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Combining digital technologies and incentives for water conservation: A Q-method study to understand preferences of French irrigators

Pauline Pedehour* & Marianne Lefebvre†

June 27, 2024

Abstract

The aim of this study was to investigate the preferences for a water conservation scheme that has not yet been implemented by combining digital tools with pilot irrigation and incentives for farmers to adopt deficit irrigation. We conducted a Q-study with 25 farmers and irrigation advisors in two French watersheds highly dependent on irrigation. We found that the material implementation of the scheme (sensors, smartphone app...) is largely accepted. However, the incentive design is less consensual, i.e., how irrigation performance is defined and what is at stake for those performing better in deficit irrigation. A wider survey with 202 farmers allows to assess how the four profiles highlighted with the Q-study distribute in the farming population of the two watersheds. This study contributes to understanding how farmers perceive a combination of technological levers and incentives to foster water conservation.

JEL Codes: O32, Q16, Q25.

Keywords: Deficit Irrigation, Water, Agriculture, Q method, Technology acceptance, Water allocation scheme.

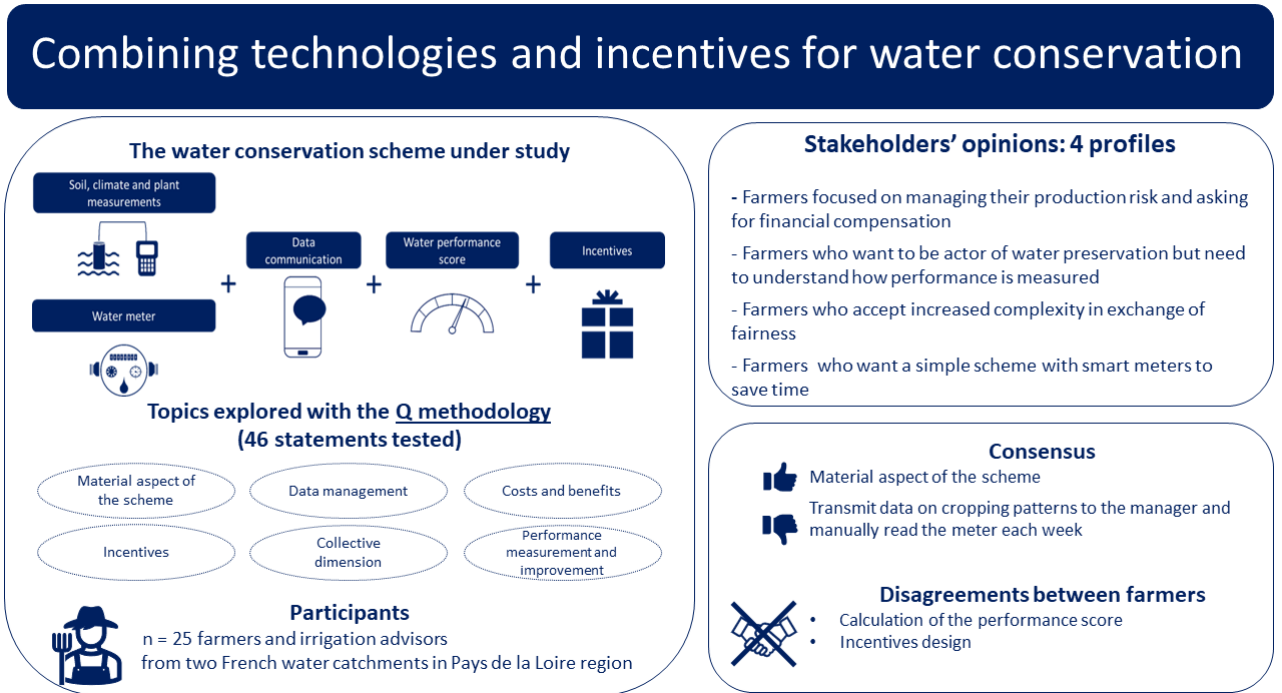
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Figure 1: Graphical abstract



1 Introduction

Agriculture is the largest freshwater user on the planet, consuming more than two-thirds of total withdrawals (FAO 2019). The contribution of irrigated agriculture to food production represents more than 40% of the total production value, whereas irrigated acreage corresponds to only 17% of the total agricultural area (Fereres et al. 2004). However, freshwater has been overexploited for irrigation in many parts of the world. With increasing competition for water from other sectors, irrigation is increasingly required to operate under water scarcity.

Two types of solutions are often proposed: technological solutions to optimise water use and increase irrigation efficiency (e.g., sensors and smart meters) and organisations to incentivise changes in practices or rationalise water allocation (Pérez-Blanco et al., 2020). Acceptability by water users and the impact of such solutions on water use have mostly been analysed separately. For example, Ouvrard et al. (2023), Wang et al. (2017), and Zekri et al. (2017) focused on the acceptability and feasibility of smart water meters in France, China, and Oman, respectively. However, some authors have focused on preferences for different incentives to save water (Giannoccaro et al. 2022) or new water allocation rules (Goetz, Martínez, and Xabadia 2017).

This study contributes to understanding how farmers perceive a combination of technological levers and incentives to increase their irrigation efficiency. In particular, we

explore preferences for a scheme that includes digital tools that provide technical assistance to implement deficit irrigation and incentives to do so. The aim of deficit irrigation (DI) is to maximise water productivity while stabilising—rather than maximising—yields by limiting water applications during drought-sensitive growth stages. More specifically, the scheme relies on (i) calculating a performance score for each farm, which depends on efforts to conduct deficit irrigation, and (ii) incentives for farmers to improve their performance score.

Literature focusing on irrigator preferences for a combination of instruments targeting agricultural water-use efficiency is scarce. Burger-Leenhardt et al. (2018) analysed how different digital tools (integrated modelling, satellite data, and smart meters) can contribute to better irrigation management in France; however, they were analysed separately, and the authors did not assess the benefits of and obstacles to their combination. El Chami et al. (2011) evaluated the impact of different scenarios combining technologies and policies on farmers' income, total water use, and the environment, but they relied on simulations and did not account for stakeholders' preferences.

Public acceptance and user adhesion are key success factors for policy efficiency (Ward 2013, Iribarnegaray et al. 2014). Increases in irrigation efficiency must be accompanied by (among others) a better understanding of the incentives and behavioural responses of irrigators to these incentives to mitigate global water scarcity (Grafton et al. 2018). Understanding users' perspectives and diversity is the first step in the acceptability puzzle (Barry and Proops 1999). Q methodology can provide empirical evidence of stakeholders' perceptions and attitudes towards a topic (Stephenson 1953). Applications of the Q method have increased significantly in areas of ecological economics, environmental management and policy in recent years (Araral et al. 2017, Asquer 2014, Brouwer et al. 2019, Forouzani et al. 2013, Davies et al. 2012, Frantzi, Carter, and Lovett 2009, Leong and Lejano 2016, Minkman et al. 2019, Ormerod 2019, to cite only few studies).

In this paper, we present a Q-study conducted with 25 French farmers and irrigation advisors on the acceptability of a scheme that has not yet been implemented, coupling digital tools to optimise irrigation practices with economic incentives to adopt DI. The contribution to the literature is twofold. First, this paper highlights four distinct visions on the topic: the farmers focused on managing their production risk and asking for financial compensation in order to participate, those who want to be actors in water preservation but need to understand how performance is measured, those who accept increased complexity in exchange for fairness, and those who want a simple scheme with

smart meters to save time. Second, we identified major consensuses and disagreements. We found that the material implementation (sensors, smartphone app...) of the scheme is largely accepted, but there are divergences in incentive design (both in terms of how performance is defined and what is at stake for those performing better in deficit irrigation). We also designed a survey to estimate the frequency of perspectives in a wider population of 202 irrigators in the two watersheds.

The remainder of this paper is organised as follows. In Section 2, we present the water conservation scheme and the case study area. In Section 3, the implementation of the Q method is described. Section 4 details the main results, which are discussed in Section 5. The final section concludes this paper.

