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# Does Modernization of Irrigation Infrastructure Create Mental Accounts? Insights from an Exploratory Experiment with Spanish Water User Associations

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Despite their potential to conserve water, technological modernization investments that increase the efficiency of irrigation systems rarely result in water savings. On the contrary, they oftentimes increase overall water consumption. An important factor for this outcome is that farmers adapt their behavior to the new technological possibilities. If actual water savings are to be achieved, water conservation policies need to be tailored to the logic adapted by water users. In this study, we investigate the applicability and relevance of mental accounting in agricultural water use. In particular, we test whether farmers' perceptions of water diverge conditional on whether it is supplied naturally or obtained from efficiency gains. We conduct a survey-based experiment among representatives of water user associations in Spain. According to the results, farmers tend to have a stronger sense of ownership over water that is obtained from efficiency increases than over water that originates from natural supply increases; however, they do not intend to use both "types" of water differently. Future policies could strongly benefit from targeting the sense of ownership of higher efficiency gains to achieve water savings. Furthermore, the responsibility of translating efficiency gains into water savings should rather be delegated to water user associations than to individual users.

*Keywords:* Mental accounting; psychological ownership; efficiency paradox; irrigation; rebound effect.

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## 1. Introduction

Many governments in arid and semi-arid regions respond to water scarcity and degraded aquatic ecosystems by promoting new technologies that increase the efficiency of water use in irrigation (Turrall *et al.* 2010). Proponents of such modernization investments argue that efficient water use increases productivity and quality of output while conserving water for the environment. However, empirical evidence suggests that those increases in water productivity rarely lead to higher environmental flows due to the so-called rebound effect or efficiency paradox (Grafton *et al.* 2018; Pérez-Blanco *et al.* 2020; Sampedro-Sánchez 2022). The irrigation rebound effect occurs when changes in water use offset the higher efficiencies gained with the infrastructure improvements (Grafton *et al.* 2018; Perry *et al.* 2017; Sears *et al.* 2018), and this manifests in various ways. As, *ceteris paribus*, higher efficiencies free up a fraction of the water used beforehand, farmers can save this water for future irrigation periods, expand their irrigated area, or replace their crop with more water-consuming varieties (which frequently promise higher economic returns). At the same time, a more efficient application of water reduces (environmentally beneficial) return flows, which, from an ecological perspective, constitute a positive externality (Gómez and Pérez-Blanco 2014). This rebound effect poses a serious threat to the sustainability of aquatic ecosystems and future food security.

Avoiding future rebound effects in water-scarce regions will require understanding what factors into farmer's decisions and perceptions as irrigation efficiency increases through technological modernization (Grafton *et al.* 2018). Research on the rebound effect in other fields, such as, e.g., energy economics, suggests that although the rebound effect can be explained by the rational agent model (Binswanger 2001; Contor and Taylor 2013), it is also affected by a number of behavioral factors, such as moral licensing, peer influence, or mental accounting (Dorner 2019; Exadaktylos and van den Bergh 2021). Considering psychological and behavioral aspects was already pointed out as indispensable for understanding and promoting water conservation behavior in similar areas, as e.g., residential water use (Russell and Fielding 2010; Russell and Knoeri 2020). In the irrigation management literature, behavioral factors were recently studied in the context of farmer's risk perceptions of climate change (Wheeler *et al.* 2021) or water markets in Australia (Haensch *et al.* 2019). Whether and how such factors shape water use decisions and perceptions remains an open question, and understanding their role and applicability will contribute to a better understanding of how rebound effects occur and how they can be avoided. For this purpose, we investigate the relevance and applicability of mental accounting in the irrigation sector. Mental accounting is

a cognitive strategy that resource users apply to optimize their consumption according to their preferences and it was previously identified to drive rebound effects (Hahnel *et al.* 2020; Thaler 1999). Researchers also pointed out that farmer's perceptions and preferences play an essential role in their participation in water markets (Palomo-Hierro *et al.* 2015) and their water use behavior (Kafle and Balasubramanya 2022), and that policies should integrate knowledge of farmer's actions and perceptions alongside irrigation efficiency increases (Grafton *et al.* 2018). Identifying the role of mental accounting further opens up possibilities to make use of advances in behavioral interventions, e.g., nudging, in targeting policies to specific mental budgets.

This study tests whether mental accounting matters for water users and their water use decisions and thus, provides a new perspective on the rebound effect in irrigation. More specifically, we ask the question of whether water users create mental accounts based on two different ways water can be obtained or materialized, which we refer to as the "origin" of water: water received by natural supply and water freed up from efficiency gains. We assume that farmers follow a "water budget" reasoning, according to which they can only use the water that is available and accessible to them via the irrigation infrastructure and the result of collective allocation decisions (Healy *et al.* 2007; Richter and Orr 2017).

Community-based or collective irrigation management is the predominant form of agricultural water governance (Garces-Restrepo *et al.* 2007) and motivates the setting for our study in Spain. Spain is known for its tradition and strength of Water User Associations (WUAs) in which collective thinking and decision-making play an indispensable role in everyday business (Lopez-Gunn 2003; Ostrom 1990). At the same time, Spain has seen a considerable wave of modernization investments as a response to the increasing strength and variability of droughts and the necessity to avoid ecological degradation (Berbel *et al.* 2019). Thus, our study is ideally placed to investigate the effect of efficiency increases through technological modernization on perceptions and decisions in the context of existing collective action arrangements.

Our study is guided by the following research question: Does water resulting from efficiency gains create a different mental account for farmers than water obtained through natural supply in the context of collective irrigation management? We address this question by conducting a scenario-based experimental survey (Holbrook and Lavrakas 2019) which combines ideas from the literature on mental accounting and psychological ownership (Pierce *et al.* 2003; Thaler 1999). We approximate mental accounting by proposing two dimensions in which it can manifest: the intention to use a resource and the psychological ownership of said resource. We measure these dimensions by presenting the surveyed farmers with a

specific scenario based on which they are asked to state their intended behavior and perceived ownership of water. The survey respondents were sampled from an irrigation congress in Spain and are almost exclusively representatives of Spanish WUAs.

