Individual Incentives or Collective Coordination ? Water Conservation in Collective Housing in the Lille Metropolitan Area

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Research proposal

April, 2026

Abstract

This research project examines whether nudges can promote water conservation in collective housing and whether any effect they produce is driven primarily by the visibility of individual benefits or can also stem from collective coordination. In collective housing, water consumption is often partly pooled, metering is not always individualized, and the link between individual behavior and the water bill may therefore remain blurred, which can weaken the effectiveness of conventional price-based instruments. Drawing on water economics, commons theory, and behavioral economics, the project studies the impact of a local social-comparison message on water consumption in individually metered and collectively metered buildings. Empirically, it relies on consumption data provided by Iléo in the European Metropolis of Lille (MEL) and proposes a field experiment combined with a difference-in-differences strategy. Beyond evaluating the effect of an informational intervention, the project seeks to identify whether water conservation in collective housing is driven mainly by individual incentives or can also be sustained by a logic of the commons.

Keywords : water sobriety, collective housing, nudges, social comparison, water demand, commons, field experiment

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1 Introduction

In dense urban areas, the issue of water management in collective housing is becoming increasingly central to water sobriety strategies. When uses are concentrated within apartment buildings, when consumption is partly pooled, and when the relationship between individual behavior and the amount of the bill becomes less immediately perceptible, demand management raises specific challenges for both service operators and public authorities. Collective housing thus constitutes a particular configuration in which conventional incentive instruments may see their effectiveness weakened by the very organization of uses and billing arrangements.

This issue is gaining increasing importance in a context marked by intensifying pressures on water resources. Public authorities have indeed emphasized that drought episodes are becoming more frequent and more severe across France, while the *Plan Eau* has elevated water sobriety to the rank of a policy priority. At the same time, the level of domestic consumption remains high: an inhabitant in France consumes on average around 149 to 150 liters of drinking water per day, that is, approximately 54 to 55 m^3 per year (Eau France, 2024). These orders of magnitude confirm that residential uses constitute a concrete lever for reducing demand, particularly in metropolitan areas where population, needs, and pressures on urban services are simultaneously concentrated.

It is within this perspective that the present project is situated, developed in partnership with Iléo, the operator responsible for drinking water distribution across a substantial part of the territory of the European Metropolis of Lille (MEL). This partnership is of interest not only from an operational perspective but also from a scientific one, insofar as it provides an empirical setting particularly conducive to analyzing the effects of informational devices on water consumption behavior in collective housing.

The project rests on a dual starting point. On the one hand, the project responds to an operational objective. Iléo is facing new contractual constraints requiring it to reduce its water purchases from resellers by 15% over a ten-year period, in a context marked by climate change and without recourse to price-based instruments. This commitment creates a strong incentive to lower household water consumption, since failure to meet the target would result in financial penalties. From a theoretical standpoint, this situation echoes a broader question concerning the determinants of changes in consumption behavior when the correspondence between individual action and private benefit is partially blurred.

In collective housing, indeed, water consumption is not necessarily measured or billed at the household level. Metering may remain aggregated at the building level, while the allocation of charges among occupants relies on rules liable to reduce the visibility and even the incentive effect of the price signal. In such a configuration, the adoption of water-saving behaviors no longer results solely from an individual calculation in response to the cost of the resource; it also depends on mechanisms of collective coordination, shared usage norms, and the concrete ways in which information circulates within the residential setting.

The present project lies at the intersection of three bodies of literature. The first, stemming from water economics, has long emphasized the decisive role of the price signal in demand management, while also showing that its effectiveness remains conditioned by the quality of available information and the readability of tariff structures. The second, that of commons theory, makes it possible to apprehend collective housing as a particular institutional configuration in which a shared resource is subject to individualized uses, while the gains associated with moderating those uses are, at least in part, collective. The third, finally, belongs to the behavioral economics literature on nudges, which highlights the capacity of limited, low-cost, and non-coercive informational interventions to steer behavior.

The project's specific contribution lies in comparing individually metered and collectively metered buildings. This distinction makes it possible to assess whether the effectiveness of an informational nudge depends primarily on the visibility of individual consumption, and thus on a clearer perception of the private gains associated with conservation efforts, or whether it can also emerge in a setting where the benefits of conservation are less directly appropriable, through collective dynamics specific to the residential environment. The issue is therefore not only empirical but also theoretical, as the project seeks to identify the causal channel through which an awareness-raising intervention may affect water use.

From this perspective, the project plans to implement a field experiment based on sending a local social comparison message to residents of collective housing in the Lille metropolitan area. The objective is to measure the impact of such a device on water consumption levels and to assess the heterogeneity of this effect across the observed informational regimes. This work seeks to contribute to a still relatively underdeveloped field of research, namely the conditions of water sobriety in collective housing. More fundamentally, it aims to answer a central question: can residential collective housing be an effective support for environmental action, and does the effect of a nudge on water conservation depend mainly on individual incentives or on the ability of a local common to create coordination between its members ?

The remainder of this research proposal is organized as follows. The next section reviews the main strands of literature on water demand, commons theory, and behavioral interventions. The paper then presents the research question and hypotheses, before detailing the experimental design, the data, and the empirical strategy. It subsequently discusses possible extensions and limitations of the project, and the final section concludes.

2 Literature review

2.1 Price signals as a standard instrument in economic analysis

In the standard economic approach, price occupies a central position among the instruments likely to shape consumption behavior. Demand is understood as the outcome of a trade-off between the satisfaction derived from consumption and the budget constraint, so that a change in the cost of use is, in principle, expected to translate into an adjustment in the quantities demanded. Applied to the water sector, this analytical framework leads to viewing pricing as a major tool for demand management. From this perspective, a large share of the literature on residential water use has focused on estimating the price elasticity of demand and assessing the magnitude of the adjustments made by households in response to changes in water prices (see Dalhuisen and al., 2003; Worthington and Hoffman, 2008; Arbués, García-Valiñas and Martínez-Espiñeira, 2003).

The findings of this body of work converge on the idea that, although water demand is indeed responsive to price, this responsiveness generally remains moderate and varies considerably across institutional settings, pricing schemes, and the ways in which the economic signal is received. In other words, the incentive effect of price does not depend exclusively on its level, but also on the conditions under which it is perceived and interpreted by users. In this respect, several contributions have shown that households do not always respond to the marginal price in the strict sense used in standard microeconomic models, but rather to more salient or more easily apprehensible indicators, such as the average price or the total bill amount (Shin, 1985; Nataraj and Hanemann, 2011; Ito, 2014). This perceptual dimension appears especially decisive in the case of water, where the infrequency of payments, the sometimes complex structure of bills, and the sophistication of pricing schedules may reduce the clarity of the price signal conveyed to households.