2 Background

2.1 The water conservation scheme under study

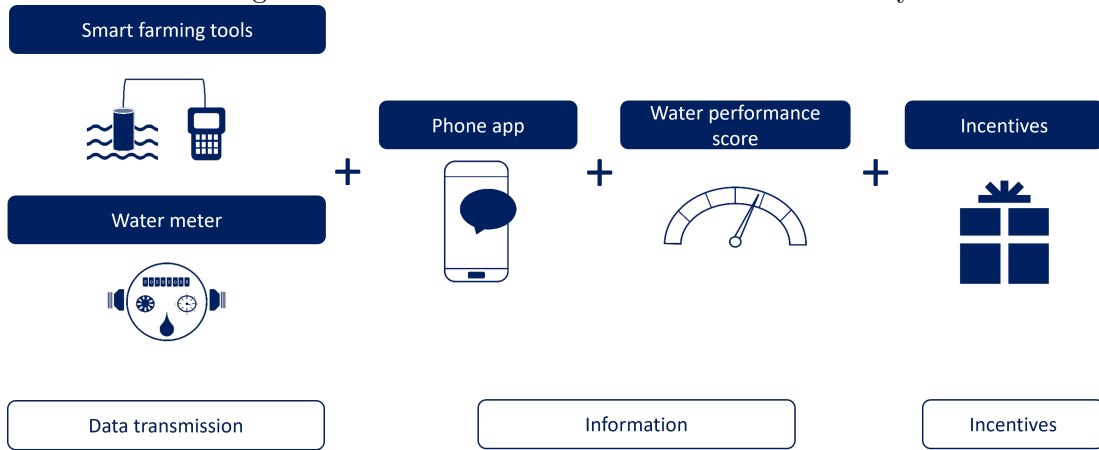
The scheme under study combines digital tools that provide technical assistance in implementing DI with economic incentives. It comprises three parts (Figure 2). Part 1 concerns the materials necessary to collect farm data. It includes sensors and piezometers installed on plots to measure plant water requirements (based on indicators of water reserves in the soil, soil moisture, and temperature). The other element is the water meter, which is used to inform the manager of the water consumption at each extraction point.

Part 2 is the digital architecture that enables the sharing of these data and the calculation of farmers' performance scores with regard to the implementation of DI. DI is an irrigation practice in which crops are irrigated with less water than the total requirement for optimal plant growth to positively improve the plant response to a certain level of water deficit (Chai et al. 2016). A farmer has a high performance score if his water consumption is lower than the theoretical needs, as calculated according to crop type and soil characteristics.¹ To calculate the performance score, crop allocation and water consumption data are required. An app enables the sharing of this information between the farmers and the manager. For example, the performance score, water allocation, and current restrictions, are stored in the same place.

Part 3 comprised incentives designed to encourage farmers to achieve high performance scores. Users can be signalled regarding the water value using a variety of policies,

¹The theoretical needs are calculated per crop. As a result, change in cropping patterns has no impact on performance.

Figure 2: The water conservation scheme under study



ranging from taxes to compensation-based incentives. The under-pricing of irrigation water is considered a major cause of low water-use efficiency (Rosegrant and Ringler 2000), and water pricing policies have received increasing attention in recent decades (Chakravorty et al. 2023). However, there is also evidence of inelastic water demand responses to water prices, particularly for high-value crops, where the water cost is marginal, which is likely to reduce the efficiency of pricing policies (Agency 2017; Lago et al. 2015; Scheierling et al. 2006). In this study, we focused on compensation-based incentives. They can take different forms, such as label-attesting efforts to preserve water resources (Nydrioni and Grigoropoulou 2023), financial compensation in the form of payment for environmental services (Wallander and Hand 2011), and insurance payments if deficit irrigation generates yield losses or secure water allocation in the case of restrictions up to a given volume (Campbell 2003).

The scheme was designed by experts in water management and a private company designing digital tools for water conservation. It was tested on a small scale under the supervision of an agricultural chamber in 2021 and 2022. Smart meters, weather stations, and tensiometric sensors were installed on the plots of nine farmers. Farmers received training on the use of an app that aggregated useful information for irrigation decisions (useful soil reserves and weather data) and the calculation of their performance scores. Farmers could also see on the app what their potential gains would be if incentives were implemented (these were hypothetical in the experimentation phase).

The water conservation scheme entails both elements that provide information to farmers (e.g. sensors measuring the temperature of the soil or a phone app which provides information on the state of the resource in a water catchment) and other elements that enable information to be passed on to the manager. They belong to a broad category

of smart farming tools for irrigation. As a first step towards understanding opinions on such a scheme, we reviewed the literature on digital tools that support irrigation. Figure 3 summarises this review. Overall, the literature highlights that smart farming irrigation technologies represent a real opportunity to increase irrigation efficiency and save water and time. However, these systems also involve material constraints (for installation and maintenance) and social constraints (need for training, impact on decision autonomy for farmers, and risks associated with the transmission of personal data), which can slow down their implementation.

2.2 The case study area

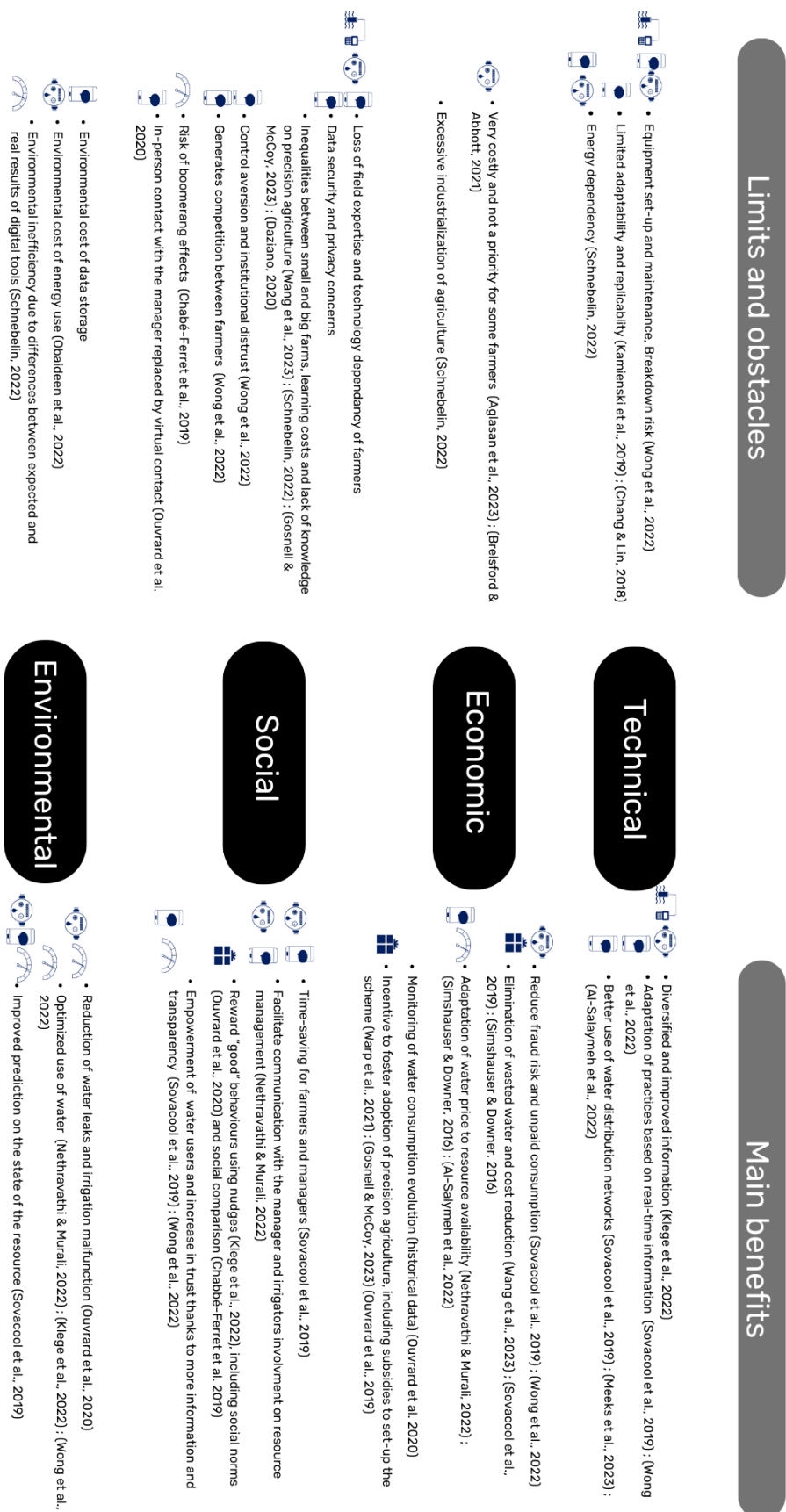
There is no water market for allocating water based on its economic value to each user in France. Instead, a water manager is mandated to allocate water among agricultural users in a watershed at risk. Farmers claim a volume of water at the beginning of the irrigation season and receive a non-tradable volumetric water allocation lower than or equal to their claim. The manager is free to decide on the allocation criteria, such as the size of the irrigated land or cropping patterns. There is no volumetric water allocation for watersheds not considered "at risk", and irrigators are not restricted as long as their extraction point has been registered with the administration. Beyond this structural management, water authorities can limit (with time or flow restrictions) or ban water extraction in both watershed types in the case of a drought. Frequent restrictions during the growing season put production at risk. Moreover, farmers face uncertainty about the volume of water they will be allowed to use when making crop rotation and soil management decisions, which slows down the adaptation of farm practices to water scarcity.

