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Attitudes towards water conservation: Evidence from households in Germany

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Attitudes Towards Water Conservation: Evidence from Households in Germany

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Manuel Frondel, Delia Niehues, Valerie Peetz,
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Attitudes Towards Water Conservation: Evidence from Households in Germany

Abstract

Based on randomized information treatments that were embedded in a large online survey among more than 6,000 single-home owners from Germany, we investigate the malleability of attitudes towards water conservation and a variety of conservation policies. While the empirical results indicate that, generally, respondents have a positive attitude towards water conservation, this positive attitude is merely slightly lowered by information treatments that included either nuanced or negatively biased information about the necessity of water conservation. In addition, we find that respondents attribute a higher level of concern for water conservation to themselves than to both people in their personal environment and the population in general. Conservation policies, such as education campaigns, price increases for heavy consumers and comparison reports on water consumption are accepted by the majority of respondents and perceived as fair, whereas smart water tariffs and frequent price increases are largely rejected.

JEL-Codes: D12, Q25, Q58

Keywords: Information experiment; policy approval; water conservation policy

December 2024

* Manuel Frondel, RWI; Delia Niehues, RWI; Valerie Peetz, RWI; Stephan Sommer, RWI and Bochum University of Applied Sciences; Lukas Tomberg, RWI. – We gratefully acknowledge financial support by the Federal Ministry of Education and Research (BMBF) within the project LICENSE under grant 01UT1701A and under grant 03SFK5C0-2 (Kopernikus Project Ariadne 2). – All correspondence to: Manuel Frondel, RWI, Hohenzollernstraße 1–3, 45128 Essen, Germany, e-mail: Manuel.Frondel@rwi-essen.de

1 Introduction

Even in traditionally water-rich countries, such as Germany, water conservation may be an ambiguous issue. On the one hand, due to climate change and the related increasing risk of droughts, the need for water conservation becomes increasingly important (EEA, 2023). Climate change and water conservation are also linked for another reason: While hot water accounts for around 35% of residential water consumption in Germany (co2online, 2024) and the heating of water is responsible for about 12% of the total energy consumption of an average household, water conservation helps to reduce greenhouse gas emissions. On the other hand, excessive water conservation may cause problems as well. For instance, one challenge that comes with lower consumption is the potential deterioration of drinking water quality due to stagnation in the network (UBA, 2023). For such reasons, nuanced policy measures to change water consumption habits may be necessary in the future.

Based on randomized information treatments that were embedded in a large online survey among more than 6,000 single-home owners from Germany, this paper investigates the malleability of attitudes towards both water conservation in general and policy measures to encourage conservation. In addition, we examine respondents' beliefs about the attitudes of others, such as people in their personal environment, as well as beliefs about the effectiveness and perceived fairness of alternative water protection measures. Hence, with our experiment, we explore two crucial factors for water conservation in private households: (i) respondents' personal attitudes towards conservation and (ii) their judgment of the effectiveness of various policy measures designed to help to save water.

Finding that attitudes towards water conservation are generally positive, there is also a tendency to believe that others do not find water conservation as important as oneself. Moreover, information about the need to save water changes attitudes towards water conservation only slightly and seems to have no effect on the attitudes towards specific water conservation policies. Taken together, the majority of respondents would be in favor of policies that make water use more costly for heavy con-

sumers, and would embrace public education campaigns and social comparison interventions with regard to water use. In contrast, the introduction of smart water tariffs and frequent increases in water prices would not be accepted by the majority of respondents, whereas the promotion of water saving technologies is generally supported.

In addition to informing the public debate on water conservation policies, our results contribute to the understanding of the conservation potential of voluntary efforts. As suggested by the Theory of Planned Behavior, along with social and subjective norms and perceived behavioral control, attitudes are important determinants of behavioral intentions, which in turn determine actual behavior (Ajzen, 1991). Indeed, some studies confirm that households with a positive attitude towards water conservation actually use less water or make greater efforts to conserve water (e.g., Willis et al., 2011), while others suggest that attitudes are important determinants of the intention to save water but not necessarily of actual water consumption behavior (e.g., Russell & Knoeri, 2020), a typical finding known in many contexts as the “intention-behavior gap” (Sheeran & Webb, 2016).

Nevertheless, it is important to know whether a lack of water conservation efforts is due to a lack of positive attitudes towards water conservation or whether there is a generally positive attitude but an intention-behavior gap. In the former case, a water-conservation campaign would either have to try to change attitudes through educational campaigns or it would have to set direct economic incentives whose effectiveness does not require positive attitudes. In the latter case, if there is a positive attitude but certain factors prevent people from behaving in accordance with the attitude or intention, behavioral economic interventions or “nudges” that help overcome these factors can also play a major role. For example, Tiefenbeck et al. (2018) find that correcting salience bias in resource use through real-time feedback when showering leads to higher resource savings among people with positive environmental attitudes than among people with less positive environmental attitudes.

The subsequent Section 2 provides an overview over our data set. Section 3 de-

scribes the experimental design, followed by three sections that present the empirical results. The last section summarizes and concludes.

2 Data

For our analysis, we draw on data originating from an online survey among single-home owners conducted in 2021 in collaboration with the survey institute forsa. In contrast to interviews conducted in person, anonymous online surveys have the advantage of a low risk of social desirability biases (List et al., 2004). Participants of our survey were randomly selected from the forsa.omninet panel, an offline-recruited panel of about 100.000 individuals that is representative of the German-speaking population aged 14 and older. Our survey respondents were at least 18 years old and responsible for the financial decisions of the household – either alone or with their partner. 6,218 respondents completed the questionnaire. For our estimation sample, we exclude 29 respondents who did not report their household size, a key determinant of water consumption. This results in a final sample size of 6,189 respondents, whose socio-economic characteristics are summarized in Table 1 and presented in more detail in Appendix Table A1.

Our focus on single-home owners is due to the fact that in Germany, separate water metering is not standard in multi-family buildings, implying measurement problems with respect to water consumption at the household level in those buildings. Instead focusing on single-home owners facilitates the collection of consumption and billing data at the household level.

Data on the households' monthly net income was gathered on an interval scale that ranged from 700 to 5,700 Euro, with an interval width of 500 Euro. For our analysis, the answers were grouped into four income categories: low-income households with a net monthly income of less than 1,200 Euro, middle-income households (1,200 to less than 2,700 Euro), high-income households (2,700 to less than 4,200 Euro), and households with a net income of more than 4,200 Euro.

Table 1: Summary Statistics of the Sample and Comparisons with the Population of Main Income Earners of Households in Germany

	Sample		Population
Age below 25 years	0.8 %		4.6 %
Age 25-64 years	58.1 %		66.7 %
Age 65 years and above	41.1 %		28.7 %
Female	34.9 %		36.6 %
University degree	35.6 %		20.0 %
Monthly net household income:			
... less than 1,200 Euro	1.0 %	less than 1,250 Euro	15.3 %
... 1,200 to less than 2,700 Euro	17.3 %	1,250 to less than 2,500 Euro	32.8 %
... 2,700 to less than 4,200 Euro	32.7 %	2,500 Euro to less than 4,000 Euro	26.4 %
... more than 4,200 Euro	36.7 %	more than 4,000 Euro	25.0 %
... N/A	12.3%	N/A	0.5%

Note: The data source for the population is Destatis (2022).

