# Empowerment of discourses in environmental economic policies: The case of French water management

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**Abstract :**

Empowerment of discourses and subjective perceptions is a real issue for economic policy makers, especially in the environmental field in order to promote public acceptance. Catching subjectivity of perceptions on a huge variety of topics, Q methodology appears as a transparent and operational alternative to complement traditional economic tools. This paper offers an overview of some theoretical and empirical applications of its use in environmental and economic public policies and an illustration on water governance. Our study, conducted in a region of France on 35 participants by face-to-face interviews, highlights the usefulness of such a method to understand consensus and disagreements between a large diversity of stakeholders on the controversial use of water. Thus, participants sorted 33 statements representing means to preserve and manage the resource in a better way. This study deals with various topics: reduction of domestic consumption, reduction of agricultural and industrial consumption, preservation of the resource in quality and quantity, city planning and innovation, water governance and information, solidarity and intergenerational issues. We finally obtained five perspectives of thoughts (Active management guided by the tradeoff quantity/quality, Everyone's involvement for a sustainable management of water, Tackle local issues thanks to knowledge, Technological optimization to compensate lack of citizen investment and Pricing and regulation to support water preservation). Concretely, we develop these views as a decision support tool on water management to calibrate potential action scenarios for economic policy makers.

**Keywords :** Q Methodology, Water policy, France, Environmental economics, public policy

**JEL**: Q25, Q58 , P41

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## -1-

# Introduction

Since the Fifth assessment report, the Intergovernmental Panel on Climate Change is providing a Summary for Policymakers including headline statements, a top-level summary and narrative key of findings in the scientific area to fight against climate change. In order to be accepted, implementation of these scientific recommendations should consider also the populations concerned, who are at the heart of these evolutions. It is thus essential to understand how public perceive environmental issues and policies, and Q-methodology helps to do so (Barry et al., 1999). Introduced by Stephenson during the 1930's, this method catches subjective perceptions of individuals, binding qualitative and quantitative approaches to create a state of play of visions on a defined topic (Stephenson, 1953). Existing literature shows many links between this method and economics in order to complete traditional economic tools (Baker et al., 2006; Wainger et al., 2017). While some Q-studies already exist in the field of environmental economics (Barry et al., 1999; Frantzi et al., 2009; Cuppen et al., 2010; Davies et al., 2012; Levesque et al., 2019, to cite only some studies), this paper aims to consolidate its use and to show the potential implications for policy makers.

In 1999, Durning underlined the possibility of a paradigm shift in policy analysis from a traditional objective scheme towards a post positivist one, favoring subjectivity with the use of Q methodology. According to him, the role of Q methodology is predominant to guide policy analysis in a way that consider more intrinsic perceptions of stakeholders (Durning, 1999). Thus, he underlines five uses of this method in policy analysis, transposed here with concrete applications in the environmental sphere.

First Durning (1999, p405) claims that Q methodology can be useful to **"obtain insights into the context of policy issues"**. In environmental economics, context of policy implementation can influence its efficiency and provide insights on divergence of interests as for the sharing of a common pool. For instance, Levesque et al. (2019) apply Q methodology on Saint Pierre's lake to understand conflicts of use that influence acceptation of water regulation. Durning (1999) also underlines that Q methodology can help both **to define the meaning of non-efficiency criteria and to identify different problem definitions**. For Bischoff et al. (2018), implementation of Q methodology allows stakeholders to provide their definition of a fair policy, specifically on fairness of cultural water use and water rights. Moreover, environmental economic actors and their own interests can shape problems related to the sharing of a common pool, when they have divergent (even conflictual) needs on water use (Bischoff et al., 2018).

Furthermore, Durning (1999) pursues by saying that Q methodology **can help to identify preferences of different group.** For instance, Forouzani et al. (2013) highlight a strong caesura between farmers and specialists on the notion of water agricultural poverty. Thus, Q methodology helps to anticipate aversion or agreement towards a policy proposal depending on characteristics of stakeholders. Durning (1999) finishes by a last use: **assist in evaluations,** for instance to understand ex post (non)efficiency of policies implemented. As an example, Frantzi et al. (2009) use the method to understand ex-post efficiency of international cooperation policy around Mediterranean action plan and environmental diplomacy. In this line Q methodology is pertinent, because knowledge by policy makers of societal viewpoints can help them to conduct a successful policy relying on public acceptance (Barry et al., 1999).

Offering an exploratory and complementary economic tool with an actor-based method, Q methodology offers new insights for environmental policy makers. Indeed, through conceptual and empirical evidence, this paper discusses power of the method in environmental economics and public policy and provides an example on French water management. This topic is appropriate for a Q study as it mobilizes a wide range of stakeholders and policy makers with conflictual vision on its preservation and its use. In particular, the Pays de la Loire region is an interesting territory because it is confronted with many challenges such as protection of wetlands and agricultural land, urbanization of coastal areas, changes in the occupation of rural and peri-urban areas, and recovery of rainwater. In conflictual context on the use of natural resources, this paper raises many questions of collective interest. **How can we empower discourses in environmental economic policies? How Q methodology can help to calibrate scenarios to guide policy makers to solve environmental issues? How French water management illustrates the operational power of Q methodology to consider stakeholders' discourses in order to favor public acceptance of policies?**

To answer these questions, we conducted a Q-study on water management and preservation in a French region grouping a multitude of stakeholders. This example illustrates the operational use of Q methodology and empowers each discourse that can play a role in final decisions and water consumption behaviors. We finally found five thought pattern on water preservation as follows: Active management guided by the tradeoff quantity/quality, Everyone's involvement for sustainable management of water, Tackle local issues thanks to knowledge, Technological optimization to compensate lack of citizen investment, and pricing and regulation to support water preservation. More generally, Q methodology gives a panorama of concerns on a topic and can analyze a situation through the statistical prism of individual subjective conceptions. It contributes to put words on conflicts of use, relying on consensus areas and dealing with disagreements in order to implement environmental policy in adequacy with implied actors.

Thus, this article introduces a conceptual and empirical framework of the use of Q methodology in environmental economic policies and more precisely on water field (2). Then, the context and method are described focusing on our French water management' case study (3). Thirdly, the main results are presented (4) and open a next part of discussion with intervention scenarios on water governance through public policies (5). Concluding comments on the empowerment of discourses with Q methodology for environmental economics and results on water governance are then summarized (6).

## -2-

## Usefulness of Q Methodology in environmental economic policies

After explaining the choice of Q methodology (2A), this part details the theoretical actor-based framework (2B) of the use of Q methodology and questions advantages and limits of the method (2C). Interactions and power of stakeholders in Q methodology are also discussed (2D), before ending with an empirical evidence in the environmental field (2E).

### A) Why to choose Q methodology rather than other qualitative methods?

Many qualitative methods are frequently used by economists such as in-depth interviews, focus group, life stories, fieldwork (Starr, 2014). Our choice felt on Q methodology for its various assets detailed in the following part. Indeed, Q methodology combines both closed-end predetermined set of data with the Q-sort (ranking grid of statements filled by a participant of the study) results, and more flexible and open ended post sort interviews. Starr (2014) justifies the use of qualitative data by economists for many uses that can also find answers through Q methodology. For instance, it can be useful if key questions remain unsolved after many quantitative studies as for water management that still raises debates. Use of Q methodology can also help to understand the inherent complexity of a topic and to catch opinions of respondents on their own situation with own based interests that can be hard to detail through a "reasonable person standard". Indeed, Q methodology same as many qualitative methods does not follows the "more n is better principle" but purposively construct the P-sample (set of participants of the study) to consider all dimensions of the studied population. Additionally, Q methodology breaks the three primary concerns of economists regarding qualitative methods that Starr (2014) presents in its paper.

Firstly, Gauttier (2017) states that this method "objectivize the researcher's subjectivity in interpretative research" in response of the undesirable influence of the researcher on the results. Thus, the method is transparent and the research process is completely reproducible. Moreover, the construction of operant factors comes from a mathematical rigorous statistical analyses and explicit criteria casting aside researcher bias (Gauttier, 2017). The research design is well described and enounced so that it attenuates researcher impact.

Secondly, Starr (2014) shows that qualitative studies' quality of self-reported information is potentially problematic if there is not enough understanding of the studied topic by respondents or because of the effect of look of others on results. In order to avoid this limit many solutions exist in Q methodology application, used in this study. On one hand, researcher can provide assurance of confidentiality and anonymity using a strict protocol. On the other hand, the Q sort grid is constructed with a neutral area where agent can sort statements where they do not have opinion on. Additionally researcher can explain statements to respondents and answer questions on the studied topic. Q sorting process threaten researcher to maintain non-judgmental stance as after instructions, respondents sort simultaneously all the statements according to their own subjectivity. There is no good or bad answer. On the last hand, researcher can ensure that respondents are key informers through a good selection of the P-sample. For instance in our case expect domestic consumers, all respondents where directly concerned by water issues in their professional activities.

Lastly, as underlined by Starr (2014), qualitative information is fine for description but not explanation. Notice that the goal of a Q study is to describe all views points and does not necessarily follows a hypothetico-deductive method. Gauttier (2017) shows that the strength of Q methodology relies also on the fact that "the interpretation of qualitative data is open to contradictory analysis as the whole process is traced". However, with Q methodology, all nuances and richness of opinions are respected as the main objective is to understand subjective thought patterns on a topic .

**B) Actor-based framework**

Many authors already questioned the use of Q methodology as a complementary actor-based method that can enrich research in economics and policy analysis (Durning, 1999). According to Baker et al. (2006) Q-methodology is a reliable supplementary method as it combines both a profound subjectivity with factor analysis and correlations but also mathematics and statistics in the foundations. According to them, this dual approach with mathematical transparency and qualitative aspects enriches economic tools without the usual critic on data analysis of the mystery of classification. Indeed, Q methodology can be associated to an actor-analysis based method associated with five characteristics defined by Hermans and Thissen (2009). It can provide a comparative overview for the multiple actors invested. It can also focus on one or several dimensions of multi-factors political process. Methods or past applications should also be described with enough details to rebuild their uses. Moreover, such a method should have proven its utility in practice to analyze the role of actors in the elaboration of real politics. Lastly, it has been subject to scientific examination with publications on its developments and uses. Thus Q methodology contributes to have a robust and scientific trustful method to elaborate an actor based state of play of visions on environmental issues.

Additionally, Raadgever et al. (2008) brighten this idea, saying that "An overview of stakeholders' perspectives can be useful in natural resource management" for many reasons. Indeed, it helps to set the research agenda and to identify differences between interests that need to be discussed. It is also interesting to create awareness among a broad range of stakeholders. Finally, this overview of stakeholders' perspectives is a way to develop scenarios. This last reason will be exploited in our own study to better know which means and economic tools as quotas, taxes and subventions should be implemented and accepted regarding water governance. Construction of interventional scenarios can thus take roots in expectations of stakeholders about important means to preserve water resources.

**C) Advantages of the method mitigate limits**

As Baker et al. (2006) show, Q methodology palliates usual critics on subjectivity by mathematical transparency and does not suffer from the limit of data analysis and biases of classification. Therefore, authors admit that Q methodology is time consuming with face-to-face interviews, the choice of the Q set (set of items ordered by participants in the grid) and the selection of appropriate voluntary participants. However, these authors also emphasize the necessity of a small number of participants to obtain a statistical significance as each Q-sort filled (result of the statements sorting process in a grid) provides a huge quantity of information.

Additionally Q methodology is not based on representativeness but on the construction of small-scaled (sample of participants) overall structure of thought on a topic. However with the hypothesis of "finite diversity" (Barry, 1999), saying that there are not as many discourses as participants, this limit can be surpassed and Q methodology is still interesting to catch a large variety of perceptions.

In terms of environmental policies, this small scaled method is adapted to the locality of issues and thus can guide the implementation of accepted policies based on actor expectations, group concerned and local context (Barry et al., 1999). Q methodology can assist

policy acceptance in two ways, relying on consensus areas; or focusing on disagreements, knowing on which group they can rely on to implement their policy.

One other advantage of Q methodology is the diversity of fields and infinity of topics. Thanks to the sort of various supports it awakes senses and ideas, it breaks the barriers of language with pictures, objects and sounds or can be very precise with statements. It is even possible as Baker et al. (2006) say to conduct intensive studies with a small sample of participants but several Q-sorts under various conditions of instructions. We also see in the literature some longitudinal studies over time to understand evolutions of perceptions on a given topic, conserving the same Q sort process and participants (Davies and al.,2012).

**D) Q methodology to understand interactions between stakeholders**

Q methodology, both through sorting process and qualitative post-sort interviews represent a mean to evaluate interactions (either cooperative or conflictual ones) of stakeholders on environmental resources. Indeed, Frantzi et al. (2009) highlight that efficiency of a policy relies on the plurality of visions and many studies focus on environmental diplomacy, treaties and agreements. Thus, Q-methodology helps to understand visions and interactions between agents in order to evaluate public acceptance that favors efficiency of a policy (Barry, 1999; Ward, 2013; Iribarnegaray, 2014).