The French department of Maine and Loire was chosen as the case study area because of the high frequency of irrigation restrictions in recent years. For example, the surface water resources of Authion were subject to restrictions for 17% of the weeks during 2020–2023, representing approximately nine weeks per year². Even more worryingly, the Couasnon hydrological zone, which is a tributary of the Authion River, was subject to restrictions 32.7% of the time over these years, representing 17 weeks, including 9 weeks at the crisis level, meaning that irrigation was totally banned for almost all crops.

Moreover, agricultural production is highly dependent on irrigation, owing to crop and soil types, and weather conditions. While 10% of the utilised agricultural area was irrigated in 2019 (compared to only 6.9% in France), irrigated production represents 25%

²These percentages are calculated based on publicly available drought orders for each hydrological area.

Figure 3: Main advantages and limitations of smart farming tools for irrigation



Note: The articles mentioned here have been identified using Google Scholar with the request ("irrigation" OR "water") AND ("smart" OR "digital" OR "precision" OR "numeric") AND ("farming" OR "agriculture" OR "agricultural")

of the total economic value of agriculture in the area. We focused on two watersheds in the department: Authion, a watershed at risk and under collective management since 2015 (with the agricultural chamber acting as manager), and Aubance (joint with southern Loire), which is not yet at risk. Aubance area is characterised by a small number of irrigators and homogeneous crops. The Authion area represents a much larger irrigation community with a high diversity of crops, soils, and farm sizes (see Appendix A1 for further details).

3 Method

3.1 A brief on Q methodology

The Q methodology developed by psychologist Stephenson (1953) is based on the subjectivity of preferences and has been used by farmers to obtain their viewpoints on various topics such as natural resources, sustainable production (Walder and Kantelhardt 2018), and environmental management of agricultural land (Davies et al. 2007). Using by-person factor analysis (Webler et al. 2009), this method offers a structured approach for identifying groups of respondents sharing distinct views on the topic (Watts and Stenner 2012). Implementing Q methodology requires the following steps: (Brown 1980; Watts and Stenner 2012).

The first step is the creation of the concourse that Stephenson (1981) refers to as “*The conversational possibilities for any subjective notion, idea, wish dream etc.*”, on the studied topic, and the Q set which is a selection of a subset of items from the concourse. The second step is the recruitment of Q-sort respondents according to the criteria that Barry and Proops (1999) call “*finite diversity*” of viewpoints to represent the diversity of stakeholders’ viewpoints. The third step consisted of the Q-sorting procedure in which respondents sorted statements in a grid following a quasi-normal distribution and then exit interviews with additional questions. The fourth step is data analysis, which reveals the main viewpoints on the topic and examines the correlation matrix of all the Q-sorting grids.

3.2 Study design: Concourse & Q-set

First we gathered information from the scientific literature and press review elements on water conservation technologies and policies, including incentive schemes. Then, the concourse of the statements was completed based on interviews with farmers, agricultural

chamber advisors and staff from a private company developing digital technologies for water conservation. In total, we obtained a concourse of 63 statements (Appendix A2), representing both general criteria to implement a water conservation scheme combining technologies and incentives and more local ones adapted to the case study area. After a discussion with five experts, the list was shortened to 46 statements based on relevance of statements to avoid redundancies (Table 1). The Q-set was structured into seven categories: materials (sensors, smart meters, and app), data management (data made available to the farmer through the app and data shared with the manager), costs and benefits, performance measures, incentives, performance levers, and collective dimensions.

Table 1: Q-set statements

Item	Category	Statement
1	Material aspects	I accept that sensors are installed on my farm to measure the temperature, moisture, and other characteristics of my soil
2	Material aspect	I accept that smart meters are installed at my farm's withdrawal points to transmit water consumption data in real time
3	Material aspects	I agree to use an application on my smartphone or a website on my computer to communicate my water volume requests to the manager
4	Data management	I agree to join the scheme to obtain information on the status of water resources and the possible restrictions in my area
5	Data management	I agree to join the scheme to obtain personalised advice to optimise my irrigation
6	Data management	I agree to join the scheme to comply with my water expenses
7	Data management	I agree to read my water consumption manually every week for the scheme to work
8	Data management	I accept that a smart meter transmits my water consumption data in real time to the manager
9	Data management	I accept that my water consumption can be communicated to other farmers in my area via the system for comparative purposes
10	Data management	I agree to communicate other data from my farm (CAP declarations) that are useful to the manager to better manage resources
11	Costs and benefits	I agree with joining the scheme to find leaks faster
12	Costs and benefits	I agree to join the scheme to avoid errors, thanks to the smart meter that avoids the manual entry of meter readings
13	Costs and benefits	I agree to join the scheme to optimise my withdrawals and reduce my water bill
14	Costs and benefits	I agree to join the scheme if I receive an individual subsidy for technical installations
15	Costs and benefits	I agree to join the scheme if I receive a subsidy for technical installation, conditional on most farmers in the watershed joining
16	Costs and benefits	I agree to join the scheme to avoid wasting time by automatically sharing data with managers
17	Costs and benefits	I agree with joining the scheme to communicate more easily with the manager
18	Costs and benefits	I accept that joining the scheme will result in an increase in the fee I pay as an irrigator to the manager
19	Costs and benefits	I agree to join the scheme if it saves the manager money and the fee is reduced
20	Costs and benefits	I agree to spend time on training to understand the scheme
21	Performance measure	I accept that my performance depends on the volume I consume (in m ³)
22	Performance measure	I accept that my performance depends on the unused share of my authorised volume.
23	Performance measures	I accept that my performance depends on the water needs of my crops
24	Performance measure	I accept that my performance depends on my irrigation area
25	Performance measure	I accept that my performance depends on the climate and weather conditions

26	Performance measure	I agree to join the scheme if the performance is calculated for the current year without considering the consumption in the previous years
28	Performance measure	I accept that my performance depends on the adequacy between the volume requested and the volume finally used
29	Performance measure	I agree to implement the scheme, even if I do not fully understand how my performance score is calculated
30	Performance measures	I agree to implement the scheme if the calculation of my performance score is fully transparent
31	Incentives	I agree to join the scheme if the performance score enables me to benefit from secure access to water in the case of an irrigation ban
32	Incentives	I agree to join the scheme if the performance score enables me to obtain a label attesting to my efforts in preserving water resources
33	Incentives	I agree to join the scheme if the performance score enables for financial compensation in the form of payments for environmental services
34	Incentives	I agree to join the scheme if the performance score enables me to obtain compensation in case of yield losses due to an irrigation deficit, which would enable me to better manage the risk
35	Performance levers	To improve my performance score, I agree to adopt water-saving equipment
36	Performance levers	To improve my performance score, I agree to adopt drought-resistant crops
37	Performance levers	To improve my performance score, I agree to modify my crop rotation.
38	Performance levers	To improve my performance score, I agree to skip the water turn at the beginning of the irrigation campaign
39	Performance levers	To improve my performance score, I agree to skip the water turn at the end of the irrigation campaign
40	Performance levers	To improve my performance score, I accept not irrigating some of my crops in favour of irrigating my sensitive crops (less drought-resistant and with higher added value)
41	Performance levers	To improve my performance score, I accept not irrigating some of my crops in favour of irrigating other farmers' sensitive crops (less drought-resistant and with higher added value)
42	Performance levers	To improve my performance score, I agree to change my tillage practices to enable crops to use water better
43	Performance levers	To improve my performance score, I accept not following the recommendations of my clients when they encourage me to irrigate more
44	Collective dimension	I agree to join the scheme if most farmers in my irrigation area do so
45	Collective dimension	I agree to adhere to the system if it is integrated into a manager's internal regulations
46	Collective dimension	I agree to join the scheme because I want to do my part to better manage water resources

on other statements. After the comments on the statements, we asked respondents to express their points of view on several aspects of the scheme: the smart meter, mobile app, collective management, different types of incentives, and calculation of the performance score. These additional questions helped us understand the perceived benefits and barriers to scheme implementation. This post-sort exchange facilitates the interpretation of the results and avoids misinterpretations of respondents' viewpoints in the qualitative interpretation of factors (Watts and Stenner 2012).

3.5 Data analysis

After collecting the data through the Q-sorting process, factor analysis was conducted using Ken-Q (Banasick 2019). Q methodology aims to find correlations between respondents according to their statement positions in the grid. The objective is to determine factors so that similarities within a factor are maximised and similarities between factors are minimised. Each factor represents a distinct vision on the studied topic.