Comparing the sample with official data on the characteristics of the main income earners of households from Germany (Destatis, 2022), it turns out that our sample is, on average, older and has a higher monthly net income (Table 1). Hence, our sample is not representative for the population in Germany, being likely the result of our focus on single-home owners.

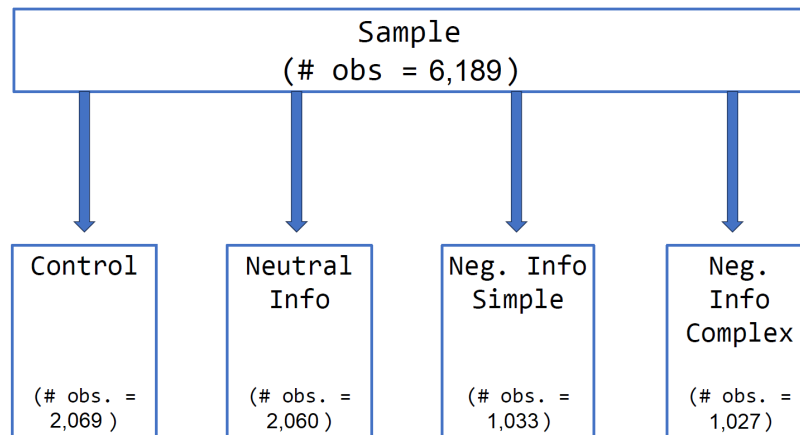
3 Experimental Design

The sample was randomly divided into four groups: a control group and three treatment groups (Figure 1). Interventions were designed as information treatments, mainly differing in the negativity and complexity of the information – for the exact wording of the treatments, see Appendix A. While the control group obtained no information, the treatment group Neutral Info got information that simply listed the arguments for and against saving water in Germany – in the form of quotes from the website of the Federal Environmental Agency.

In contrast, treatment group Neg. Info Simple received brief arguments against water conservation, whereas group Neg. Info Complex was presented more detailed

information on the same counterarguments. Assuming that negative aspects of water conservation are rather unknown to the public, the focus of the experiment was on this type of information. With these interventions, our intention was to exert a strong influence on attitudes when assessing the malleability of attitudes toward water conservation.

Figure 1: Experimental Design



The experiment comprised of two parts. In the first part, after receiving either of the information treatments or no treatment, respondents were confronted with the following five statements on water conservation:¹

- *Not necessary* statement: "Saving water in Germany is not necessary."
- *Negative effects* statement: "Saving water in Germany has predominantly negative effects."
- *Hot water* statement: "Saving water in Germany is particularly useful in areas where hot water is consumed."
- *Future* statement: "For the future, ways should be found to use water more sparingly in Germany and in private households."
- *Morality* statement: "Irrespective of the technical discussions about saving water in Germany, saving water is the right thing to do from a moral point of view."

¹The words in italics are employed in the following tables and figures.

Respondents were requested to rate their personal agreement with each statement on a five-point Likert scale, as well as their perception of their personal environment's agreement and that of most Germans.

The second part dealt with the acceptance and effectiveness of the following six political measures, with answers being measured on a five-point Likert scale:

- *Education* measure policy: "Increased information campaigns (e.g. leaflets, advertising spots, poster campaigns) are used to raise the awareness of water consumption and highlight opportunities to save water."
- Promotion of water-saving *technologies*: "The purchase of water-saving appliances, such as water-saving shower heads in the shower or water-saving dishwashers/washing machines, is promoted by the state so that they are used in as many households as possible."
- *Price increase* policy: "The price per liter of water consumption is increased year after year. This creates a permanent incentive to reduce water consumption."
- *Smart tariffs* policy: "The water price is based on the overall demand for water and adjusts dynamically with the help of digital technology. These price adjustments are also communicated directly to consumers using digital technology. For example, the price can be reduced at times when very little water flows through the pipe network. This provides an incentive to temporarily consume more water in order to ensure that the pipe network is sufficiently flushed. However, if the available water becomes scarce during the midday hours of hot summer days, for example, the price could rise temporarily to provide an incentive to reduce consumption."
- Price increase policy for *heavy users*: "The price per liter of water consumption remains the same for the first 200 cubic meters per year (this is more than the vast majority of German households consume per year). However, if this volume is exceeded, the price for the volume of water in excess of this will rise significantly. This creates a permanent incentive to limit very high water consumption."

- *Comparison* reports policy: "At regular intervals, e.g. every 3 months, households receive a presentation of their own water consumption from their water supplier as well as a comparison of their own consumption with the consumption of other households. In this way, heavy consumers are made aware of potential savings in their household and low consumers are encouraged in their efforts to save water."

All these policies have been discussed in the literature – see e.g. Schleich & Hillenbrand (2009; 2019) on the effectiveness of price-based measures on residential water demand in Germany, as well as Frondel et al. (2021), who highlight the importance of price knowledge for the effectiveness of prices in reducing water consumption. Examining the potential of smart water tariffs, Sahin et al. (2017) conclude that such tariffs can induce behavioral changes. Tiefenbeck et al. (2018) and Tiefenbeck et al. (2019) focus on real-time feedback while showering and find substantial evidence of the effectiveness of these feedback technologies on water consumption.

To enable consumers to make water-efficient investment choices and change their habits, Martínez-Españeira & García-Valiñas (2013) highlight the importance of educational campaigns. Indeed, studying the impact of educational measures on outdoor water use, Wang & Chermak (2021) found that the measures helped to reduce average household water use, but the effect quickly diminished.

Ferraro & Price (2013) explored the effectiveness of measures such as technical advice on how to save water, as well as the promotion of social norms and social comparisons. Although all three measures turned out to be effective, the effect of technical advice is smallest, and mainly driven by low-consumption users, whereas social comparisons have the strongest impact in reducing residential water demand, an effect that is persistent (Ferraro et al., 2011; Ferraro & Price, 2013). This result is also confirmed by a more recent study by Schultz et al. (2019).

4 Attitudes towards Water Conservation

This section presents descriptive results on the agreement with the five statements on water conservation presented in the previous section, thereby focusing on the control group alone. Most notably, a slight absolute majority of 51% of the control group strongly disagrees with the statement “Water conservation in Germany is not necessary”, another 20% of the respondents disagree (Figure 2). Only a small minority of about 17% of the control group agrees or even strongly agrees with this statement.