The French case of Dunkerque provides a particularly illuminating illustration of these mechanisms. Examining the introduction in 2012 of an increasing block tariff designed to pursue both environmental and social objectives, Mayol (2017) identifies a decline in aggregate consumption, but also a strong heterogeneity in responses across household categories. In particular, the author highlights the existence of a windfall effect among low-consuming households, while intermediate and high-consuming households reduce their usage more substantially. He also brings to light equity concerns, especially for large families, which reach the upper tariff blocks more quickly without this necessarily reflecting avoidable overconsumption. Mayol and Porcher (2019) extend this analysis by showing that households do not primarily respond to the theoretical marginal price, but rather to more immediately perceptible signals, such as the average price or the total bill amount. In a similar vein, Mayol and Staropoli (2021), in an experimental setting, show a marked preference for the simplest tariff structures, suggesting the existence of a genuine aversion to complexity. Other studies reach similar conclusions by emphasizing that the response to price depends closely on billing frequency, the quality of available information, and households' ability to connect their daily behaviors to an identifiable monetary cost (Gaudin, 2006; Wichman, 2014; Brent and Ward, 2019).

Taken together, these results call for a qualification of the centrality of price signals as a sole instrument for steering behavior. A first limitation is cognitive in nature: households do not necessarily make decisions on the basis of the marginal price, but often rely on simpler reference points, which reduces the effectiveness of the most sophisticated pricing arrangements. A second limitation is empirical: responses to price remain highly heterogeneous depending on consumption levels, household composition, and social context, so that a uniform policy may produce contrasted effects and raise distributive concerns. A third limitation, particularly important for the purposes of the present study, is technical in nature. In collective housing, water metering is not systematically individualized; when consumption is measured at the building level and the bill is allocated according to flat-rate or semi-flat-rate rules, the link between individual effort and the cost borne becomes largely opaque. In such a configuration, the price signal loses a substantial part of its incentive power, precisely because users no longer clearly perceive the effect of their behavior on the amount they pay.

Thus, while price constitutes a natural entry point for the economic analysis of consumption behavior, it cannot be regarded as a universally sufficient instrument. This limitation becomes particularly acute in collective housing, where the absence of individualized metering substantially weakens the intelligibility of the tariff signal. In such a setting, two interpretations are possible. The first is to consider that, in the absence of a clear link between individual behavior and the cost borne, any demand management policy is bound to have limited effectiveness. The second, which guides the present study, is instead to explore other coordination mechanisms capable of compensating for this weakening of the price lever. It is precisely within this analytical space that commons theory and behavioral approaches are situated.

2.2 The logic of the commons and collective coordination

The analysis of water consumption in collective housing can usefully be situated within the broader framework of the management of shared resources. Considered at the scale of the building, water conservation indeed exhibits a central property: the effort required to reduce consumption is borne individually, while the resulting benefits (lower overall bills, improved environmental performance of the building, and contribution to the preservation of the resource) are, at least in part, collective. This dissociation between private cost and shared benefit directly relates to the classical problem of the tragedy of the commons. In its canonical formulation, Hardin (1968) shows that, when a resource is held in common, each user is incentivized to maximize his or her individual interest even though the cost of overexploitation is diffused across the whole group. From this perspective, the spontaneous outcome of collective interaction tends toward inefficiency: in the absence of clearly individualized rights, external monitoring mechanisms, or sufficiently strong private incentives, cooperation remains fragile and free-riding behavior tends to prevail. Applied to collective housing, such a reading leads to the view that, without individualized metering or without a clearly perceptible private benefit, residents have weak incentives to reduce their consumption, since each may hope to benefit from the efforts of others without contributing to them.

Ostrom's work (1990), however, allows this pessimistic interpretation to be substantially qualified. It shows that the overexploitation of a shared resource is not an inevitability and that, under certain institutional and social conditions, groups of users can self-organize so as to generate durable forms of cooperation. The governance of commons then depends less on the mere existence of a price signal than on the capacity of the collective to produce legitimate rules, reciprocal expectations, monitoring mechanisms, sanctioning arrangements, and, more broadly, shared norms of behavior. This perspective is particularly fruitful for thinking about collective housing. A building is not merely a technical unit of consumption; it can also be viewed as a local community sharing charges, uses, and, potentially, a common responsibility toward the resource. From this standpoint, proximity among residents, the visibility of peers' behavior, and the activation of social norms may support conservation efforts, even in the absence of a strictly individualized monetary incentive.

The experimental literature on public goods points in the same direction by showing that behavior within a collective is far from homogeneous. Fischbacher, Gächter, and Fehr (2001) thus identify the existence of conditional cooperators, willing to contribute provided they believe that others do the same, alongside free riders who seek to benefit from the collective good without participating in the effort. Subsequent work confirms the robustness of this behavioral heterogeneity (Thöni and Volk, 2018). This point is central to our object of study, as it suggests that, within a building, the effectiveness of an intervention will depend not only on the content of the message, but also on its capacity to activate conditional cooperation, reduce opportunities for free-riding, and make collective effort visible.

Thus, the literature on the commons leads to an important hypothesis for the present study: even in the absence of a strictly individualized monetary incentive, behavioral change may emerge through collective mechanisms. From this perspective, the comparison between individually metered and collectively metered buildings goes beyond a simple technical opposition between two modes of measurement. It makes it possible to empirically test two distinct logics of behavioral change: an individualistic logic, closer to Hardin, in which effort depends primarily on the perception of a private benefit; and a logic of collective coordination, more closely inspired by Ostrom, in which conservation may also emerge from a shared relationship to the resource and from a community effect.

2.3 Nudges as behavioral instruments for water conservation

In this context, nudges may be viewed as a complement to, or even an alternative to, traditional pricing instruments. Following the definition proposed by Thaler and Sunstein (2008), a nudge may be defined as a modification of the choice environment intended to influence behavior without restricting the set of available options or substantially altering economic incentives. In the field of water, their relevance lies precisely in their capacity to operate in environments where agent's rationality is imperfect, information is incomplete, and the price signal alone is insufficient to structure behavior. In collective housing, they therefore offer the possibility of making information more salient, more intelligible, and more directly actionable in contexts where the effectiveness of the pricing lever is weakened by the imperfection or absence of individualization of the economic signal.

The empirical literature based on experiments involving nudges applied to residential water consumption generally concludes that their effects are modest but statistically significant. Most interventions lead to consumption reductions ranging from 1 to 5% (Willis and al., 2010; Ferraro and Price, 2013; Bernedo and al., 2014; Smith and Visser, 2014; Datta and al., 2015; Brent and al., 2015; Brick and al., 2017; Miranda and al., 2020). Some studies, however, report larger effects, reaching 16 to 27.5% (Schultz and al., 2014; Quesnel and Ajami, 2017; Novak and al., 2018). These higher estimates should nevertheless be interpreted with caution. They frequently emerge in specific contexts, particularly in territories already highly sensitized to water scarcity or exposed to repeated drought episodes, but they may also reflect characteristics of the experimental protocol itself, such as the small sample sizes used, which limits the scope and external validity of the conclusions (Novak and al., 2018). Some studies report null effects, reminding us that the effectiveness of nudges depends closely on the social, cultural, and environmental context in which they are received. Kazukauskas and al. (2021), for example, find no significant effect of social comparisons on water consumption in Sweden, in a context where water is perceived as relatively abundant and where the norm of water conservation appears weakly salient. This result is particularly important for the present project, as it raises a question of external validity in a context of climate change: in France, and more specifically within the MEL, is water in fact perceived by users as a major issue? At the national level, this hypothesis appears plausible given the extensive media coverage of droughts. It remains necessary, however, to determine whether this sensitivity is equally present in northern France, where rainfall is more frequent and drought episodes are generally less severe.

