provide this prior knowledge that is invaluable in goal setting, and consequently, greatly contribute to water-use reductions. Based on water consumption related to (i) showering, (ii) watering the garden and (iii) and clothes washing, more

specific goals can be formulated that directly relate to specific behaviour. Since users have a behaviour intention, the formulation of a promotion-framed goal that focuses 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 [1]. By formulating a set of implementation intentions (i.e., 'When situation x arises, I will perform response y'), anticipated critical situations are linked to goal-directed responses. In this way, various situational decisions that require a lot of willpower or mental energy are avoided. In fact, after numerous similar situations, such goal-oriented actions may become more automatic and effortless. Hence, DWM and implementation intentions can reinforce each other in the pursuit of water conservation behaviour.

6. Conclusions

The goal of this study is to obtain insights into the attitude towards the introduction of Digital Water Meters (DWM) and explore opportunities for message tailoring. We conclude that messages tailored to (i) people's set of normative beliefs, motives and attitudes towards water conservation, (ii) water-use activities and (iii) phase of decision-making, are particularly promising in enhancing water conservation behaviour. In this context, DWM 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 water 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 digital energy meters are more likely to accept a free DWM offer. Beyond socioeconomic segmentation approaches, we observed that an attitude-based segmentation may be more a 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 seems most feasible for respondents classifying as "aware and committed" perspective on drinking water (emphasising joint sustainability efforts) or "egalitarian and solidary" perspective on drinking water (emphasising equality for disadvantaged people and future generations). The other two perspectives that are focused on comfort (down to earth and confident) and health and water quality (quality and health concerned) are primarily interested in DWM for leakage detection and cost reductions. Finally, the deployment of more advanced DWMs 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. Based on our work, we propose to this end an advanced strategy which can be summarised in four steps:

I. Evoke water conservation awareness,
II. Emphasise feasibility of water savings with a digital meter,
III. Anticipate people's perspective on drinking water,
IV. Tailor reminders of implementation intentions.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su13116440/s1.

Author Contributions: Conceptualisation, S.H.A.K. and S.B.; methodology, S.H.A.K. and S.B.; software, S.H.A.K.; validation, E.J.M.B.; formal analysis, S.H.A.K.; investigation, S.H.A.K., S.H.P.C. and S.B.; resources, E.J.M.B., S.B., S.H.P.C. and S.H.A.K.; data curation, S.H.A.K. and S.H.P.C.; writing—original draft preparation, S.H.A.K. and S.H.P.C.; writing—review and editing, S.B. and E.J.M.B.; visualization, S.H.P.C.; funding acquisition, S.H.A.K., S.B., E.J.M.B. and S.H.P.C. All authors have read and agreed to the published version of the manuscript.

Funding: This paper was based on research financed by the joint research programme that KWR carries out for the Dutch drinking water companies and De Watergroep, Flanders.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. 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. [CrossRef]
2. Wada, Y.; Florke, M.; Hanasaki, N.; Eisner, S.; Fischer, G.; Tramberend, S.; Satoh, Y.; van Vliet, M.T.H.; Yillia, P.; Ringler, C.; et al. 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. [CrossRef]
3. Bierkens, M.F.P.; Wada, Y. Non-renewable groundwater use and groundwater depletion: A review. *Environ. Res.* **2019**, *14*, 063002. [CrossRef]
4. Russell, S.; Fielding, K. Water demand management research: A psychological perspective. *Water Resour. Res.* **2010**, *46*, 5. [CrossRef]
5. 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. *J. Environ. Manag.* **2011**, *8*, 1996–2009. [CrossRef]
6. Koop, S.H.A.; Van Dorssen, A.J.; Brouwer, S. Enhancing domestic water conservation behavior: A review of empirical studies on influencing tactics. *J. Environ. Manag.* **2019**, *247*, 867–876. [CrossRef]
7. 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 Resour. Res.* **2011**, *47*, W08537. [CrossRef]
8. Worthington, A.; Hoffman, M. An empirical survey of residential water demand modelling. *J. Econ. Surv.* **2008**, *22*, 842–871. [CrossRef]
9. Pinto, C. Tariff structures for water and sanitation urban households: A primer. *Water Policy* **2015**, *17*, 1108–1126. [CrossRef]
10. 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. [CrossRef]
11. 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. [CrossRef]
12. Borisova, T.; Useche, P. Exploring the effects of extension workshops on household water-use behaviour. *HortTechnology* **2013**, *23*, 668–676. [CrossRef]
13. 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. [CrossRef]
14. 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. [CrossRef]
15. 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. [CrossRef]
16. 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. [CrossRef]
17. 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. [CrossRef]
18. 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.
19. Stewart, R.A.; Nguyen, K.; Beal, C.; Zhang, H.; Sahin, O.; Bertone, E.; Vieira, A.S.; Castelletti, A.; Cominola, A.; Giuliani, M.; et al. Integrated intelligent water-energy metering systems and informatics: Visioning a digital multi-utility service provider. *Environ. Model. Softw.* **2018**, *105*, 94–117. [CrossRef]
20. 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. [CrossRef]
21. 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. [CrossRef]
22. 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. [CrossRef]
23. 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. [CrossRef]
24. Boyle, T.; Giurco, P.; Liu, A.; Moy, C.; White, S.; Stewart, R. Intelligent metering for urban water: A review. *Water* **2013**, *5*, 1052–1081. [CrossRef]