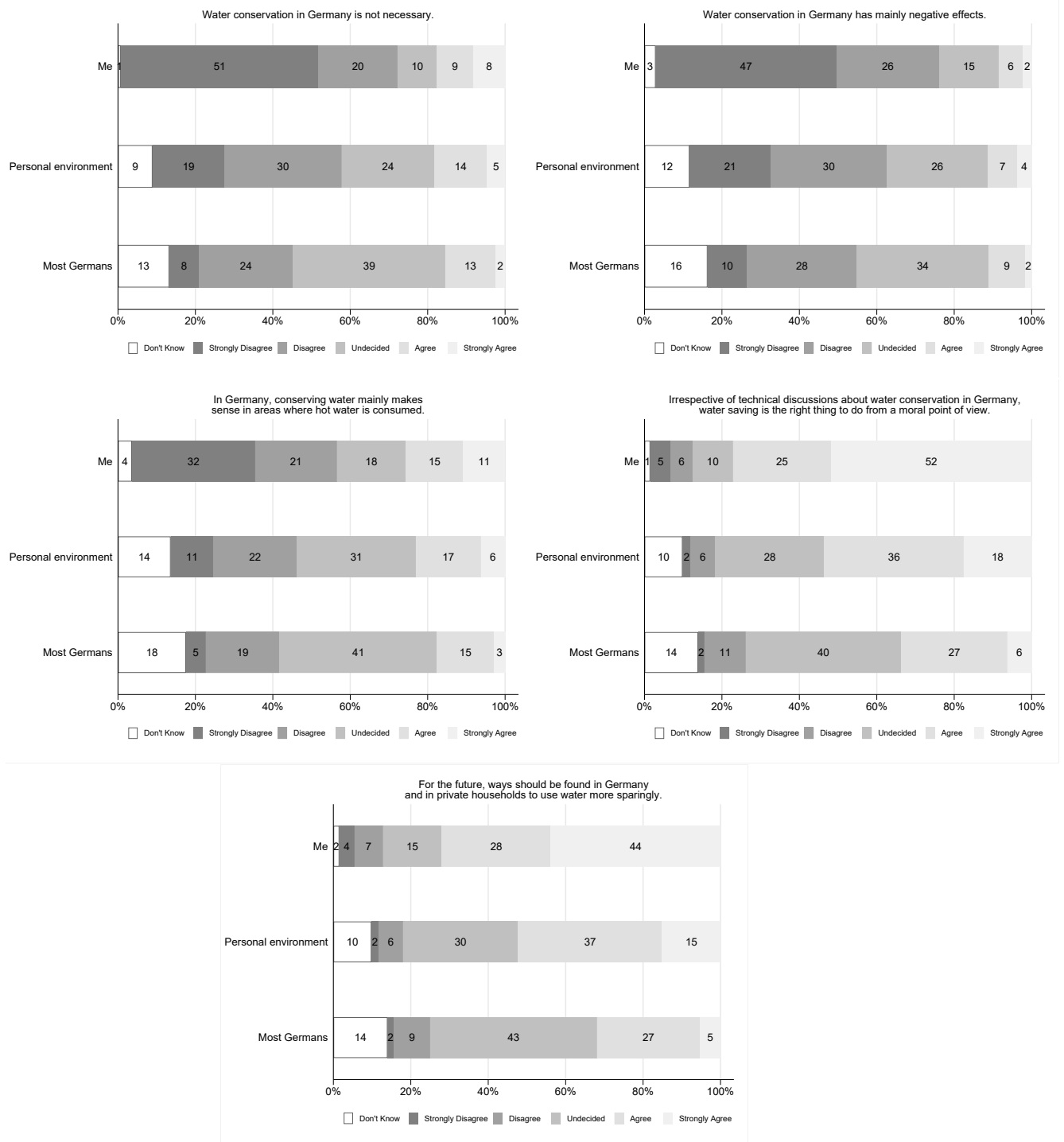
Moving from the personal perspective to what respondents think about the broader view of most Germans, a sharp drop in disagreement occurs: While personally around 71% of the respondents disagree or strongly disagree with this statement, only a minority of 32% believes that most Germans would disagree or strongly disagree. The drop in disagreement is mainly due to the increasing share of respondents who selected the response option “undecided” or “don’t know”, which increased from 11% to 52% when the perspective of most Germans shall be adopted. A very similar picture of objection emerges for the statement: “Water conservation in Germany has mainly negative effects”.

The next statement, “In Germany, conserving water mainly makes sense in areas where hot water is consumed”, points to a more differentiated view and emphasizes the role of hot water conservation as a contribution to reduce both energy use and carbon emissions. Yet, a narrow absolute majority of 53% of the control group disagrees with this statement. Respondents therefore appear to believe that there are other reasons for saving water, apart from reducing energy consumption and carbon emissions.

This hypothesis is consistent with the moral dimension of water conservation expressed in the statement: “Irrespective of technical discussions about water conservation in Germany, saving water is the right thing to do from a moral point of view”. This statement meets a very high level of agreement of almost 80% of the control group, indicating that respondents clearly see a moral dimension in conserving water. Whether this perspective is influenced by a more nuanced discussion of the advantages and disadvantages of saving water is examined on the basis of the information treatments

in the next section. The remaining statement "For the future, ways should be found in Germany and in private households to use water more sparingly" is also met with approval from around 75% of the respondents, which is consistent with the apparently positive attitude towards saving water overall.

Figure 2: Attitudes of the Control Group towards Water Conservation



In sum, it appears that the homeowners of the sample have a positive attitude towards saving water and ascribe a moral dimension to saving water beyond the technical discussion of positive and negative effects of water conservation. At the same time, it becomes clear that respondents think that their own attitude towards saving water is stronger than that of their personal environment and the majority of Germany's population.²

5 Malleability of Attitudes towards Water Conservation

To examine the malleability of attitudes towards water conservation, we employed randomized information treatments that provided either nuanced or negatively biased information about the need to conserve water in Germany. Summing up the most important results, the information treatments lead to a slightly higher agreement with the statement that questions the need to save water in Germany, the statement that emphasizes the negative effects of saving water, and the statement that emphasizes the importance of reducing hot water consumption (Figure 3).

To be able to draw conclusions about the statistical significance of the differences in the agreement shares, we estimate Linear Probability Models in which the dependent variable equals unity if the respondent (strongly) agrees with a given statement on water conservation or (strongly) accepts a given conservation policy and zero otherwise.³