Among the various nudges used in the water sector, social comparison (SCT) occupies a central place. It is based on the idea that informing a household or a collective of its relative position compared with a reference group may induce an adjustment toward the norm. This lever is pervasive in field experiments and appears as one of the most promising in existing reviews (see Nauges and Whittington, 2019; Binet and al., 2024). However, its effectiveness depends closely on the choice of the reference group. Comparisons that are too broad, for example at the scale of a city, often produce weaker effects than more locally grounded comparisons (Datta, 2015; Miranda and al., 2020; Torres and Carlsson, 2018; Tomic and al., 2024). Miranda and al. (2020) thus show that a neighborhood-level comparison is more effective than a city-level comparison, while Wang and al. (2025) find better results when the comparison is made at the condominium level. These studies converge on the idea that the proximity of the reference group, its credibility, and its perceived relevance play a decisive role. In our field setting, this suggests that a comparison between neighboring buildings could constitute a more effective benchmark than an aggregated comparison.

Overall, although the literature on nudges applied to water consumption is now relatively abundant, it remains much more limited when it comes to collective housing, aggregated metering, and, even more so, comparisons between individually metered and collectively metered buildings. It is precisely within this still underexplored space that the present article is situated. In this respect, the recent working paper by Balado-

Naves and al. (2025) constitutes an important contribution, as it proposes a field experiment based on nudges and approaches water consumption in condominiums as a public good problem. The project presented here is part of the same broader research agenda, while differing in its field setting, the data used, and, above all, its explicit comparison between individually metered and collectively metered buildings. It thus seeks to deepen a question that remains largely open: in collective housing, does the effectiveness of a nudge depend primarily on the visibility of an individual benefit, or can it also emerge from a locally credible collective frame of reference?

3 Research question and hypothesis

The present article lies at the intersection of water economics, behavioral economics, and the economics of the commons. Its central objective is to examine whether, in collective housing, the effectiveness of a nudge designed to reduce water consumption depends primarily on the degree of information available to households about their own consumption, or whether it may also arise through mechanisms of collective coordination around a shared resource. More specifically, the article asks whether an informational intervention is more effective when households face low information asymmetry, when water consumption is individually metered and the private returns to conservation are more easily identifiable or whether such an intervention can also affect behavior in a context of collective metering, where individual consumption remains imperfectly observable and the link between personal effort and monetary gain is less direct.

The issue at stake is therefore not merely whether an informational nudge can reduce water consumption, but through which mechanism such an effect may occur. In economic terms, the question is whether environmental behavior in collective housing is primarily constrained by imperfect information. When households do not observe their own consumption clearly, and when the consequences of individual effort are diluted within collective charges, they may fail to internalize the marginal benefit of conservation. In such a setting, information asymmetry may weaken behavioral responsiveness by making the private return to effort less salient. Conversely, when consumption is individually metered, households are in a better position to observe their own usage and to connect conservation effort to a more visible private benefit. Under this interpretation, the effectiveness of the nudge should increase as information becomes more individualized and the private incentive becomes easier to perceive.

Yet incomplete information does not necessarily imply the absence of behavioral change. Even in the presence of collective metering, water conservation may still be supported by mechanisms that are not reducible to narrowly individual economic calculation. Households may respond to a message because they are attentive to shared charges, because they are influenced by local social norms, or because the building itself functions as a relevant social unit in which reciprocal expectations and a sense of shared responsibility matter. In that case, the nudge would not operate only by clarifying private gains, but also by activating collective motivations linked to the management of a common resource.

From this perspective, the comparison between individually metered and collectively metered buildings is not merely a technical comparison between two billing systems. It provides an empirical way to distinguish between two broad interpretations of conservation behavior. A first interpretation, consistent with a standard informational and incentive-based framework, suggests that conservation depends mainly on the visibility of individual consumption and on the ability of households to identify a sufficiently salient private return to effort. A second interpretation, closer to the literature on collective action and the commons, suggests that conservation may also emerge under imperfect information, through locally embedded forms of coordination, shared norms, and concern for the collective outcome.

Beyond this opposition, the article also contributes to a broader question in environmental economics: how do households behave when they face imperfect information about their own resource use? Do they adopt suboptimal behavior because they cannot properly internalize the consequences of their consumption? Or can collective mechanisms partly compensate for informational imperfections? Put differently, why would a household be willing to reduce its water use when the link between its own effort and the aggregate outcome remains only partially visible? The empirical design proposed here is intended precisely to address this question.

H1. *An informational nudge reduces, on average, water consumption in treated buildings.*

The first hypothesis is that sending a behavioral message at the building level leads, on average, to a decline in water consumption in treated buildings. This corresponds to the existence of an average treatment effect of the intervention, regardless of the metering regime. In this sense, the hypothesis tests whether an informational nudge can modify behavior even in the context of collective housing, where incentives are often less direct than in standard household-level settings.

H2. *The effect of the nudge is stronger when information asymmetry is lower.*

More concretely, the second hypothesis is that the treatment effect should be larger in individually metered buildings than in collectively metered buildings. The economic intuition is that when households observe their own consumption more clearly, they are better able to understand the consequences of their behavior and to perceive the private benefit associated with conservation. Lower information asymmetry should therefore strengthen the effectiveness of the message by making the expected return to effort more visible and more immediate.

H3. *Even under high information asymmetry, the nudge may still reduce water consumption.* The third hypothesis is that a significant treatment effect may nonetheless be observed in collectively metered buildings, where households have only imperfect information about their own water use. If such a result is found, it would indicate that the effectiveness of the intervention does not depend exclusively on the individualization of information. Instead, it would suggest that other mechanisms—such as social norms, attention to shared charges, or building-level collective dynamics—may also support conservation behavior.

H4. *If the nudge remains effective despite strong information asymmetry, then water conservation cannot be explained by individual self-interest alone.* The fourth hypothesis follows directly from the previous one. If the nudge produces a significant reduction in consumption even in collectively metered buildings, then conservation behavior cannot be interpreted solely as the outcome of improved private calculation. In that case, the treatment effect would reflect not only the role of information in reducing individual uncertainty, but also the capacity of the residential collective to sustain more water-saving behavior through shared norms, mutual expectations, or concern for a common resource.

Taken together, these hypotheses make it possible to distinguish empirically between two mechanisms of behavioral change. If the treatment effect is observed only, or much more strongly, in individually metered buildings, the most convincing interpretation will be that conservation depends primarily on better information and on the visibility of private benefits. If, by contrast, the nudge also proves effective in collectively metered buildings, this would indicate that incomplete information does not fully prevent conservation and that collective mechanisms may partly compensate for the weakness of individualized incentives.

Ultimately, the research question may be formulated as follows: in collective housing, does water conservation depend mainly on the reduction of information asymmetries and on the clearer perception of individual benefits, or can it also be supported by collective dynamics despite imperfect information? The contribution of the article is precisely to provide an empirical answer to this question by testing whether environmental behavior in a shared residential setting is driven only by individual informational incentives or also by mechanisms of coordination around a common resource.