The results suggest that water gains resulting from efficiency increases are more likely to be perceived as owned by the farmers, but they are not intended used differently than “natural” water gains by additional supply. That said, while the effect of said origin on psychological ownership is significant, it is not significant on the intention to use. Furthermore, we observe that the perception of what other farmers within the same WUA would do strongly correlates with an individual’s own intention to use, suggesting a strong role of social norms and peer influence. Contextual conditions, such as the degree of modernization, the type of crop produced, the size of the WUA and the experience of drought do not seem to influence the creation of mental accounts. The remainder of the paper has the following structure. Section 2 introduces the relevant theoretical concepts and presents the research model and hypotheses. Section 3 describes the method and data collection. Section 4 presents the results of the data analysis. Section 5 discusses and interprets them in the context of community-based irrigation management. Finally, Sec. 6 concludes and offers suggestions for more sustainable irrigation practices and associated public policies.

## 2. Theory

Our study builds on the theories of mental accounting and psychological ownership and combines these two concepts into a research model that reflects how we expect the origin of water to affect the creation of mental accounts.

### 2.1. *Mental accounting*

Mental accounting refers to the observation that individuals tend to mentally categorize goods or resources into separate accounts, with implications for the individual’s attitude or perception toward those goods or resources (Thaler 1985, 1999). For example, financial income is mentally categorized depending on whether it is regular income or, for instance, a tax rebate or bonus (Antonides *et al.* 2011). Hence, keeping mental accounts helps people to decide on how to allocate or spend their financial resources. Established originally in the financial domain, mental accounting has found increasing application also in non-financial domains, such as energy use (Exadakytylos and van den Bergh 2021; Hahnel *et al.* 2020) and food consumption (Antonides 2022; Huang *et al.* 2020).

Mental accounts in finance have been argued to stem from sources and uses of funds or sets of choices and outcomes (Zhang and Sussman 2018). The former suggests that mental accounts manifest as a result of differing channels through which an income or resource is received (i.e., based on its origin), and its propensity to be consumed (Antonides *et al.* 2011; Heath and Soll 1996; Zhang and Sussman 2018). In other words, the way an individual obtains a good or resource prompts a mental account, and the association to that mental account can potentially influence their decision on how they use or spend it. For instance, studies have found that people value equal objects differently depending on whether they were obtained by chance or effort (Cherry and Shogren 2008; Loewenstein and Issacharoff 1994). In other studies, monetary gains were unequally spent depending on whether they were displayed as dividends or capital gains (Baker *et al.* 2006), or consumers increased their spending when a fraction of it was redeemed in the form of coupons (Milkman and Beshears 2009). In the energy sector consumers were found to be prone to make energy-related decisions based on how previous energy savings have been achieved (Hahnel *et al.* 2020). In another study, Zhang *et al.* (2016) applied a mental accounting framework to understand farmers' decision-making in China and found that it can explain the negative behaviors of farmers regarding the payment of agricultural water fees. Despite the clear potential of mental accounting to contribute to explaining rebound effects, to our knowledge, we are the first to introduce this approach to the domain of agricultural water use. We theorize that if farmers keep different mental accounts for water, this should manifest in their intention to use the water, which we measure by their stated choices.

## **2.2. Psychological ownership**

Psychological ownership refers to an individual's perceived rights over using a good or service, regardless of legal status (Dawkins *et al.* 2017; Pierce *et al.* 2001) and arises via three major experiences: controlling the ownership target, knowing the target intimately and investing the self in the target (Pierce *et al.* 2003). In addition, earlier research has pointed out that the context of origin can also be an influential factor in psychological ownership (Pierce *et al.* 1991). Originating from organizational economics research, psychological ownership has recently received attention in natural common pool resource contexts. For instance, psychological ownership was found to foster the management of public goods and natural resources (Matilainen *et al.* 2017; Peck *et al.* 2021) and strengthen commitment to the environment (Jiang *et al.* 2019). To date, we are aware of one study that relates psychological ownership directly to mental accounting: conducting a set of choice experiments, Sharma *et al.* (2021) provide evidence that psychological ownership

of money differs across payment forms (i.e., whether money is borrowed as a credit or a loan), affecting its assignment to mental accounts and propensity to be spent. Building on this evidence, we suggest that the way an individual perceives ownership over a resource will affect their mental categorization of said resource and hence, serve as a proxy dimension for mental accounting. In our study, we measure psychological ownership through the stated choices of the farmers as to whom the water belongs.

### **2.3. Collective water management in Spain**

Spanish irrigation is a well-known example of a common-pool resource system. Since the Spanish Water Act of 1985, surface and groundwater in Spain is mainly publicly owned (Molinero *et al.* 2011) and water rights are generally assigned by river basin authorities to farmers on a collective basis. Traditionally, water rights are allowed only for using but not buying or selling water. Since 1999, however, Spanish legislation introduced formal water markets that allow temporary transfer and exchange of rights with economic compensation (Palomo-Hierro *et al.* 2015). Usually, water users organize into WUAs and manage the water collectively via common property regimes (Gómez-Limón *et al.* 2021; Villamayor-Tomas *et al.* 2020). With a longstanding tradition in the country, farmers in WUAs have learned to cope with the social dilemmas inherent to the provision of irrigation infrastructure and the allocation of water relatively well (Lopez-Gunn 2003; Thuy *et al.* 2014). Hence, informal rules, such as social norms or peer pressure, play an important role in farmer perceptions and decision-making within this institutional context (Ostrom 1993). We expect the creation of mental accounts also to be influenced by such factors (Krishnamurthy and Prokopec 2010).

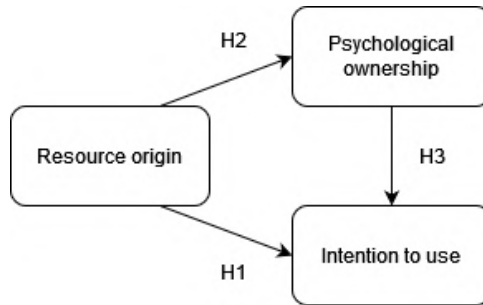
### **2.4. Hypotheses**

Based on the literature presented above, we theorize that an individual's psychological ownership and intention to use a resource vary with the origin of the resource and that there exists a connection between intention to use and psychological ownership (Lee *et al.* 2019; Strahilevitz and Loewenstein 1998). In other words, we are interested in uncovering alternating perceptions and use intentions of water depending on whether it is freed up after efficiency-driven water savings or obtained from increases in water availability (see next section for a detailed description). We formulate the following research hypotheses:

**H1:** The materialization of water affects the intention to use it.

**H2:** The materialization of water affects its psychological ownership.

**H3:** Psychological ownership affects the intention to use.



**Figure 1.** Research Model Showing the Relationships to be Tested by Hypotheses H1–H3

The hypotheses illustrate connections between the origin of water and the two proposed dimensions of mental accounting, as synthesized in Figure 1.