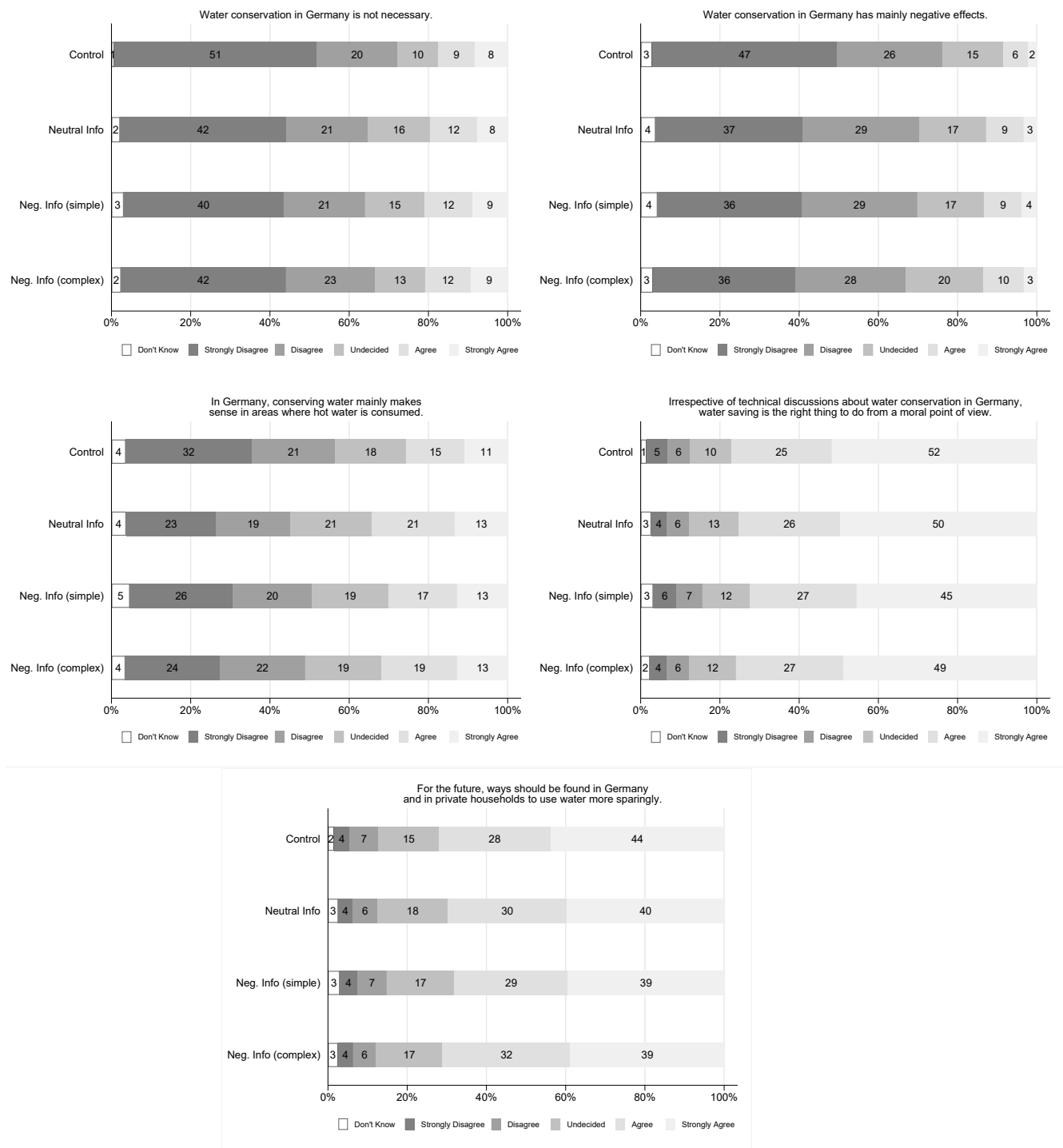
The statistically significant treatment effects on the acceptance of these statements

²The estimation results reported in Table A2 in the appendix confirm these descriptive results by statistically significant coefficient estimates, especially for the "Future" and the "Morality" statements. Whether this contrast between one's own attitude and the perceived attitude of others is an actual misperception or rather a self-serving "holier-than-thou effect" (Epley & Dunning, 2000), which could be caused by the apparent moral dimension of saving water, cannot be determined here. It thus remains a task for future research whether a correction of this misperception would lead to more water saving efforts, as it could e.g. trigger conditional cooperation (Fischbacher et al., 2001), or rather to less, as it would reduce one's own sense of moral superiority through water saving efforts.

³Estimating Linear Probability Models not only allows for a straightforward interpretation of the results, but, in contrast to non-linear models, allows for straightforward estimation of cluster-robust standard errors when there is a cluster structure in the error terms. This is the case for the repeated observations on respondents' on personal agreement with conservation statements, as well as their perception of their personal environment's agreement and that of most Germans – see the tables in the appendix.

is supported by the Linear Probability Model results reported in Table 2. For instance, the acceptance of the statement that emphasizes the negative effects of saving water is substantially higher among those respondents who received treatments with negatively biased information, by about 5 percentage points relative to the control group.

Figure 3: Attitudes towards Water Conservation across Information Treatments



There is no significant difference, though, between the neutral-information treatment and those that provide negatively biased information.

Table 2: Linear Probability Model Estimations Results for the Effects of the Information Treatments on the Agreement with 5 Statements about Water Conservation

	Not necessary		Negative effects		Hot water		Future		Morality	
	Std.		Std.		Std.		Std.		Std.	
	Coeff.	error	Coeff.	error	Coeff.	error	Coeff.	error	Coeff.	error
Neutral info	0.02	(0.01)	0.05**	(0.01)	0.09**	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Neg. info simple	0.04*	(0.02)	0.05**	(0.01)	0.05**	(0.02)	-0.03	(0.02)	-0.04*	(0.02)
Neg. info complex	0.04*	(0.02)	0.05**	(0.01)	0.06**	(0.02)	-0.00	(0.02)	-0.01	(0.02)
Constant	0.18**	(0.01)	0.09**	(0.01)	0.27**	(0.01)	0.73**	(0.01)	0.78**	(0.01)
# observations	6072		5975		5954		6046		6046	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable is binary and takes the value 1 if the respondent agrees or strongly agrees with the respective statement, and 0 otherwise. Participants who chose the “Don’t know” option are omitted.

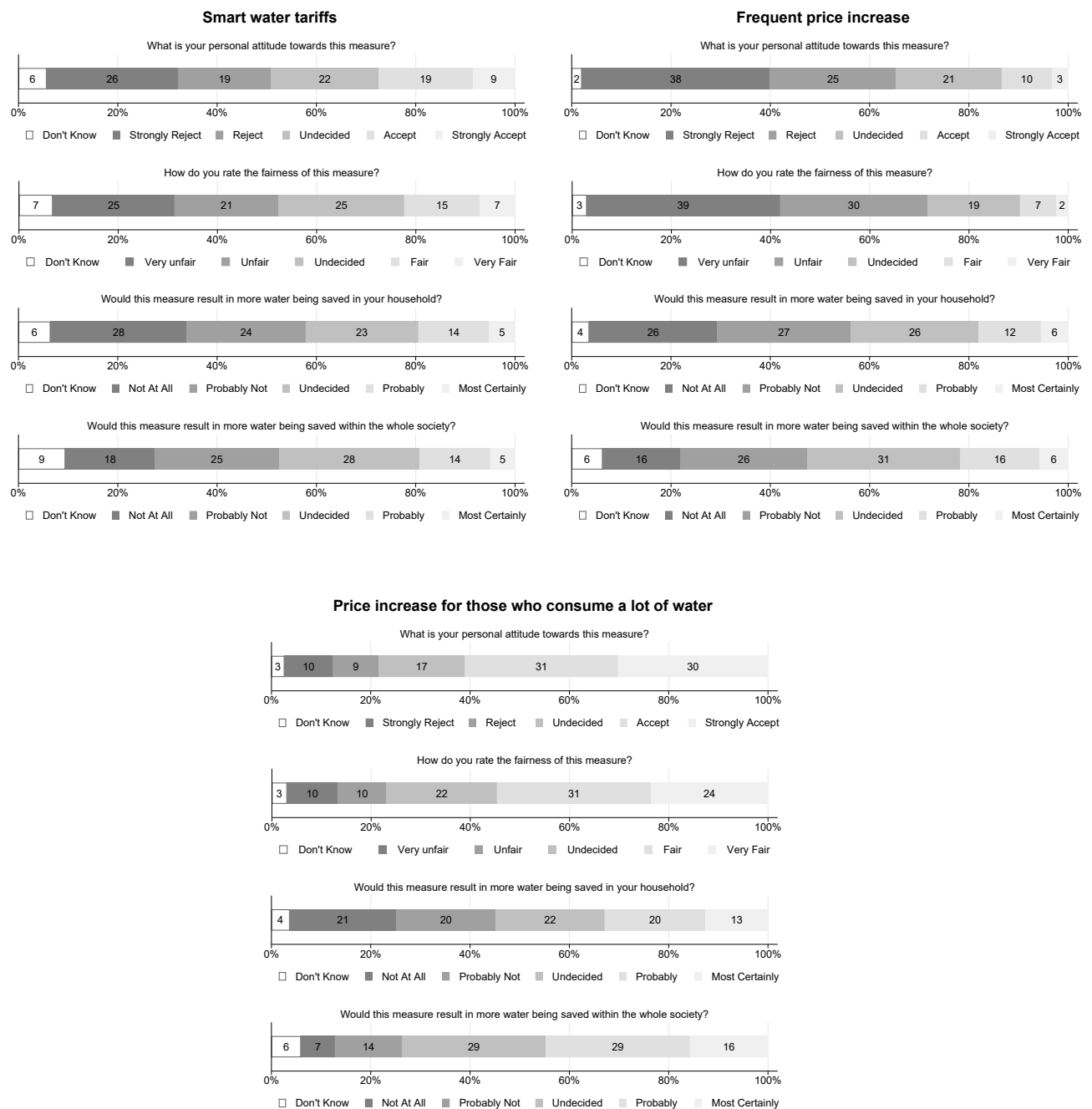
6 Attitudes towards Water Conservation Policies