Moreover, Frantzi and al. (2009) show that cooperation can lead to multilateral agreement on environmental issues and can create a dialogue between agents to find a consensus. Q-study of Stevenson (2019) on green political economy illustrates this power of cooperation between stakeholders on the path of "Cooperative reformism". Following this idea of interactions on a common environmental pool, Forouzani (2013) illustrates the power of Q methodology to understand conflicts of use and assist implementation of adapted policy, even facing opposite opinions. Their study on water agricultural poverty clearly divide specialists and farmers in profiles, it reveals the huge gap and divergence of interests that policy makers have to face. As Cuppen et al. (2010) notice, it is often difficult to find an agreement as stakeholders are often discrepant on policies. However, Q methodology introduces the comprehension of all point of views so that actors can know all shared visions and create an appropriate dialogue. Indeed, Cuppen et al. (2010) use Q-study as a first step to select participants of a final dialogue to represent all knowledge, past influences, functions and expectations of stakeholders that should be defended in the final discussion. Then, Q study refines selection of stakeholders in order to co-construct policies and complement other tools on interactions between agents to find an agreement on a given environmental issue.

**E) Empirical evidence: An overview of Q methodology in environmental issues and policies**

Q methodology has empirically proven its reliability to catch discourses on environmental issues through diverse applications presented in annex 1, highlighting consumer behaviors, conflicts of use around a common pool, regulation matters and so. Thanks to the adaptability and pertinence of the method in environmental economic policy we try to provide new insights than previous studies. First, our study mobilize a huge variety of actors around water resources. We do not focus only on one use as it is often the case in papers either on agriculture (Davies et al., 2012 ; Forouzani et al., 2013) or on domestic water (Asquer, 2014;

Ormerod, 2019). We decided to study water as a whole because it is a good way to evaluate conflicts of uses at a large scale and to understand the prior uses in a case of water scarcity.

## -3-

## An applied case study on water management in France

This part provides an application of Q methodology on water management in France to understand all the implications of discourses on water policies, it details the context (3A) and research method with data collection (3B).

### A) Context and issues

The region Pays de la Loire is located in western part of France over 32 082 km squared that houses more than 3.7 million of inhabitants. It is facing a huge annual population growth, which questions sustainability of actual water management. Moreover, the territory suffers from heterogeneity on the allocation of water. While the Eastern part benefits from huge quantity of groundwater, the western part is deprived of it and relies mainly on polluted surface water resources. Interdependency emerging from the eastern upstream part of the huge river la Loire (that influences flooding quantity and pollution in the western downstream one) can also accentuate disparities of available water.

In order to avoid any conflicts of use both between territories and between types of consumers (industries, farmers, domestic consumers,…) it is crucial to find agreements on the way to allocate, to preserve and to manage water in this region. For that reason we decided to use Q methodology to "give a voice to the voiceless" (Gauzente et al., 2019) and to consider all discourses.

More concretely, our study was conducted between November 2019 and February 2020 over a large variety of stakeholders including participants from all departments of the region (Sarthe, Mayenne, Loire Atlantique, Vendée, Maine et Loire) presented in Figure 1. To catch complexity of water management in France, we tried to represent the diversity of views and interests of the multiplicity of actors (Figure 2) that have a role to play for water preservation.

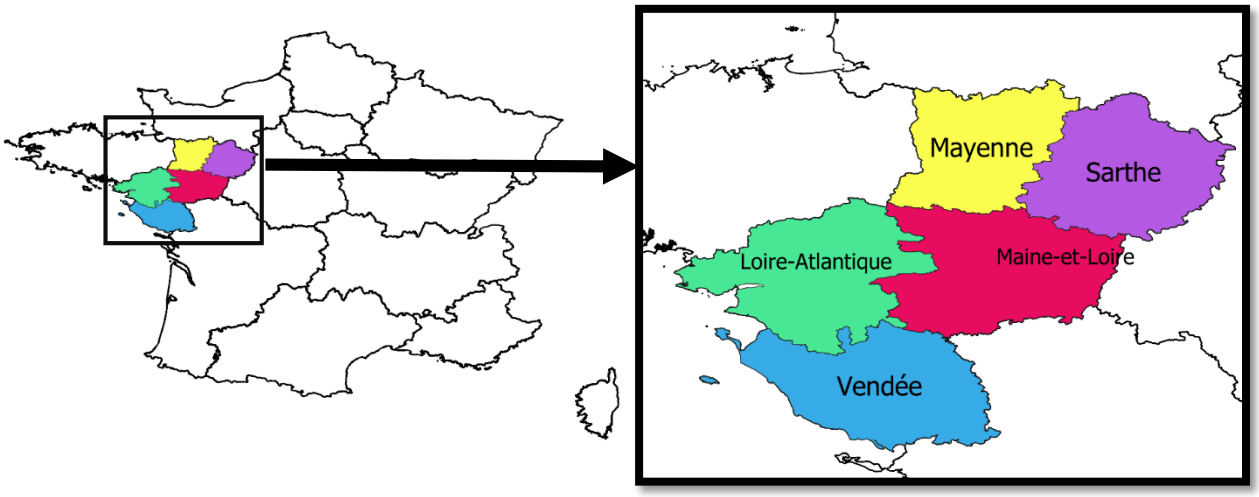


Figure 1: Localisation of the region Pays de la Loire

*Source : author, Qgis software*

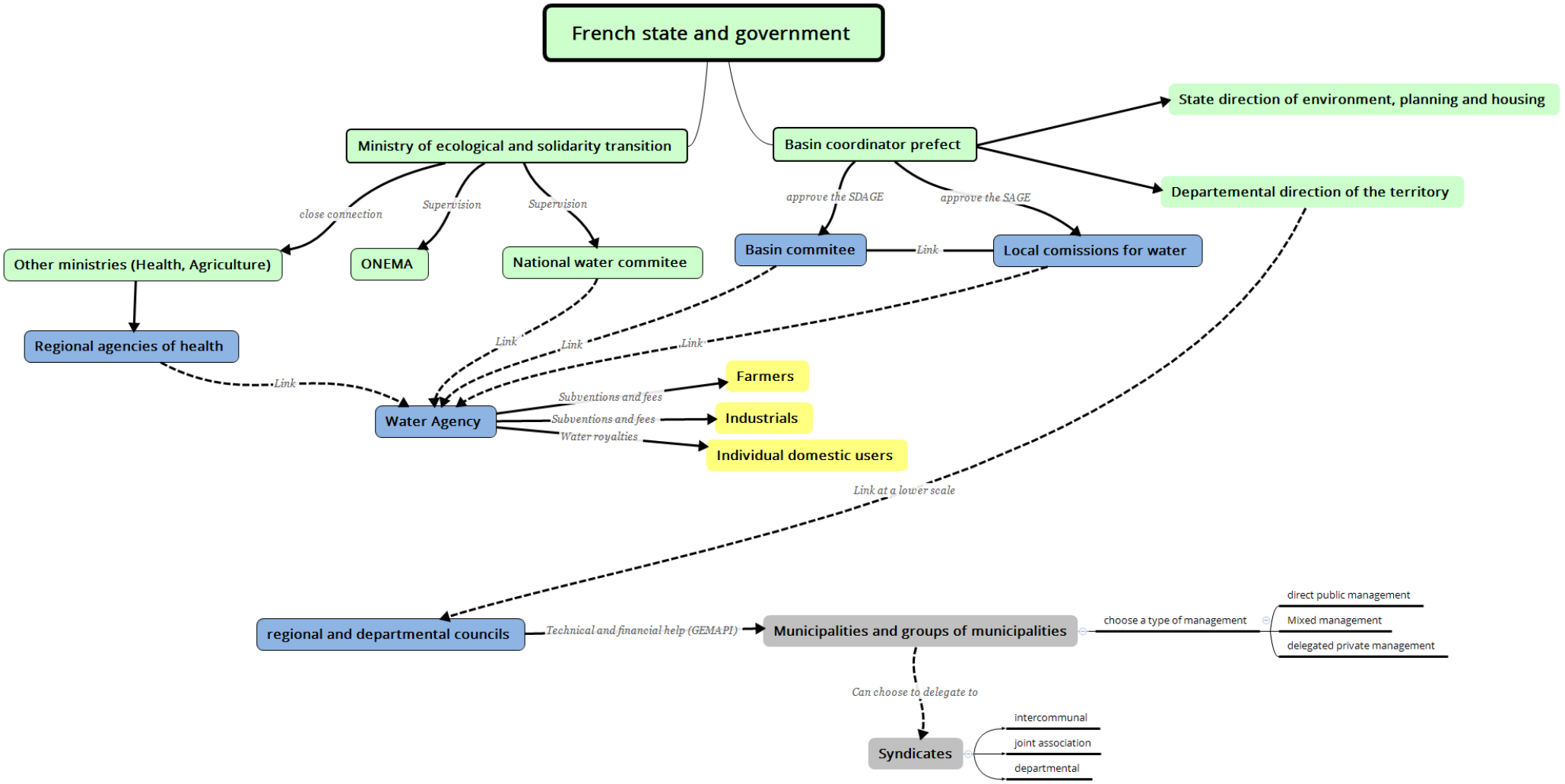


Figure 2: Map of stakeholders

*Source : author, XMind software*

**B) Research method and data collection**

Our study follows the common steps of Q methodology presented in the annex 6. Firstly, the concourse (set of all items and ideas to preserve water in the region) was obtained on the following thematic universe: water management and preservation. We use many keywords, as the goal is to have the widest range of possibility to catch all views, such as water management, water preservation, qualitative and quantitative aspects, pollutions, domestic/ industrial/ farming uses, conflicts of use, water governance, water laws, water price and so. Statements coming from quotes were gathered through various media:

- Websites of water actors such as water agency, governmental pages of DREAL/ DRAAF/ONEMA…, public organizations dedicated to water preservation, legal texts sur as the Loi sur l'Eau et les Milieux Aquatiques, local authorities and so.
- Articles dealing with water issues in newspapers of the national / regional and local press (examples: Ouest France, Le courrier de l'Ouest, Presse Océan, le journal de la Vendée…).
- Reports of local authorities on water such as the Rapport sur l'eau de Nantes Métropole, Le Mans notre ville Métropole.
- Technical reports of water management agencies and authorities
- Five interviews of the general public answering to the question "According to you what are the means to preserve and manage water in a better way?"

We got a total of 155 statements on various themes (reduction of domestic consumption, Reduction of industrial and farming consumption, preservation in quantity and quality, city planning and innovation, water governance, solidarity and intergenerational issues, cooperation and shared initiatives). After grouping common statements, deleting the less important and redundant ones, choosing the central sentences, ensuring that all themes were represented we conserved 33 statements in the Q-set (Annex 2). We even conducted 5 pre-tests on water domestic consumers who approved that all statements were useful and that it includes all the main ideas on the thematic universe.

Secondly potential participants (presented in Figure 3) were contacted by email and face-to-face interviews were conducted with voluntary ones. Recall that Q-methodology does not look for representativeness but for a small-scaled overview of the structure of thought on a topic. We tried to have a P-sample (sample of participants selected for the study) with various kind of actors at all scales (delegated power from state, regional actors, departmental ones and individual consumers) to catch all views and interests. Note the diversity of uses represented here, sometimes at the origin of conflicts between farmers, industrials, and domestic consumers, associations and collectivities or public and private sectors. We also tried to have participants from each departments and from the region in its entirety to represent local specificities and spatial heterogeneity of the resource. It is generally equilibrated except for Mayenne, represented only by regional actors but it is not surprising regarding its smaller population and good water endowment.