### 3. Methodology

The data for this study were collected at the XV National Congress of Spanish Irrigation Communities which took place in León, Spain, from May 30 to June 3, 2022. This congress is organized quadrennially under the patronage of the National Federation of Irrigation Communities of Spain (FENACORE) and constitutes the main event around irrigation in Spain. FENACORE invites researchers and high-ranking policymakers from Spain as well as representatives and associates of its member communities to discuss the current state and future of irrigation. Therefore, it gathers an ideal and representative sampling pool for the group of Spanish WUAs. For the duration of the congress, we conducted in-person surveys with representatives and farmers of the participating WUAs.<sup>1</sup> Survey participants were selected following convenience sampling and with the aim of maximizing sample size and number of WUAs. We approached potential participants on the spot in the main hall of the Congress and asked them to take part in our survey. In most of the cases, representatives agreed to take part in the survey on the spot or at a later moment. Answers as well as qualitative comments made by the respondents were written down on paper. The number of completed surveys at the end of the congress was 63 ( $M_{age} = 62.8$  years,  $SD = 10.5$ , 97% male, response rate 90%) and respondents were associated with 59 different WUAs. Given that 97 WUAs were listed as participants at the congress, our sample represents more than 60% of the participating communities.<sup>2</sup> The survey was split into two parts. The first part

<sup>1</sup>In fact, 97% of the surveyed farmers were representatives or had a similar mandate.

<sup>2</sup>As of 2022, FENACORE counts more than 350 associated WUAs in total which represent about 80% of irrigation in Spain (FENACORE 2022).

consisted of a scenario-based experiment, which presented each participant with one of two hypothetical situations followed by three closed questions. The second part of the survey entailed closed and open questions about how WUAs cope with droughts, whether administration and management are affected by droughts, energy-related problems, participation in social movements and satisfaction with administrative aspects. Completion time for the survey was approximately 15 min per participant.

In the experiment, participants were randomly assigned to one of two hypothetical situations. In the baseline (hereafter: nature), participants were asked to imagine that favorable biophysical conditions had led to an increase in water supply by 20% based on the water they usually receive and use. In the treatment (hereafter: technology), participants were asked to imagine that due to a (cost-free) infrastructure modernization investment, the higher efficiency reduced their water requirements by 20%. We also emphasized that this change would apply to all water users of the corresponding WUA. Hence, in both treatments, the respondents were faced with the same “extra” amount of water. Subsequently, each participant was asked three questions regarding: (a) their intended individual use of the additional 20%, (b) their expectations regarding the intended use of other water users in the WUA, and (c) their perceived ownership of the additional 20%. For questions (a) and (b), the participants were asked to distribute the 20% among three possible options: individual use, communal use and environmental use. For question (c), participants had to state whether they felt that the 20% belonged to themselves, to the community, or to the environment. The questions were closed but we allowed participants to qualify their answers verbally and took notes of it. This type of methodology has been applied prominently in experiments on social choice theory, where the mere presentation of a (mathematically identical) situation in different ways leads to different responses (see e.g., [Yaari and Bar-Hillel 1984](#)). Furthermore, we asked the participant about their WUA’s degree of modernization (i.e., how much of the irrigation system consists of sprinkler or drip irrigation), the dominantly cultivated crop (herbaceous, woody and vegetables), and the size of their WUA. The former variable captures a relevant distinction because previous studies have demonstrated that modern irrigation technologies can shape institutions and management practices over time ([Benouniche et al. 2014](#); [Ortega-Reig et al. 2017](#); [van der Kooij et al. 2017](#)). Farmers working in modernized irrigation systems may develop different perceptions and beliefs regarding water use and ownership compared to farmers in predominantly traditional irrigation systems. The distinction between woody (e.g., citrus or olives) and arable (herbaceous or vegetable) crops can also be relevant as woody plants cannot be easily replaced from one period to another, constraining the flexibility of farmers to adapt to

changes in water availability. Lastly, size is a relevant variable as it usually affects professionalization (Villamayor-Tomas *et al.* 2020) and degree of modernization, which in turn might impact perceptions about collective decision-making processes and water use (Araral 2009; Meinzen-Dick *et al.* 2002). As a suggested methodological best practice (Palm-Forster *et al.* 2019), a pre-analysis plan and the survey design were preregistered on [aspredicted.org](https://aspredicted.org).

The analysis unfolds in two steps: First, we present a descriptive analysis based on frequency counts and tests for differences across treatments with Fisher's exact and Kruskal-Wallis tests. Second, we run a binomial logistic regression model to further examine relationships while controlling for contextual variables.

#### 4. Results

In total, 62 water users answered one of the two treatments<sup>3</sup>: 33 did it for the baseline and 29 for the treatment. It should be noted that although we gave the participants the possibility to distribute the 20% excess water freely, most of them ( $n = 52$ ) assigned the full percentage to only one category. Given this highly skewed distribution toward the extremes (see Figures A.1 and A.2 in the Appendix), we opted to dichotomize the answers. This was done by assigning the value of the variable to that category, to which the highest percentage was assigned.<sup>4</sup> In the case of the intention to use, both "individual use" as well as "communal use" refer to "investing" the water for economic activity (i.e., irrigation). Hence, we grouped those responses into "economic use" to compare it with "environmental use". The same logic holds for the other's intention to use and psychological ownership, which was clustered into "non-environmental" (i.e., individual, communal, other) and "environmental". Lastly, we also dichotomized the type of technology used and type of crop cultivated predominantly. A system is classified as traditional if more than 50% of its area is irrigated by gravity, and modern if more than 50% of its area is irrigated by drip or sprinkler. Table 1 summarizes the sample characteristics as well as the variables included in the analysis, respectively. Figure 2 presents their spatial distribution across Spain.

