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Water scarcity: regional analyses in the Czech Republic from 2014 to 2018

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Abstract

Research background: Water is a scarce natural resource essential for life and also many economic activities. Scarcity of drinking water is a problem that is ad-dressed at national and international levels. Global water demand continues to rise, but the quantity and quality of water resources is declining in many regions. Recent surveys of the population of the Czech Republic show that the most serious global problems are waste accumulation, water pollution, lack of drinking water and air pollution. Average temperatures continue to rise across Europe due to climate change and water is expected to become increasingly scarce in many areas. An adequate supply of good-quality water is a pre-requisite for economic and social development, and thus it is necessary to learn to save water and better manage our available resources in this area.
Purpose of the article: The purpose of this study was to investigate to what degree environmental problems — especially the issue of drinking water scarcity — have been evaluated in the Czech Republic from 2014 to 2018 and whether the fear of a lack of drinking water has motivated water conservation.
Methods: A regional analysis of water availability in the Czech Republic and the possible causes of water scarcity has been carried out. Subsequently, selected socio-economic factors that could have an impact on the assessment of drinking water scarcity are analyzed using Gamma and

Kendall's Tau and logistic regression. The analyzed time period is from 2014 to 2018. Microdata was taken from the Centre for Research of Public Opinion, and selected regional-level statistics from the Czech Statistical Office have been added to this data to supplement it.
Findings & Value added: The perception of drinking water shortages is not only influenced by indicators representing the volume and price of water in each region, but can also be determined by other socio-economic factors such as income, gender, age and education.

Introduction

Water scarcity is a very current topic in global fora dealing with sustainable development (Fang *et al.*, 2000). Water is an essential aspect of human wellbeing and plays a very important role in the area of economic growth. Water plays a fundamental role in food and sanitation, and therefore water can be claimed to be an irreplaceable commodity and a basic resource for economic activity (Hervás-Gámez & Delgano-Ramos, 2019).

Problems with water have local, regional, continental and global dimensions and these problems cause changes in water resources. This includes issues such as reduced availability, deterioration in the quality and quantity of water and subsequent impacts on human and public health (Tundisi, 2008).

Today, the world is facing a water crisis, and problems with drinking water are expected to increase in the future. The escalating world population has led to an increase in water demand in municipal and drinking water and also the agricultural and industrial sectors. However, not only the escalating world population leads to water problems (Davijani *et al.*, 2016). There are many factors affecting the quantity and quality of water. There are also important factors affecting water scarcity, such as economic development and dietary shifts (i.e. increasing production of animal products), which have resulted in an ever-increasing water demand that has consequently put pressure on water resources (Liu *et al.*, 2017). Shrinking water resources and the increasing trend of droughts and the serious damage they cause plays a strong role in intensifying the water crisis (Davijani *et al.*, 2016).

The problem of water scarcity is becoming not only an environmental, but also an economic and social issue. Water scarcity is a major global and multidisciplinary problem that needs to be addressed by many disciplines and from many perspectives. The need to deal with water scarcity should be seen in the broader social, economic and environmental context of the 21st century (Tundisi & Barbosa, 2008). Water scarcity problems are perhaps more widely discussed outside Europe's borders, but many problems can also be found within them (Fang *et al.*, 2000; Cole *et al.*, 2018).

In Europe, water scarcity and the problems caused by drought are a growing phenomenon. Europe is not an arid continent, but nearly half of the European Union's population is currently struggling with water problems. Water distribution is uneven in the European Union due to its varied geography and climate, and this situation is made worse by human activity. Since 1980, droughts in Europe have increased and become more serious. In addition to their environmental impacts, they are increasingly becoming an economic problem and are more and more relevant in discussions on the sustainability of the system. Droughts have cost an estimated 100 billion EUR over the past 30 years, and, as climate change is occurring, more water scarcity and drought-related problems can be expected in Europe in the future (European Commission, 2010).