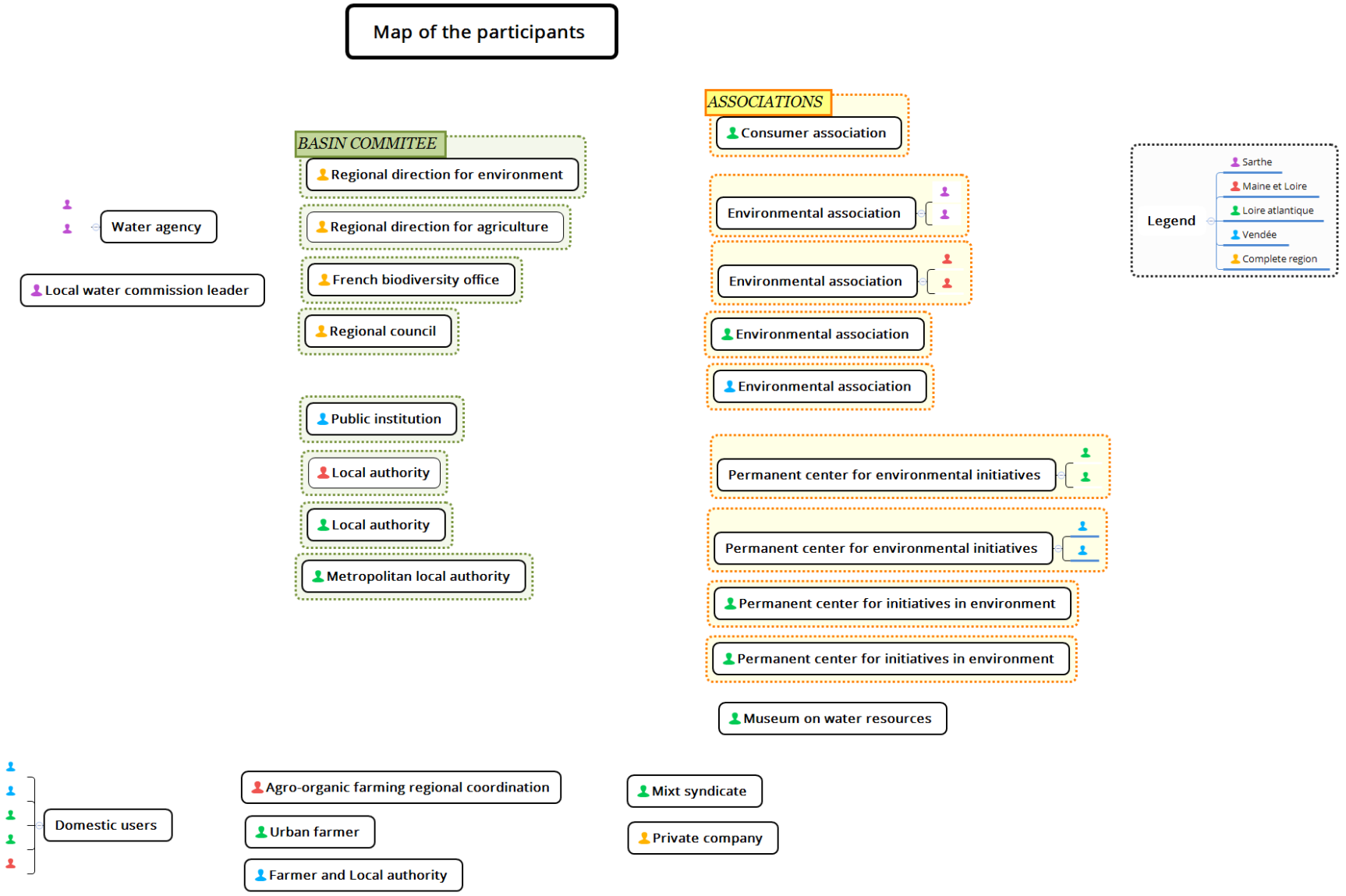


Figure 3: Map of the participants of the Q study

*Source : author, XMind softwar*

We conducted 35 Q-sorting interviews divided in two parts. First we asked participants to sort the Q-set of 33 statements in a grid according to the instruction "What means do you consider as important to manage and preserve water in a better way?". Basics of Q methodology state that the grid of sorting follows a quasi-normal forced distribution (Stephenson, 1953; Brown, 1980) that helps to catch psychological significance, highlighting the importance of extreme choices. As underlined by Brown (1980) the larger is the number of statements, the wider should be the range of available scores so in our case we selected a continuum of 7 columns between -3 and 3 (Figure 4). Distribution is forced to allow for mathematical comparison between Q sorts and to compel agents to prioritize statements. Indeed, as underlined by Wainger et al. (2017), Q-sorting process looks like an economic valuation analysis as it forces individuals to prioritize goals and to make tradeoffs regarding strengths of preferences.

| Really not important<br>-3 | -2 | -1 | Neutral/ Do not know<br>0 | +1 | +2 | Very important<br>+3 |
|---|---|---|---|---|---|---|
| | | | | | | |
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| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
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Figure 4: Representation of the grid

Then we asked participants to explain their choices, especially in the extreme parts of the grid to understand more their vision and avoid any qualitative misunderstandings. Post-sort interviews included also questions to understand the role and interactions (conflicts, cooperation, supervision) of stakeholders around water. Note that our sample groups mainly actors (excepted domestic consumers) that knows well water issues and that are aware of regional problems regarding this resource. However they are facing conflicts of use and divergence of interests that helps to extend the variability of perceptions. Some additional questions were asked about their visions of water as a common or a merchandised good and the private or public management to help interpretation and contextualization of the results. The following repartition (Figure 5) provides some additional information about the sample:

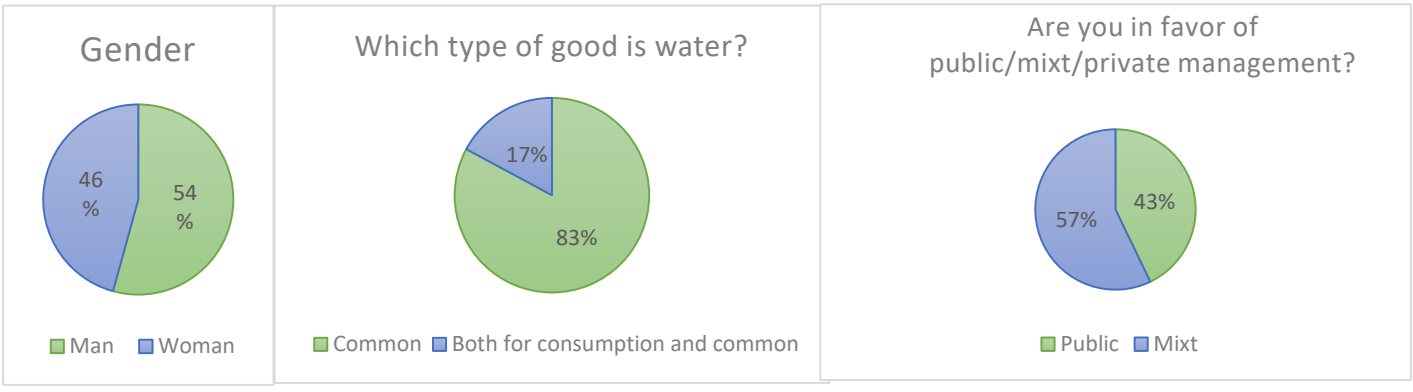


Figure 5: Additional sampling characteristics

*Source: author*

After interviews, results were obtained using the software *Ken Q* which provides data on correlations, factors characteristics and consensus /disagreement areas. The first step to

define profiles, based on participants' subjectivity, is to calculate the correlation matrix to understand degrees of similarities between participants. As given by Baker et al. (2006) we calculate the correlation r between each pair of actors to construct the matrix:

$$R = 1 - \left( \frac{\sum Diff^2}{\sum Indiv^2} \right)$$

Where *Diff* is the difference of rank score between two participants concerned with respect to each statement and *Indiv* is the rank score given by each participant to the statement. A correlation of one indicates perfect similarity of answers between participants while a negative correlation between individuals indicates strong disparities in perceptions. Following Brown's estimations (1993), we consider ± 2 to 2.5 times the standard error (calculated as $SE = \frac{1}{\sqrt{N}}$ with N the number of statements, for us at least $\frac{1}{\sqrt{33}} * 2 = 0.348$ ) as a guide to establish if a correlation is significant or not[2].

A second step of data analysis consists in the factor loadings that relies on concordance between individual Q sorts and factors. We conduct a varimax rotation (classical orthogonal factorial analysis that tends to maximize similarities into a factor and differences between factors) based on level of explained variance and similarities between participants. We accompanied this first analysis by a judgmental rotation that relies more on contextual information as the researcher guides the rotation. These two complementary analysis allow the selection of the number of factors (views) and in our case only seven participants were not flagged with 5 factors because they were non-loaders and too much divided between views as detailed in Annex 4.

| **Factor** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
|---|---|---|---|---|---|---|---|---|
| **Eigenvalues** | 11,135 | 3,146 | 2,553 | 2,247 | 2,171 | 1,897 | 1,622 | 1,364 |
| **% of Explained Variance** | 32 | 9 | 7 | 6 | 6 | 5 | 5 | 4 |
| **Cumulative % of explained Variance** | 32 | 41 | 48 | 54 | 60 | 65 | 70 | 74 |

Table 1: Results of eigenvalues and explained variance for factors

Usually, we conserve factors with an eigenvalue superior to 1 to consider them independents, 8 factors here. However, regarding local context and results of the flagging we decided to keep only 5 factors to distinguish and interpret them clearly (Table 1). Individual perceptions in this study are widely divided and eigenvalues or percentages of explained variance highlights no elbow in the last factors. For this reason we decide to focus on factor loadings and try various cuts before ending with 5. Indeed, with 8 factors, factors 5 and 6 are composed only by one participants and 17 individuals are not flagged with a p value < 0.05 while with 5 factors, all factors are associated to 3 to 8 Q sorts flagged. With less than 5 factors, many respondents are non-loaders and we lose too much information. As Q methodology bases its force on commonality and regarding the local conflictual context, our five factors already represent a cumulative variance of 60% and catches the main diversity of perceptions. However,

[2] To be more precise we could have use ± 1.96 or 2.58 times the standard error for a confidence interval respectively of 95% and 99% but our measure faithfully reproduces those of the original literature.

it is still interesting to consider that our topic divides participants, and it is not surprising as water governance in the region creates conflicts of use. Moreover, only one statement of consensus does not distinguish any pair of factors (#15: "Restrict/ Ban pesticides, fertilizers, phytosanitary products …") which shows the representativeness of scattered views of stakeholders on water governance.

After factor loading, weight of each statement regarding each factor is calculated to know if a statement is more or less important through the following formula:

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

With $W_{s/f}$ the weight of statement *s* for factor *f*, $\sum_{i=1}^{n} r_{s/i}$ the sum of the ranks of statement *s* for each Q sort of individuals *i* that compose f and $w_{i/f}$ the weight of the Q sort of agent *i* on the factor *f*.

Note that the weight of an individual *i* flagged for a factor is calculated as follows:

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

The following table gives factors weights:

| Factor 1 | Weight |
|---|---|
| Rep27 | 10 |
| Rep21 | 7,8 |
| Rep8 | 5,428 |
| Rep14 | 5,394 |
| Rep33 | 5,207 |
| Rep13 | 4,787 |
| Rep22 | 3,111 |

| Factor 2 | Weight |
|---|---|
| Rep7 | 7,499 |
| Rep24 | 6,530 |
| Rep28 | 5,745 |
| Rep16 | 5,033 |
| Rep35 | 3,493 |

| Factor 3 | Weight |
|---|---|
| Rep15 | 7,071 |
| Rep23 | 5,749 |
| Rep31 | 9,352 |
| Rep1 | 7,862 |
| Rep26 | 4,366 |

| Factor 4 | Weight |
|---|---|
| Rep12 | 9,197 |
| Rep34 | 6,85 |
| Rep5 | 6,356 |
| Rep4 | 5,606 |
| Rep3 | 4,978 |
| Rep10 | 11,718 |
| Rep9 | 9,951 |
| Rep2 | 3,667 |

| Factor 5 | Weight |
|---|---|
| Rep18 | 9,166 |
| Rep20 | 6,963 |
| Rep17 | 4,252 |

When we have the weight of each statement we can reconstruct the table associated to each factor as a composite Q sort derived from the weighted mean associated to individual sorts of statements. The more the score of a statement is high the more it is in the positive scores values of the grid.

A last indicator is composite reliability of factors calculated as follow: with *p* the number of individual Q sorts defining the concerned factor. Not surprisingly, our composite reliability are between 0.966 and 0.923 as they rely on factors that have between 3 and 8 associated Q sorts.

$$\mathrm{CR}_f = \frac{0.80\, p}{1 + (p - 1) * 0.80}$$

Consensus and disagreements on statements are also ranked to understand the common answers or on the contrary, the diverging views with the Z-score variance (Annex 3). Based on this method, the following part consists in the interpretation of the results

**- 4 -**

# Empirical results

This part provides empirical results of our water study and highlights factors obtained (4A) and areas of consensus and disagreements between views (4B).