To do so, we first calculated the inter-individual correlation matrix to better understand the similarities and divergences between respondents. According to Baker et al. (2006), these correlations can be calculated as follows:

$$r = 1 - \frac{\sum D^2}{\sum I^2}$$

where D is the difference between the scores (between -4 and +4 with the grid of this study) given to each statement by the two concerned respondents, and I is the score given by each participant to a statement. This calculation is repeated to build an $n * n$ matrix for n respondents. A perfect correlation between individual grids is given by $r = 1$, and strong disagreements are highlighted by very low or even negative correlations between individuals.

The second step was to highlight the main viewpoints on the studied topic which characterise each factor, that is, respondents with a common perspective of thought (Gauzente 2005). Each factor represents the main vision of the studied topic loaded by several respondents' viewpoints. While factors are traditionally extracted depending on their eigenvalues and then rotated through both judgemental and Varimax rotations (Baker et al. 2006), best practices in Q methodology research recommend triangulation between multiple criteria to decide how many factors to extract (Sneegas et al. 2021). For instance we can keep factors depending on the following criteria : an eigenvalue higher than one (Kaiser-Guttman), at least two significant participant loadings (Humphrey's

Rule), cross product of the two highest loadings exceeds two times the standard error, solution counts for over 50% of total variance, factors based on scree plot analysis, subjective meaning importance and interpretability.

When the factors are selected, the weight of each statement s denoted $W_{s/f}$, is given by

$$W_{s/f} = \sum_{i=1}^n r_{s/i} * w_{i/f}$$

This is the sum of all individuals i pertaining to factor f of the score given to statement s in the Q sort multiplied by the weight of this individual i on this factor. The weight of each individual i loading factor f is given by (Gauzente, 2005)

$$w_{i/f} = \frac{F}{(1 - F^2)}$$

where F is a factor loading value. Then, with the weights of the Q-sorts, it is possible to construct artificial composite Q-sorts, representing the arrangement of statements from a hypothetical respondent with hundred percent of loading on that factor (Van Exel and De Graaf 2005). This composite Q-sort was created based on the average scores of statements in the grids of respondents associated with this viewpoint (Brown 1993). The higher the positive weight of a statement, the more this statement will be on the right side of the sorting grid, and vice versa. These composite Q sorts enabled us to understand the general shared vision of the topic. These are provided in Appendix 2-5. Finally, the data analysis provided statements of consensus and disagreement. The lower the variance of the Z-score, the more consensual the item was between the factors. A null Z-score variance indicated no difference in the ranking of items among the factors. Table A.9 ranks the items from most to least consensual.

4 Results

Results are twofold. First, we identified groups of respondents sharing similar vision on the studied topic, and further explore the share of irrigators of each profile within the watersheds under study. Second, we present the areas of consensus and disagreement between the respondents.

4.1 Factors

Maintaining all factors with an eigenvalue higher than one³, eight factors were extracted (Table A3), suggesting a high diversity in the visions of the topic. However, there were many non-loaders, and a high correlation between some factors indicated similar visions on the topic. Finally, we selected four factors representing 23 loaders at a p-value significance level of 5%, where each factor represented a distinct vision of the topic. These four factors represented a cumulative explained variance of 56%. They all had very high composite reliability and were clearly defined by between three and eight respondents. This analysis validated the selection criteria defined above.

These four selected factors were rotated through a varimax rotation to maximise the amount of explained variance (Van Exel and De Graaf 2005), minimise the difference between factors, and maximise similarities within factors. Table 2 shows that only two respondents had significant loadings in more than one factor (T6 and I11) and were, therefore, too confounded to be included in the analysis. Note that the obtained factors were non-bipolar. Table A4 in the Appendix provides the weights of the individual sorts for each of the factors with which they are associated.

Based on the composite Q-sorts for each factor and post-sort interviews, we provide the following interpretation for each of the four factors:

Factor 1: Profile of those who want to manage their production risk and receive compensation for participation in the scheme

Factor 1 had an eigenvalue of 8.33 and explained 20% of the variance in the Q sort. Eight respondents loaded this factor, advisors and irrigation farmers in equal proportion.

For this factor, the acceptability of the system is conditional on obtaining a reward for irrigation efforts. Indeed, all statements representing incentives were positioned on the positive side of the grid (Items 31 and 34 were ranked +4; Items 32 and 33 were ranked +1). The higher importance of incentives for respondents loading to Factor 1 is visible, in particular, through the high positive weight they give to the possibility of obtaining compensation in the case of yield losses due to irrigation deficit to better manage risk (Item 34 ranked +4, significantly higher grid ranking for Factor 1 than the other factors ($p < 0.01$)).

This importance of compensation goes with the fact that those respondents consider as unacceptable any impact of the scheme on farm practices (i.e., cropping patterns and

³A factor with an eigenvalue higher than one is generally qualified as significant (Kaiser 1960), explaining more variance than a single variable, and is thus considered interpretable.

Table 2: Rotated factors matrix with factor characteristics

id	Factor 1	Factor 2	Factor 3	Factor 4
T1	0.1624	0.239	0.165	0.5296
T2	0.5265	0.5891	0.1628	0.124
T3	0.117	0.6661	0.0233	0.3065
T4	0.6495	0.244	0.2371	-0.0294
T5	0.5571	0.6117	-0.0703	-0.0182
T6	0.519	0.3614	0.0347	0.4582
T7	0.7255	0.0224	-0.0123	-0.0484
T8	0.8116	0.201	0.1978	0.1601
T9	0.7316	0.0819	-0.0479	0.2605
T10	0.0909	0.4954	0.1839	0.4362
T11	0.581	0.2887	-0.1585	0.3042
I1	0.1501	-0.0024	-0.3682	0.7229
I2	0.6885	0.3559	0.0769	-0.2692
I3	0.1741	0.676	0.1774	0.2232
I4	0.2338	0.7521	0.0149	0.1309
I5	0.0576	0.4432	0.1129	0.4786
I6	0.2313	0.2368	0.5406	0.2344
I7	0.099	0.2455	0.0933	0.5438
I8	0.2043	0.5049	-0.2987	0.1894
I9	0.4724	0.1936	0.0047	0.3066
I10	0.2826	-0.3253	0.6675	0.1316
I11	-0.2025	0.4241	0.2903	0.449
I12	-0.0273	0.1577	0.7557	-0.063
I13	0.3136	0.6502	0.0465	0.1691
I14	0.7312	0.076	0.2329	0.3502
% Explained Variance	20	17	8	11
Number of defining variables	8	8	3	4
Average relative coefficient	0.8	0.8	0.8	0.8
Composite reliability	0.97	0.97	0.923	0.941
S.E. of Factor Z-scores	0.173	0.173	0.277	0.243

Note: In bold if the participant is flagged with the factor. For example, Factor 1 is flagged by respondents T4, T7, T8, T9, T11, I2, I9, and I14.

irrigation turns) (Items 37 ranked -2, 39 ranked -3, 40 ranked -2, and were significantly lower than that of all other factors). In post-sort interviews, respondents associated with this vision highlighted the importance of “*securing volumes and productions*” (respondent T8). Moreover, water use optimisation (in relation to the authorised volume) is important (Items 22 and 28 ranked +2, significantly higher than that of other factors), as is reducing water bills (Item 13 ranked +3, significantly higher in this factor ($p < 0.05$)).

For respondents loading to Factor 1, data transmission is less acceptable, both to other farmers of the area and to the manager (Item 9 ranked -4 and Item 8 ranked -3, both significantly lower than in all other factors). These respondents were also the only ones opposed to smart meters (Item 2 ranked -2, significantly ($p < 0.05$) lower than in

other factors).

In summary, for the scheme to be accepted by respondents loading onto Factor 1, some incentives and a guarantee that it will not substantially impact farm practices will be needed. This should also reduce the need for data transmission, particularly when considering the rejection of smart meters.

Factor 2: Profile of those who want to be actors of water preservation but first need to understand the scheme

Factor 2 had an eigenvalue of 2.43 and explained 17% of the variance in the Q sort. Eight respondents loaded this factor, advisors and irrigation farmers in equal proportion.

Therefore, an acceptable implementation of the scheme is subject to long-term consideration. Indeed, this factor sees water resources as a major issue for the profession, and environmental aspects dominate economic aspects. One participant even stated “*Managing the resource is not mainly of financial interest but a problem for production. Water is not yet an economic issue*”(T3), and another said “*I want to do my part to preserve and better manage water resources*” (I13), which echoes Item 46 (ranked +1). Along this line, it is important for this factor to adapt practices to resource availability and to adapt the performance calculation to climatic conditions (Item 25 ranked +4, significantly higher than in all other factors ($p < 0.01$)). Performance should also account for the efforts made in previous years (Item 27 ranked +3).

This factor also favours transparency. For instance, automatic data transmission with the manager is accepted if it saves time (Item 16 ranked +2, significantly higher than all other factors ($p < 0.01$)). However, symmetrically, these respondents opposed the implementation of the performance score if they did not understand how it worked (Item 30 ranked +4; Item 29 ranked -4, significantly lower than in all other factors ($p < 0.01$)).

