# *The Water Fresco Workshop: evaluating the impact of a teaching device on students' water-saving behaviors and their social-psychological factors*

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# *The Water Fresco Workshop: evaluating the impact of a teaching device on students' water-saving behaviors and their social-psychological factors*


## *Abstract:*

This article examines the extent to which a game-based educational program can influence students' water-saving behaviors and their underlying social-psychological factors. The research draws on the Water Fresco workshop, a participatory and game-based intervention conducted in France between 2025 and 2026 with postgraduate students from business schools. A quasi-longitudinal design is currently underway, with data collected before participation, immediately after, and six months later. This paper reports only the pre-test results, based on 210 valid responses analyzed using structural equation modeling. Findings from this preliminary stage show that personal norms and attitudes are strong predictors of water-saving behaviors, while knowledge alone does not significantly affect concern, perceived control, or moral obligation. Social norms appear to reinforce personal norms but show limited direct influence on attitudes or behaviors. These results suggest that effective educational programs must go beyond raising awareness to foster moral engagement, social influence, and a sense of efficacy.



## *Keywords:*

Water conservation; Theory of Planned Behavior; Socio-psychological factors; Knowledge; Game-based educational program; Water Fresco.

## *Introduction*

Among the most pressing sustainability challenges, water conservation stands at the forefront. Not only has the demand for water been steadily increasing in recent years (UNESCO, 2022), but its quality and availability are also deteriorating, endangering many ecosystems and generating strong tensions between populations (Abbott et al., 2019). Tomorrow's solutions for preserving water resources will depend not only on scientific and technological innovations, but also on shifts in how water is perceived and consumed (Haeffner et al., 2023). In this regard, the UNDP emphasizes that awareness raising, and education can play a key role in "*promoting sustainable practices*" and "*significantly increasing the rational use of water resources*". However, only a handful of studies have focused on pedagogical interventions. For example, de Kraker et al. (2021) showed that a serious multiplayer game enhanced water knowledge and awareness among populations with already strong developed knowledge of water-related issues (professionals, scientists and/or MSc students). More recently, Bilancini et al. (2023) evaluated the impact of a board game-based education program to promote sustainable water use among primary school children. The findings of the study highlighted an increase in sustainable water practices among the children following participation in the program. These works, relatively isolated within the existing literature, open up interesting perspectives, but also call for a broader investigation. The question of what Water-Saving Behaviors (WSB) are adopted, and through which socio-psychological factors, remains largely unanswered. Consequently, two research questions have been formulated to guide our efforts: "*What are the social-psychological driving factors of students' water-saving behaviors?*" (RQ1) and "*To what extent does a game-based education program influence students' water-saving behaviors and their social-psychological factors?*" (RQ2).

To address these two research questions, this ongoing research draws on a game-based education program. Named Water Fresco workshop, the program aims to raise awareness of water-related issues and promote sustainable water use. The target of the program is postgraduate students from various educational institutions (Public and private Business Schools, Engineering Schools, Agri-food Schools, etc.). A questionnaire will be administered to these students on three occasions: prior to their participation in the Water Fresco workshop (T0), immediately after the completion of the program (T1), and six months later (T2). Using structural equation modeling (SEM), a theoretical model will be thus tested. This theoretical model will investigate, first, the influence of several socio-psychological factors, namely water knowledge, subjective norms, personal norms, water concerns, attitude and perceived behavioral control, on students' intention and water-saving behaviors (RQ1). Second, a statistical analysis will be conducted to assess the impact of the game-based education program over time (RQ2). This working paper reports the pre-test of the measurement model and the conceptual model. The final results are expected to provide insights for public policies, education professionals, and water stakeholders, encouraging them to develop educational programs that foster awareness and more sustainable water use.