4 Experimental design

The proposed experimental protocol is designed to evaluate the effect of a non-price informational intervention on water consumption in collective housing within the MEL. More specifically, the aim is to determine whether a nudge based on a locally grounded social comparison can reduce water consumption at the building level, and whether the magnitude of this effect differs between individually metered and collectively metered buildings. The protocol is therefore not purely evaluative. It is also intended to shed light on the mechanism underlying behavioral change, by testing whether conservation depends primarily on the visibility of individual benefits or whether it may also emerge in a context of imperfect information through collective coordination around a shared resource.

At this stage, the protocol remains a preliminary proposal intended to be discussed with both academic supervisors and Iléo. The current version should therefore be understood as a first draft whose purpose is to organize discussion, especially regarding feasibility, sample construction, and access to the relevant consumption data.

In its general logic, the experiment would compare two situations within the collective housing stock of the MEL: buildings with individual metering and buildings with collective metering. In each case, a distinction would be made between treated buildings receiving the informational intervention and untreated buildings serving as controls. This design would make it possible to answer two related questions. First, does a behavioral message reduce water consumption on average? Second, is the effect stronger when households benefit from a more individualized informational environment, or can a significant effect also be observed when information remains imperfectly appropriable at the household level?

In practical terms, the treatment would take the form of a paper letter sent to all residents of the selected buildings. The choice of a letter is justified by the characteristics of collective housing. It is a relatively low-cost and tangible medium, and it allows the intervention to target all occupants. More importantly, it is likely to reduce the selective exposure problems associated with digital communication. As Brent and Wichman (2020) and Bhanot (2021) suggest, the delivery channel does not necessarily matter more than the actual exposure to the content, but digital messages may be more easily ignored. Schultz (2014) likewise emphasizes that messages requiring an additional action to be accessed, such as visiting a webpage, may reach only a fraction of the intended audience. In the specific context of collective housing, a letter therefore appears to be the most suitable and realistic medium for a first intervention.

The informational content of the intervention would rely on a social comparison treatment, which is widely identified in the literature as one of the most effective nudges for influencing water consumption (Nauges and Whittington, 2019). The core principle would be to compare the consumption of one building with that of another nearby reference building displaying similar characteristics. This type of approach has already been used in several studies and provides a particularly relevant empirical framework. However, its effectiveness depends strongly on the credibility and relevance of the comparison group. For the message to have an effect, households must genuinely feel concerned by the benchmark to which they are compared. This is why the protocol would prioritize geographically close comparison groups, ideally located in the same neighborhood, in order to reinforce the sense of proximity, similarity, and belonging. This point is consistent with the findings of Datta (2015), Miranda and al. (2020), Torres and Carlsson (2018), Tomic and al. (2024), and Wang and al. (2025), all of whom stress the importance of the local credibility of the reference group in social comparison interventions.

The originality of the proposed intervention lies in the fact that the nudge would not be expressed primarily in cubic meters or liters, but in euros (Brent and al., 2017, 2020; Brent and Ward, 2019). The recent working paper by Balado-Naves and al. (2025) uses a treatment framed in terms of water volumes and efficiency targets, for instance by indicating to households that they consume more liters than a recommended benchmark. The idea proposed here is different. For many households, a volume of water remains relatively abstract, whereas an amount in euros is more concrete, more directly understandable, and more closely connected to the household budget. Framing the message in monetary terms may therefore make the consequences of water overconsumption more salient and possibly increase behavioral responsiveness.

More specifically, the protocol could test two variants of the informational message. A first variant would rely on a negative framing emphasizing losses, while a second would rely on a positive framing emphasizing potential gains. For example, the negative version could state: "*At present, your building pays around 2,000 euros more than comparable neighboring buildings because of excessive water consumption.*" The positive version could instead state: "*By reducing your water consumption, your building could save 2,000 euros per year.*" This distinction is motivated by the literature on framing effects and loss aversion, and it would make it possible to assess which formulation is more effective in the context of collective housing. In both cases, the intervention would remain a nudge rather than a gamified device: no challenge, no reward, and no external prize would be offered. The only potential gain for households would be the one resulting from their own reduction in water use and, where relevant, from its eventual effect on shared charges or water bills.

At the same time, the wording of the letter should remain behaviorally cautious. The objective is not to overload households with technical information, but to make visible a simple and credible performance gap between comparable buildings and to suggest that improvement is both possible and desirable. This point is especially important in light of Balado-Naves and al. (2025), who show that messages based on technical efficiency norms may produce boomerang effects in condominiums, whereas simpler and more concrete messages appear to be more effective. In the same spirit, it may be preferable to combine the descriptive comparison with a light injunctive component, or at least with wording that clearly encourages conservation, in order to reduce the risk that low-consuming buildings interpret the message as implicit validation of their current behavior (Schultz, 2007 ; Otaki and al., 2022).

At this stage, a possible experimental sample would consist of around 60 buildings, divided between individually metered and collectively metered buildings. Within each metering regime, buildings would then be split into treated and untreated groups. One possible configuration would therefore be 15 treated and 15 untreated buildings in the individual metering group, and 15 treated and 15 untreated buildings in the collective metering group. Such a design would provide a straightforward framework for comparing average treatment effects across informational environments. Naturally, the final size of the sample will depend on data availability, operational feasibility, and the level of comparability that can be ensured between buildings.

The selection of buildings is itself an important dimension of the protocol. Two broad options could be considered. A first option would be to work with standard condominiums, mixing owners, tenants, and a broad range of household profiles. A second option would be to work through social housing providers. The latter option appears particularly attractive from the perspective of empirical design, because it would likely provide a more homogeneous population in terms of socioeconomic conditions and institutional setting, thereby facilitating the construction of control variables and reducing unobserved heterogeneity. It may also be the case that more financially constrained households are more responsive to messages framed in monetary terms, although this remains an empirical question. By contrast, working with conventional condominiums would provide a more heterogeneous population and therefore a setting that is perhaps more externally valid, but also more complex in terms of identification and control.

From an empirical point of view, the main outcome variable would be the change in water consumption observed at the building level before and after the intervention. The design would ideally rely on a sufficiently long pre-treatment period in order to establish baseline consumption trajectories and to improve the comparability of treatment and control groups. A post-treatment observation period of several months would then make it possible to assess not only the immediate effect of the intervention but also its persistence over time.

5 Model

5.1 Incentives, information, and nudging

This section develops a simple theoretical framework to clarify how metering regimes, information, and nudges may affect water consumption in collective housing. The aim is not to provide a fully structural model, but rather to formalize the main economic mechanisms underlying the empirical analysis.

Consider a building composed of N households, indexed by $i = 1, \ldots, N$. Each household chooses its water consumption $q_i \geq 0$. Aggregate consumption at the building level is

$$Q = \sum_{i=1}^{N} q_i. \tag{1}$$

The total water bill is assumed to be linear:

$$C(Q) = F + pQ, \tag{2}$$

where $F \geq 0$ is the fixed component of the bill and $p > 0$ is the marginal price of water. Each household derives utility from water consumption according to a concave benefit function $B_i(q_i)$, with

$$B_i'(q_i) > 0, \qquad B_i''(q_i) < 0. \tag{3}$$

A general representation of household i's utility is

$$U_i = B_i(q_i) - s_i(C(Q)) + \Psi_i, \tag{4}$$

where $s_i(C(Q))$ denotes the share of the water bill effectively borne by household i, and Ψ_i captures informational, cognitive, or normative components that may affect behavior. This formulation is useful because it makes it possible to distinguish clearly between the pricing rule, the informational environment, and the behavioral effect of the nudge.