Factor 2 respondents tended to comply with rules. They accepted the implementation of all the material sensors, smartphone applications, and smart meters (Item 1 ranked +3; Item 3 ranked +2; Item 2 ranked +1). Moreover, they rejected the possibility of bypassing the irrigation recommendations of their clients (Item 43 ranked -3, significantly lower than in all other factors ($p < 0.01$)). In summary, respondents loading on Factor 2 favoured a long-term and transparent approach to water conservation. They are likely to follow the recommendations of both water managers and clients.

Factor 3: Profile of those who accept increased complexity in exchange of fairness

Factor 3 had an eigenvalue of 1.80 and explained 8% of the variance in the Q sort. Three farmers were loaded on this factor.

First, respondents loading on Factor 3 gave more importance to the calculation of the performance score. Indeed, most statements of this category were ranked in the extreme parts of the grid (Items 24, 26 and 29 ranked between -3 and -4; and Items 22, 30, 28, and 21 ranked between +3 and +4). More precisely, this scheme is acceptable if the performance accounts for the unused share of the authorised volume (Item 22 ranked +4, significantly higher than in all other factors ($p < 0.01$)) and the adequacy between the requested volume and the volume finally used (Item 28 ranked +4, significantly ranked higher than in all other factors ($p < 0.05$)). In contrast, these respondents did not accept joining the scheme if the performance was calculated without considering historical water consumption (Item 26 ranked -4, significantly lower than in all other factors ($p < 0.01$)). However, this approach may be perceived as unfair. Surprisingly, respondents loaded on Factor 3 did not accept spending time understanding the scheme (Item 20 ranked -2, significantly higher than in all other factors ($p < 0.01$)), whereas they wanted the performance score to consider many dimensions.

Fairness is an important factor for these respondents. In post-sort interviews, a participant even said *"I want the scheme to be mandatory for everyone, with a principle of equity"* (I12). To guarantee fairness, they prefer the scheme to be integrated into the manager's rules (Item 45 ranked +3, which is significantly higher than in all other factors ($p < 0.01$)). They also wanted the scheme to be transparent towards other stakeholders, with label-attesting efforts to preserve water resources (Item 32 ranked +2, significantly higher than in all other factors ($p < 0.05$)).

Quotes from post-sort interviews also highlight that respondents loading to Factor 3 value independence: *"I am the boss on my exploitation"*(I6) or *"Everyone should remain independent of others, free. So we should remain individual farmers. I am not ready to give water back to others who are not careful"* (I10). The other dimensions translated into a self-centred vision. They rejected personalised advice (Item 5 ranked -2, significantly higher than in all other factors ($p < 0.01$)) and rejected the scheme implementation being conditional on others' participation (Item 44 ranked -3, significantly lower than in all other factors ($p < 0.01$)). They rejected their role in the functioning of water institutions. For example, cost saving for managers was not important (Item 19 ranked -3, significantly

lower than in all other factors ($p < 0.01$). They also did not consider whether they should take part in water conservation (Item 46 ranked -1, significantly lower than in all other factors ($p < 0.05$)) or reduce their water extraction and bill (Item 13 ranked -2, significantly lower than in all other factors ($p < 0.01$)).

In summary, respondents loaded on Factor 3 accepted the scheme if they perceived it as fair; they wanted it to be mandatory for all water users and the performance score to account for many dimensions. However, their preferences are not driven by the motive of contributing to the public good of water conservation. Rather, these farmers valued their independence and freedom in deciding how to irrigate their farms.

Factor 4: Profile of those who want a simple scheme with smart meters to save time

Factor 4 had an eigenvalue of 1.44 and explained 11% of the variance in the Q sort. Four respondents (one advisor and three farmers) loaded onto this factor.

Collective adherence to the scheme was important for respondents loading on Factor 4. They accept this if other farmers in the area also do so (Item 44 ranked +4, significantly higher than in all other factors ($p < 0.01$)). It can be illustrated by this quote from one of the respondents *“It is important to understand the calculations and to share them collectively. This implies taking time out of the irrigation season to understand the technique and this can be done through workshops with other farmers”*(I5). However, they disagree with the incentive to join (i.e., a subsidy) to be conditional to the participation of most farms in the watershed (Item 15 ranked -2, significantly lower than in all other factors ($p < 0.05$)).

Factor 4 respondents perceived smart meter installation as completely acceptable and useful (Item 2 ranked +3, significantly higher than in all other factors ($p < 0.05$)). This is recognised as necessary to avoid errors in data transmission and save time, especially during the summer season (Item 12 ranked +4, significantly higher than in all other factors ($p < 0.01$)).

Finally, Factor 4 respondents rejected administrative complexity. For example, they do not accept that the performance score depends on climatic conditions, most probably because they are too uncertain and it complexifies the score (Item 25 ranked -4, significantly higher than in all other factors ($p < 0.01$)). They were also against subsidies to cover technical installation costs (Item 14 ranked -1; Item 15 ranked -3) and labelling of efforts in water conservation (Item 32 ranked -3, significantly lower than in all other

factors ($p < 0.01$). While the participation of most farmers is important (Item 44 ranked +4, significantly higher than in all other factors ($p < 0.01$)), they reject the integration of manager's rules, which will most likely make participation compulsory (Item 45 ranked -2, significantly lower than in all other factors ($p < 0.05$)).

In summary, respondents loading onto Factor 4 accepted the scheme because it enabled them to save time. They prefer simple administrative setups and value the benefits of smart meters. They will accept the scheme under these conditions and if most farmers in the watershed participate.

4.1.1 Repartition of profiles in the watersheds

Furthermore, we quantitatively quantified the repartitioning of the irrigators in each profile. Although the Q method is useful for providing insights into the range of opinions about a topic within a certain sample of stakeholders, it does not enable generalisation about the representativeness of different opinions within a larger population (Grimsrud et al. 2020; Zabala et al. 2018). This is a limitation of policy analysis. While the Q-method does not target the factors' representativeness, this information can be of interest to policymakers. We complemented the Q results with a quantitative study to estimate the frequency of perspectives in the wider population of irrigators of the two watersheds of the case study area to address this criticism. The main purpose of this quantitative study was to analyse preferences for data sharing when a water manager used the information to allocate water using a discrete choice experiment (DCE) (Pedehour and Lefebvre 2024). At the end of the DCE, we presented infographics depicting the four factors (Figure 5) and asked respondents in which profile they best recognised themselves. A total of 641 irrigators from the Aubance and Authion watersheds received an online survey, and 202 answers were collected. We found that irrigators were distributed across the four factors (Table 3). We found that Factor 3, loaded only by farmers, represented 34.16% of the sample which is the largest group, whereas Factor 4 represented only 13.86%.

4.2 Consensus and disagreement statements

The results highlight differences across these four profiles but also enable us to list the main consensus and disagreements (see Appendix A9 for a complete view). The lower the Z-score, the more an item is classified as a consensus, and the higher the Z-score, the more an item shows a disagreement between factors. We decided to comment on the six items with the lowest and highest Z-scores to highlight these areas of consensus and

Figure 5: Infographics presented to respondents in the quantitative study

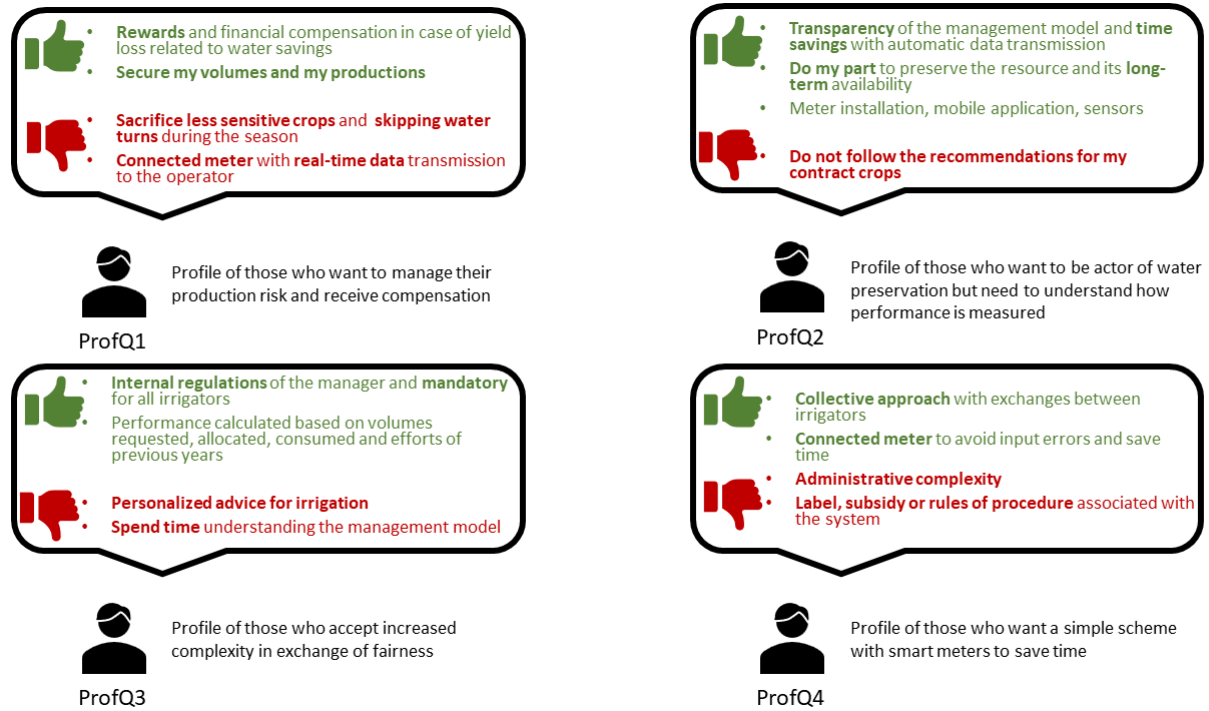


Table 3: Quantitative repartition of irrigators by Q profiles (n=202)