## *2. Theoretical framework: extension of TPB with the inclusion of additional variables*

### *2.1. The theory of planned behavior (TPB)*

The TPB has been applied successfully to explanations of various saving behaviors related to environmental issues, including energy saving (Tan et al., 2023), reducing food waste (Chen, 2023), and water saving (Diaz et al., 2020; Yazdanpanah et al., 2014). In this theory, the model causal relations in which Attitude, Social Norms (SN), and Perceived Behavioral Control (PBC) jointly affect individuals' behavior (Ajzen, 1991). Attitude refers to the degree of a person's favorable/unfavorable evaluation or appraisal for performing a behavior. SN is the social pressure people perceive when they perform a specific behavior. PBC can be

thought of as the level of difficulty that people are aware of when performing a particular behavior or the extent to which an individual perceives this behavior to be under his/her volitional control.
Over time, researchers have argued that TPB is a flexible model, allowing the integration of additional predictors to better explain specific behaviors (Fielding et al., 2008). Building on this perspective, the present study incorporates three additional constructs drawn from prior literature to enrich the understanding of water-saving behaviors.

### *2.2. Personal norms*

Personal Norms (PN) refer to an individual's internalized moral values or perceptions about what is morally right or wrong (Schwartz, 1977). If SN shape PN, these two constructs differs; the latter focusing on intrinsic beliefs and a moral obligation. Several existing studies have found that introducing PN to TPB can obtain a better explanation of intentions and subsequent behaviors (Roos and Hahn, 2019; Yang and Sato, 2025). For example, Yazdanpanah et al. (2016) and Oteng-Peprah et al. (2020) indicated that the inclusion of PN in the original TPB increased its predictive power and made it possible to better explain intention to adopt sustainable behaviors, particularly in domains that are morally charged, such as preservation of water resources. Similarly, Cauberghe et al. (2021) found that a feeling of moral obligation can deeply affect water conservation behaviors.

### *2.3. Water concerns*

Environmental concern refers to individuals' anxieties and perceptions regarding the adverse/hazardous consequences of human activities on the environment, such as pollution, biodiversity loss, and climate change (Fielding et al., 2008; Fielding and Hornsey, 2016). Some research has been particularly interested in the case of water and have found evidence supporting the connection between environmental concern and people's predispositions to perform water conservation activities (Cauberghe et al., 2021; Chen et al., 2023; Willis et al., 2011).

### *2.4. Water knowledge and education programs*

The relationship of knowledge with water conservation behaviors has also been acknowledged in existing literature. Prior research emphasizes that WK contributes to strengthening individuals' environmental attitudes (Hu et al., 2023) and behavioral intentions (Amaris et al., 2021; Hasan et al., 2024). Su et al. (2021) argued, for their part, that the WK indirectly affects WSB by acting on PN. Rosenberg Goldstein et al. (2024) have shown that the more knowledge about water, the greater the WC of consumers and the more inclined they are to adopt water conservation behaviors. Segev (2015) also highlights a link between Water Knowledge (WK) and Water Concerns (WC), as well as with individuals' PBC.

In view of the challenges of water resource sustainability, public policies regularly implement communication campaigns to encourage individuals to adopt water-saving and conservation behaviors (Li and Roy, 2021; Martínez-Espiñeira et al., 2014; Pérez-Urdiales and García-Valiñas, 2016). Nevertheless, Fielding et al. (2013) claimed that campaigns focusing on direct and/or specific targets are more likely to promote sustainable practices. In this perspectives, Rosenberg Goldstein et al., (2024) focuses on student population, and reported that water reuse educational videos to favorably change students' perceptions. de Kraker et al. (2021) and Bilancini et al. (2023) showed respectively that multi-player serious game and board game-based education program are effective methods for increasing students' WK and to promote WSB.
Drawing on these insights, the conceptual framework of this research (Appendix 1) proposes the following hypotheses:

- **H1:** Water knowledge is significantly and positively associated with personal norm (H1a), water concerns (H1b) and perceived behavioral control (H1c);
- **H2:** Water concerns are significantly and positively associated with attitude;
- **H3:** Personal norm is significantly and positively associated with attitude;
- **H4:** Social norm is significantly and positively associated with personal norm (H4a), attitude (H4b) and water conservation behaviors (H4c);
- **H5:** Perceived behavioral control is significantly and positively associated with personal norm (H5a), water concerns (H5b), attitude (H5c) and water conservation behaviors (H5d);
- **H6:** Attitude is significantly and positively associated with water conservation behaviors;
- **H7:** Teaching device is significantly and positively associated with water knowledge.