5.1.1 Collective metering

Under collective metering, the bill is paid at the building level and then allocated across households according to an exogenous sharing rule. Let $\alpha_i > 0$ denote household i's share, with

$$\sum_{i=1}^{N} \alpha_i = 1. \tag{5}$$

Utility is then given by

$$U_i^{coll} = B_i(q_i) - \alpha_i(F + pQ). \tag{6}$$

Since $Q = \sum_{j=1}^{N} q_j$, household i chooses q_i taking the others' consumption as given. The first-order condition is

$$\frac{\partial U_i^{coll}}{\partial q_i} = B_i'(q_i) - \alpha_i p = 0, \tag{7}$$

so that, at equilibrium,

$$B_i'(q_i^{coll}) = \alpha_i p. \tag{8}$$

The key point is that under collective metering the household internalizes only a fraction α_i of the true marginal cost of water consumption. As long as $\alpha_i < 1$, the private marginal cost is below the full marginal price p, which weakens incentives to save water and creates a standard free-riding problem. This is the basic Hardinian intuition: when part of the cost is diffused over the collective, individual overconsumption becomes privately rational.

5.1.2 Individual metering

Under individual metering, each household pays directly for its own consumption, possibly together with a fixed component F_i. Utility becomes

$$U_i^{ind} = B_i(q_i) - F_i - pq_i. \tag{9}$$

The first-order condition is

$$\frac{\partial U_i^{ind}}{\partial q_i} = B_i'(q_i) - p = 0, \tag{10}$$

hence

$$B_i'(q_i^{ind}) = p. \tag{11}$$

Under individual metering, the household therefore bears the full marginal cost of its own consumption. Since $\alpha_i p < p$ whenever $\alpha_i < 1$, concavity of B_i implies

$$q_i^{coll} > q_i^{ind}. \tag{12}$$

Proposition 1. *Holding preferences constant, water consumption is higher under collective metering than under individual metering.*

The intuition is purely incentive-based: collective metering dilutes the private marginal cost of water use, whereas individual metering aligns private and actual marginal cost more closely.

5.1.3 Imperfect information

The pricing rule alone does not exhaust the problem. In collective housing, households may not correctly perceive the cost associated with their own water use. Under collective metering, let the perceived marginal cost be

$$\tilde{p}_i^{coll} = \alpha_i p - \theta_i, \tag{13}$$

where $\theta_i \geq 0$ captures the perception error due to imperfect information. Household i then solves

$$\max_{q_i \geq 0} \; B_i(q_i) - \tilde{p}_i^{coll} q_i - \alpha_i F, \tag{14}$$

which yields

$$B_i'(q_i) = \tilde{p}_i^{coll}. \tag{15}$$

If $\tilde{p}_i^{coll} < \alpha_i p$, then the household underestimates the effective cost of water consumption and chooses a higher level of q_i than under perfect information. Information asymmetry therefore amplifies the incentive problem already created by collective billing.

Under individual metering with more precise feedback, for instance through remote meter reading, one may similarly define

$$\tilde{p}_i^{ind} = p - \theta_i^{ind}, \tag{16}$$

with

$$0 \leq \theta_i^{ind} < \theta_i^{coll}. \tag{17}$$

Remote meter reading can thus be interpreted as a device that reduces information asymmetry, even when it does not alter the actual price of water. In an Ostromian perspective, this informational improvement matters because it makes the consequences of individual behavior more visible and therefore makes coordination more plausible.

Proposition 2. *A reduction in information asymmetry decreases water consumption, all else equal.*
Better information increases the perceived marginal cost of consumption and therefore strengthens incentives to conserve.

5.1.4 The nudge as a salience device

A first way to model the nudge is to treat it as an increase in the salience of water-related costs. This is especially relevant in the present project, since the intervention is framed in monetary rather than volumetric terms. Let $\lambda_i \geq 0$ denote the salience effect induced by the message. The perceived marginal cost becomes

$$\tilde{p}_i = p_i^{base} + \lambda_i, \tag{18}$$

where

$$p_i^{base} = \begin{cases} \alpha_i p - \theta_i^{coll} & \text{under collective metering,} \\ p - \theta_i^{ind} & \text{under individual metering.} \end{cases} \tag{19}$$

Utility can then be written as

$$U_i^{nudge} = B_i(q_i) - \tilde{p}_i q_i - \Gamma_i, \tag{20}$$

where Γ_i gathers fixed terms. The first-order condition is

$$B_i'(q_i^{nudge}) = \tilde{p}_i. \tag{21}$$

Since $\lambda_i \geq 0$, the nudge raises the perceived marginal cost of water consumption and tends to reduce consumption:

$$q_i^{nudge} \leq q_i^{no\ nudge}. \tag{22}$$

Proposition 3. *A nudge reduces water consumption if it increases the perceived marginal cost of consumption.*

In this interpretation, the nudge does not change the actual price of water. It acts instead as a cognitive correction device that makes the cost of consumption more salient and more actionable.

5.1.5 The nudge as a normative device

A second, complementary interpretation is that the nudge activates a social or behavioral norm. Let $\bar{q}$ denote a reference level of consumption, for example the average consumption of comparable nearby buildings. Define

$$N_i(q_i, \bar{q}) = \max(q_i - \bar{q}, 0), \tag{23}$$

and let $\phi_i \geq 0$ denote household i's sensitivity to the norm conveyed by the message. Utility becomes

$$U_i^{norm} = B_i(q_i) - s_i(C(Q)) - \phi_i N_i(q_i, \bar{q}). \tag{24}$$

The first-order condition is

$$B_i'(q_i) - \frac{\partial s_i(C(Q))}{\partial q_i} - \phi_i \mathbf{1}_{q_i > \bar{q}} = 0. \tag{25}$$

This formulation captures the idea that the nudge may operate not only through monetary salience, but also through a normative channel: consuming above the reference level becomes psychologically or morally costly. In that sense, the intervention does not merely reveal information; it also structures a locally relevant benchmark against which behavior is evaluated.

5.1.6 Gain versus loss framing

The empirical protocol also distinguishes between gain-framed and loss-framed messages. This can be represented by allowing households to react differently to the two framings. Let ϕ_i^+ measure sensitivity to a gain-framed message and ϕ_i^- sensitivity to a loss-framed message. One may write

$$U_i = B_i(q_i) - s_i(C(Q)) - \phi_i^- \max(q_i - \bar{q}, 0) + \phi_i^+ \max(\bar{q} - q_i, 0). \tag{26}$$

If

$$\phi_i^- > \phi_i^+, \tag{27}$$

then households are more sensitive to losses than to gains, implying that a negatively framed message should have a stronger effect on conservation than a positively framed one.