For each of the six policies to encourage water conservation presented in Section 3, survey participants could indicate their degree of acceptance, the perceived fairness and their expectation to what extent the measure would help to save water both on a personal and societal level. Figures 4 and 5 illustrate the approval for the six policy measures for the control group alone.

Explained to the respondents as tariffs that increase water prices at times and places where water supply is scarce, smart water tariffs would be accepted by less than 30% of the respondents of the control group, but almost 50% of the respondents reject or even strongly reject the measure. Likewise, almost half of the respondents of the control group do not think that it is a fair measure and slightly more than half doubt its helpfulness in water conservation. Even stronger disapproval is found for frequent increases in water prices.

In contrast to smart water tariffs, a non-linear tariff where prices are higher for

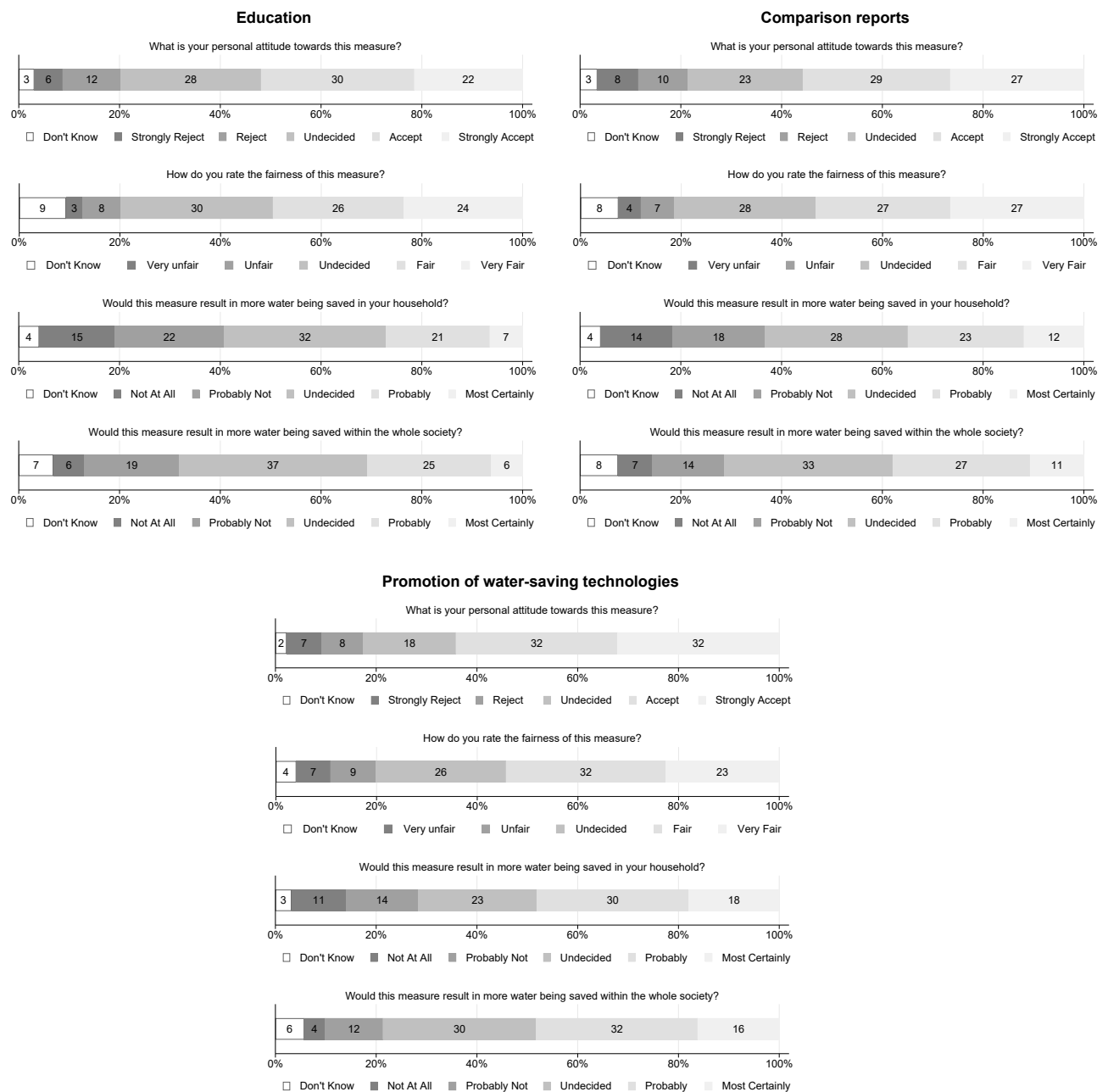
Figure 4: Attitudes of the Control Group towards Monetary Water Conservation Policies



heavy consumers than for users with a low consumption is supported by more than 60% of the respondents. Non-linear tariffs are also considered fair by a large majority of the respondents and 45% of them regard such tariffs as effective in reducing water consumption at the societal level. The latter result is in line with the findings of Grafton et al. (2011), who stress the effectiveness of price-based measures, in particular

volumetric pricing, to regulate residential water consumption.

Figure 5: Attitudes of the Control Group towards Non-Monetary Water Conservation Policies



The agreement with three non-pecuniary water conservation policies – education campaigns, comparison reports, and the promotion of water-saving technologies – is illustrated by Figure 5. All of these three policies are supported by the majority of respondents and perceived as fair. Notably, the promotion of water-saving technologies is seen as the most effective of these three measures, whereas education campaigns are seen as rather ineffective, yet more effective than increased water prices and smart

water tariffs. Social comparison reports on water consumption fall in between.

Our findings fit to the results of Stavenhagen et al. (2018), who used a mixed-methods approach to survey water utility officials to identify the most effective policies for water demand management. These authors conclude that campaigns for water-saving technologies are perceived more effective than public awareness campaigns, but tariff reforms only play a minor role for most of the surveyed cities.