## *3. The game-based education program*

The Water Fresco is a structured, game-based educational workshop designed to raise awareness among young adults about the challenges of freshwater management in Western societies. Much like the BLUTUBE program described by Bilancini et al. (2023), the Water Fresco seeks not only to transmit knowledge but to elicit reflection and discussion by embedding learning in a participatory and game-like structure. In contrast to traditional water awareness and conservation campaigns, the Water Fresco leverages the power of peer interaction and cooperative problem-solving to foster critical thinking and collective responsibility (Appendix 2).

Developed and disseminated by the Eau'Dyssée association, this program engages participants in a 3-hour collaborative experience that combines scientific rigor with ludic interactions. Inspired by the format of the widely adopted "Climate Fresco" workshop, "Water Fresco" consists of 57 illustrated cards, divided into four sequential games that are played in small teams (4–8 participants) under the guidance of a facilitator. Each of the four stages explores a distinct thematic focus: the natural water cycle, the anthropogenic water cycle, human water uses, and the impacts of climate change on water resources. The progression through these stages enables participants to reconstruct a comprehensive and systemic understanding of water dynamics – from its natural circulation to the pressures exerted by human activity. The pedagogical content is grounded in authoritative scientific sources, notably the reports of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Development Programme (UNDP), ensuring the reliability and relevance of the information delivered.

## *4. Methodology*

### *4.1. Sample and data collection*

As part of this ongoing research, the workshop is delivered to postgraduate students across a range of higher education institutions in France: business, engineering, and agri-food schools. Just prior to their participation in the Water Fresco workshop, the postgraduate students are invited to answer an online questionnaire accessible via QR code (T0). Once the workshop is completed, a debriefing session is scheduled during which each participant completes the same questionnaire again (T1). In addition, a third round of data collection is conducted six months after the workshop (T2), allowing the evaluation of the program's medium-term effects. Data collection is currently underway through the sessions conducted during the 2025–2026 academic year. Therefore, this paper presents the results of preliminary research. Specifically, we pre-tested the measurement model and the conceptual model without including hypothesis 7. For this initial step, data were collected from October to January

2024. A total of 210 postgraduate students from a business school completed an online questionnaire.

*4.2. Measures*

The questionnaire consists of four parts. In the first section, respondents were asked about their WSB, namely their use of water-saving technologies and their sobriety behaviors. The second section measured actual knowledge. Following the methodological protocol implemented by Hu et al. (2023), we developed fifteen items, based on a "true or false" question, and fitted our context and targeted informants. The third section consists of items designed to measure the 5 latent variables: Attitude, Perceived Behavioral Control, Social Norm, Personal Norm and Water concern. Most items were used or adapted from the in-depth review of previously published literature and modified slightly or developed to fit Water Fresco workshop's content (Appendix 3). Variables from sections 1 and 3 have been measured with a five-point Likert response scale, ranging from "strongly disagree" = 1 to "strongly agree" = 5. Finally, the fourth section is the collection of sociodemographic information of respondents, including gender, age, educational level, and educational pathway. An attention checks and question for common method bias were added to the questionnaire to ensure that respondents read the questions carefully before answering them.

*4.3. Data analysis*

To analyze data, we use structural equation modeling to test our hypotheses (R 4.4.1, package lavaan). R open software was adopted for structural equation modeling analysis. This latter contains two basic components, including the measurement model and the structural model. The measurement model is a confirmatory factor analysis (CFA), which is used to examine and explore relationships between constructs and indicators. The structural model investigates the relationships between model constructs and examines the research hypotheses.

## *5. Results*

*5.1. Measurement model*

To assess the measurement model, we conducted confirmatory factor analysis (Anderson & Gerbing, 1988) with the lavaan package (Rosseel, 2012) and complied with the requirements of particular indices (Fornell and Larcker, 1981; Hair et al., 2018). Confirmatory factor analysis results revealed satisfactory goodness-of-fit indices. The measurement model fit indices are listed as follows, respectively: $\chi 2/df = 1.52$ (lower than 2.0); AGFI = .89 (higher than .85); GFI = .93 (exceed .90); IFI = .97 (exceed .90); CFI = .97 (higher than .90); TLI = .95 (exceed .90); RMSEA = .05 (below .06). We then assessed the psychometric properties of the measurement instruments. The reliability (i.e., Cronbach's $\alpha > 0.8$), convergent validity (i.e., average variance extracted [AVE] > 0.5) (Bagozzi and Yi, 1988), and discriminant validity (< 0.85; Henseler et al., 2015) were satisfactory.