	Factor 1	Factor 2	Factor 3	Factor 4	No answer
Number of irrigators associated to this profile	49	42	69	28	14
In percentage	24.26%	20.79%	34.16%	13.86%	6.93%

disagreement between the factors.

We found consensus statements among all respondents, meaning that they all accepted or did not accept the following statements: First, they all accepted the implementation of sensors (Item 1) on their exploitation or the use of a smartphone app (Item 3) to obtain all the information (Item 4) about their water consumption and communicate with the manager. They also accepted adopting irrigation materials to favour water use reduction (Item 35). This indicates that the material aspect of the digital scheme does not seem problematic for irrigators. Only smart meters were slightly more controversial (with one factor rejecting them). However, the resistance to smart meters seems lower than that generally depicted in the literature, highlighting perceived health, functional, and data security risks (Ram et al. 1989; Chamaret et al. 2020).

However, data management remains controversial. For example, there was a negative consensus on the communication of farm data, which is useful for water managers (Item 10). There was also a strong global negative consensus on weekly manual water consumption readings for the scheme to work (Item 7). Indeed, all irrigators explained that the regular monitoring and transmission of water consumption data were too time-consuming. However, there is no full consensus on smart meters (Item 2).

There were strong disagreements between the profiles regarding certain aspects. In particular, respondents disagreed on the financial aspects of scheme implementation, such as the relevance of an individual subsidy covering the costs of technical installation (Item 14) or compensation in case of yield losses due to deficit irrigation (Item 34). Only certain respondents valued the reduction in their water bills (Item 13).

There was no consensus on the calculation of the performance score. Only certain respondents favoured a performance score depending on the climatic conditions (Item 25) or the unused share of the authorised volume (Item 22). Finally, large participation in the watershed (Item 44) was acceptable, but not for all farmers.

5 Discussion

Our study analyses the conditions under which farmers and irrigation advisors accept a water conservation scheme that combines digital technologies and incentives to adopt deficit irrigation. The Q-method enabled us to highlight some consensus and disagreements between respondents that raised our interest in the discussion, particularly when compared with the pre-requisites for the scheme to operate.

Monitoring deficit irrigation performance requires data to calculate crop theoretical

needs and to compare with the water volumes applied. Therefore, the acceptability of data sharing is the cornerstone of this scheme. The farmers interviewed were reluctant to share their water consumption data frequently. All respondents agreed that weekly manual water consumption readings was not acceptable. These concerns are regarding the practicality (*"We do not take manual readings every month, so it would be impossible to do it every week"* (T4)). Smart meters offer an alternative that is still under investigation. Although there is a large body of literature on the potential of smart meters to reduce energy consumption (Carroll et al. 2014; Chamaret et al. 2020; Gans et al. 2013), water meters and their impact on irrigation practices have been less explored. Some examples are Wang et al. (2017) in China, Zekri et al. (2017) in Oman, Chabé-Ferret et al. (2019) in southwest France, and Ouvrard et al. (2023) in France. Smart water meters can help identify water leaks (Beal and Flynn 2015, Gourbesville 2019, Ouvrard et al. 2023) and adapt water consumption to the resource during peak demands (Beal and Flynn 2015; Collard, Garin, and Montginoul 2019); therefore, contributing to reduce water bills (Gourbesville 2019; Gupta et al. 2020). However, despite these potential benefits, the adoption of smart water meters and changes in irrigation practices owing to better consumption monitoring remain challenging in France (Chabé-Ferret et al. 2019, Ouvrard et al. 2023). While the literature on the promise of digital technologies to reduce the environmental impact of farming is booming, there is very limited evidence on farmers' preferences regarding data protection and we, therefore, contribute to it. New forms of control and value extraction based on the use of data by tech companies providing the material did not appear in the exit interviews, although they were commented on in the literature (Prause et al. 2021). Only one respondent expressed ethical concerns: *"We are in the process of digitalising our businesses, but we work with living matter"* (I2).

Respondents disagreed on the importance of collective adhesion, despite the fact that this is a pre-requisite for the scheme to work, for example in the framework of the "Single Unique Organisation for collective water management", an organisation dedicated to water allocation between farmers in watersheds at risk in France. For some respondents, participation was central, while for others, it remained an individual choice. In interviews, some respondents say that it is *"A good initiative, provided that everyone works on the system. It is a step in the right direction in terms of managing water resources while producing suitable crops"* (I9) and *"If it is a system that makes it possible to better manage water resources and if this system is widespread among all users of water resources, then we are ready to sign up to it"* (I13). However, one other respondent says

that *"Not everyone is aware that there will be less water tomorrow. However, with collective management, a large majority has to be involved. What's more, it adds yet another administrative burden to our businesses.(I3)*. This echoes the literature and experiments conducted with farmers on the collective adoption of environmentally friendly practices fostered by financial incentives triggered when most farmers in a given area adopt the practice, the so-called "collective bonus" (Kuhfuss et al. 2016; Ouvrard et al. 2023). Furthermore, we have highlighted the divergence between those who value collective adoption but do not want it to be mandatory (Factor 4) and those who want participation to be made mandatory even if they do not value the fact that other farmers also participate (Factor 3).

Respondents were more or less attentive to performance score calculations. According to one respondent, *"Acceptability will depend on the robustness of the data and indicators" (T10)*. Several criteria were envisaged in the Q-set to refine the definition of performance. The basic version of the deficit irrigation performance score compares a crop's theoretical water needs and the water volumes applied in a given timeframe. Respondents understood the concept because Items 21 and 23 were well accepted by all. While some respondents accept that climatic conditions are considered in the performance (Item 25) (e.g. a higher irrigation deficit would be needed to have a high performance score in case of a strong water shortage), others reject this possibility in order to have more control over their performance. The interactions between the incentive to perform deficit irrigation and structural water management are also controversial, particularly regarding the influence of authorised volumes allocated before the irrigation season on performance (Items 22 and 28). Other dimensions of the performance score definition are likely to impact fairness perceptions, such as the influence of the total irrigated area (Item 24) and water consumed in the past (Item 26); however, they are relatively consensual.

Only one item regarding changes in farming practices that are likely to increase performance was: all respondents agreed on the need to adopt water-saving equipment (Item 35). Skipping water turns (Items 38 and 39), particularly at the beginning of the irrigation season (Item 38), was mostly considered unacceptable. We observed no consensus on the acceptability of other changes in current farming practices to perform deficit irrigation, such as changes in cropping patterns (Item 37) or the adoption of drought-resistant crops (Item 36)). We found that half of the factors accepted giving up irrigation for less sensitive crops to save water for more sensitive ones on their own farm (Item 40), but most factors reject the possibility of implementing these trade-offs across farms (Item 41).

These results call for a more in-depth analysis of the scheme’s extensive margin effects, for example, on decisions to expand or reduce irrigated surfaces. Furthermore, such an evaluation of stakeholder preferences should be complemented by an impact evaluation of farmers’ income and total water use in the watershed. Indeed, an increase in irrigation efficiency at the farm scale cannot increase water availability at the watershed scale when water unconsumed by a crop is recovered and reused by other crops and farms in the watershed.

Finally, we found no strong consensus on the acceptability of financial payments for environmental services, labelling rewarding water conservation efforts, or deficit irrigation insurance. However, all respondents accepted secure access to water as an incentive to improve their performance. This strong preference was highlighted in post-sort interviews: *“secure water access is the argument to which everyone will be most sensitive” (T11)*. Further investigation is needed to assess the feasibility of such derogations as well as their acceptability by other stakeholders, particularly those defending the need to safeguard environmental flows to preserve biodiversity.