The Czech Republic also has problems with water scarcity and droughts. This research paper focuses on the issue of water scarcity in the Czech Republic and is devoted to the regional analysis of this problem from 2014 to 2018. This paper begins with a brief overview of selected research and strategic documents on the topic of water scarcity, with an emphasis on problems in the European Union and especially in the Czech Republic. Subsequently, methodology and data collection are described and the results of the empirical study are presented and discussed. At the end of the paper, the authors list the conclusions of research and some suggestions for possible future research in this field.

Literature review

There are many facts surrounding water scarcity in the European Union, and the most important ones can be listed as follows: “Water scarcity is an increasingly frequent and worrying phenomenon that affects at least 11% of the European population and 17% of EU territory. One of the worst droughts occurred in 2003, when one-third of EU territory and over 100 million people were affected. Between 1976 and 2006, the number of people and areas hit by drought rose by almost 20 %, and the yearly average cost has quadrupled. The demand for water continues to rise across Europe, putting a strain on our resources. It is estimated that some 20–40 % of Europe’s available water is being wasted (leakages in the supply system, no water saving technologies installed, too much unnecessary irrigation, dripping taps etc.). In a ‘business as usual’ scenario, water consumption by the public, industry and agriculture would increase by 16 % by 2030” (European Commission, 2010).

In Europe, droughts and water scarcity are a very large problem, primarily in the south of Europe, as this part of the continent is very prone to drought and suffers great economic damages as a result of it. In other parts of Europe, drought is generally not recognized as a major problem, but this does not indicate that everything in this environmental area lacks negative consequences. For example, there are also problems with flooding (Bressers *et al.*, 2016). Drought may not be as visible as flooding, but this does not mean that droughts in other parts of Europe are not a problem. For example, heat and drought in the summer of the year 2003 caused tens of thousands of lives to be lost in Europe and had financial consequences of 13 billion EUR (Cogeca, 2003).

There are many various approaches which are used in the EU to preserve Europe’s water. Primary tools for water conservation in the EU include legislation, market instruments, monitoring, research and awareness activities concerning this great problem (European Commission, 2010).

In the light of the fact that water scarcity and droughts will inevitably become more important as a result of climate change, it will be necessary to solve these problems in some way. The primary role here will be played by water governance. According to some specialists in the water management field, the water crisis in the 21st century is much more related to management than to a real crisis of scarcity and stress (Rogers *et al*., 2006). Water management, including drought management, consists of different factors in the area of water. Water governance is a very important factor in public policy, because water is a complex and highly interconnected system that affects many disciplines, such as agriculture, economic development, social development, ecology and health (Lubell & Edelenbos, 2013). There are many different subjects with different interests in the issue of drought and water scarcity, and it is very difficult to solve problems related to this topic (Leach & Pelkey, 2001).

From the perspective of legislative framework, a very important document dealing with the problem of water scarcity in the EU is the “Water Framework Directive”, which was introduced by the European Union in 2000. It is the most ambitious and comprehensive document of EU legislation ever approved in water policy. In 2007, the EU put forward its “Communication addressing the challenge of water scarcity and droughts”. In it, the EU defines policy initiatives that should move towards a water-efficient and water-saving economy. Each year, a report is presented on annual progress towards the implementation of the set orientations. The next important step from the EU is a water policy based on the principle of a “water hierarchy”. Member states of the European Union must focus on prevention in dealing with the threat of drought and water scarcity. The EU needs consolidated data and drought indicators. The next strategy policy on the level of the EU is the “Blueprint”, which outlines actions that concentrate on better implementation of current water legislation, integration of water policy objectives into other policies, and filling the gaps as regards water quantity and efficiency. The objective is to ensure that a sufficient quantity of good-quality water is available for people's needs, the economy and the environment throughout the EU (European Commission, 2010). The “Water Blueprint for Europe to safeguard Europe’s water resources sets out to strengthen and fill the gaps in the EU water policy, so as to make a real impact right across Europe” (European Commission, 2012).