*5.2. Structural model*

The structural model fit achieves satisfactory goodness-of-fit indices. The structural model fit indices are listed as follows, respectively: $\chi 2/df = 1.83$ (lower than 2.0); AGFI = .86 (higher than .85); GFI = .90 (exceed .90); IFI = .94 (exceed .90); CFI = .94 (higher than .90); TLI = .92 (exceed .90); RMSEA = .06 (below .08). The model explains 20% of the variance of the water conservation behaviors and 68% of the attitude. Water knowledge is not significantly associated with personal norm ($p > .05$), water concerns ($p > .05$) nor perceived behavioral control ($p > .05$), **we reject H1a, H1b and H1c**. Water concerns are significantly and positively associated with attitude ($b = .26$, $p < .01$), **we accept H2**. Personal norm is significantly and positively associated with attitude ($b = .60$, $p < .001$), **we accept H3**. Social norm is significantly and positively associated with personal norm ($b = .51$, $p < .001$), but not

with attitude ($p > .05$) nor water conservation behaviors ($p > .05$), **we accept H4a but we reject H4b and H4c**. Perceived behavioral control is significantly and positively associated with personal norm ($b = .51$, $p < .001$) and water concerns ($b = .61$, $p < .001$), but not with attitude ($p > .05$) nor water conservation behaviors ($p > .05$), **we accept H5a and H5b, but we reject H5c and H5d**. Attitude is significantly and positively associated with water conservation behaviors ($b = .80$, $p < .01$), **we accept H6**. We do not test **H7** in that study. Appendix 4 presents result of the hypothesis tests.

### *6. Discussion and conclusion*

The growing urgency of global environmental challenges has made water conservation an issue of critical importance. This study sheds light on the socio-psychological mechanisms that drive water-saving behaviors among students, offering valuable insights for the design of educational and policy initiatives. Understanding these mechanisms is particularly relevant in the context of increasing water scarcity worldwide.

Our findings highlight some divergences from expectations based on prior literature. Contrary to studies such as Su et al. (2021), which suggested that water knowledge strongly influences personal norms, our analysis did not reveal significant associations between knowledge and personal norms, concerns, or perceived behavioral control. This outcome suggests that simply enhancing factual knowledge may be insufficient to create a sense of moral duty toward water conservation among students. Similarly, while previous research (Martínez-Espiñeira et al., 2014; Rosenberg Goldstein et al., 2024) reported that greater awareness increases environmental concern, our results did not confirm such a relationship. This points to a potential disconnect between cognitive understanding and the emotional or efficacy-based dimensions of behavior, highlighting the need for more engaging educational strategies that can translate information into personal norms and concern.

At the same time, the study reinforces the strong influence of personal norms and attitudes in shaping water-saving behaviors, echoing findings by Shahangian et al. (2021). Social norms were also found to affect personal norms, underscoring the role of social influence in internalizing values. Moreover, perceived behavioral control was significantly associated with both personal norms and water concerns, which emphasizes the importance of strengthening individuals' confidence in their ability to make a difference, an idea consistent with Ajzen's (1991) framework and further supported by García-Valiñas et al. (2023).

Several limitations must be acknowledged. First, the sample is relatively homogeneous, as it is composed exclusively of postgraduate students. Second, this work represents a pre-test stage and lacks longitudinal data, which prevents us from evaluating how attitudes and behaviors evolve over time under the sustained influence of educational interventions. Another limitation concerns perceived behavioral control: many students do not have autonomy over household water-related decisions, as they often live with their parents or in rented accommodations. This reduces their capacity to implement water-saving technologies even if they have the motivation and knowledge to do so. Future research could address these limitations by including a more diverse population, such as adult homeowners, who have greater agency in adopting water-efficient practices.

Additionally, given the prominent role of social norms and perceived behavioral control observed here, future work should explore different sources of social influence (peers, family, media) as well as strategies to enhance individuals' sense of control, for instance through access to affordable water-saving tools or community programs. These directions could strengthen the effectiveness of educational interventions like the *Water Fresco* workshop.