<sup>3</sup>We excluded one participant from the original 63 surveys who claimed not to be a water user but a technician of a WUA.

<sup>4</sup>Our sample includes four equal-split answers for the (own and other) intention to use. One of them distributed the 20% equally among the three categories "individual", "community", and "environment", and three distributed the 20% equally among the two categories "community" and "environment". The former was counted as "economic use" while the latter three were assigned to "environmental use", following the logic that at if least half of the water was assigned to the environment, it counts as an environmentally conscious intention.

**Table 1.** Description of Variables and Sample Characteristics

Sample	Full (62)	Baseline (33)	Treatment (29)
Male	96%	94%	100%
Mean age	64 years	64 years	64 years
Mean total agricultural area	8,515 ha	3,278 ha	14,122 ha
Farmer	100%	100%	100%
Farmer with a responsibility function within the community	98%	97%	100%
Experienced drought since 2012	63%	67%	59%
Usage of drip and sprinkler technology	52%	54%	51%
Mean usage of electricity	43%	37%	51%
Crop mixes			
Herbaceous	47%	55%	38%
Wooden	44%	39%	48%
Vegetables	10%	6%	14%
Variable	Values		Mean
<b>Dependent variables</b>			
Intention to use	Economic (0), Environmental (1)		0.24
Psychological ownership	Non-environmental (0), Environmental (1)		0.27
<b>Independent variables</b>			
Treatment	Baseline (0), Treatment (1)		0.47
Other's intention to use	Economic (0), Environmental (1)		0.19
Technology	Traditional (0), Modern (1)		0.52
Type of crop	Arable/Non-woody (0), Woody (1)		0.44
WUA size	200–120,000 ha (SD = 2,0424.1)		8,514.6

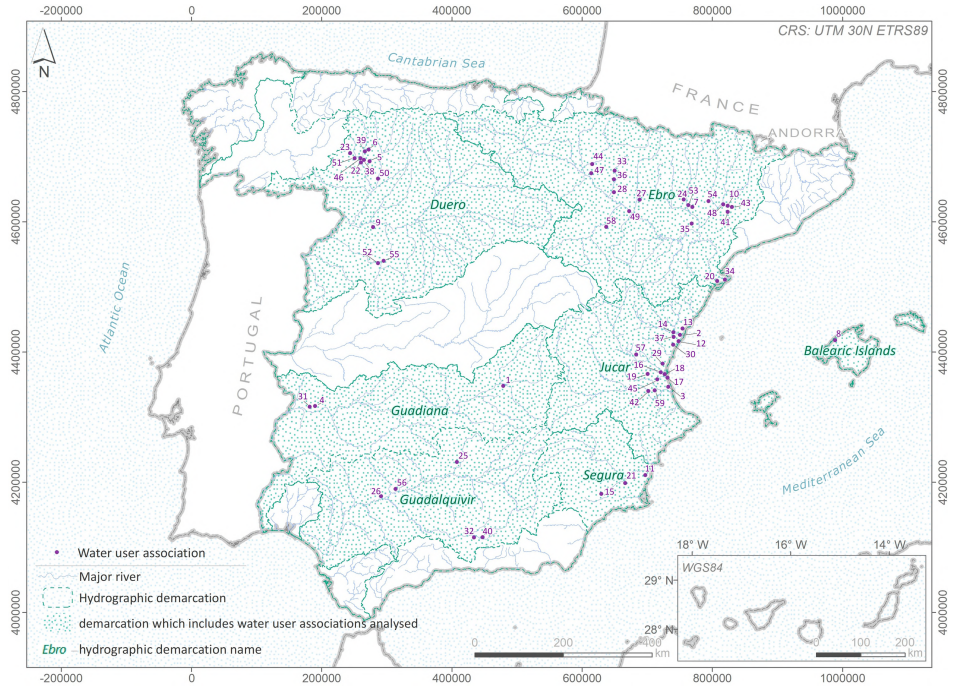
#### 4.1. Descriptive analysis

Figure 3 shows the distribution of responses to the question “How would you use the extra 20% water?” across scenarios.

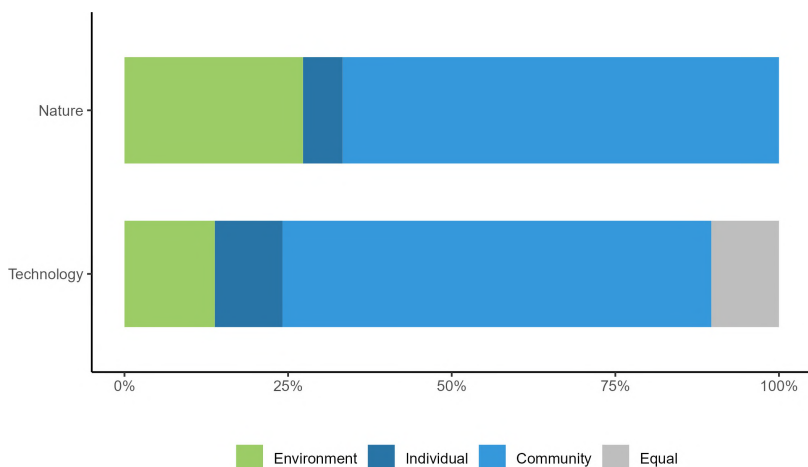
The most frequent answer for the intended use of the extra water, regardless of scenario, was to leave it for use (i.e., distribute it) within the community. To a much lesser extent, the second and third most frequent intended use was to leave it for the environment and oneself, respectively. Three respondents opted for “distributing” freed-up water among all potential uses, or between community and environment. As explained previously, we used the dichotomized version of the variable for the statistical tests. We observe more assignments to the environment in the baseline compared to the treatment, but this difference is not statistically significant.

Figure 4 shows the frequency of responses to the question “How would other farmers from your community decide?”.