Table 3: Linear Probability Model Estimations Results for the Effects of the Information Treatments on the Agreement with 6 Water Conservation Policies

	Smart tariffs		Price increases		Heavy users		Education		Comparison		Technologies	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Neutral info	0.02	(0.01)	0.02	(0.01)	-0.00	(0.02)	-0.02	(0.02)	0.00	(0.02)	-0.02	(0.02)
Neg. info simple	0.01	(0.02)	0.01	(0.01)	-0.02	(0.02)	0.02	(0.02)	0.00	(0.02)	0.02	(0.02)
Neg. info complex	0.04*	(0.02)	0.03*	(0.01)	-0.00	(0.02)	0.02	(0.02)	0.01	(0.02)	-0.04	(0.02)
Constant	0.29**	(0.01)	0.14**	(0.01)	0.63**	(0.01)	0.54**	(0.01)	0.58***	(0.01)	0.66***	(0.01)
# observations	5855		6063		6025		5975		5945		6037	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable is binary and takes the value 1 if the respondent agrees or strongly agrees with the respective policy, and 0 otherwise. Participants who chose the “Don’t know” option are omitted.

The information treatments on the necessity of water conservation hardly affect the acceptance of the six policy measures presented in Section 3. Merely the complex negatively biased information treatment slightly increases support for the smart water tariffs and frequent price increases, by 4 and 3 percentage points, respectively (Table 3). Since smart tariffs are designed to mitigate the negative effects of water conservation by reducing prices in times of low water demand, the increase in support for this policy in response to the complex negative information treatment is in line with what is to be expected.

7 Socio-economics of Water Consumption

In this section, we examine the extent to which attitudes towards water conservation and conservation policies are related to both socio-economic characteristics and the

households' water consumption. Note that the correlation of attitudes with socioeconomic characteristics is separately estimated from that with household water consumption, because, first, water consumption is an outcome of the households' characteristics, so that water consumption represents a bad control variable (Angrist & Pischke, 2009).

Second, water consumption is only available for the subsample of those respondents who also took part in the previous survey wave a year earlier and who provided their water meter readings in both the previous and current survey wave. These requirements are due to the fact that water consumption is calculated as the difference between the two meter readings, divided by the difference in days between the two meter readings.

Most notably, we find that women have, on average, more favorable attitudes towards water conservation than men (Table 4), as women are, on the one hand, 4 to 6 percentage points less likely to agree with statements that question the need to conserve water and are, on the other hand, more likely to support statements that emphasize the need to conserve water, including the statement about the moral dimension of water conservation. This kind of environmental gender gap is in line with the findings by Singha et al. (2022). More generally, Zelezny et al. (2000) observe that women report stronger environmental attitudes than men. Ramstetter & Habersack (2020), who investigate the environmental gender gap at elite levels, come up with a similar conclusion.

Agreement with the statements "saving water is not necessary" and "water conservation mainly has negative effects" is positively correlated with the respondents' age, as is agreement with the statements that emphasize the necessity of water conservation in the future and the moral dimension of water conservation, suggesting an inconsistent relationship between age and attitudes towards water conservation. Our results thus only partly confirm the received literature: For example, Gilg & Barr (2006) report that in their sample, the mean age of those who are committed to resource conservation is higher than the average age of those who are not committed. Similarly,

Table 4: Linear Probability Model Estimation Results on the Relationship between Household Characteristics and the Agreement with 5 Statements on Water Conservation

	Not necessary		Negative effects		Hot water		Future		Morality	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Female	-0.06**	(0.01)	-0.04**	(0.01)	-0.04**	(0.01)	0.05**	(0.01)	0.05**	(0.01)
University degree	-0.02	(0.01)	-0.00	(0.01)	0.03*	(0.01)	0.04**	(0.01)	-0.01	(0.01)
Treatments:										
Neutral info	0.02	(0.01)	0.05**	(0.01)	0.09**	(0.01)	-0.01	(0.01)	-0.01	(0.01)
Neg. info simple	0.04*	(0.02)	0.05**	(0.01)	0.05**	(0.02)	-0.03	(0.02)	-0.04*	(0.02)
Neg. info complex	0.04*	(0.02)	0.05**	(0.01)	0.07**	(0.02)	-0.00	(0.02)	-0.01	(0.02)
# household members:										
2 persons	0.03	(0.02)	-0.01	(0.02)	0.05*	(0.02)	-0.04*	(0.02)	-0.01	(0.02)
3 persons	0.02	(0.02)	0.01	(0.02)	0.03	(0.03)	-0.03	(0.02)	0.00	(0.02)
4 and more persons	0.02	(0.02)	0.01	(0.02)	0.07**	(0.03)	-0.03	(0.03)	0.01	(0.02)
Age quartiles:										
2nd quartile	0.01	(0.02)	0.03**	(0.01)	0.02	(0.02)	0.06**	(0.02)	0.01	(0.02)
3rd quartile	0.01	(0.02)	0.01	(0.01)	0.06**	(0.02)	0.10**	(0.02)	0.05**	(0.02)
4th quartile	0.07**	(0.02)	0.05**	(0.02)	0.14**	(0.02)	0.12**	(0.02)	0.08**	(0.02)
Income classes:										
Middle income	0.00	(0.05)	-0.04	(0.05)	-0.13*	(0.07)	0.06	(0.06)	0.04	(0.05)
High income	-0.03	(0.05)	-0.06	(0.05)	-0.17*	(0.07)	0.10	(0.06)	0.05	(0.05)
Very high income	-0.03	(0.05)	-0.07	(0.05)	-0.16*	(0.07)	0.08	(0.06)	0.02	(0.06)
Income missing	-0.01	(0.05)	-0.05	(0.05)	-0.17*	(0.07)	0.03	(0.06)	0.01	(0.06)
Constant	0.18**	(0.05)	0.14**	(0.05)	0.32**	(0.07)	0.59**	(0.06)	0.71**	(0.06)
# observations	6072		5975		5954		6046		6046	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable takes the value 1 if the respondent agrees or strongly agrees with the respective statement, and 0 otherwise. Participants who chose the “Don’t know” option are dropped.

Singha et al. (2022) observe that, compared to younger participants, older individuals show higher levels of awareness and water conservation behavior. In short, apart from the clear pattern that women are more likely to have positive attitudes towards water conservation, the correlations with other socio-economic characteristics, such as age, are less consistent.

Using the four quartiles of water consumption per day as sole explanatory variables, households of the highest consumption quartile are 8 percentage points more likely to agree with the statement that saving water mainly has negative effects, com-

Table 5: Linear Probability Model Estimation Results of the Relationship between the Agreement with 5 Statements on Water Conservation and Water Consumption in the Previous Year

	Not necessary		Negative effects		Hot water		Future		Morality	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Water consumption:										
Second quartile	0.03	(0.03)	0.03	(0.02)	0.03	(0.04)	-0.05*	(0.03)	-0.07*	(0.03)
Third quartile	0.01	(0.03)	0.02	(0.02)	-0.01	(0.04)	-0.07*	(0.03)	-0.04	(0.03)
Fourth quartile	0.05	(0.03)	0.08**	(0.02)	0.03	(0.04)	-0.10**	(0.03)	-0.13**	(0.03)
Constant	0.20**	(0.02)	0.08**	(0.01)	0.35**	(0.03)	0.82**	(0.02)	0.86**	(0.02)
# observations	1412		1393		1395		1410		1407	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable takes the value 1 if the respondent agrees or strongly agrees with the respective statement, and 0 otherwise. Participants who chose the “Don’t know” option are dropped.

pared to households of the lowest quartile (Table 5).⁴ It also bears noting that respondents from the highest consumption quartile are 13 percentage points less likely to attribute a moral dimension to saving water.