Proposition 4. *If households exhibit loss aversion, a loss-framed nudge has a stronger effect on water conservation than a gain-framed nudge.*

This extension is directly relevant for the design of the field experiment, since it links the framing of the intervention to potentially different behavioral responses.

5.1.7 Interpretation

Taken together, the model yields four central predictions. First, collective metering leads to higher consumption than individual metering because households internalize only part of the marginal cost. Second, better information reduces consumption by narrowing the gap between perceived and actual cost. Third, a nudge can reduce consumption either by increasing the salience of monetary costs or by activating a norm of sobriety. Fourth, the effect of the nudge may be stronger in an environment where individual information is already more precise, because households are then better able to connect the message to their own behavior. More broadly, the model suggests that collective housing is best understood as a constrained institutional setting in which billing rules, informational devices, and behavioral interventions jointly shape the degree of effective coordination.

5.2 A simple game-theoretic interpretation

The same intuition can be illustrated through a stylized game between two households living in the same building. Each household chooses between making a water-saving effort, denoted E, and making no effort, denoted N. Effort entails a private cost $c > 0$, but may reduce the water bill.

5.2.1 Collective metering

Under collective metering, a household that makes an effort bears the private cost c, but internalizes only a fraction αb of the collective benefit, where $b > 0$ is the total monetary gain generated by conservation and $\alpha \in (0, 1)$ is the share privately appropriated by each household. The payoff matrix is

	E	N
E	$(\alpha b - c,\ \alpha b - c)$	$(\alpha b - c,\ \alpha b)$
N	$(\alpha b,\ \alpha b - c)$	$(0,\ 0)$

Table 1: Collective metering

If $\alpha b < c$, then effort is never privately worthwhile and N is the dominant strategy. The unique Nash equilibrium is therefore (N, N). This captures the standard free-riding logic of collective metering. More generally, the matrix shows that the game is not always a prisoner's dilemma in the strict sense: depending on the parameter values, one may obtain under-provision of effort or an anti-coordination structure. That is precisely why the game-theoretic part should be read as an illustration of incentives rather than as the core formal model.

5.2.2 Individual metering

Under individual metering, the private gain from effort becomes more directly appropriable. Let b_i denote the individual benefit from reducing one's own water consumption. The payoff matrix becomes

	E	N
E	$(b_i - c,\ b_i - c)$	$(b_i - c,\ 0)$
N	$(0,\ b_i - c)$	$(0,\ 0)$

Table 2: Individual metering

If $b_i > c$, then making the effort becomes individually rational and (E, E) is the equilibrium. Relative to collective metering, the change in the metering regime therefore transforms the strategic structure of the game by aligning private and collective incentives more closely.

5.2.3 Collective metering with nudge

The effect of the nudge can be represented by adding a term $\lambda > 0$ to the perceived payoff from effort under collective metering. The payoff matrix becomes

	E	N
E	$(\alpha b + \lambda - c,\ \alpha b + \lambda - c)$	$(\alpha b + \lambda - c,\ \alpha b)$
N	$(\alpha b,\ \alpha b + \lambda - c)$	$(0,\ 0)$

Table 3: Collective metering with nudge

If initially $\alpha b < c$, the equilibrium is (N, N). But if the nudge is strong enough so that

$$\alpha b + \lambda > c, \tag{28}$$

then effort becomes individually worthwhile and the equilibrium may shift toward (E, E). In this simple representation, the nudge reduces free-riding by increasing the perceived attractiveness of conservation.

5.2.4 General interpretation

The game-theoretic reading highlights the same core result as the microeconomic model. Metering systems modify the extent to which households internalize the gains from conservation, while information and nudges alter the perceived payoff from effort. Under collective metering, diluted incentives and imperfect information make under-contribution more likely. Under individual metering, and even more so when precise feedback is available, the private return to conservation becomes easier to identify. The nudge can then be interpreted as a complementary institutional device that either raises the salience of the private gain or activates a local norm of water sobriety. In that sense, the experimental protocol can be viewed as an empirical test of whether modest informational changes are sufficient to shift behavior away from a free-riding equilibrium toward a more cooperative outcome.

6 Data

The empirical analysis relies on water consumption data provided by Iléo. These data are particularly valuable for the project because they make it possible to observe actual water consumption in collective housing under different information regimes. Depending on the level of detail effectively made available, the dataset may provide information on total building consumption, consumption per household or per meter, the type of metering, and some technical or administrative characteristics of the buildings.

A major empirical advantage of these data is that they allow consumption to be observed repeatedly over time, making it possible to construct a panel dataset and to analyze consumption trajectories before and after the intervention. This is essential for evaluating the effect of the nudge and for comparing buildings under individual metering and collective metering. More broadly, the coexistence of these two metering regimes provides a relevant framework for studying how differences in the visibility of consumption information may shape behavioral responses.

At this stage, the exact content and level of disaggregation of the data have not yet been finalized. Nevertheless, the data partnership already appears promising and original both because it relies on observed rather than self-reported consumption and because it should make it possible to study water use at a relevant scale for the question under investigation.

7 Empirical strategy

At this stage, the experiment has not yet been implemented, so the empirical strategy remains preliminary. The idea is to rely on a difference-in-differences approach, which consists in comparing the change in water consumption before and after the intervention between a treated group and a control group. This method makes it possible to identify the specific effect of the nudge while controlling for fixed differences across buildings and for common shocks over time.

The specification of greatest interest for the project is the following:

$$Y_{it} = \alpha + \beta_1(Treat_i \times Post_t) + \beta_2(Treat_i \times Post_t \times Info_i) + \mu_i + \lambda_t + X_{it}\gamma + \varepsilon_{it} \quad (29)$$

where Y_{it} denotes the water consumption of building i at time t, $Treat_i$ indicates whether the building belongs to the treated group, and $Post_t$ takes the value 1 after the intervention. The variable $Info_i$ captures the information regime, for example whether the building is individually metered rather than collectively metered. The terms μ_i and λ_t denote building fixed effects and time fixed effects, respectively, while X_{it} represents a set of control variables depending on the data actually available.

In this framework, β_1 measures the average effect of the nudge in the reference category, while β_2 indicates whether this effect is stronger or weaker depending on the information regime. In other words, this coefficient allows us to test directly whether reducing information asymmetry makes the nudge more effective.

8 Extensions and limitations

It is important to highlight both several possible extensions of the project and some of the usual limitations associated with nudge-based interventions.

A first challenge concerns timing. Between the implementation of the protocol and the observation of results, especially in the medium term, the delay can be substantial. For this reason, one possible extension would be to complement the field experiment with a laboratory experiment, implemented either upstream to test and calibrate the protocol before deployment, or downstream to help interpret the results observed in the field. Such an extension would be fully consistent with the recent literature on nudges and water consumption. In particular, Binet and al. (2024) identify as a priority avenue for future research a closer articulation between field evidence and controlled protocols, in order to better isolate the behavioral mechanisms at work. This perspective is all the more relevant since Balado-Naves and al. (2025) adopt precisely this type of combined approach, by linking a laboratory experiment in France with a field experiment in Spain, and show that what works in a controlled setting does not necessarily produce the same effects under real-world conditions.