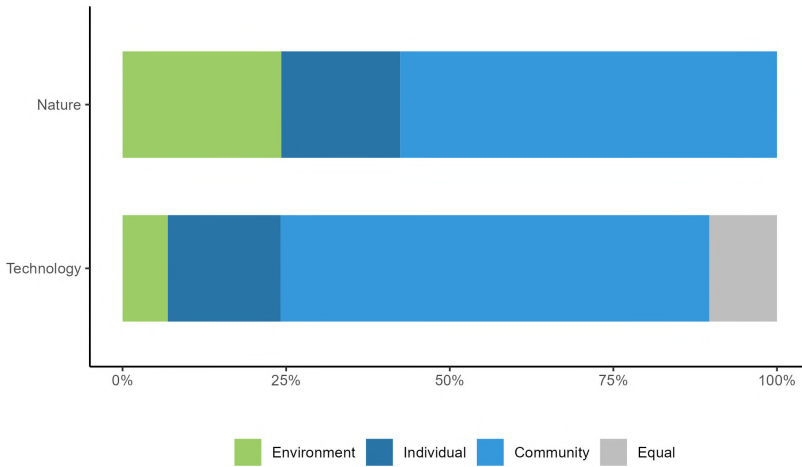
The results present a similar picture as for the previous question. Allocations to the environment seem not to be significantly different in the nature treatment compared to the technology treatment (according to a Kruskal–Wallis rank sum



**Figure 2.** Geographical Location of the Sample WUAs in Spain. Elaborated with Cartographic Data from the Sources: Administrative Boundaries, GADM Database of Global Administrative Areas (<http://www.gadm.org>), April 2018; Major Rivers, Ministerio De Agricultura y Pesca, Alimentación (MAPA), January 2007; Hydrographic Demarcations, Ministerio Para La Transición Ecológica (MITECO), November 2019



**Figure 3.** Frequency Bar Chart Based on the Individual's Intention to Use. Fisher's Exact Test Between Environmental and Economic Use:  $p = 0.35$ . Kruskal-Wallis Test:  $p = 0.28$



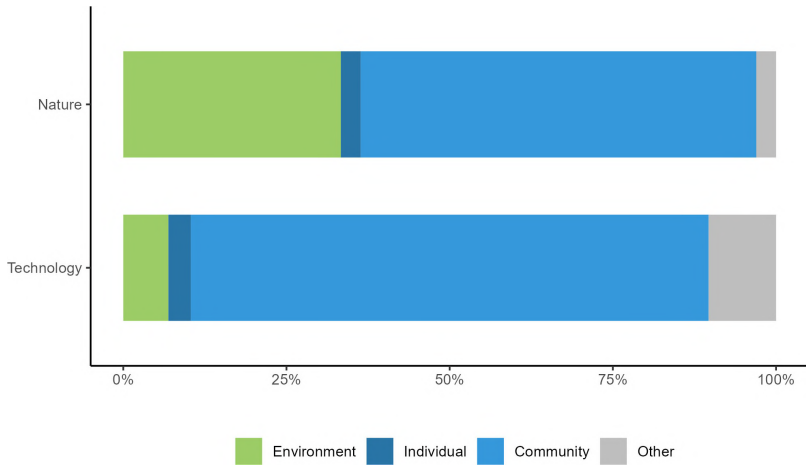
**Figure 4.** Frequency Bar Chart Based on the Expected Other's Intention to Use. Fisher's Exact Test Between Environmental and Economic Use:  $p = 0.16$ . Kruskal–Wallis Test:  $p = 0.095$

test they are at the 10% level). One observable difference is that others are more frequently expected to use additional water individually compared to one's own intention. This difference, however, is not statistically significant for any of the treatments (Nature: Fisher's exact  $p = 0.25$ , Technology:  $p = 0.70$ ).

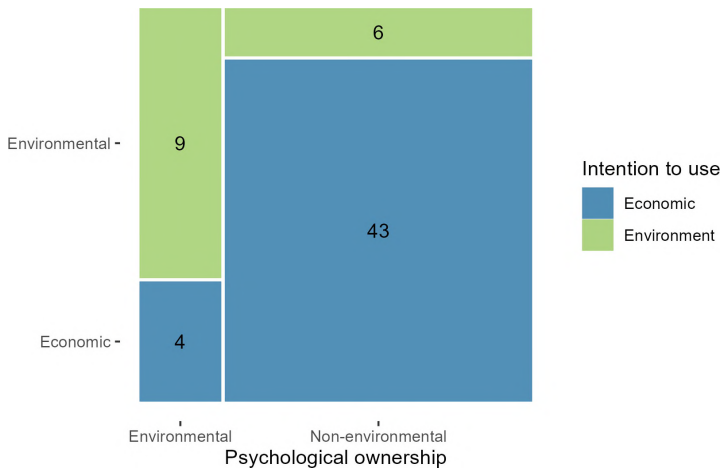
The overall distribution of responses with regards to psychological ownership of the additional 20% water is similar to the intention to use: a majority perceives additional water as belonging to the community, regardless of the scenario (Figure 5). However, the difference here is significant almost at the 1% level: a larger number of respondents in the nature treatment state that the additional water belongs to the environment compared to the technology treatment.

Examining the relationship between the two dimensions of mental accounting, we find alignments across intended use and psychological ownership responses (Figure 6, Fisher's exact and Kruskal–Wallis both  $p = 0.00$ ): 69.2% (= 9/13) of those participants who stated that the environment is the owner of the extra water also preferred leaving it for environmental use, and 87.7% (= 43/49) of the participants that said that the community or individual farmer owned the extra water preferred keeping it for community or themselves for economic use. This association is shown graphically in Figure 6. The top left rectangle represents responses where environmental use was associated with environmental ownership and the bottom right rectangle shows responses where economic use was associated with non-environmental ownership.

Finally, we find strong correlation between one's own intention to use and the expected intention to use of others (Pearson's correlation coefficient  $\rho = 0.96$ ), i.e.,



**Figure 5.** Frequency Bar Chart Based on Psychological Ownership. Fisher’s Exact Test Between Environmental and Non-Environmental Ownership:  $p = 0.01$ . Kruskal–Wallis Test:  $p = 0.01$



**Figure 6.** Mosaic Plot of the Dimension Consistency Between Intention to Use and Psychological Ownership. The Numbers within the Rectangles are Frequency Counts of Participants Perception of Psychological Ownership (Environment vs. Non-Environment) and their Own Intention to Use (Economic vs. Environment)

96% of the individual intention to use responses align with what is expected to be done by others.