Examining the extent to which socio-economic and household characteristics are associated with the approval of various policy measures, we again find that women show a higher agreement with water conservation policies (Table 6). Increasing age is also associated with higher agreement for all policies, except for comparison reports. These results seem to be in line with the literature, as well as with what we found for the attitudes. Respondents with a university degree are more likely to support all policies, except for education campaigns and the promotion of water-saving technologies.

When investigating the relationship between water use and policy approval (Table 7), it stands out that households of the highest quartile of water consumption are, on average, 11 percentage points less likely to support prices increases for households that use a lot of water. A possible explanation for this outcome is that these households may be aware of their relatively high consumption and therefore reject policies that imply a higher burden for them.

⁴This categorical approach prevents outliers or other unusual features of the distribution from distorting the estimates and allows for easy interpretation.

Table 6: Linear Probability Model Estimations Results on the Relationship between Socio-economic Characteristics and the Agreement with 6 Water Conservation Policies

	Smart tariffs		Price increases		Heavy users		Education		Comparison		Technologies	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Female	0.04**	(0.01)	0.03**	(0.01)	0.02	(0.01)	0.08**	(0.01)	0.06**	(0.01)	0.10**	(0.01)
University degree	0.06**	(0.01)	0.04**	(0.01)	0.07**	(0.01)	0.02	(0.01)	0.04**	(0.01)	0.01	(0.01)
Treatments:												
Neutral info	0.02	(0.01)	0.02	(0.01)	0.00	(0.02)	-0.02	(0.02)	0.00	(0.02)	-0.02	(0.01)
Neg. info simple	0.02	(0.02)	0.01	(0.01)	-0.02	(0.02)	0.02	(0.02)	0.00	(0.02)	0.02	(0.02)
Neg. info complex	0.04*	(0.02)	0.03*	(0.01)	-0.00	(0.02)	0.02	(0.02)	0.01	(0.02)	-0.04*	(0.02)
# household members:												
2 persons	0.01	(0.02)	-0.01	(0.02)	-0.02	(0.02)	-0.01	(0.02)	0.03	(0.02)	-0.01	(0.02)
3 persons	0.02	(0.03)	-0.01	(0.02)	-0.06*	(0.03)	-0.01	(0.03)	0.05	(0.03)	0.03	(0.03)
4 and more persons	0.01	(0.03)	-0.01	(0.02)	-0.04	(0.03)	0.02	(0.03)	0.05	(0.03)	-0.00	(0.03)
Age quartiles:												
2nd quartile	0.01	(0.02)	0.01	(0.01)	0.05**	(0.02)	0.06**	(0.02)	-0.01	(0.02)	-0.00	(0.02)
3rd quartile	0.08**	(0.02)	0.07**	(0.02)	0.09**	(0.02)	0.11**	(0.02)	0.02	(0.02)	0.02	(0.02)
4th quartile	0.11**	(0.02)	0.08**	(0.02)	0.08**	(0.02)	0.11**	(0.02)	0.03	(0.02)	0.05*	(0.02)
Income classes:												
Middle income	-0.00	(0.06)	-0.03	(0.05)	0.06	(0.07)	0.00	(0.07)	0.00	(0.07)	0.00	(0.06)
High income	0.04	(0.06)	-0.01	(0.05)	0.08	(0.07)	0.05	(0.07)	0.03	(0.07)	0.01	(0.06)
Very high income	0.07	(0.06)	0.01	(0.05)	0.07	(0.07)	0.07	(0.07)	0.07	(0.07)	-0.01	(0.06)
Income missing	-0.01	(0.06)	-0.04	(0.05)	-0.02	(0.07)	-0.01	(0.07)	-0.00	(0.07)	-0.01	(0.06)
Constant	0.16*	(0.06)	0.09	(0.05)	0.51**	(0.07)	0.39**	(0.07)	0.46**	(0.07)	0.60**	(0.06)
# observations	5855		6063		6025		5975		5945		6037	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable takes the value 1 if the respondent agrees or strongly agrees with the respective policy, and 0 otherwise. Participants who chose the “Don’t know” option are dropped.

8 Summary and Conclusions

Attitudes are regarded as important determinants of behavioral intentions, which in turn are essential for behavioral change (Ajzen, 1991). Therefore, an understanding of the attitudes towards certain behaviors that policy makers are trying to influence is important for the design of effective policy measures to induce behavioral change (van Valkengoed et al., 2022).

With our study, we have contributed to the understanding of attitudes in the domain of water conservation and have investigated the malleability of attitudes towards

Table 7: Linear Probability Model Estimation Results on the Relationship between the Agreement with 6 Water Conservation Policies and the Water Consumption in the Previous Year

	Smart tariffs		Price increases		Heavy users		Education		Comparison		Technologies	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Water consumption:												
Second quartile	-0.01	(0.04)	-0.05	(0.03)	-0.05	(0.03)	-0.08*	(0.04)	-0.04	(0.04)	-0.02	(0.04)
Third quartile	-0.00	(0.04)	-0.05	(0.03)	-0.04	(0.03)	0.03	(0.04)	0.01	(0.04)	-0.02	(0.04)
Fourth quartile	-0.02	(0.04)	-0.04	(0.03)	-0.11**	(0.03)	-0.06	(0.04)	-0.02	(0.04)	-0.03	(0.04)
Constant	0.34**	(0.03)	0.19**	(0.02)	0.75**	(0.02)	0.59**	(0.03)	0.64**	(0.03)	0.66**	(0.03)
# observations	1383		1413		1405		1397		1392		1410	

Note: Robust standard errors are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable equals 1 if the respondent agrees or strongly agrees with the respective policy, and 0 otherwise. Participants who chose the “Don’t know” option are dropped.

both water conservation and policy measures to encourage conservation based on randomized information treatments that were embedded in a large online survey among more than 6,000 single-home owners from Germany. In the randomized information experiment, three treatment groups randomly received either neutral, simple negatively biased or complex negatively biased information on the necessity of water conservation in Germany. A fourth group served as control and did not receive any information.

We find that, in general, respondents have positive attitudes towards water conservation. These attitudes are only slightly altered by our information treatments, indicating that attitudes are at least somewhat malleable. Additionally, we have asked respondents to state what they believe about what people in their personal environment or most Germans would think about the need to conserve water, finding that respondents attribute a higher level of concern for water conservation to themselves than to others.

With regard to policy measures to promote water conservation, we find that the promotion of water-saving technologies, education campaigns, price increases for heavy consumers and comparison reports are most widely accepted and perceived as fair. Smart water tariffs and frequent price increases, however, are not widely

accepted. At the individual level, the promotion of water-saving technologies and comparison reports are regarded as the most effective measures, while at the societal level respondents would consider price increases for heavy consumers, education campaigns, comparison reports and the promotion of water-saving technologies to be the most effective measures.

With potentially more hot and dry summers in the future and less rainfall in at least certain regions of the country, our results can help politicians and practitioners to implement measures that help to conserve water and are widely accepted. Our information treatment also shows that the provision of negatively biased information, that is, counterarguments on the necessity of water conservation in Germany, is able to alter attitudes, at least to some extent. The limited degree of variation in the acceptance rates across intervention groups indicates that in the domain of water consumption, changes in attitudes are rather moderate – which is consistent with the evidence on the impact of interventions on attitudes in other areas, such as climate change mitigation (Rode et al., 2021).