## A) Factors

Table 2 provides information of the repartition of participants between factors, even including non-loaders.

| FACTOR | NUMBER OF PARTICIPANTS | CATEGORIES OF PARTICIPANTS |
|---|---|---|
| **1** | 8 | Environmental associations and permanent center for initiatives in environment (4), water agency (2), Regional direction for environment, Local authority of a huge city |
| **2** | 6 | Environmental association and permanent center for initiatives in environment (3), water local commission leader, mixt syndicate, regional council |
| **3** | 8 | Domestic consumer, permanent center for initiatives in environment, Urban agriculture, farmer in basin committee, museum, public institution, regional direction for agriculture, local authority |
| **4** | 8 | Domestic users (4), environmental and consumers associations (3), French biodiversity office |
| **5** | 5 | Environmental association, permanent center for initiatives in environment, agro-organic coordination of the region, local authority in basin committee |

Table 2: Repartition of participants in factors

### Factor 1: Active management guided by the trade-off between quantity and quality

Common of these participants was the importance of concrete actions to preserve the resource. While other factors put the statement “guaranty the access to drinking water for present and future generations” (Statement #32) in the most important things, this factor consider this statement more as a declaration of intent rather than a real improvement. This factor promotes securing of the distribution and restoration of the resource (#23 / #19) actively and does not tolerate that some individuals, industries and the farming sector pollute water and affect others without retribution, even more when it induces sanitary problems. For it, agricultural practices are a crucial lever to improve water management in both quality and quantity. Indeed, this factor thinks that "restrictions on pesticides and fertilizers” (#15) and “favor an organic production” (#14) are necessary to preserve water in quality. Regarding quantity, this factor also thinks that favor crops that consume little water (#8) and quotas on $m^3$ consumed by industries or farmers (#12) are important. These actions are necessary to preserve and restore watercourses and wetlands (#21). Conversely, for this factor we must stop “bandage” actions such as recycling urban water for agriculture and industry (#9) or eco-friendly household products (#4) because they do not tackle the problem at source. For this

factor, water storage (#12) is not a good solution contrary to factors 3 and 4, because the problem is elsewhere. If we implement crops that consume little water and organic production, agriculture will need less inputs of water and storage is consequently not necessary. Moreover, stakeholders around water have to be invested in preservation of water and then subventions for water saving installations (#3) is a wrong solution because it relieves consumers of their economic responsibility. Thus, for this factor, water management should be guided by concrete and large-scale actions to solve both quantity and quality issues through the main levers as agricultural production.

**Factor 2: Everyone's involvement for a sustainable management of water**

This factor is characterized by the desire of a systemic evolution in the use and preservation of water resources, considering the challenges of climate change (#28 in +3 of the grid while for other factors it is less important) to guaranty an access to water for future generations (#30). This factor is in favor of a long run, forward looking and transversal approach of water governance, which requires many changes in practice. Thus, it is crucial to restore the quality of aquatic environments and wetlands (# 19) and to prevent the degradation of watercourses (# 23). It is therefore necessary to improve the resource in the gross state which, among other things, involves restrictions on the use of pesticides and pollutants (#15). Water management also needs a transition towards organic farming (#14) which requires fewer water inputs, placed in +2 while it is less important for other factors. This factor highlights the importance of user practices (#4) both in the domestic sphere with a distinguishing statement : promote the use of eco-friendly and natural household putted in +2 while it is neutral or even very not important for other factors, but also in the agricultural sphere favoring crops that consume little water (#8). Thus water management is a shared concern between all users and actors and everyone's involvement is needed to preserve the resource. Conversely, factor 2 thinks that accountability of polluters and huge consumers cannot be done by costs because they are not dissuasive enough. Thus, it thinks that an increase of fees (#27), taxes on $m^3$ of water consumed in drought (#11) and increasing prices (#13) are not efficient means to improve water management. Cost is not a good lever because huge consumers are not dissuaded to overconsume economically and do not really care about the resource because the price is very low in the region. The most important is to empower users and make them aware of the problems. To conclude, this factor is in favor of everyone's involvement in a long run perspective but prices are not the good lever to manage water in a better way.

**Factor 3: Tackle local issues thanks to knowledge**

This last factor is quite particular in that it brings together a majority of the respondents from Vendée and agricultural sector (farmers, regional direction for agriculture,…). It marks orientations on local problems regarding water. For this factor, as for many others, restoring wetlands and aquatic environments (#19) and prevention of degradation of watercourses (#23) are essential for the preservation of the resource. However, for this factor, we should take care of indicators of the degradation of watercourses that should be adapted to contextual specificities and local parameters to be relevant. On this line, statement on transparency and access to good data (#25) is placed in +3 while it is neutral or very not important in other perceptions. For factor 3, conversely to the others, it is very important to take into account risks of flood (#24), because it is a local concern with significant risks. It is a huge problem linked to waterproofing of the lands and roads, which prevent resource to return to earth in departments

on the coastline of western France (Vendée and Loire Atlantique). However, for this actor, beyond the technical aspects of flood, it is necessary to provide psycho-socio supports for the inhabitants and create withdrawal zones. Moreover, water storage (#12) is also essential especially in departments with little supply and bad quality water while there is a huge necessity of water furniture for agriculture and tourism in summer. For this factor, storage is a solution to anticipate challenges of climate change (#28) and to support future droughts. Conversely, some statements do not make sense in the regional context like "modernization of sanitation station and supply factories" (#20) placed in -3 because they are already efficient enough. Same idea holds for neutrality on water leaks (#21) as they are low in this factor's mind. Moreover, subventions of domestic installations (#3) do not represent an important mean to preserve water, as it is only a gain for the person who install it but not for the resource. To resume, important actions and infrastructures should be adapted to the local context and specificities of the territory. It goes regionally with knowledge of the resource to improve restoration of aquatic environments, prevents flood and secure access to water for agriculture in the long term with storage.

**Factor 4: Technological optimization to compensate lack of citizen engagement**

For factor 4, important means to preserve water involve a technically efficient approach with the modernization of sanitation stations and water supply factories (#20) but also agricultural water-saving technologies to act on huge volumes (#6). Preservation of water also needs improvement of the distribution networks to repair leaks (#21) placed in +2 while it is neutral or not important for other factors. Unlike other factors except the fifth one, it places the statement "Use good quality water only for uses that really need it, or otherwise lower quality water" (#16) as an important one. This statement indicates the distinction of uses, which should not be suboptimal at the risk of wasting the resource. While optimization of the resource is crucial, citizen investment is not the good lever to preserve and manage water according to this factor. Indeed, individual actions are not efficient enough so that inform and educate consumers about eco-friendly actions (#4), domestic water saving installations (#3) are not important. Moreover, for it, empowerment of citizen is not impactful so mission actors to help public services and citizen consultations and co-construction programs are not important to preserve water. This factor thinks that habits will always underpass the rest and set up social pricing will encourage this population not to take care of the resource. To conclude, this factor favors progress regarding water preservation with the modernization and optimization of the allocation of the resource rather than investment of domestic users.

**Factor 5: Pricing and regulation to support water preservation**

For this factor, water preservation and distribution requires adapted pricing tools, which take into account the scarce aspect of the resource and its fair value. Indeed this factor places an increase of water fees (#27) in the neutral area while for some other factors it is not important at all. Moreover, this factor considers that increasing prices to discourage overconsumption (#13) are very important conversely to other factors, in order to adjust the amount consumed to the real value of water and to optimize water consumption choices of consumers. While taxes are also a good mean to regulate water consumption in periods of drought and summer, according to this factor, quotas (#10) and water storage are not important because the regulation of the quantity can go through the price. Moreover, for this factor, regulation and control of quality of wastewater treatment (#17) is very important to fight against pollution and to restrict

pesticides and fertilizers. Thus to achieve the objectives of access to drinking water for future generations and consider the challenges of climate change, prices are the most direct mean it to alerts on value and scarcity of the resource. Moreover, these prices should be adapted to financial resources of the population with the implementation of a social pricing (#31). Thus, this factor highlights the fact that laws, regulation and prices are the most efficient way to control and preserve the quantity and the quality of the resource, restricting sources of pollutions and dissuading overconsumption.

**B) Areas of distortion and consensus**

**1. Disagreements**

A crucial advantage of Q methodology is the construction of consensus areas between profiles and on the contrary divergences why policy implementation can fail. Correlation matrix (Table 3) between factors shows that the factors 1, 3 and 4 have a relatively high correlation, meaning common vision on some statements. However, distinguishing views on some sentences are high enough to consider them independents. Factor 5 seems very different from the four others with a low correlation except the second one, which underlines its complete independence.

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 1 | 0,386 | 0,42 | 0,476 | 0,369 |
| F2 | 0,386 | 1 | 0,414 | 0,338 | 0,426 |
| F3 | 0,42 | 0,414 | 1 | 0,431 | 0,258 |
| F4 | 0,476 | 0,338 | 0,431 | 1 | 0,241 |
| F5 | 0,369 | 0,426 | 0,258 | 0,241 | 1 |

Table 3: Factor score correlations

We even constructed a graph (Figure 6) with strong disagreement statements (difference in the Z-score in absolute value higher than 2). It consolidates the disparities between factor 5 and others such as factor 3 and 4 on statements 25, 12, and 19 and 20, 19, 12 respectively. However, some other factors as 1 and 3 do not have strong disagreements like that, which can explain a higher score correlation between them. Concretely disagreement statements (as #12 “Improve water storage”) highlighted in this study appear in local water commissions and basin committee.

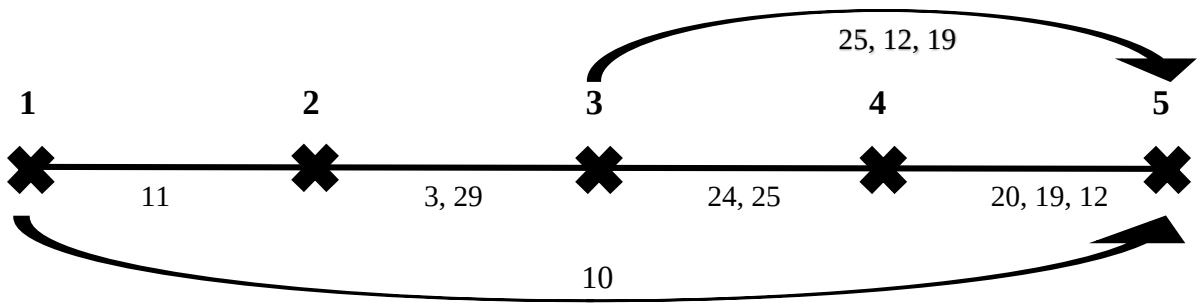


Figure 6: Network of disagreements between factors

Modernization of sanitation stations and water supply factories (#20) is not important for factor 2, 3 and 5 while it is for 4. Similarly, water storage (#12) is not important for many factors, while it is for factor 3. Factors 1 and 5do not agree on taxes over $m^3$ consumed in periods of drought and summer (#25) because they think that it is important, while others think that it is not. Furthermore, increasing prices represent a good way to preserve and manage water for factors 3, 4 and 5 while it is not the case for factors 1 and 2. Contradictory views are indeed existent on many statements.

**2. Consensus**

On the contrary, some statements find a common tendency between all factors as "Inform on good daily habits" (#5) and "Restrict watering schedules for agricultural activities" (#7) which are considered as not really important by all. It is not surprising as in complementary interviews and commentaries on domestic water, many participants said that domestic consumers do not represent a huge volume of consumption comparing to industries or agriculture and are already informed enough. Moreover, restrict water schedule is not important if we implement other alternatives such as crops that consume little water or quotas on $m^3$ consumed and it can have consequences on the vital production of food.

Another consensus shows the strong importance of systemic shifts in agriculture towards an organic production (#14) and all factors placed "restrict and/or ban pesticides and fertilizers" in + 3 (#15). This positive agreement can be at the hearth of an accepted forthcoming policy towards a less polluting agriculture. Additionally, in complementary interviews, one main idea is to stop stigmatization of agricultural world but accompany this profession in a virtuous transition. Other forms of pollutions are also at the heart of consensus areas like facilities to trap pollutants in order to decrease water pollution, as region faces many quality issues on water.

More generally, we can notice that exact similarity in priorities of all factors are scarce. It is not surprising when we know the context of conflicts of use between agents and variety of expectations of stakeholders which stand out from this study. However, some huge consensus on agricultural shifts, non-point pollutions and climate change issues appears and are fully in line with regional problems on water. These agreements are encouraging and constitute priorities that can base a common efficient policy.

**-5-**

# General discussion

According to Baker et al. (2006), Q methodology find three areas of application in Economics: Preference elicitation, Economic evaluation using case study methods (see also Wainger et al., 2017) and Behavioral economics. This study gathers partially these three areas by a concrete example on water governance. Regarding profiles and levels of their associated intensity with a given viewpoint, we know that domestic consumers included in this study prefer technological optimization, as they are mainly included in factor 4. It reveals at least partly their preferences on the way to deal with water issues. Moreover, case study methods with local factors and contextual economic valuation appear through Q study. In our case, we use instruments as taxes, quotas, subventions and price of water to understand determinants of economic valuation of water at a small scale. Finally, with Q methodology we consider human actions and behaviors, which are relying on their perceptions and expectations. For instance in

our study, if someone find that a statement and a mean to act is not important, he will probably not want to invest time and money on it. Based on this observation and perspectives of thought we can construct potential scenarios of intervention for policy makers to preserve water.

- In factor 1's place :

In the context of interdependency around the watercourse la Loire that crosses the entire region, security of access to water downstream depends on cooperation with departments located upstream. In our studied territory nine water masses over ten do not reach a good ecological state so water quality is also a crucial concern that is why factor one promotes concrete actions with immediate impact. This scenario of intervention to fight for preservation in both quality and quantity can thus be done by the implementation of restrictions on fertilizers to promote a better quality and a general restoration of wetlands and quality of watercourses. Regarding quantity issues, in this region with a high density of population and consequently important agriculture, it can be interesting to favor crops that consume little water to economize water. We can thus imagine a scenario adapted from this view with regulation on fertilizers, direct actions on watercourses and means in favor of a less intensive agriculture.