#### 4.2. Regression analysis

To further tests our hypotheses, we ran a binomial logistic regression. The simplest model (column 1 in Table 2) shows that the odds of the intention to use being

**Table 2.** Full Regression Results

Predictors	Intention to Use						Psychological Ownership					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Odds Ratios	p	Odds Ratios	p	Odds Ratios	p	Odds Ratios	p	Odds Ratios	p	Odds Ratios	p
(Intercept)	0.38	0.012	0.08	0.001	0.03	0.027	0.50	0.061	0.18	0.002	0.11	0.054
Technology	0.70	0.547	2.36	0.321	4.28	0.353	0.15	0.020	0.09	0.017	0.05	0.019
Psych. Ownership [env]			24.77	< 0.001	41.76	0.029						
Modernized [modern]					0.23	0.244					1.36	0.744
Crop [woody]					3.39	0.462					0.44	0.408
WUA size					1.00	0.913					1.00	0.164
Drought (since 2012) [yes]					0.22	0.241					1.94	0.500
Intention to use [env]									24.77	< 0.001	31.20	0.029
Other's intention to use [env]					199.31	0.002					0.90	0.949
Observations	62		62		60		62		62		60	
R <sup>2</sup> Tjur	0.006		0.301		0.674		0.105		0.443		0.415	

leaving water for the environment decrease by the factor 0.7; i.e., by 30% for the technology treatment compared to the nature treatment. However, this effect is statistically not significant ( $z = -0.602$ ,  $p = 0.547$ ) and consistent across model specifications (columns 2 and 3 of Table 2). Hence, it confirms the finding that technology cannot explain the differences in the intention to use, and we reject hypothesis H1.

For psychological ownership the model states that technology decreases the odds of assigning ownership to the environment by a factor of 0.15 (column 4 in Table 2). In other words, the odds of feeling that the additional water belongs to the environment are 85% lower in the technology treatment compared to the nature treatment. While the base odds of believing the water belongs to the environment are 0.5 for nature, they are only 0.075 for technology. In line with the descriptive results, this effect is significant at the 5% level ( $z = -2.327$ ,  $p = 0.020$ ), and holds across different model specifications, adding support to our hypothesis H2.

The regression also confirms the strong relationship between the two dependent variables ( $p \leq 0.001$ ) (supporting hypothesis H3) and indicates that none of the included contextual variables has a significant effect on any of the dependent variables. In sum, the regression model confirms the results from our descriptive analysis which leads us to reject hypothesis H1 and confirm hypotheses H2 and H3.

## 5. Discussion

### 5.1. Mental accounting

The main premise of the study was that water users categorize water into different mental accounts based on how water is materialized, and that this manifests in varying intentions to use the resource and psychological ownership over it. Contrary to previous findings from financial and energy-related studies (Hahnel *et al.* 2020; Zhang and Sussman 2018), we do not find a significant effect of our technology treatment on the intention to use. However, our results show a significant effect of technology on psychological ownership, which aligns with findings from the respective literature (Pierce *et al.* 1991; Sharma *et al.* 2021). Moreover, we find that psychological ownership and intention to use are correlated. Hence, we interpret our results as a first indication for mental accounts of water budgets.

Especially interesting is the dominance of community use and ownership in the responses of the participants. To understand this outcome, it is worthwhile to recall the institutional context in which water users (inter-)act, and its potential impact on mental accounting. The fact that water is governed collectively limits the capability of individual farmers to freely decide on the quantity of water they can apply,

which in turn shapes their perceptions and beliefs of ownership. This could explain why we saw almost no individual use or ownership responses in the results. To be sure, some farmers might have individual access to water via their own wells, while others depend fully on collective water distribution mechanisms. While we would expect this to have an effect on the creation of mental accounts as well, our sample did not allow for testing this hypothesis as we had almost no variation in the indicated water sources used by the WUA representatives. Controlling for the type of water source used is an important recommendation for future work, as different sources of water are associated with different costs, which in turn could affect the creation of mental accounts. Our finding of a strong collective sense in water use decisions and perceptions, however, can become relevant for addressing the efficiency paradox in collectively managed irrigation systems, particularly given the ubiquity of community-based irrigation management systems worldwide (Gany *et al.* 2019; Garces-Restrepo *et al.* 2007).

Relatedly, participants in our study frequently brought forward the justification that WUAs need to save any additional or freed-up water resources for upcoming periods of drought because their water rights are frequently not met during these periods.<sup>5</sup> This constitutes a strong reason for WUAs not to be willing to contribute to environmental flows. More importantly, some participants explained to us that allocating any additional water to the community was the environmentally beneficial action because any let go water would be “lost”, while the community could regulate it to maintain runoffs in water scarcity periods. This suggests a lack of farmer’s awareness for the negative impacts or the existence of rebound effects. In our case, however, it helps to understand the relatively few allocations to the environmental option and reflects the persisting idea among farmers that any water not used in agriculture is lost and that sustainability is seen as a form of agricultural profitability (Baccar *et al.* 2020). In other words, farmers seem to create a “false” environmental account (Grüner and Hirschauer 2016) when they allocate water to the community. In this case, mental accounting would be reinforcing water use as users “book” resources into the community account under the belief that their collective consumption does not impact the ecosystem or does so positively (Hahnel *et al.* 2020). Future research shall also control for the awareness of rebound effects among farmers, as it might constitute an important determinant for intended behaviors and perceptions.

<sup>5</sup>Despite having received numerous qualitative comments alongside the completion of the survey, their anecdotal nature made it difficult for us to code and systematically analyze them.