In the context of the present project, a laboratory experiment would offer several advantages. It would first make it possible to test different variants of the message at limited cost before launching the field intervention. It would also provide a more controlled environment for studying the central distinction of the project, namely the difference between individual and collective metering regimes. In stylized form, such a protocol could reproduce a situation in which the gains from conservation are either more individually appropriable or, by contrast, remain largely collective. In that sense, the laboratory would not substitute for the field, but would complement it by helping to identify more precisely the conditions under which a nudge is likely to be effective.

A second limitation concerns the risk of boomerang effects, which is well documented in the literature. When the intervention makes the signal more intelligible, some households may discover that they consume less than they had thought, or that water costs them less than anticipated, and may then adjust their consumption upward (Wichman, 2017; Brent and Ward, 2019). Similarly, informing a household that it already consumes less than average may lead to a relaxation of effort (Chung, 2021; Agarwal and al., 2022), whereby the increase in consumption among low-consuming households may offset, or even reverse, the savings achieved by high-consuming households, unless the message is accompanied by a positive injunctive signal (Schultz and al., 2007). Demotivating effects may also arise when the intervention relies too heavily on a logic of ranking or competition, particularly among the least well-positioned households (Bhanot, 2017). Taken together, these results show that a nudge cannot be reduced to the mere transmission of information: its effectiveness depends closely on its formulation, the conditions under which it is received, and the profiles of those to whom it is addressed.

A third issue concerns the persistence of effects over time. The literature remains mixed on this point: in some studies, the effects of informational interventions persist (Bernedo and al., 2014; Torres and Carlsson, 2018; Agarwal and al., 2022; Otaki and al., 2022), while in others they fade relatively quickly (Fielding and al., 2013; Ferraro and Price, 2013; Otaki and al., 2019; Seyranian and al., 2015). Yet reducing water consumption once is already difficult; sustaining that effect over time is an even greater challenge. Several options may be considered in this respect, such as repeating the intervention, providing regular feedback (Davies and al., 2014), improving the targeting of households (Binet and al., 2024), or combining nudges with more structured incentive devices, including reward mechanisms or gamification (Novak and al., 2018). Ultimately, the challenge is not only to trigger a short-term reaction, but to transform this reaction into a more stable habit of conservation.

Another extension, suggested by Binet and al. (2024), would consist in exploring not only the logic of the nudge, but also that of the boost, often presented as an alternative to, or an extension of, classical behavioral approaches. Whereas the nudge primarily seeks to steer behavior by modifying the choice architecture, the boost aims more at strengthening individuals' decision-making capacities by providing them with simple tools to better understand, assess, and adjust their practices. In the context of the present project, such an approach could be particularly relevant if the objective is not merely to trigger a one-off adjustment, but to foster a more durable appropriation of the challenges associated with water conservation. Concretely, such an extension could take the form of distributing, alongside the letter, a small water-saving kit or a simplified educational support presenting in very concrete terms the main actions through which daily water consumption can be reduced. Such a combination would thus make it possible to test whether the effect of the message is strengthened when households are provided, beyond the mere informational signal, with explicit support for transforming the information received into effective practices.

More broadly, these limits point to a general caution regarding nudges. Their effects may be significant, but they are often context-dependent, sensitive to framing, and potentially fragile over time. For this reason, the present project should not only be seen as an evaluation of a specific informational intervention, but also as an opportunity to better understand under which conditions such behavioral tools can produce meaningful and lasting changes in water consumption in collective housing.

9 Conclusion

This research proposal has developed a question that remains insufficiently explored in the literature: under what conditions can an informational nudge reduce water consumption in collective housing? More specifically, the project asks whether the effectiveness of such an intervention depends mainly on the visibility of individual consumption and on the private incentives associated with conservation, or whether behavioral change may also emerge in more collective settings where information remains imperfect and the benefits of effort are only partly individualized.

The proposed framework highlights why collective housing constitutes a particularly relevant setting for this question. In such environments, the conventional price signal is often weakened by aggregated metering, shared charges, and limited visibility over individual consumption. Yet these same characteristics also make collective housing a useful empirical terrain for testing whether water conservation can be supported by other mechanisms, including local social norms, conditional cooperation, and building-level coordination around a shared resource. The comparison between individually metered and collectively metered buildings is therefore central not only from an operational point of view, but also from a theoretical one, as it makes it possible to distinguish between an individual incentive-based interpretation of conservation behavior and a more collective one.

To address this issue, the project proposes a field experiment based on a locally grounded social comparison nudge implemented in collective housing within the MEL. By relying on real consumption data provided by Iléo and by exploiting variation in metering regimes, the project seeks to identify both the average effect of the intervention and the heterogeneity of this effect across informational environments. In doing so, it aims to contribute to a growing literature on behavioral instruments for water conservation, while extending it toward a context in which the articulation between individual incentives and collective dynamics is particularly salient.

More broadly, the project speaks to a wider debate in environmental policy. If the intervention proves effective only where consumption is individualized, this would support the view that conservation depends primarily on better information and clearer private returns to effort. If, by contrast, a significant effect is also observed in collectively metered buildings, this would suggest that environmental behavior cannot be reduced to individual self-interest alone and that collective housing may itself provide a meaningful support for coordination around resource sobriety. In that sense, the project does not only seek to evaluate a specific nudge; it also aims to better understand how collective residential settings can contribute to the governance of everyday environmental behavior.

References

Agarwal, S., Araral, E., Fan, M., Yu, Q., & Zheng, H. (2022). Water conservation through plumbing and nudging. *Nature Human Behaviour, 6*, 858–867.

Arbués, F., García-Valiñas, M. Á., & Martínez-Espiñeira, R. (2003). Estimation of residential water demand: A state-of-the-art review. *The Journal of Socio-Economics, 32*(1), 81–102.

Balado-Naves, R., García-Valiñas, M. Á., Binet, M., & Teyssier, S. (2025). *Social norm nudging in public goods management: New insights from two experiments.* Working paper.

Bernedo, M., Ferraro, P. J., & Price, M. K. (2014). The persistent impacts of norm-based messaging and their implications for water conservation. *Journal of Consumer Policy, 37*, 437–452.

Bhanot, S. P. (2017). Rank and response: A field experiment on peer information and water use behavior. *Journal of Economic Psychology, 62*, 155–172.

Bhanot, S. P. (2021). Isolating the effect of injunctive norms on conservation behavior: New evidence from controlled and natural field experiments. *Journal of Environmental Economics and Management, 107*, 102445.

Binet, M. E., García-Valiñas, M. Á., & Suárez-Fernández, S. (2024). Nudges in sustainable water management practices: Implementation, key findings and research agenda. *Journal of Cleaner Production, 458*, 142282.

Brent, D. A., Cook, J. H., & Olsen, S. (2015). Social comparisons, household water use, and participation in utility conservation programs: Evidence from three randomized trials. *Journal of the Association of Environmental and Resource Economists, 2*(4), 597–629.

Brent, D. A., & Ward, M. B. (2019). Price perceptions in water demand. *Journal of Environmental Economics and Management, 98*, 102266.

Brent, D. A., & Wichman, C. J. (2020). Do behavioral nudges interact with prevailing economic incentives? Pairing experimental and quasi-experimental evidence from water consumption. *Journal of Environmental Economics and Management, 100*, 102289.