- In factor 2's place :

There is a need for long consideration changes such as a systemic evolution of water management in the process of production (farmed and industrial) and consumption by all stakeholders. Agricultural production is a huge lever of consumption of water and preservation of groundwater resources so that a policy in this direction can be interesting thanks to crops that consume little water, restrictions on pesticides and organic production. There is already an increasing regional tendency of shifts towards organic production and According to the part of organic farms in 2017 represented already 9.2 % of the total farming activity (report of regional chamber of agriculture) and is still increasing. We can thus imagine a scenario with subventions for organic shifting producers to promote a more global systemic evolution. We took the example of agricultural evolution, but it is one among others, we can also favors use of eco-friendly household products for domestic users. Everyone have to be invested at his scale into the preservation of water

- In factor 3's place :

This scenario considers more local specificities and participants from Vendée are overrepresented. The water deficit weighing on this department with a high population, especially during summer touristic season does not facilitate water management. Thus, specific alternatives as water storage are important such as consideration of risks of flood for the coastline departments. A first direction can be to adapt city planning to problems of quality and to plan the territory creating facilities to trap pollutants. Even if it is controversial in the region, dams and storage can be also envisaged regarding quantity secure the distribution over seasons. Lastly, knowledge on the topic for all stakeholders is crucial to measure the scale of local necessary actions and data and indicators are important so they should be more developed and updated.

- In Factor 4's place :

This scenario is based on technological optimization to allocate water in the most efficient way. Based on technical progress in both agriculture with the use of water saving technologies, and

in domestic distribution with modernization of sanitation stations and water supply factories, it is possible to improve water availability. A potential scenario would be to invest in order to repair leaks as in France it represents more than 20% of distributed water. We can thus imagine a higher budget allocated to renewal and repairing actions for the networks of distribution. More generally, individual actions are not the solution in this scenario. Indeed, progress and new technologies are the answer to save water and preserve its quality.

- In Factor 5's place :

According to the Water Agency, in 2018, domestic consumers paid more than 70% of water fees. For this factor, to preserve the resource it is necessary to pay the fair price of water to be aware of its scarcity and its real value. This would imply a scenario where huge consumers pay more and small consumers pay less. This scenario would include for instance an implementation of an increasing price scheme. Moreover, preservation of the resource goes through a regulated allocation of water in quality with control on retreatment and restrictions on pesticides. Then pricing and regulations are direct to change behaviors of users, avoid overconsumption, alert and reduce waste.

These scenarios rely on both contextual issues of the region and importance that people give to means of preservation defined in the Q sorts where consensus can roots a co-construction of a program to better use water. More generally, Q methodology offers an exploratory method for other economic tools and we do think that scenarios guided by the expectations of stakeholders can inspire calibration of policies explored in agent-based models. Indeed, in these kind of simulations it is possible to represent real stakeholders by agents with various characteristics (the quantity of water they consume, the territory where they live, their interactions with others and some other characteristics) and parameters. It is also possible to calibrate the environment where agents are acting on real data like water depending on seasons. Thanks to agent-based modeling, it is possible to see the evolution of agents in such an environment and potential impacts of scenarios described before. For example if we implement quotas on domestic consumers, we can imagine that it will favor a decrease of global domestic water consumption and conversely for other actors that benefit from more availability. Thus, Q methodology can help to calibrate good scenarios of interventions for policy makers and to model them with other economic tools.

## -5-

## Concluding comments

This paper presents a Q method study conducted in the region Pays de la Loire involving 35 participants from different groups of interests (collectivities, state directions, water consumers, associations,…) around a common issue: Preservation and management of water. Participant sorted 33 statements organized on several topics like preservation of water in water uses, city planning, governance, shared initiatives and so. We finally obtained five narratives of thought. Factor 1 exhibits an immediate active management with means to preserve both quality and quantity of water. Factor 2 gathers regional institutions and associations and offers a holistic view of water governance towards a sustainable systemic evolution that guaranty long run access. Third factor is composed mainly by farming sector and respondents from Vendée and is characterized by local issues regarding water management. Factor 4, grouping consumers and environmental associations, promotes an optimal use of water through technological

advances. Factor 5 is subject to pricing and regulation recommendations as it is a direct lever to support water quality with control of retreatment and increasing prices to discourage quantitative waste.

More than a state of play of vision on water management our Q-study stirs up statistical measures of disagreements and consensus which are notable in water governance bodies but not observed through the scientific prism. Based on subjective social perspectives it raises consensus on climate change issues, agricultural systemic shifts towards organic and sustainable ways of production, and fight against increasing non-point pollutions. This observatory field study can guide policy makers towards an accepted trend to preserve and manage water and put words on misunderstanding and diverging views of actors. More generally, this paper shows empirical and theoretical usefulness of such a method to complete traditional tools from environmental economics in public policy analysis.

This paper opens the door of improvements and further research on empowerment of discourses in environmental economic policies. First, additional Q-sort interviews could be conduct with some other actors to achieve relevance of this extensive study (Brown, 1980). In a long run perspective, we would also propose new insights on centrality of stakeholders in networks and influences of agents on the Q-sorting process. Regarding links between agents, depending on tensions or peaceful relationships, we see that participants pertains or not to the same factor, they agree or not on the way to manage water. Then networks, relations and centrality of participants represent a good perspective for future research in the interpretation of Q methodology. For instance, it can go with results from Q methodology to calibrate interactions in a game theoretical network or to build scenarios of interventions that we can try through Agent-based modeling simulations.

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## Annex 1: Empirical analysis of Q-studies on water and environmental issues

| Authors and year | Context and place studied | Main topic | Selection of statements and Q sorting | Number of participants and functions | Profiles and results |
|---|---|---|---|---|---|
| **Barry et al. (1999)** *Ecological economics* | United Kingdom, on participants of the Local Employment Trading Systems ( LETS) | The theme of the Q sort is "Environmental concern, awareness and Sustainability", to understand the vision of individuals on environmental policies, their public acceptation and their implementation | 36 statements kept after a concourse on medias and interviews with studied populations | 25 participants related to the LETS, individuals of a common group | 4 profiles :<br>-Techno-sceptical and non-green holism ;<br>Anti-capitalism, techno-skepticism and non-green ecologism ;<br>Political ecologism ;<br>Pro-technologism, acquisitiveness |
| **Raadgever et al. (2008)** *Hydrology and hearth system sciences* | Rhine bassin between Germany and Netherlands | Study different perspectives on management of future water flood in the downstream part of the Rhine basin and define a common vision on it by 2050 | Literature review and 23 semi-structured interviews led to 46 statements on 4 themes (actual situation, autonomous developments, management strategies and future desired situation). | 22% answers on 200 interviewed by mail, well balanced between German and Dutch. Larger representation of governmental organization, academics than NGO, citizens and scientific entrepreneurs from Germany. | 3 profiles : anticipation et institution ;<br>Space for floods ;<br>Engineering knowledge.<br>Common vision of the actors on the provision of security in front of flood and the future vision allows to consider scenarios of intervention. |
| **Frantzi et al. (2009)** | Territory of the Mediterranea | Extension of research on environmental | 25 semi-structured interviews, concourse of 294 | 25 Q sorts filled by a huge variety of stakeholders | 4 profiles on regime efficiency : international political cooperation ; legal |

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|---|---|---|---|---|---|
| *Journal of environmental management* | n action plan to understand the efficiency of the implementation of international cooperation policies | diplomacy, international treaties and agreements. It focuses on efficiency of regimes already implemented. | statements, sorted by topics and selected to have as much negative and positive arguments. Final total of 44 statements for the Q sort. | (academicians, external consultants, NGOs, center of research, ministry of environment, …) | implementation and environmental performance ;<br>Practical VS political effectiveness; governance through participation.<br>It shows that efficiency relies on different elements depending on perception of participants: role of institutions, legal measures, cultural, scientific and environmental aspects. This diversity of opinions underlines the hardness of consultation to defend different interests and conduct an efficient policy |
| **Cuppen et al. (2010)** *Ecological economics* | Netherlands, during a dialogue on energy options from biomass. | This study should help all actors to know the visions and perceptions of others, to get a mapping of all the perspectives before the dialogue and reflects each view equally. | Concourse built with discussions, reports, public debates, articles and so. 62 statements selected and 60 kept after 5 pre-tests to catch the amplitude of the perspectives | 75 participants in total from various institutions: institutes, academics, NGOs, big/ medium and small firms, local/regional/national instance of the government. 30 participants over 75 participated at the final dialogue representing the different views, interests and expectations. | 6 profiles: Keep all options open; Hit the brakes; support small-scale innovation initiatives; security of supply with global, certified, 2nd generation biomass; efficiency the goal, biomass a mean? ; Just do it, step by step. |
| **Davies et al. (2012)** *Ecological economics* | United Kingdom, comparative study conducted | Study focuses on changes of environmental perception frameworks of | Use of the same Q set in the two studies to have a perfect comparison of the results | 102 face-to-face interviews in 2001 and a re-test of 34 completed studies by post box in 2008. | 4 evolutions between the two studies: Increasing reluctance to endorse environmentalism, surge of support for technological stability, decline in enthusiasm for payments for service, |

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| | both in 2001 and 2008 on agricultural changes | individuals over a long period with a longitudinal approach | | | increasing concern with farming communities. These results show the evolutions over time and not the profiles because the longitudinal approach allows us to show the structural stability of some agricultural perspectives or on the contrary the evolving elements in perceptions of respondents. |
| **Forouzani et al. (2013)** *Journal of arid environments* | Province of Harvdasht Couty of Fars in Iran during the development of « water agricultural poverty » (AWP) on the territory , confronted to the insufficiency of qualitative water for agriculture production, overexploitation and climate change. | This study wants to understand what is the «Agricultural water poverty » for farmers and specialists of the agricultural world and their different interpretations between the two groups. It is even more interesting that agriculture is one of the main activities on the territory and all the population faces a deterioration of underground water | Transcript of semi-structured interviews (6 farmers, and 9 focus group with farmers and specialists), literature review. Initially, 750 statements collected and at the end, 54 statements were selected to develop all the main themes. | 75 participants (50 Farmers and 25 specialists). | 7 profiles : 4 dominated by farmers ( Management-adherents , adaptative adherents, Fatalists, Support seekers) and 3 dominated by specialists (Farmer-blamer pessimists, technocratic realists, Optimists). Generally, the results question the sustainability of the actual model : Access to water, reasonable use, availability of the resource, means of extraction, vision of the AWP, future, and optimization. |
| **Lucas Ward (2013)** | Paraguay | The goal of this study is to | 24 semi structured interviews on the | | 3 factors with a mitigated vision on adoption and implementation of the |

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| *Geoforum* | | understand the implementation of the "Integrated Water Resource Management" (IWRM) and its approval | actors invested in the IWRM (civils, NGO, government of Paraguay, …). 50 statements on 4 topics : Local management and development conditions, the role of science in governance, politics of the IWRM model , values of environment and development | | program: IRWN Acolytes in favor of the adoption of program rules; Centralized IRWM who represent three high level governmental persons in favor of the central role for government agencies in managing civil society participation; selective IRWM represented by the public sector and NGOs who are opposed to the acolytes vision on the market and think that power over water should not be diminished. |
| **Asquer (2014)** *Water* | Italy, a territory with a furniture of water partly private since a reform of 1994 but 2/3 of the distribution network stays public. | Study of the perceptions of water services on a territory shared between public and private sectors. They are all regulated by norms on quality of water and a limit of prices for water. | A concourse of 150 statements on water services regulation for local water services was built on documentaries, 20 interviews with public officers at a governmental, local and national scale with water regulators, managers, laws and reforms on water in Italy. The final Q | This study asked 481 elected members of 19 municipalities and 5% answered at the end, so a total of 24 participants The elected members of the public service of local governments have a role to play in water regulation and legal conception of pricing rules and supervision of distribution firms of water. | 5 factors identified: interventionists of public sector; pessimists ; pragmatists ; prudent privatizers and fatalists privatizers. These 5 profiles show distortions on the importance of public and private sectors in the furniture service of water. A majority of profiles say that principles of solidarity and accessibility for the poorest should be applied while the last profile emphasizes more protection for firms than for users with a recover of engaged costs. This heterogeneity is linked to the historical concept and the recent implementation of the private sector in services of distribution of water. |