## **5.2. The collective rebound effect**

The finding that there is only a negligible number of water allocations to individual use illustrates, in our understanding, the ability of farmers from the sampled WUAs to overcome common pool resource dilemmas associated with the incentive for individuals to free-ride on other farmer's water conservation efforts (Ostrom *et al.* 1994; Villamayor-Tomas 2014). At the same time, our results suggest that the public goods dilemma regarding the potential impact of irrigation water use on the environment and other potential water users (Villamayor-Tomas *et al.* 2019b) remains salient and unresolved. This is seen in the low number of "pro-environmental" responses, meaning that contributions to the ecosystem, which constitutes a global public good, do not appear to be a major concern. These findings confirm literature on nested social dilemmas, which highlights how sustainable local resource management requires solving collective action problems at different levels and with regard to different management tasks (Bisaro and Hinkel 2016; Villamayor-Tomas *et al.* 2021); and how users are more likely to cooperate with their peers and in the presence of external competition for the resources than otherwise (Wit and Kerr 2002). It is therefore possible that resolving the dilemma at the irrigation system level is to some extent at odds with solving it at the global public good level. Keeping the extra water for the community illustrates farmer's capacity for cooperation (and for defending their collective interests) but also enters into conflict with freeing water for other uses outside of the realm of the community. This would explain why efficiency increases do not automatically translate into water savings in the WUA management context. Any efforts in trying to reduce water consumption after efficiency increases should therefore be more effective if directed at the collective rather than the individual level, which is an important implication for future policy design (Hoffmann and Villamayor-Tomas 2023).

## **5.3. Implications for water conservation policies**

After at least two decades of promoting infrastructure modernization of irrigation systems worldwide, policymakers are concerned about the need to curb rebound effects that undermine the contribution of efficiency gains to water conservation. Reaching such objectives is further hindered by the increasing occurrence of drought as a consequence of the changing global climate. Although cutting water rights appears to be a relatively successful measure in some cases (Berbel *et al.* 2015), its implementation faces strong farmer opposition more frequently than not (Garrick *et al.* 2013) and does not always lead to a direct or visible increase in ecological flows (Sampedro-Sánchez 2022). Our results show that although

farmers are capable of holding different mental accounts of water, their perceptions are strongly influenced by prevalent WUA institutions and collective action beliefs (Lubell 2003). Several recommendations emerge from this finding; all of them point to similar directions but each emphasizes different policy instruments. A first straightforward means to convey water-saving strategies would be to make WUAs co-responsible for said savings and confront them with the need to accommodate competition over water resources at the basin level. In Spain and many other countries, WUAs sit on decision boards of river basin organizations; however, to our knowledge, these boards have not seriously treated structural water conservation priorities (Schütze *et al.* 2022). WUAs have not only the formal authority to constraint farmers' behavior locally, but also the legitimacy, monitoring capacity and firsthand knowledge to make it real.

Second, since beliefs constitute an important determinant of water conservation behavior (Russell and Fielding 2010), the potential advantages of reshaping them to motivate water conservation are evident. One such common belief is that water that is kept and used by the WUA constitutes the ecologically "best" option, disregarding the importance of environmental flows. In order to counteract this belief, a step forward could be to promote participatory processes within the WUAs to question and deliberate around this idea. Equally, farmers might revise their beliefs based on demonstration projects that illustrate the connection between consumptive uses of water and ecological flows for aquatic ecosystems. Such ideas could be initiated as part of the growing literature on participatory research (Sanchis-Ibor *et al.* 2021).

Finally, our results also show that individuals tend to act in accordance with peer behavior (or at least what they believe other farmers would do), which suggests the importance of social norms in Spanish WUAs. The importance of so called "neighborhood effects", i.e., peer pressure or conformity behavior, on conservation behavior has been already shown in other conservation contexts (Chen *et al.* 2009; Villamayor-Tomas *et al.* 2019a). Therefore, farmers might be incentivized to reduce consumption within certain mental budget accounts if a reference group does similarly (Krishnamurthy and Prokopec 2010); and WUAs could promote said learning via regular feedback to their members (Tiefenbeck *et al.* 2019). Future research could explore how reference levels from successfully water-saving farmers and WUAs can be communicated effectively within and across WUAs.

#### **5.4. Limitations**

Our study has three limitations. First and likely foremost, we acknowledge the possibility of hypothetical bias in the responses given by the participants (Loomis

2011). As the survey was not incentivized, there is a risk that farmers erred on the altruistic side, resulting in an overestimation of environmental water allocations. Also, our hypothetical scenarios might have appeared unrealistic for some WUA representatives. For instance, an additional increase in efficiency of 20% for an already modernized system is difficult to reach, and a sudden increase in 20% of natural supply is equally unrealistic in cumulative years of drought. In addition, we framed the increase in efficiency in the treatment condition as a cost-free “gift”. Although this might appear unrealistic from a farmer’s perspective, we opted for this design feature to ensure comparability between the two treatments. If there is effect even in this condition, it is likely that there will also be an effect under conditions of costly modernization investments. Overall, we cannot exclude the possibility that farmers gave responses that deviate from how they would actually behave in real contexts. We expect this hypothetical bias, however, to affect mainly one own’s assignment but not psychological ownership or beliefs of other’s decisions.

Second, we had to work with a relatively small sample size. This has to be attributed to the chosen approach of in-person surveys at an event. Conducting online-surveys remains challenging due to the low use of technologies among farmers (in our sample, less than 50% of respondents estimated email usage by farmers within their WUAs to be above 50%), and comparably low response rates (Glas *et al.* 2019). In our case, another issue related to the small sample size is that irrigators do not always show homogeneous preferences toward water use or how improved water supply is obtained (Guerrero-Baena *et al.* 2019; Villanueva and Glenk 2021). However, our sample is homogenous in a sense that it only includes representatives of WUAs. Although individual farmers’ intentions and psychological ownership might deviate from their representatives’, we consider that WUA representatives responses constitute a substantial strength of the sample given that they are most qualified to make statements about their community and can capture prevalent or average perceptions or discourses within their communities. Furthermore, we sampled about 60% of participating WUAs at the congress, and their characteristics seem to be homogeneous in relevant aspects also between nature and technology samples. Nevertheless, research with larger sample sizes, including also regular farmers and other case studies will be required to be able to generalize the results. Although the small sample size mostly undermines the power of our statistical analysis and the risk of Type II error (Palm-Forster *et al.* 2019), it does not undermine the direction of findings. Our findings are not conclusive about mental accounting effects of water origin on intention to use but are relatively so regarding psychological ownership.