Overall, we question the external validity of the results beyond the two watersheds of the case study area in the Pays de la Loire, France. First, the Q set was adapted to a potential local implementation of the water-conservation scheme and may be irrelevant for implementation in other areas. Second, we cannot reject the possibility of self-selection bias because all respondents voluntarily participated in this study. Nevertheless, our sample was diverse in terms of the main farm production and age. We also diversified perspectives by including different types of stakeholders, i.e., farmers and advisors. As shown by Barry et al. (1999), the Q methodology is very helpful in guiding public policy implementation, as it relies on stakeholders’ expectations, the preoccupations of the studied group, and the local context. The study should be replicated in other territories with the adaptation of the Q-set, if necessary, to further identify other levers and obstacles to adopting deficit irrigation. Nevertheless, our results echo the perceptions of stakeholders in other territories, and our methodological approach is fully replicable in other territories.

6 Conclusion

We conducted a Q-study with 25 French farmers and irrigation advisors to understand the levers and obstacles to adopting an innovative scheme that promotes deficit irrigation through a combination of digital technologies and incentives to conserve water.

In the territory under study, irrigators accept the digital technologies embodied in the scheme (sensors and a smartphone app aggregating water-related information) but are reluctant to transmit data, while it is a condition to monitor deficit irrigation performance and trigger performance-related incentives. More generally, it shows that the details of implementing a water conservation scheme influence its acceptability and, most likely, its efficiency in resource preservation.

Our results highlight four distinct visions: farmers focused on managing their production risk and asking for financial compensation to participate, those who want to be actors in water preservation but need to understand how performance is measured, those who accept increased complexity in exchange for fairness, and those who want a simple scheme with smart meters to save time. Although the scheme requires collective support, our results highlight the fact that it generates heterogeneous opinions. In this context, policymakers must adapt their discourse and communicate differently with groups with different thought patterns to convince them to participate in water conservation on different grounds.

7 Appendix

A1: Characteristics of the two water catchments in the case study area

	Aubance	Authion
Number of irrigators	70	570
Number of ha irrigated each year	around 3000	between 16000 and 18000
Volumes of extracted water	around 15 million m^3	between 10 and 30 million m^3
Crops types	Mainly corn, grassland and seeds	Very diversified (corn and other cereals, arboriculture, horticulture, vegetables)
Type of water resources used for irrigation	Mainly retention water	Very diversified (surface and ground water, retention)

A2: Ideas collected from the academic literature on water conservation schemes

	Reference	Associated ideas of statements
Sensors and piezometric measures	Beal et al. (2015)	Reduce the amount of irrigation water that passes through the soil without being absorbed by the plant
	Gourbesville (2019)	Implement sensors to have soil temperature and moisture to determine the exact amount of required water, depending on nature of soil, variety of cultures, types of crops.
Connected or smart meter	Ouvrard et al. (2020)	<ul style="list-style-type: none"> • Agreement to no longer have a link with the advisors in charge of the control of manual meter • Agreement to install a smart meter to have access easily to past consumptions of water • Avoid water leaks/ irrigation malfunction and be able to track them more easily
	Beal et al. (2015)	<ul style="list-style-type: none"> • Better knowledge of water demand especially peak ones • Defer infrastructure expansion • Reduce manual meter readings and associated costs • Improve accuracy of meter readings and solve problems associated with reading in the field • Reduce operating costs • Improve billing system, frequency and accuracy of accounts • Social benefits associated with water preservation satisfaction, community acceptance, user engagement and trust • Require time to acquire, install and commission smart meters
	Gourbesville (2019)	<ul style="list-style-type: none"> • Field intervention management • Electromechanical maintenance • Avoid fraud in water consumption declarations • Real-time network management • Leak detection • Automatic meter reading • Public management contract • Billing of the meter • Consumer care and communication • Supervised control and data acquisition • Repair and immediately invest in the meter • Pricing tools for water • Solve leakages problems, field malfunctions and routine defaults • Less time consuming
	Gupta et al. (2020)	<ul style="list-style-type: none"> • Eliminate non-revenue water • Avoid water leakage which depends on water pressure and consumption and can lead to contamination of the resource • Appropriate billing • Avoidance of fraud • Financing of meters and maintenance which must be part of an important local governance • Data security and misuse • Political support for the development of the initiative • Idea that technology neglects environmental protection • Maintain transparency about the tool • Use of electricity to run these smart meters
Performance score	Chabe-Ferret et al. (2019)	<ul style="list-style-type: none"> • Peer effects through social comparison • Boomerang effect among very low consumers
	Gourbesville (2019)	To conduct performant irrigation : <ul style="list-style-type: none"> • Irrigate at the right time • Minimise runoff • Accurately irrigate depending on soil moisture levels • Eliminate human errors and save time with advices
	Ouvrard et al. (2020)	Role of social norms in adoption of new technology and best practices
Smartphone app	Beal et al. (2015)	Improve the handling of consumer complaints and report them quickly to the manager
	Gourbesville (2019)	<ul style="list-style-type: none"> • Information on daily consumption, • Notification of weird use of the resource • Messages and notifications with information to consumers • Communication to the authority • Measuring consumption data and resource availability • Knowledge of consumption in real time makes it possible to identify the seasonal needs of individuals in order to anticipate the volumes of the resource that will have to be mobilised
Rewards	Deconinck et al. (2010)	<ul style="list-style-type: none"> • Reward "desirable" behaviours • Increase feedback • Contribute to positive internal or external evaluation of desired behaviour
	Harou et al. (2014)	Increasing pricing scheme depending on actual and historical consumption of water users
	Gourbesville (2019)	<ul style="list-style-type: none"> • Prices according to seasonality and time of consumption • Avoid leaks which are costly : financial reward
	Ouvrard et al. (2020)	<ul style="list-style-type: none"> • Subsidies to farmers who adopt the scheme • Subsidy conditional on collective adoption

A3 : Characteristics of extracted factors

	F1	F2	F3	F4	F5	F6	F7	F8
Eigenvalues	8.331	2.434	1.803	1.442	1.275	1.271	1.089	1.062
% Explained variance	33	10	7	6	5	5	4	4
% of cumulative expl. Var	33	43	50	56	61	66	70	74

A4 : Weights of sorts

Item	Respondent associated Q sort	Weight of the Q sort on the factor
Factor 1	T8	10
	T9	6.62
	I14	6.61
	T7	6.44
	I2	5.50
	T4	4.72
	T11	3.69
	I9	2.56
Factor 2	I4	7.28
	I3	5.23
	T3	5.03
	I13	4.74
	T5	4.11
	T2	3.79
	I8	2.85
	T10	2.76
Factor 3	I12	10
	I10	6.83
	I6	4.33
Factor 4	I1	6.37
	I7	3.25
	T1	3.10
	I5	2.61

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
7	29	43	25	20	1	4	**13	31
9	41	**2	26	27	3	44	35	*34
18	***8	***40	24	6	46	**22	5	14
	39	*37	21	11	*32	15	30	
		38	12	42	19	*28		
			16	36	17			
			10	45	33			
				23				

Legend	
*	Distinguishing statement at P< 0.05
**	Distinguishing statement at P< 0.01
▶	z-Score for the statement is higher than in all the other factors
◀	z-Score for the statement is lower than in all the other factors
□	Consensus statement

A5: Composite Q-sort of Factor 1

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
18	9	**32	**5	*40	35	44	27	31
7	38	34	**22	19	20	13	23	***25
***29	***43	11	*37	24	42	***16	14	30
	41	*39	10	*12	8	3	1	
		33	45	6	4	17		
			36	28	46			
			26	*15	2			
				21				

Legend	
*	Distinguishing statement at P< 0.05
**	Distinguishing statement at P< 0.01
▶	z-Score for the statement is higher than in all the other factors
◀	z-Score for the statement is lower than in all the other factors
□	Consensus statement

A6: Composite Q-sort of Factor 2

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
24	7	17	**▶9	43	23	**▶32	**▶45	**▶22
**▶26	29	**▶20	42	3	4	35	**▶34	30
18	**▶19	**▶5	41	**▶31	36	15	40	**▶28
	**▶44	**▶13	6	10	8	37	21	
		16	11	2	1	27		
			**▶46	25	**▶38			
			12	*14	33			
				39				

Legend	
*	Distinguishing statement at $P < 0.05$
**	Distinguishing statement at $P < 0.01$
▶	z-Score for the statement is higher than in all the other factors
◀	z-Score for the statement is lower than in all the other factors
□	Consensus statement

A7: Composite Q-sort of Factor 3

Composite Q sort for Factor 4

-4	-3	-2	-1	0	1	2	3	4
38	33	*15	17	46	42	13	1	**▶44
**▶25	18	24	43	11	30	40	5	31
7	**▶22	**▶45	34	19	3	8	20	**▶12
	**▶32	9	10	39	6	35	**▶2	
		29	16	41	21	36		
			26	27	37			
			**▶14	23	4			
				28				