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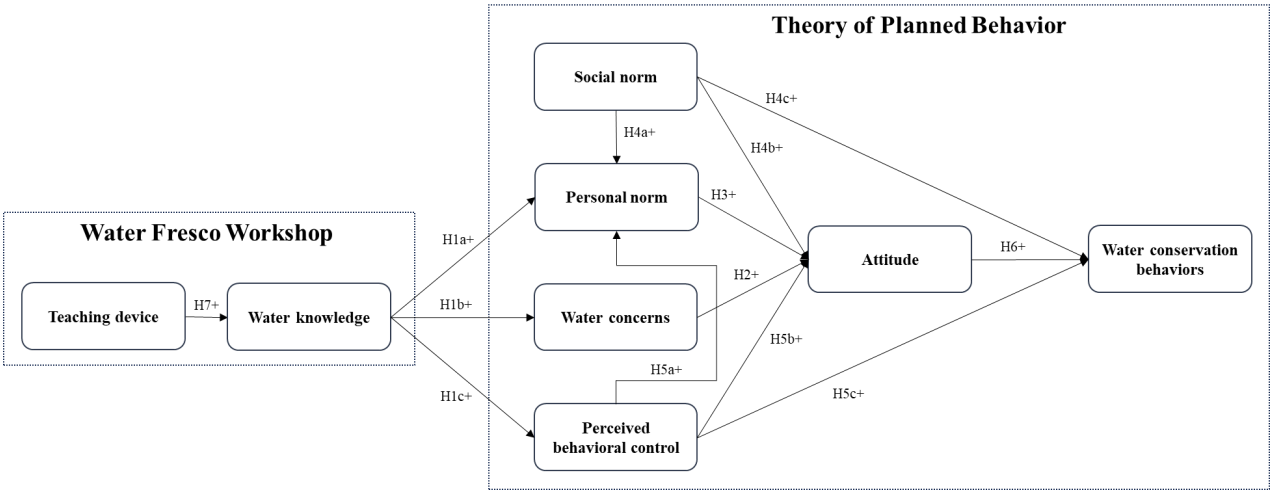
## *Appendix 1. The conceptual framework of the research*



## *Appendix 2. Description of Water Fresco workshop*

# La Fresque de l'Eau

L'atelier de la **Fresque de l'Eau** permet de construire une vision **globale** du cycle de l'eau, grâce à un jeu de cartes qui est mis en place par les joueurs selon 4 lots : le **cycle naturel** de l'eau, le cycle **anthropique** de l'eau (influencé par l'homme) ainsi que les **impacts de l'Homme** et **l'impact du changement climatique** sur ces cycles. Un échange permet ensuite de discuter des mesures **individuelles** et **collectives** qui peuvent être prises.

- Entre 8 et 16 participants
- Atelier de 3h
- Tout public, 15 ans et +
- En ligne ou en présentiel
- Français, Anglais, Espagnol, Chinois

EAU'DYSSÉE


***Appendix 3. Constructs, measurement items, and related references***

| Construct | Number of items | References | Items |
|---|---|---|---|
| Water-saving behaviors: | | | |
| - Use of water-saving technologies | 3 | Shahangian *et al.* (2021) | (5-point likert scale)<br>I use low-flow toilets in my home.<br>I use low-flow faucets in my home.<br>I use low-flow/smart shower heads in my home. |
| - Sobriety behaviors | 4 | | (5-point likert scale)<br>I prefer showering to bathing to wash myself.<br>While soaping up, I turn off the tap when I wash my hands.<br>While brushing my teeth, I turn off the water when soaping up.<br>I collect the water used for cooking to water the plants. |
| Water knowledge: | | | |
| - Quality | 5 | Hu *et al.* (2023) | *(True)* Runoff and infiltration of water can carry fertilizers and pesticides into waterways and aquifers.<br>*(True)* Treated wastewater can legally be discharged into drinking water sources.<br>*(False)* In France, 85% of waterways are in good or very good ecological condition, and 5% are in poor or poor condition.<br>*(False)* Pesticides are present in only 2% of groundwater and rivers. Agricultural regions, such as Brittany or the Paris basin, are particularly affected.<br>*(True)* 98% of the French population was supplied with water that constantly complied with the quality limits set by |