Nonetheless, the moderate malleability of attitudes indicates that the pros and cons of water conservation are not yet generally known in Germany. Hence, the implementation of water conservation measures should be accompanied by information campaigns: On the one hand, this can reduce the risk that the acceptance of such measures can be undermined by interested parties through the spread of negatively biased information. On the other hand, it can prevent citizens from perceiving the state's behavior as erratic if it calls for water conservation at certain times and in certain places, while at other times and in other places it deliberately makes no effort to conserve water to maintain water network quality.

Appendix

A Information Treatments

A.1 Neutral Information

There are different positions on the need for water conservation in Germany. In the following section, we briefly present the discussion on this topic.

In general, there is no water shortage in Germany, and the public water supply - which includes the supply of private households - only represents a small part of water consumption. According to the German Federal Environment Agency, only 2.7 percent of the available surface and groundwater is used for public water supply.

The following are three of the most common arguments for and against water conservation:

- Climate change could regionally exacerbate the pressure on groundwater reserves, if precipitation decreases or a higher proportion of precipitation water does not run off properly (UBA, 2023).
- Reduced water consumption can cause localized problems in the pipes. Demographic changes, increased water conservation, and the relocation of many people away from rural areas can cause water to stagnate in drinking water networks, which can affect the water quality. In some places, foul-smelling digester gases can form in the sewer system because too little water flows through the pipes (UBA, 2023).
- The environment benefits most when households use as little hot water as possible, so that less energy is needed to heat water. The German Federal Environment Agency estimates that the energy required to heat water accounts for an average of 12 percent of a household's total final energy consumption(UBA, 2023).

A.2 Negative Information Simple

There are different positions on the need for water conservation in Germany. A common argument is the following: "In general, there is no shortage of water in Germany. In fact, a lower water consumption can even lead to localized problems in the pipes. Demographic changes, increased water conservation, and the relocation of many people away from rural areas can cause water to stagnate in drinking water networks, which can affect the water quality. In some places, foul-smelling digester gases can form in the sewer system because too little water flows through the pipes" (UBA, 2023).

A.3 Negative Information Complex

There are different positions on the need for water conservation in Germany. A common argument is the following: "In general, there is no shortage of water in Germany. In fact, a lower water consumption can even lead to localized problems in the pipes. Demographic changes, increased water conservation, and the relocation of many people away from rural areas can cause water to stagnate in drinking water networks, which can affect the water quality. In some places, foul-smelling digester gases can form in the sewer system because too little water flows through the pipes" (UBA, 2023).

The existing drinking water network was built with the assumption that the population would continue to grow and water consumption would increase.

However, it is now clear that per-capita consumption has continued to decline in recent years: Between 1990 and 2018, per-capita consumption fell from 150 to 120 liters per day. This was accompanied by a decline in consumption in the industrial and service sectors.

In addition, the population is not growing as fast as assumed. Population density is declining, especially in rural areas. For example, between 1995 and 2017, the population in rural areas of Germany decreased by 3 percent, while it increased by 4.1 percent in urban areas.

Low water flow through the pipes can affect the quality of drinking water. In some places, foul-smelling digester gases (e.g. hydrogen sulphide, H_2S) and germs form in the sewer system because too little water flows through the pipes, resulting in debris. The contamination also causes corrosion in the pipes.

B Tables

Table A1: Detailed Summary Statistics of the Sample

Variable	Description	Mean	Std. Dev.	# obs.
Age	Age of the respondents	59.9	13.5	6,189
Female	Dummy: 1, if the head of the household is female	0.349	-	6,189
Children in the household	Dummy: 1 if there are children living in the household	0.187	-	6,100
Household size	Number of persons living permanently in the household	2.4	0.9	6,189
Abitur	Dummy: 1, if the household head as an university entrance degree	0.375	-	6,143
University degree	Dummy: 1, if the head of the household has a university degree	0.356	-	6,189
Employed	Dummy: 1, if the head of the household is employed	0.499	-	6,127
Full time employed	Dummy: 1, if the head of the household works full time	0.395	-	6,120
Income	Monthly net income, Dummy: 1 if the monthly net household income is...			
Low income	... less than 1,200 Euro	0.010	-	6,189
Middle income	... 1,200 to less than 2,700 Euro	0.173	-	6,189
High income	... 2,700 to less than 4,200 Euro	0.327	-	6,189
Very high income	... more than 4,200 Euro	0.367	-	6,189
Income missing	... not reported	0.123	-	6,189
Member	Dummy: 1, if the head of the household is a member of an environmental protection organization	0.164	-	6,142
Political orientation	Political orientation on a scale from 1 (left) to 11 (right)	5.4	1.8	5,717

Table A2: Linear Probability Model Estimations Results on the Agreement with 5 Statements about Water Conservation within the Control Group

	Not necessary		Negative effects		Hot water		Future		Morality	
	Std.		Std.		Std.		Std.		Std.	
	Coeff.	error	Coeff.	error	Coeff.	error	Coeff.	error	Coeff.	error
Personal environment	0.02*	(0.01)	0.04**	(0.01)	-0.01	(0.01)	-0.17**	(0.01)	-0.20**	(0.01)
All Germans	0.00	(0.01)	0.04**	(0.01)	-0.06**	(0.01)	-0.37**	(0.01)	-0.39**	(0.01)
Constant	0.18**	(0.01)	0.09**	(0.01)	0.27**	(0.01)	0.74**	(0.01)	0.78**	(0.01)
# observations	5307		4971		4758		4719		4653	
# individuals	1769		1657		1586		1573		1551	

Note: Standard errors clustered at the respondent-level are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable is binary and takes the value 1 if the respondent agrees or strongly agrees with the respective statement, and 0 otherwise. Participants who chose the “Don’t know” option are dropped.

Table A3: Linear Probability Model Estimations Results on the Responses to 4 Questions on 6 Water Conservation Policies within the Control Group

	Smart tariffs		Price increases		Heavy users		Education		Comparison		Technologies	
	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.	Coeff.	Std. E.
Fairness	-0.06**	(0.01)	-0.04**	(0.01)	-0.07**	(0.01)	0.00	(0.01)	-0.02*	(0.01)	-0.10**	(0.01)
Effectiveness (self)	-0.08**	(0.01)	0.05**	(0.01)	-0.29**	(0.01)	-0.26**	(0.01)	-0.22**	(0.01)	-0.16**	(0.01)
Effectiveness (society)	-0.09**	(0.01)	0.09**	(0.01)	-0.16**	(0.01)	-0.21**	(0.01)	-0.18**	(0.01)	-0.16**	(0.01)
Constant	0.30**	(0.01)	0.14**	(0.01)	0.64**	(0.01)	0.55**	(0.01)	0.60**	(0.01)	0.68**	(0.01)
# observations	7300		7120		6952		6616		6476		6408	
# individuals	1825		1780		1783		1654		1619		1602	

Note: Standard errors clustered at the respondent-level are in parentheses. ** and * indicate statistical significance at the 1 and 5% level, respectively. The dependent variable is binary and takes the value 1 if the respondent agrees or strongly agrees with the respective policy, and 0 otherwise. Participants who chose the “Don’t know” option are omitted.

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