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|---|---|---|---|---|---|
| | | | sample counts 30 statements. | | |
| **Iribarnegaray et al. (2014)** *Water policy* | City of Salta (Northwestern Argentina) with a really huge water consumption about 600 liters per person per day, due both to over-consumption, leaks and so. | Efficiency of means to reduce water consumption (awareness campaigns, mass-media advertisement, leaks of the distribution system) and to test their public acceptance. | Concourse was obtained from analysis of the local media, conference proceedings, scientific articles, interviews and experience of authors. They found more than 150 potential statements and kept between 13 and 20 on the four following themes: service provider, water rights, public participation and water availability. | Total of 29 persons interviewed from diverse horizons (water company managers, technical staff, public relations representatives, government officials, NGOs, water users, environmental engineers …) in 2011 and a post-Q semi-structured interview was conducted in 2013 with the more representatives of each profile to confirm the results obtained. | 4 main profiles : "Right based consumption advocate" composed by 6 participants and mainly customers who think that water is a human right and the inefficiency is due to lack of management capacity of water companies and inadequate control by state ; "proponent of market based and technical water management" composed by 6 participants whose 3 members of water company) ; "Participatory governance advocate" in favor of a more participatory and environmentally friendly water governance composed by 4 participants mainly engineers and student in environmental sciences ; "State-led governance supporter" with three participants ( university professors and a philosopher invested in NGO) in favor of a relatively hierarchical, state-led, needs-oriented governance. |
| **Forrester et al. (2015)** *Applied geography* | Cross-border regions between Scotland and England | Study of social commitment on the problem of flood management and ability of risks, adaptability of the population | Huge literature review and informal interviews. | Participative cartography with 3 communities (2 in Scotland and 1 in England) with a global study of stakeholders in the citizen population, GIS study on a public with all actor types. | Coupling Q methodology with a participatory mapping construction and GIS allows to combine spatial data to promote the consideration of all stakeholders and to put forward the "cooperative policy action" (Bischof, 2010) on cross-border management of floods. |

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|---|---|---|---|---|---|
| **Strickert et al. (2015)** *Water policy* | This study takes place in the South Saskatchewan river basin, in western Canada. | It questions the concept of water security and its many definitions, linked with flooding, pollution, drought, lack of access. | Statements are collected in workshops on water and gave a concourse with 57 statements, reduced into 40 for the Q sample to suppress redundancy. | 37 respondents, including 13 headwaters, 14 midstream and 10 downstream and also various types of citizens (ranchers, water managers, Scientifics, municipalities, agricultural producers , urban planners, …) | 5 main profiles: idealistic sustainability with the need to protect environment by managing growth ; Pragmatic sustainability which supports intergeneration progress ; reliability which emphasizes reliability and recognize there will be some shortages ; social and ecological justice which supports basic needs for all humans and limited resources with a sustainable use of water. |
| **Minkman et al. (2017** | Dutch regional water resource authorities | Citizen implication and motivation for water resource management | Concourse of 229 on citizen motivation, level of citizen engagement , … 46 statements on regional water resource management after pretests on 6 students | 33 participants from 8 water authorities | 3 points of view: participation to analysis and data collection by citizens, citizen science is a mean to obtain data and additional illustrations , citizen science as a mean to educate. |
| **Wainger et al. (2017)** *Agricultural and Resource Economics Review* | A rural coastal fishing community area in the Chesapeake bay (USA) | Socioecological services derived from coastal marshes and communities | 19 statements divided into consumptive or non-consumptive uses, intangible benefits categories | 42 Q sorts for pre-engagement and 23 of post-engagement. It groups local residents, state and federal governments and academic/ NGO/researchers. | Pre-engagement interviews provide 3 profiles : ecological sustainability emphasis, Balanced and community livelihood emphasis. Post engagement profile aligned a few the viewpoints into something more homogenous. |
| **Bischoff et al. (2018)** *Water policy* | Murray Darling Basin in Australia | Discussion on the concept of cultural water for | 31 selected statements from a public speech of the | A sampling method semi targeted used to choose the participants | 4 profiles: Structural barriers and restitution (ask justice to give back to indigenous their right to water; scope and |

| | | | | | |
|---|---|---|---|---|---|
| | | indigenous and debates / conflicts around its use. | culture of water indigenous and on the study of 130 documents in newspaper, scientific reviews, and governmental papers. They are selected from an initial concourse of 350 initial statements. | with a final number of 51 (22 in face to face), all concerned by proximity or work around the Murray Darling's basin. | routing of water resource (the role of experts and science); a common ground and collaboration ( the role of water in an environmental point of view) ; collaboration and restitution (Both the environmental and cultural views). This study presents the base to build a new constitutive reform to allocate power of decision and intervention and to respect the interests of each. |
| **Levesque et al. ( 2019)** *Journal of environmental planning and Management* | Saint Pierre's Lake in Québec (Canada) | This territory is at the heart of interest divergences between agriculture, conservation and development around the water resource threatened by climate change and ecosystem's disruption. A consensus is needed.<br><br>. | Medias review over 25 years of the uses and problems on the lake (814 articles), reports, meetings and conferences with organizations which work on the lake to find at the end 19 statements on the coexistence of uses, collective actions for the ecosystem, agricultural and agro environmental practices, regulation policies of agriculture and resource conservation | 4 sectors are represented by elective represented, farmers, agronomists, and government employees, members of associations and conservation organizations, fishing and hunting sectors. Participants have been divided in 4 sectors: Agriculture, governmental and municipal, conservation, Hunting/fishing sector; with approximately 15 persons in each. A total of 57 participants | 3 profiles: Proconservation (mainly represented by conservation associations, researchers, governmental agencies, elected members), pro-agriculture (farmers, agronomists, one fisherman, one elected member and one environmentalist), farmers in the heart of the lake (Only farmers). The profiles of this study shows the existence of conflictual interests with different opinion groups. They agree on a few things but it is still hard to find an agreement on the activities around the lake. This study underlines the different levels of conflicts and a better comprehension of all social perspectives. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | finished the completed Q study. | |
| **Ormerod (2019)** *Journal of political ecology* | South western United states | This paper aims to understand viewpoints on potable water reuse and its planning | 30 recommendations on the possible potable water reuse , for example in the case of toilets | 176 key actors asked by mail to answer but 41 completed the study. The sample was diverse to consider all views with city planners, water managers, operators, activists, administrations, engineers, Scientifics, elected representatives | 2 main profiles and 6 unique views not considered as Q methodology catches commonality: The neo-sanitarian which includes a lot of participants and the rest in the eco-sanitarian view. Neo-sanitarian trust in water treatment, recycling actions, modern industry and progress of technologies while eco-sanitarian view promotes holistic and ecological approaches like with dry toilets |

**Table 4: Applications of Q methodology in the field of water and environment**

# Annex 2 : Q-set

**Reduce domestic consumption**

1. Drink tap water rather than bottled water
2. Install water saving equipment ( double flow flush, aerators, tap timers, …)
3. Subsidize domestic water-saving installations ( water collector …)
4. Promote the use of eco-friendly and natural household products ( washing powder, …)
5. Inform on good daily habits (more shower than baths, wash the car in the station, …)

**Reduce agricultural and industrial consumption**

6. Use water-saving technologies for agriculture
7. Restrict watering schedules for agricultural activities
8. Favor crops that consume little water
9. Recycle municipal wastewater for agriculture and /or industry use
10. Set up quotas on the $m^3$ consumed by the farmers and/or industries
11. Tax the $m^3$ consumed in summer or periods of drought

**Preservation of the resource in quality and quantity**

12. Improve water storage
13. Implement increasing prices to discourage overconsumption ( The more I consume, the more expensive is the water units)
14. Encourage organic agricultural production
15. Restrict/ Ban pesticides, fertilizers, phytosanitary products, …
16. Use good quality water only for uses that really need it, or otherwise lower quality water
17. Regulate and control the quality of wastewater treatment
18. Create natural facilities to trap pollutants ( hedges, …)

**City planning and innovation**

19. Restore and manage wetlands and aquatic environments
20. Modernize sanitation stations and water supply factories
21. Improve water distribution networks and repair leaks
22. Include the economy/ecology trade-off in the urban planning tools ( like the SAGE)
23. Prevent degradation and improve watercourses quality (biodiversity, …)
24. Develop the territory but taking into account the risk of flood

**Water governance and information**

25. Pursue the acquisition and transparency of data on water, make it accessible and usable
26. Inform and educate consumers about eco-friendly actions at school or at work ( awareness campaigns, billboards
27. Increase water fees

**Solidarity and shared initiatives**

28. Consider the challenges of climate change in water management ( drought, …)
29. Foster solidarity between territories (for example between rural and urban ones,…)

30. Guaranty the access to drinking water for present and future generations
31. Set up social pricing for water for the most disadvantaged consumers
32. Set up citizen consultations and co-construction programs on water conservation
33. Mission actors to help the public service on awareness programs for water ( NGOs, environmental associations, …)

## Annex 3 : Consensus and disagreement statements

| Statement Number | Statement | factor 1 | factor 2 | factor 3 | factor 4 | factor 5 | Z-Score variance |
|---|---|---|---|---|---|---|---|
| 15 | Restrict/ Ban pesticides, fertilizers, phytosanitary products, … | 3 | 3 | 3 | 3 | 3 | 0.041 |
| 5 | Inform on good daily habits | -2 | 0 | -1 | -1 | -1 | 0.124 |
| 7 | Restrict watering schedules for agricultural activities | -1 | -2 | -2 | 0 | -1 | 0.152 |
| 28 | Consider the challenges of climate change in water management | 3 | 3 | 1 | 1 | 3 | 0.214 |
| 14 | Encourage organic agricultural production | 2 | 2 | 1 | 0 | 1 | 0.253 |
| 21 | Improve water distribution networks and repair leaks | 0 | -1 | 0 | 2 | -1 | 0.259 |
| 22 | Include the economy/ecology trade-off in the urban planning tools | 1 | -1 | 1 | 0 | -2 | 0.261 |
| 18 | Create natural facilities to trap pollutants | 1 | -1 | 2 | 1 | 1 | 0.265 |
| 33 | Mission actors to help the public service on awareness programs for water | 0 | -1 | 0 | -3 | 0 | 0.294 |
| 9 | Recycle municipal wastewater for agriculture and /or industry use | -3 | 0 | 0 | 0 | 0 | 0.308 |
| 2 | Install water saving equipment | -2 | 0 | -1 | 0 | -2 | 0.33 |
| 6 | Use water-saving technologies for agriculture | 0 | 1 | 0 | 1 | -1 | 0.345 |
| 26 | Inform and educate consumers about eco-friendly actions at school or at work | -1 | 1 | -1 | -2 | 0 | 0.348 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | Regulate and control the quality of wastewater treatment | 1 | 0 | -1 | 1 | 2 | 0.351 |
| 23 | Prevent degradation and improve watercourses quality | 2 | 1 | 2 | 2 | 0 | 0.355 |
| 8 | Favor crops that consume little water | 2 | 2 | 1 | 3 | 2 | 0.4 |
| 31 | Set up social pricing for water for the most disadvantaged consumers | -1 | -1 | -1 | -3 | 1 | 0.402 |
| 1 | Drink tap water rather than bottled water | -2 | 1 | 0 | -1 | 1 | 0.413 |
| 32 | Set up citizen consultations and co-construction programs on water conservation | 0 | 0 | -1 | -3 | -1 | 0.421 |
| 16 | Use good quality water only for uses that really need it, or otherwise lower quality | -1 | -2 | -2 | 1 | 1 | 0.465 |
| 30 | Guaranty the access to drinking water for present and future generations | 1 | 3 | 2 | 2 | 3 | 0.473 |
| 27 | Increase water fees | 0 | -3 | -3 | -2 | 0 | 0.523 |
| 10 | Set up quotas on the m3 consumed by the farmers and/or industries | 2 | 0 | 0 | 1 | -3 | 0.526 |
| 3 | Subsidize domestic water-saving installations | -2 | 0 | -3 | -2 | -1 | 0.527 |
| 19 | Restore and manage wetlands and aquatic environments | 3 | 1 | 3 | 3 | 0 | 0.659 |
| 4 | Promote the use of eco-friendly and natural household | -3 | 2 | 0 | -1 | 0 | 0.674 |
| 24 | Develop the territory considering the risk of flood | -1 | 1 | 2 | -1 | 1 | 0.675 |
| 29 | Foster solidarity between territories | 1 | 2 | -2 | -1 | -2 | 0.809 |
| 11 | Tax the m3 consumed in summer or periods of drought | 1 | -2 | -2 | -2 | 2 | 0.827 |
| 25 | Pursue the acquisition and transparency of data on water, make it accessible and usable | 0 | -1 | 3 | -1 | -3 | 0.982 |
| 20 | Modernize sanitation stations and water supply factories | 0 | -2 | -3 | 2 | -2 | 1.047 |
| 13 | Implement increasing prices to discourage overconsumption | -1 | -3 | 1 | 0 | 2 | 1.076 |
| 12 | Improve water storage | -3 | -3 | 1 | 0 | -3 | 1.18 |

Table 5: Scores of consensus and disagreements

*Comment: Associated rounded Z scores of statements in the grid of factors are presented in the columns of 3 to 7.*