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| | | | | the regulations for microbiological parameters. |
| - | Risk | 5 | Hu *et al.* (2023) | *(False)* Vital to the survival of many living beings, fresh water represents 25% of the water on earth.<br><br>*(True)* Soil sealing increases the risk of water shortages.<br><br>*(False)* Seawater is less and less likely to rise up rivers and penetrate into groundwater.<br><br>*(True)* Excessive irrigation can lead to an accumulation of salts in soils, making them unproductive for cultivation.<br><br>*(True)* Among the human activities that consume water in France, electricity production is at the top of the activities that return the most water to its natural environment. Conversely, none (or almost none) of the water used for agriculture is returned. |
| - | Water-saving behaviors | 5 | Hu *et al.* (2023) | *(True)* To reduce water consumption, it is advisable to use a dishwasher rather than washing dishes by hand.<br><br>*(True)* The indirect consumption of water (e.g. food, clothing, transport, etc.) of a French person per day is more than 20 times higher than their direct consumption.<br><br>*(True)* In France, approximately 20% of water is lost in the network due to leaks.<br><br>*(False)* On average, it takes 30 liters of water to fill a bathtub.<br><br>*(False)* A garden with tall grass or covered with mulch requires more water consumption to be maintained. |
| Attitude | | 4 | (Ajzen, 1991; Lam, 1999; Shahangian et al., 2021; Yazdanpanah et | (5-point likert scale)<br><br>For me, adopting water conservation behaviors is very important. |

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| | | al., 2022, 2016, 2014) | I feel good, and I am satisfied when I adopt water conservation behaviors.<br>For me conserving water is very beneficial.<br>I think that conserving and/or saving water is very wise. |
| Personal norms | 4 | (Russell and Knoeri, 2020; Shahangian et al., 2021; Yazdanpanah et al., 2016, 2014) | (5-point likert scale)<br>I feel a moral obligation to conserve water, no matter what others do.<br>I feel guilty if I consume more water and/or did not conserve water.<br>Water conservation is my moral duty to the community and the environment in which I live.<br>Wasting water is against my moral principles. |
| Subjective norms | 4 | (Ajzen, 1991; Fielding et al., 2013; Lam, 1999; Russell and Knoeri, 2020; Shahangian et al., 2021; Yazdanpanah et al., 2016, 2014) | (5-point likert scale)<br>The people who are important to me (e.g., family, friends) would approve of me if I save/conserve water.<br>The people who are important to me (e.g., family, friends) believe that I should save/conserve water.<br>The people who are important to me (e.g., family, friends) expect me to save/conserve water.<br>My family and friends encourage me to conserve water. |
| Perceived behavioral control | 5 | (Ajzen, 1991; Fielding et al., 2013; Russell and Knoeri, 2020; Shahangian et al., 2021; Yazdanpanah et al., 2016, 2014) | (5-point likert scale)<br>For me, engaging in water saving and/or conservation activities is easy.<br>For me, engaging in water saving and/or conservation activities requires little effort.<br>If I wanted to, I could easily save and/or conserve water. |

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| | | | It is largely up to me whether I want to save and/or conserve water.<br>If I want to save and/or conserve water, it is possible for me. |
| Water concerns | 4 | (Cauberghe et al., 2021; Chen et al., 2023; Untaru et al., 2016; Willis et al., 2011) | I think water problems are very important.<br>I think water problems cannot be ignored.<br>Humans must live in harmony with nature and water in order to survive.<br>I think we should care about water problems. |
| Age | | | (Single choice question)<br>How old are you? |
| Gender | | | (Single choice question)<br>You are: |
| Degree | | | (Single choice question)<br>What year of study are you in: |
| Pathway | | | (Single choice question)<br>What is your pathway? |
| Household composition | | | (Single choice question)<br>How many people are there in your accommodation? |
| Type of accommodation | | | (Single choice question)<br>What type of accommodation do you live in? |
| Owner | | | (Single choice question)<br>Do you own your home? |
| Garden | | | (Single choice question)<br>Does your accommodation have a garden? |
| Location | | | (Single choice question)<br>In which regions do you reside? |

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| Size of the municipality | (Single choice question)<br>How big is the municipality you live in? |

## *Appendix 4. Results of the conceptual model*