25. Liu, A.; Giurco, D.; Mukheibir, P. Advancing household water-use feedback to inform customer behaviour for sustainable Urban Water. *Water Supply* **2016**, *17*, 198–205. [CrossRef]
26. 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. [CrossRef]
27. Otaki, Y.; Ueda, K.; Sakura, O. Effects of feedback about community water consumption on residential water conservation. *J. Clean. Prod.* **2017**, *143*, 719–730. [CrossRef]
28. Chang, G. Factors influencing water conservation behaviour among urban residents in China's arid areas. *Water Policy* **2013**, *15*, 691–704. [CrossRef]
29. 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. [CrossRef]
30. 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. [CrossRef]
31. 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. [CrossRef]
32. Laurent, L.A.; Lee, J. Nudging greywater acceptability in a Muslim country: Comparisons of different greywater reuse framings in Qatar. *Environ. Sci. Poilcy* **2018**, *89*, 93–99.
33. 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. [CrossRef]
34. Sheeran, P.; Webb, T.L. The intention-behavior Gap. *Soc. Personal. Psychol. Compass* **2016**, *10*, 503–518. [CrossRef]
35. 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. [CrossRef]
36. Crainic, M. A short history of residential water meters part III Improvements of water meters. In Proceedings of the Installations for Buildings and Ambiental Comfort Conference XXI Edition, Timisoara, Romania, 18–20 April 2012.
37. Cole, G.; Stewart, R.A. Smart meter enabled disaggregation of urban peak water demand: Precursor to effective urban water planning. *Urban Water J.* **2011**, *3*, 174–194. [CrossRef]
38. 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.
39. Britton, T.C.; Stewart, R.A.; O'Halloran, K.R. Smart metering: Enabler for rapid and effective post meter leakage identification and water loss management. *J. Clean. Prod.* **2013**, *54*, 166–176. [CrossRef]
40. Kossieris, P.; Panayiotakis, A.; Tzouka, K.; Gerakopoulou, P.; Rozos, E.; Makropoulos, C. An eLearning Approach for Improving Household Water Efficiency. *Procedia Eng.* **2014**, *89*, 1113–1119. [CrossRef]
41. 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 Eng.* **2015**, *119*, 1348–1355. [CrossRef]
42. 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. [CrossRef]
43. 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*, 673–693. [CrossRef]
44. Bostrom, A.; Böhm, G.; O'Connor, R.E. Targeting and tailoring climate change communications. *Wiley Interdiscip. Rev. Clim. Chang.* **2013**, *4*, 447–455. [CrossRef]
45. 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. *J. Clean. Prod.* **2018**, *172*, 1607–1619. [CrossRef]
46. Loureiro, D.; Coelho, S.T.; MacHado, P.; Santos, A.; Alegre, H.; Covas, D. Profiling residential water consumption. In Proceedings of the 8th Annual Water Distribution Systems Analysis Symposium 2006, Cincinnati, OH, USA, 27–30 August 2006.
47. 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. [CrossRef]
48. 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. [CrossRef]
49. Issock, P.B.I.; Mpinganjira, M.; Duh, H. Segmenting and profiling South African households' electricity conservation behavior. *Soc. Mark. Q.* **2017**, *23*, 249–265. [CrossRef]
50. 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 (accessed on 30 March 2021).
51. Funk, A.; Sütterlin, B.; Siegrist, M. Consumer segmentation based on Stated environmentally-friendly behavior in the food domain. *Sustain. Prod. Consum.* **2021**, *25*, 173–186. [CrossRef]
52. Del Chiappa, G.; Lorenzo-Romero, C. Environmental issues to profile the consumers' attitude: A latent segmentation approach. *Environ. Eng. Manag.* **2015**, *10*, 2449–2457.
53. Liu, A.; Giurco, D.; Mukheibir, P. Motivating metrics for household water-use feedback. *Resour. Conserv. Recycl.* **2015**, *103*, 29–46. [CrossRef]