Brick, C., Sherman, D. K., & Kim, H. S. (2017). "Green to be seen" and "brown to keep down": Visibility moderates the effect of identity on pro-environmental behavior. *Journal of Environmental Psychology, 51*, 226–238.

Chung, F. (2021). *The power of information: Information, leak notices, and water conservation in Edina, MN* (Economics Honors Projects No. 107).

Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F., & Nijkamp, P. (2003). Price and income elasticities of residential water demand: A meta-analysis. *Land Economics, 79*(2), 292–308.

Daminato, C., Diaz-Farina, E., Filippini, M., & Padrón-Fumero, N. (2021). The impact of smart meters on residential water consumption: Evidence from a natural experiment in the Canary Islands. *Resource and Energy Economics, 64*, 101221.

Datta, S., Miranda, J. J., Zoratto, L., Calvo-Gonzalez, O., Darling, M., & Lorenzana, K. (2015). *A behavioral approach to water conservation: Evidence from Costa Rica* (Policy Research Working Paper No. 7283). World Bank.

Davies, K., Doolan, C., van den Honert, R., & Shi, R. (2014). Water-saving impacts of smart meter technology: An empirical 5-year, whole-of-community study in Sydney, Australia. *Water Resources Research, 50*(9), 7348–7358.

Ferraro, P. J., & Price, M. K. (2013). Using nonpecuniary strategies to influence behavior: Evidence from a large-scale field experiment. *The Review of Economics and Statistics, 95*(1), 64–73.

Fielding, K. S., Spinks, A., Russell, S., McCrea, R., Stewart, R., & Gardner, J. (2013).

An experimental test of voluntary strategies to promote urban water demand management. *Journal of Environmental Management, 114*, 343–351.

Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters, 71*(3), 397–404.

García-Valiñas, M. Á., Arbués, F., & Balado-Naves, R. (2023). Assessing environmental profiles: An analysis of water consumption and waste recycling habits. *Journal of Environmental Management, 348*, 119247.

García-Valiñas, M. Á., & Suárez-Fernández, S. (2022). Are economic tools useful to manage residential water demand? A review of old issues and emerging topics. *Water, 14*(16), 2536.

Gaudin, S. (2006). Effect of price information on residential water demand. *Applied Economics, 38*(4), 383–393.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*(3859), 1243–1248.

Ito, K. (2014). Do consumers respond to marginal or average price? Evidence from nonlinear electricity pricing. *American Economic Review, 104*(2), 537–563.

Kazukauskas, A., Broberg, T., & Jaraite, J. (2021). Social comparisons in real time: A field experiment of residential electricity and water use. *Scandinavian Journal of Economics, 123*(2), 558–592.

Mayol, A. (2017). Social and nonlinear tariffs on drinking water: Cui bono? Empirical evidence from a natural experiment in France. *Revue d'économie politique, 127*(6), 1161–1185.

Mayol, A., & Porcher, S. (2019). Tarifs discriminants et monopoles de l'eau potable: Une analyse de la réaction des consommateurs face aux distorsions du signal-prix. *Revue économique, 70*(2), 213–247.

Mayol, A., & Staropoli, C. (2021). Giving consumers too many choices: A false good idea? A lab experiment on water and electricity tariffs. *European Journal of Law and Economics, 51*(2), 383–410.

Miranda, J. J., Datta, S., & Zoratto, L. (2020). Saving water with a nudge (or two):

Evidence from Costa Rica on the effectiveness and limits of low-cost behavioral interventions on water use. *The World Bank Economic Review, 34*(2), 444–463.

Nataraj, S., & Hanemann, W. M. (2011). Does marginal price matter? A regression discontinuity approach to estimating water demand. *Journal of Environmental Economics and Management, 61*(2), 198–212.

Nauges, C., & Whittington, D. (2019). Social norms information treatments in the municipal water supply sector: Some new insights on benefits and costs. *Water Economics and Policy, 5*(3), 1950010.

Novak, J., Melenhorst, M., Micheel, I., Pasini, C., Fraternali, P., & Rizzoli, A. (2018). Integrating behavioural change and gamified incentive modelling for stimulating water saving. *Environmental Modelling & Software, 102*, 120–137.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Otaki, Y., Honda, H., & Ueda, K. (2019). Historical self-comparison of water consumption as a water demand management tool. *Water, 11*(4), 844.

Otaki, Y., Iwata, S., Honda, H., & Ueda, K. (2022). Using nudges for water demand management: A field experiment for water conservation. *PLOS Water, 1*(10), e0000057.

Quesnel, K. J., & Ajami, N. K. (2017). Changes in water consumption linked to heavy news media coverage of extreme climatic events. *Science Advances, 3*(10), e1700784.

Schultz, P. W. (2014). Strategies for promoting proenvironmental behavior: Lots of tools but few instructions. *European Psychologist, 19*(2), 107–117.

Schultz, P. W., Messina, A., Tronu, G., Limas, E. F., Gupta, R., & Estrada, M. (2014). Personalized normative feedback and the moderating role of personal norms: A field experiment to reduce residential water consumption. *Environment and Behavior, 48*(5), 686–710.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science, 18*(5), 429–434.

Seyranian, V., Sinatra, G. M., & Polikoff, M. S. (2015). Comparing communication strategies for reducing residential water consumption. *Journal of Environmental Psychology, 41*, 81–90.

Shin, J. S. (1985). Perception of price when price information is costly: Evidence from residential electricity demand. *The Review of Economics and Statistics, 67*(4), 591–598.

Smith, G., & Visser, M. (2014). *Behavioural nudges as a water savings strategy* (Water Research Commission Report No. 2091/1/13).

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press.

Thöni, C., & Volk, S. (2018). Conditional cooperation: Review and refinement. *Economics Letters, 171*, 37–40.

Tomic, U., Sütterlin, B., Lobsiger-Kägi, E., et al. (2024). Reducing hot water consumption through real-time feedback and social comparison using persuasive technologies: Evidence from a Swiss energy-efficient district. *Energy Efficiency, 17*, 15.

Torres, M. M. J., & Carlsson, F. (2018). Direct and spillover effects of a social information campaign on residential water-savings. *Journal of Environmental Economics and Management, 92*, 222–243.

Wang, J., Wen, L., Li, Y., Liu, J., & Che, S. (2025). Uncovering the impacts of social comparative information on water saving behavior among urban residents: A field experiment in China. *Journal of Cleaner Production, 492*, 144863.

Wichman, C. J. (2014). Perceived price in residential water demand: Evidence from a natural experiment. *Journal of Economic Behavior & Organization, 107*, 308–323.

Wichman, C. J. (2017). Information provision and consumer behavior: A natural experiment in billing frequency. *Journal of Public Economics, 152*, 13–33.

Willis, R. M., Stewart, R. A., Panuwatwanich, K., Jones, S., & Kyriakides, A. (2010). Alarming visual display monitors affecting shower end use water and energy conservation in Australian residential households. *Resources, Conservation and Recycling, 54*(12), 1117–1127.

Worthington, A. C., & Hoffman, M. (2008). An empirical survey of residential water demand modelling. *Journal of Economic Surveys, 22*(5), 842–871.