Legend	
*	Distinguishing statement at $P < 0.05$
**	Distinguishing statement at $P < 0.01$
▶	z-Score for the statement is higher than in all the other factors
◀	z-Score for the statement is lower than in all the other factors
□	Consensus statement

A8: Composite Q-sort of Factor 4

A9: Consensus-disagreement statements

Item	F1	F2	F3	F4	Z-Score (from more to less consensual items)	var.					
						9	-4	-3	-1	-2	0,391
						23	0	3	1	0	0,407
35	3	1	2	2	0,048	39	-3	-2	0	0	0,45
10	-1	-1	0	-1	0,057	26	-1	-1	-4	-1	0,471
7	-4	-4	-3	-4	0,063	28	2	0	4	0	0,48
4	2	1	1	1	0,07	40	-2	0	3	2	0,527
3	1	2	0	1	0,091	37	-2	-1	2	1	0,532
1	1	3	1	3	0,111	20	0	1	-2	3	0,544
30	3	4	4	1	0,145	15	2	0	2	-2	0,56
6	0	0	-1	1	0,158	33	1	-2	1	-3	0,609
42	0	1	-1	1	0,159	45	0	-1	3	-2	0,61
18	-4	-4	-4	-3	0,162	31	4	4	0	4	0,637
11	0	-2	-1	0	0,174	16	-1	2	-2	-1	0,651
46	1	1	-1	0	0,178	38	-2	-3	1	-4	0,655
29	-3	-4	-3	-2	0,185	12	-1	0	-1	4	0,674
36	0	-1	1	2	0,272	8	-3	1	1	2	0,771
24	-1	0	-4	-2	0,317	5	3	-1	-2	3	0,827
43	-2	-3	0	-1	0,318	32	1	-2	2	-3	0,969
27	0	3	2	0	0,328	14	4	3	0	-1	0,973
17	1	2	-2	-1	0,341	13	3	2	-2	2	1,056
21	-1	0	3	1	0,367	25	-1	4	0	-4	1,289
2	-2	1	0	3	0,369	34	4	-2	3	-1	1,312
19	1	0	-3	0	0,377	44	2	2	-3	4	1,38
41	-3	-3	-1	0	0,39	22	2	-1	4	-3	1,474

A10: Individual sorts of irrigation advisors

Sort Value	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
-4	23	29	7	7	38	18	7	39	29	29	18
-4	41	18	29	43	9	9	18	41	9	22	38
-4	29	9	18	36	43	29	39	18	18	38	9
-3	28	43	38	25	18	23	40	7	7	33	26
-3	39	15	33	39	7	43	8	9	8	4	33
-3	38	7	34	5	39	38	37	24	20	9	45
-3	27	41	39	23	41	10	27	38	37	7	30
-2	25	32	32	21	2	22	42	16	25	16	46
-2	32	26	22	41	33	41	33	12	32	41	12
-2	7	39	24	29	8	33	9	2	26	11	7
-2	9	46	41	37	5	39	41	8	39	27	22
-2	24	8	42	12	12	24	2	29	38	18	39
-1	6	38	43	26	15	21	43	21	36	13	21
-1	22	4	40	38	29	11	17	10	27	15	41
-1	15	2	36	18	37	26	19	23	2	5	8
-1	13	36	19	9	32	7	21	6	16	6	29
-1	19	10	20	8	45	46	6	43	21	17	40
-1	18	12	21	40	40	37	25	40	30	28	32
-1	5	33	11	10	10	20	38	46	15	21	37
0	35	21	13	24	11	1	44	20	1	43	43
0	36	17	26	6	17	44	11	37	23	42	20
0	11	6	45	42	36	8	3	32	10	14	27
0	17	28	27	2	34	2	10	1	11	34	16
0	4	37	5	3	21	4	4	45	24	46	2
0	45	42	37	28	16	17	46	25	41	44	19
0	43	20	28	33	46	15	30	11	43	26	28
0	16	14	35	11	14	45	12	17	42	39	10
1	46	40	15	46	35	35	32	42	3	45	42
1	12	24	6	44	44	13	23	4	40	23	24
1	20	11	4	13	4	28	22	28	19	12	44
1	1	3	30	45	1	14	24	27	35	40	36
1	14	5	25	17	22	16	1	3	22	24	6

1	10	16	9	20	23	3	16	33	45	20	35
1	33	34	44	16	19	32	29	44	12	10	23
2	21	1	1	19	42	12	36	22	5	2	13
2	42	44	2	27	24	36	35	19	46	8	3
2	34	19	12	4	3	25	14	15	28	32	14
2	26	22	8	30	26	42	5	26	33	37	15
2	40	35	10	32	30	40	26	36	14	19	17
3	2	45	16	22	20	6	15	5	6	3	11
3	3	27	17	35	6	30	31	13	17	36	5
3	37	23	3	14	13	27	45	35	44	1	4
3	8	25	46	15	28	34	28	34	34	35	1
4	30	13	31	1	31	31	20	14	4	25	31
4	31	30	23	34	27	19	13	31	13	30	25
4	44	31	14	31	25	5	34	30	31	31	34

Table 7: A11: Individual sorts of farmers

Sort value	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
-4	45	9	36	29	29	18	33	10	29	18	29	18	18	18
-4	22	41	41	26	18	29	7	29	26	41	33	7	29	9
-4	25	8	43	11	7	24	18	22	18	26	41	26	9	7
-3	26	40	34	41	24	10	9	7	10	24	43	16	45	29
-3	38	2	33	7	21	12	16	4	9	5	38	13	43	24
-3	32	37	29	18	33	9	15	9	8	25	45	19	6	43
-3	14	10	28	33	38	41	32	41	41	46	26	29	38	45
-2	10	36	21	32	22	17	17	38	31	44	28	44	5	26
-2	15	38	24	34	3	11	12	39	22	12	13	1	26	16
-2	33	39	7	45	28	33	14	37	28	16	18	5	19	39
-2	37	29	11	15	25	44	27	45	20	37	15	17	37	25
-2	7	18	9	38	43	13	34	43	21	42	17	20	39	23
-1	9	16	10	40	11	45	10	36	25	4	46	24	7	42
-1	18	20	32	3	42	3	29	35	43	27	42	6	22	40
-1	24	45	17	39	13	26	41	28	38	20	20	11	13	38
-1	34	15	19	9	46	19	26	24	16	19	19	46	36	37
-1	16	5	6	46	45	20	4	46	45	43	11	33	28	19
-1	43	12	39	43	34	42	36	12	17	6	14	39	8	8
-1	30	11	18	10	36	23	35	33	36	14	35	31	32	41
0	17	33	20	36	26	6	23	25	7	13	4	12	34	15
0	4	1	26	42	8	36	8	6	19	11	25	2	10	12
0	2	26	46	2	19	30	25	44	12	2	39	14	33	36
0	29	6	37	6	9	2	24	40	32	23	7	35	12	10
0	19	4	38	19	32	38	46	5	39	7	5	40	41	11
0	6	21	5	12	17	39	22	11	30	8	3	36	24	6
0	39	17	2	21	41	8	38	3	23	17	34	43	11	17
0	23	7	8	37	40	7	11	34	40	3	30	9	35	2
1	28	42	16	44	14	21	43	31	44	45	44	3	17	28
1	3	13	13	35	16	22	30	23	33	39	10	15	30	27
1	11	27	22	1	1	34	28	26	34	29	32	34	40	35
1	27	3	4	5	37	14	42	1	2	10	12	25	20	1
1	40	32	12	28	10	32	13	32	4	9	1	10	21	22

1	46	14	23	22	44	5	21	2	24	31	37	38	15	46
1	20	19	45	20	5	16	39	42	37	38	16	42	16	21
2	8	35	14	8	31	4	2	14	11	30	22	27	3	13
2	1	44	25	4	35	46	45	21	42	32	24	32	1	20
2	42	23	27	24	39	25	19	30	3	21	23	4	4	4
2	41	43	35	31	15	31	3	15	6	28	21	8	42	3
2	21	28	15	23	27	28	20	18	35	15	2	21	2	44
3	5	46	31	17	30	40	5	13	27	1	31	28	14	5
3	35	24	42	25	2	43	6	27	15	22	9	37	23	14
3	31	25	1	27	6	27	40	17	13	36	6	41	31	30
3	44	22	30	14	23	15	31	16	1	35	8	23	27	33
4	13	31	40	30	20	37	1	8	5	34	36	30	46	31
4	12	30	3	13	4	35	37	20	46	33	40	22	44	34
4	36	34	44	16	12	1	44	19	14	40	27	45	25	32

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