Third, this study did not include data from farmers operating in irrigation systems that are not managed by WUAs or which are found outside of Spain. Our finding about the strong influence the collective management institutions on mental accounting point, however, to the interest of exploring other institutional contexts. To be sure, we believe our results are quite generalizable given the widespread dominance of community-based irrigation systems worldwide (Garces-Restrepo *et al.* 2007), as for example Mexico (Villamayor-Tomas and García-López 2017) or Nepal (Frey *et al.* 2016). That said, other forms of governance (i.e., state-led or market-based governance) might underly different behavioral dynamics. Also, there is considerable institutional diversity even among community-based irrigation systems worldwide (Wang and Chen 2021) and in Spain (Villamayor-Tomas *et al.* 2020). Further research should therefore address mental accounting and rebound effects in different institutional and regional contexts.

## 6. Conclusion

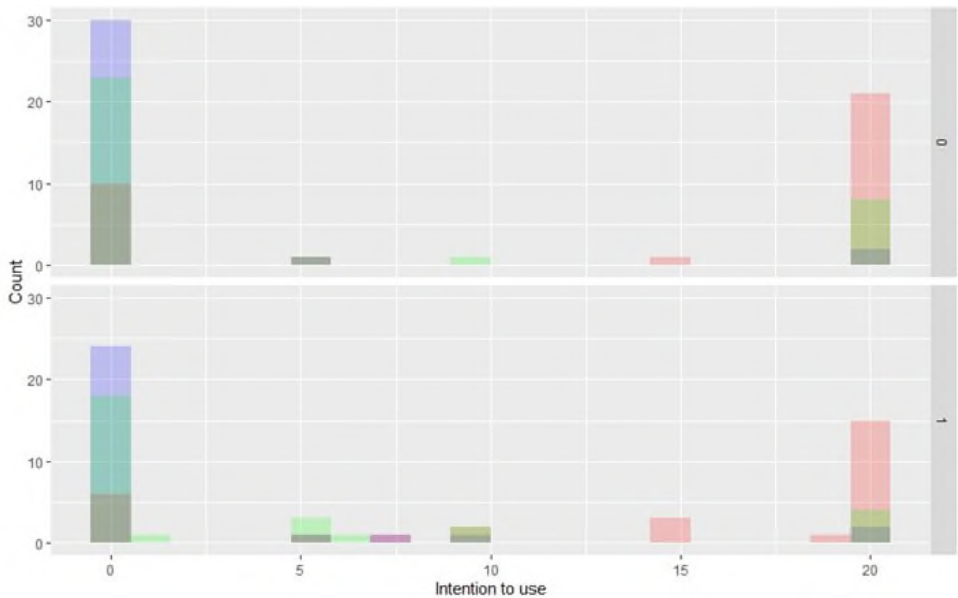
The goal of this study was to identify whether mental accounting plays a role in water use rebound effects after irrigation efficiency increases. In order to do so, we conducted a scenario-based survey experiment with representatives from Spanish WUAs and asked them about their intention to use and sense of ownership under two different water origin scenarios. Although the majority of the respondents claimed the intention to allocate any type of water to their community and perceived water usually as owned by the community, we found a significant difference in psychological ownership across the two treatment scenarios. Water users are significantly more likely to perceive additionally supplied water as owned by the environment than water that is freed-up from efficiency gains. While the treatment effect was not significant for the intention to use, we still find a strong correlation between the two proposed dimensions of mental accounting. Overall, we interpret this as evidence for mental accounting processes and emphasize the importance of understanding these processes to better tackle water use rebound effects. Furthermore, the data suggest that an individual's intention to use strongly correlates with expectations or beliefs about what other water users within the WUA would do. Although this cannot be interpreted without speculation, it suggests that conformity and other forms of social norms and peer pressure or identity-based loyalty also play an important role. Our results allow to expect community-based management institutions (e.g., the conformity of farmers with collective management rules and norms) to play an important role in shaping the perceptions of water users, demonstrating the key role of WUAs and prevalence of collective action dynamics in the Spanish irrigation sector. Our study is meant to be a first

exploration toward better understanding the behavioral consequences of irrigation modernization investments and should lay the groundwork for future research on behavioral dynamics in community-based irrigation systems.

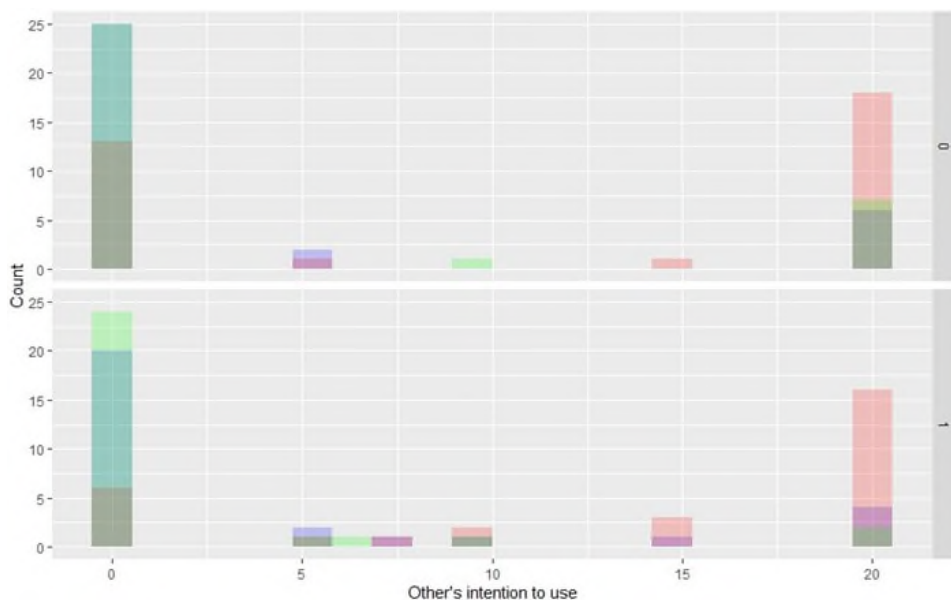
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### Appendix A



**Figure A.1.** Distribution of Responses with Regards to (Own) Intention to Use. Red Shade Represents Communal Use, Green Shade Environmental Use, and Blue Shade Individual Use. 0 = Baseline, 1 = Treatment



**Figure A.2.** Distribution of Responses with Regards to Other's Intention to Use. Red Shade Represents Communal Use, Green Shade Environmental Use, and Blue Shade Individual Use. 0 = Baseline, 1 = Treatment

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