54. 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. *Can. Psychol.* **2008**, *3*, 210–217. [CrossRef]
55. Feng, M.F. Impact of fear appeals on pro-environmental behavior and crucial determinants. *Int. J. Advert.* **2016**, *35*, 74–92.
56. 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. *Rev. Gen. Psychol.* **2007**, *11*, 258–285. [CrossRef]
57. Das, E.H.J.; de Wit, J.B.F.; Stroebe, W. Fear appeals motivate acceptance of action recommendations. *Personal. Soc. Psychol. Bull.* **2003**, *29*, 650–664. [CrossRef]
58. Gollwitzer, P.M. Implementation intentions: Strong effects of simple plans. *Am. Psychol.* **1999**, *54*, 493–503. [CrossRef]
59. Sheeran, P.; Webb, T.L.; Gollwitzer, P.M. The interplay between goal intentions and implementation intentions. *Personal. Soc. Psychol. Bull.* **2005**, *31*, 87–98. [CrossRef] [PubMed]
60. Walton, A.; Hum, M. Creating positive habits in water conservation: The case of the Queensland Water Commission and the Target 140 campaign. *Int. J. Nonprofit Volunt. Sect. Mark.* **2011**, *16*, 3. [CrossRef]
61. United Nations Development Program. *Human Development Report 2006 Beyond Scarcity: Power, Poverty and the Global Water Crisis*; UNDP: New York, NY, USA, 2006.
62. 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. *Sci. Total Environ.* **2021**, *771*, 145366. [CrossRef] [PubMed]
63. Van Summeren, J.; Blokker, M. Modeling particle transport and discoloration risk in drinking water distribution networks. *Drink. Water Eng. Sci.* **2017**, *10*, 99–107. [CrossRef]
64. 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.; et al. Drinking Water Temperature around the Globe: Understanding, Policies, Challenges and Opportunities. *Water* **2020**, *12*, 1049. [CrossRef]
65. Stuyfzand, P.J.; Raat, K.J. Benefits and hurdles of using brackish groundwater as a drinking water source in the Netherlands. *Hydrogeol. J.* **2010**, *18*, 117–130. [CrossRef]
66. Brouwer, S.; Hofman-Caris, R.; van Aalderen, N. Trust in Drinking Water Quality: Understanding the Role of Risk Perception and Transparency. *Water* **2020**, *12*, 2608. [CrossRef]
67. Cohen, J. *Statistical Power Analysis for the Behavioural Sciences*, 2nd ed.; Academic Press: New York, NY, USA, 1988.
68. Cohen, J. A power primer. *Psychol. Bull.* **1992**, *112*, 155–159. [CrossRef] [PubMed]
69. Field, A. *Discovering Statistics Using SPSS*, 3rd ed.; SAGE Publications Ltd.: Newbury Park, CA, USA, 2009.
70. 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. [CrossRef]
71. Rubio, J.E.; Alcarez, C.; Lopez, J. Recommender system for privacy-preserving solutions in smart metering. *Pervasive Mob. Comput.* **2017**, *41*, 205–218. [CrossRef]
72. Espinosa, B.; Lavrijssen, S. Exploring the regulatory challenges of a possible rollout of smart water meters in the Netherlands. *Compet. Regul. Netw. Ind.* **2018**, *19*, 159–179. [CrossRef]
73. Salomons, E.; Housh, M.; Sela, L. Hedging for Privacy in Smart Water Meters. *Water Resour. Res.* **2020**, 56. [CrossRef]
74. TNO. *Risicoanalyse Slimme Meter Keten; Privacy en Security in het Nieuwe Marktmodel*; TNO Rapport nr. R10633; TNO: The Hague, The Netherlands, 2012.
75. Zabkowski, T.; Gajowniczek, K. Smart metering and data privacy issues. *Inf. Syst. Manag.* **2013**, *2*, 239–249.
76. 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.
77. 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. [CrossRef] [PubMed]