## Annex 4 : Flagging of participants

| Q sort | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|---|---|---|---|---|---|
| Rep1 | 0,019 | 0,052 | 0,689 F | -0,094 | 0,036 |
| Rep2 | 0,166 | 0,189 | 0,222 | 0,449 F | 0,102 |
| Rep3 | 0,180 | 0,29 | 0,106 | 0,540 F | 0,096 |
| Rep4 | 0,297 | -0,313 | -0,075 | 0,575 F | -0,04 |
| Rep5 | -0,134 | -0,071 | -0,195 | 0,611 F | -0,378 |
| Rep6 | 0,519 | 0,013 | 0,259 | 0,495 | 0,214 |
| Rep7 | -0,081 | 0,745 F | 0,349 | 0,046 | 0,115 |
| Rep8 | 0,669 F | 0,017 | 0,024 | 0,180 | 0,033 |
| Rep9 | 0,132 | 0,189 | 0,459 | 0,724 F | 0,117 |
| Rep10 | 0,251 | 0,075 | 0,069 | 0,759 F | 0,055 |
| Rep11 | 0,389 | -0,351 | 0,414 | 0,222 | 0,48 |
| Rep12 | 0,068 | 0,302 | 0,394 | 0,706 F | 0,104 |
| Rep13 | 0,636 F | 0,117 | 0,127 | 0,264 | 0,377 |
| Rep14 | 0,667 F | 0,325 | 0,209 | 0,025 | 0,031 |
| Rep15 | 0,333 | 0,381 | 0,663 F | 0,084 | 0,036 |
| Rep16 | -0,091 | 0,649 F | 0,504 | -0,009 | 0,238 |
| Rep17 | 0,284 | -0,116 | 0,218 | 0,21 | 0,519 F |
| Rep18 | 0,286 | 0,325 | 0,156 | -0,100 | 0,725 F |
| Rep19 | -0,082 | 0,432 | 0,509 | 0,442 | 0,346 |
| Rep20 | -0,035 | 0,293 | -0,115 | 0,212 | 0,659 F |
| Rep21 | 0,753 F | 0,234 | 0,04 | 0,292 | 0,135 |
| Rep22 | 0,512 F | 0,292 | -0,071 | 0,148 | 0,138 |
| Rep23 | 0,152 | 0,078 | 0,607 F | 0,307 | 0,098 |
| Rep24 | 0,370 | 0,714 F | -0,048 | 0,119 | 0,027 |
| Rep25 | 0,273 | 0,391 | 0,234 | 0,228 | -0,447 |
| Rep26 | 0,502 | 0,079 | 0,527 F | 0,027 | -0,094 |
| Rep27 | 0,800 F | -0,095 | 0,278 | -0,052 | 0,034 |
| Rep28 | 0,287 | 0,683 F | -0,1 | 0,128 | -0,146 |
| Rep29 | 0,333 | -0,033 | 0,517 | 0,178 | -0,433 |
| Rep30 | 0,23 | 0,318 | 0,571 | 0,425 | 0,069 |
| Rep31 | 0,079 | 0,046 | 0,73 F | 0,29 | 0,023 |
| Rep32 | 0,384 | 0,458 | 0,319 | 0,313 | 0,255 |
| Rep33 | 0,658 F | 0,193 | 0,133 | 0,268 | -0,135 |
| Rep34 | 0,508 | 0,087 | 0,178 | 0,631 F | 0,08 |
| Rep35 | 0,197 | 0,546 F | 0,190 | 0,163 | 0,208 |

*Comment:* "F" *indicates that a respondent (rep) is flagged for the associated factor and thus loading the results.*

## Annex 5 : Q sort grids of factors

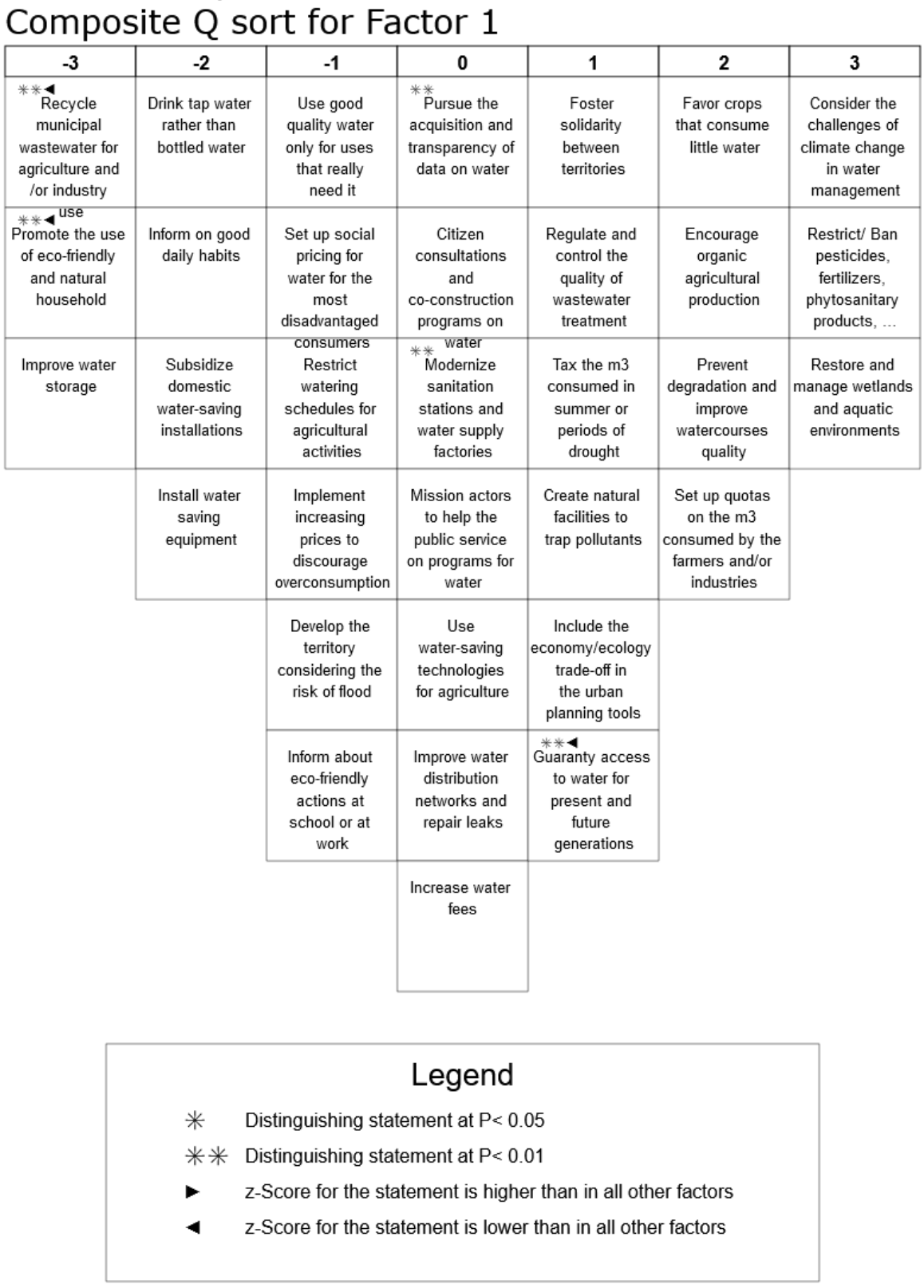


Figure 7: Q sort of factor 1

*Source: author, KenQ software*

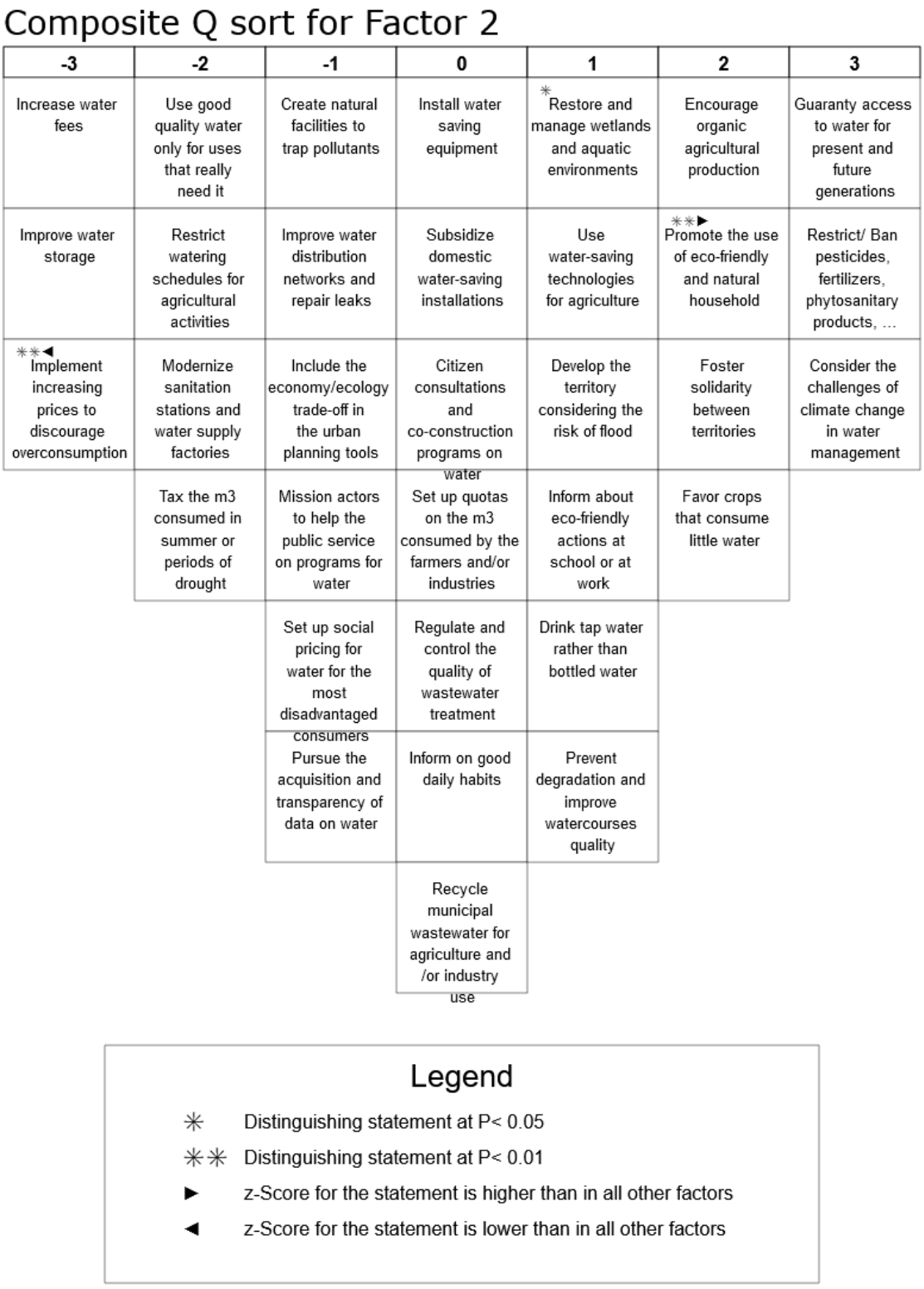


Figure 8: Q sort of factor 2

*Source: author, KenQ software*

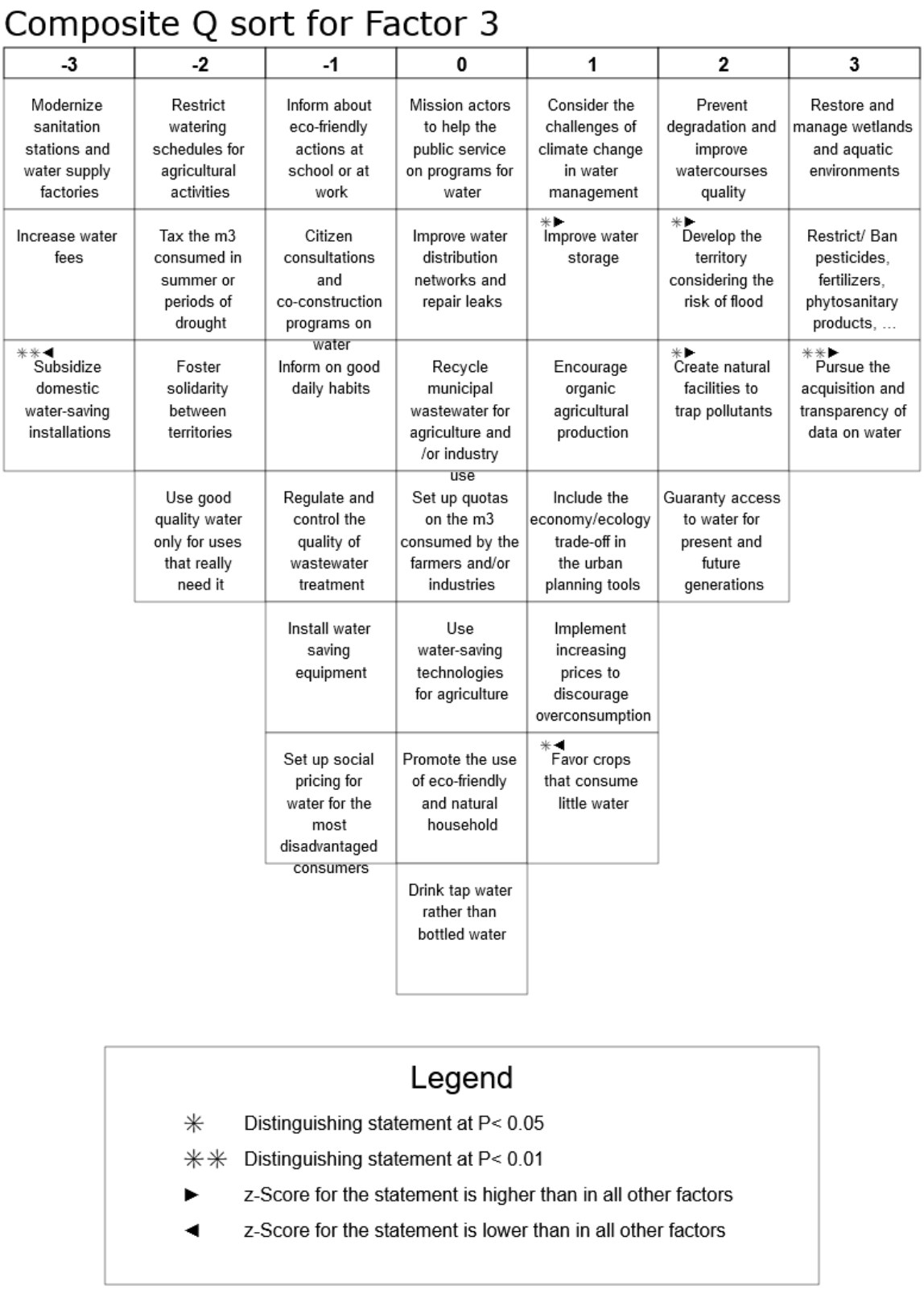


Figure 9: Q sort of factor 3

*Source: author, KenQ software*

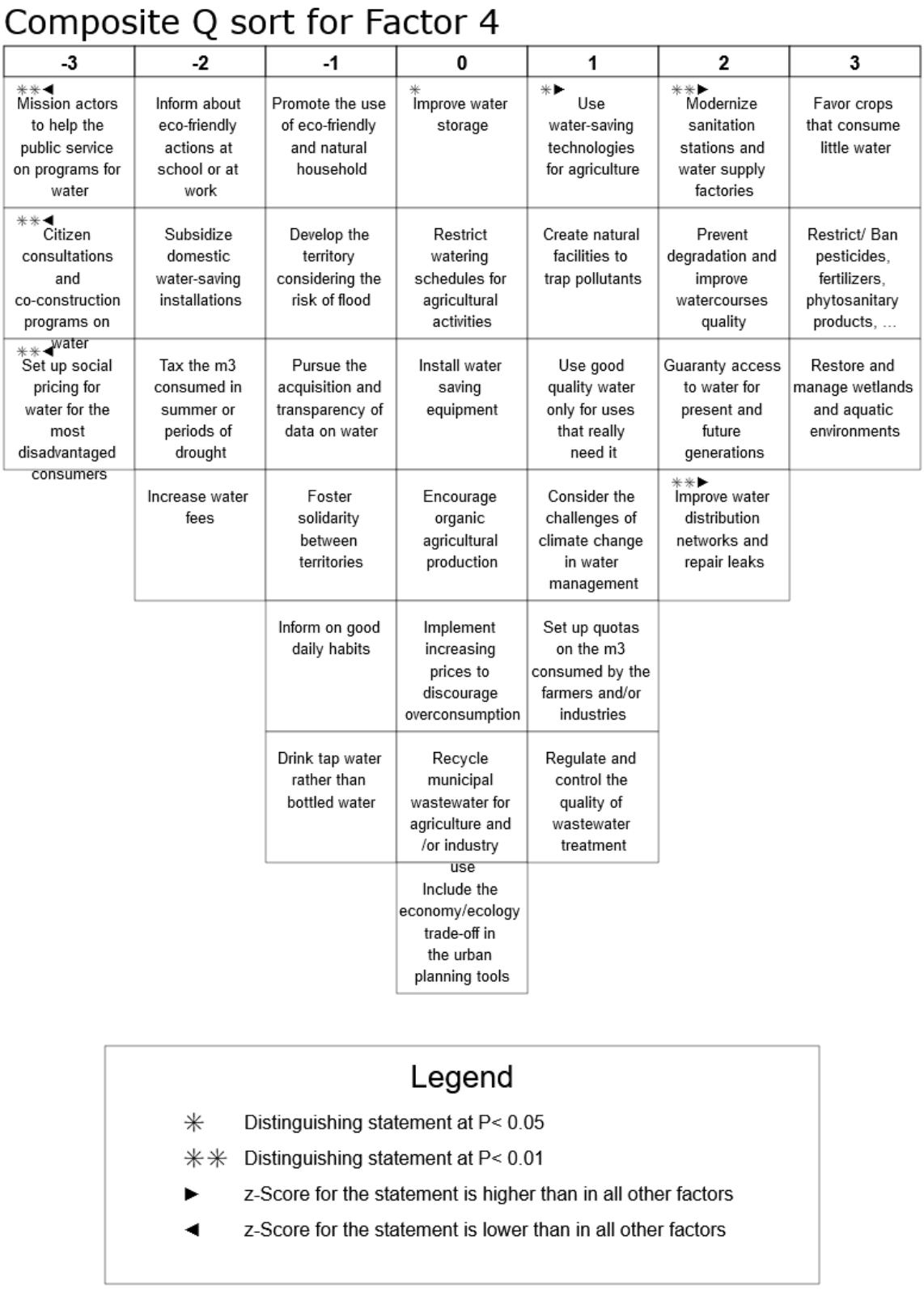


Figure 10: Q sort of factor 4

*Source: author, KenQ software*

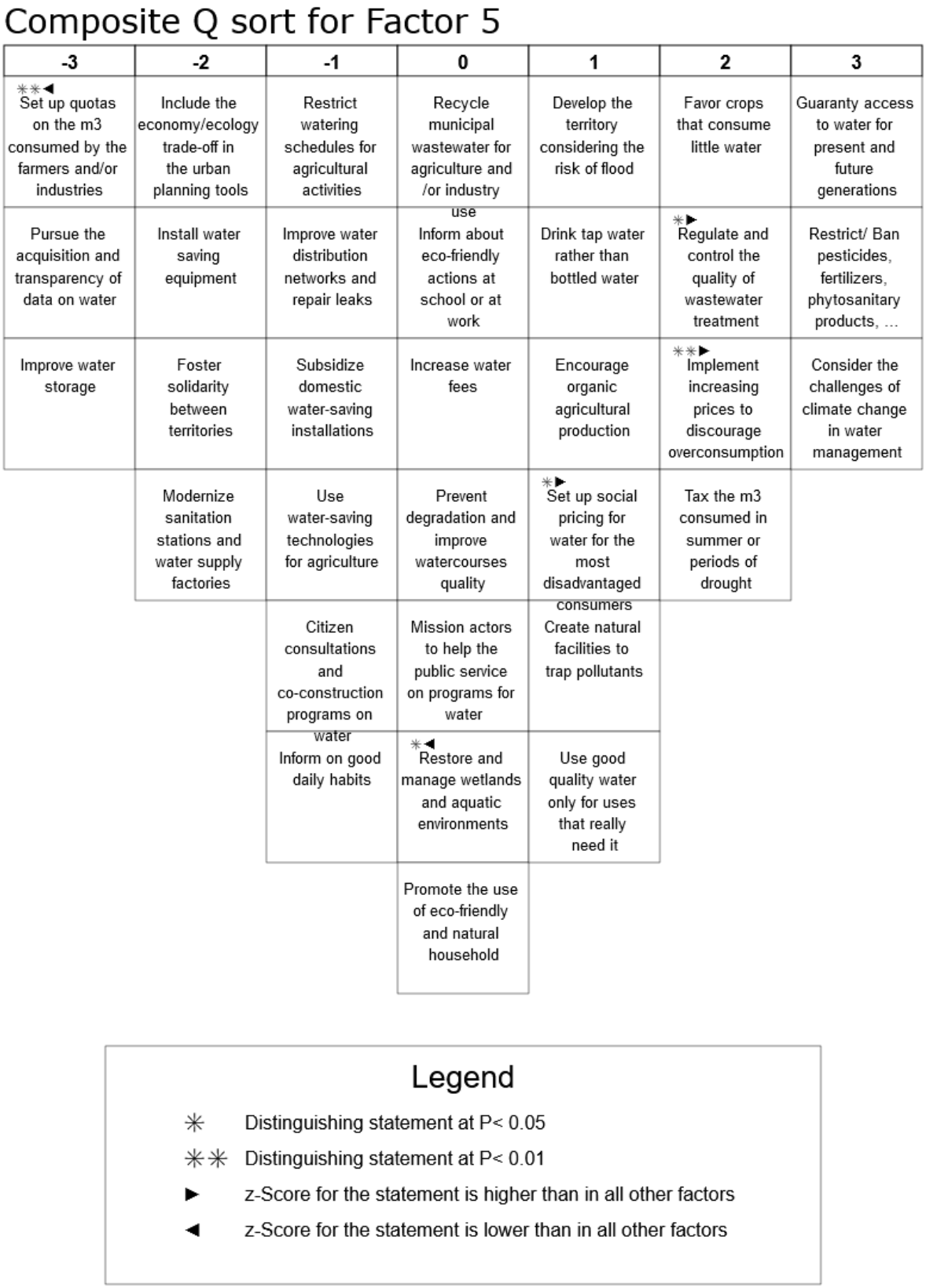


Figure 11: Q sort of factor 5

*Source: author, KenQ software*

# Annex 6: Schematized method process of the Q study

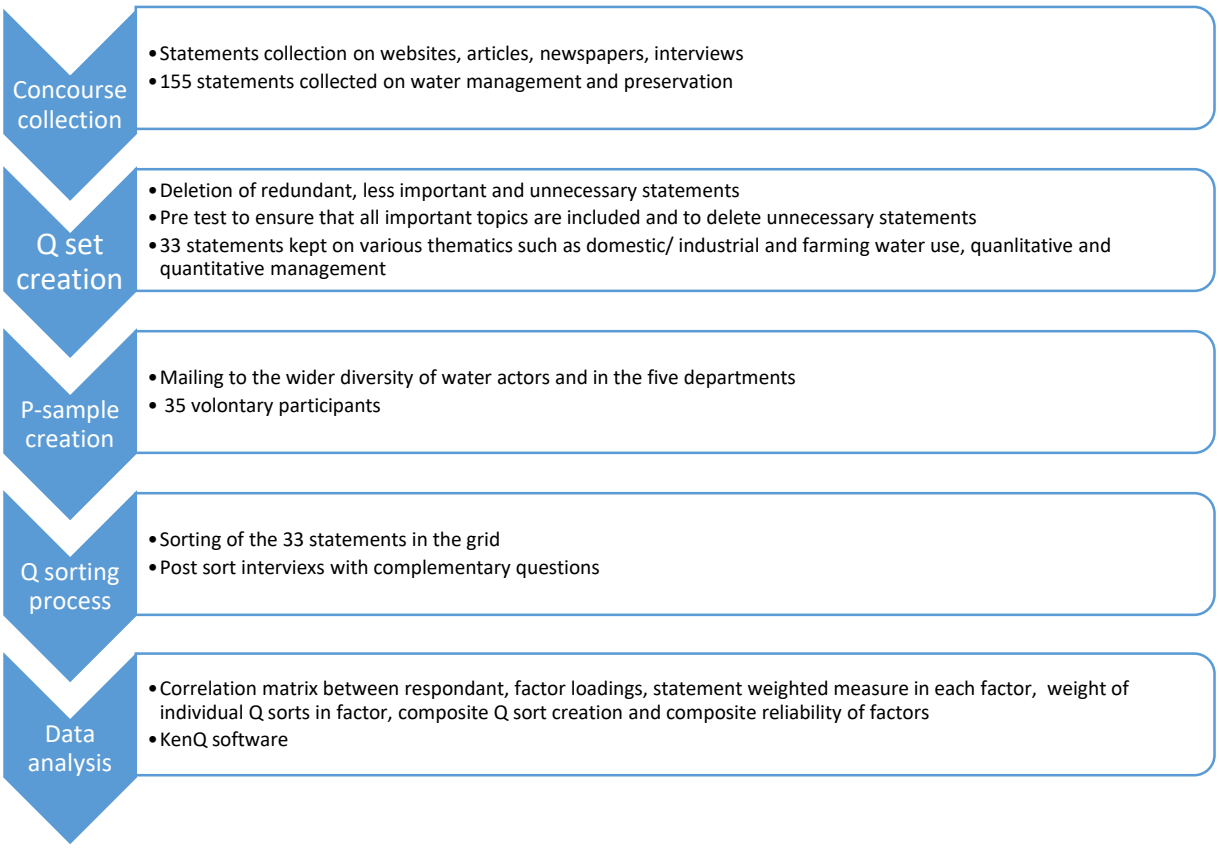


Figure 12: Scheme of the steps of the Q study