As a member of the European Union, the Czech Republic must accept and implement the legislation of the European Union in its strategic documents in the field of environmental management. The Ministry of the Environment of the Czech Republic is taking very important steps in response to climate change. Adaptation to climate change is dealt with on the national level by the Strategy for the Adaptation to Climate Change in the Czech Republic (hereinafter referred to as the "Adaptation Strategy of the Czech Republic”. The aim of the Czech Republic’s Adaptation Strategy is to mitigate the impacts of climate change by adapting to it as much as possible, preserving well-being and preserving and possibly improving the economic potential for future generations. The Czech Republic’s adaptation strategy identifies priority areas (sectors) where the greatest impacts of climate change are expected. The Implementation Document of the Adaptation Strategy of the Czech Republic is the National Action Plan for Adaptation to Climate Change. The action plan contains a list of adaptation measures and tasks, including responsibility for implementation, deadlines, identification of relevant sources of funding and an estimate of the costs of implementing the measure. The Action Plan also includes setting up a climate change vulnerability assessment and adaptation system. The Action Plan was preceded by the elaboration of a Comprehensive Study of Impacts, Vulnerability and Risks Related to Climate Change in the Czech Republic, which assessed the likely impacts in individual areas of interest/sectors, including cost analysis (financial impacts) in case of inactivity. In 2017, the first assessment of the Czech Republic’s vulnerability to climate change was carried out, which makes it possible to better identify the potential of threats arising from climate change (Ministry of Environment of the Czech Republic, 2017).

In the Czech Republic, the problem of drinking water supply is taken very seriously. This is also evidenced by the fact that the problem is a part of the “Strategic framework 2030” strategy created by the Czech Government. Water management infrastructure must reliably supply municipalities with clean drinking water and efficiently drain and treat wastewater, despite long-term deterioration in hydrological conditions. Together, the state, regions and local authorities must strengthen the resilience of cities and municipalities. Adaptation to extreme weather conditions requires better management of greenery, better interconnection of green areas and the spread of greenery in cities. Conserving drinking water — and water in general — will become increasingly important and become a normal part of life. Planning must support the increase of the infiltration area, measures to capture and use rainwater, revitalize watercourses, even in cities, and increase the amount of water in public space. Such solutions must include gaining a fair influence on decisions on the use of water resources and not only over infrastructure control (Government of the Czech Republic, 2017).

Water scarcity in the countryside has been caused by a handful of reasons and the path to finding a solution is long-term and difficult. Main factors affecting local limnic ecosystems and local hydrologic cycles in past decades include the following: draining of wetlands, conversion of natural water courses into straight manmade channels, and the intensification of agriculture connected with intensive (and often excessive) land draining and massive pesticide application (Fučík *et al.,* 2015; Zajíček *et al.,* 2018). Another factor decreasing accessibility of high-quality water are point pollution sources such as industrial area outlets and communal pollution. Systematic agricultural drainage systems represent the main source of nitrates and some forms of phosphorus as the main biogenous elements (Martínková *et al.,* 2018), and also pesticides and their residuals (Zajíček *et al.,* 2018). The dynamics of drainage runoff and consequently changes of pollutant concentrations and loads are often driven by rainfall-runoff events. During these events, drainage runoff could consist of a large portion of event water, which rapidly infiltrates through polluted topsoil by preferential pathways, and bring this pollution into drainage water (Zajíček *et al.,* 2016; Fučík *et al.,* 2017). Recently, with changes in precipitation distribution during the season, rainfall-runoff events have become an important component of the total runoff. This situation leads to further deterioration of surface water quality.

Research methodology and data collection

The purpose of this study was to investigate to what degree environmental problems — especially the issue of drinking water scarcity — have been evaluated in the Czech Republic from 2014 to 2018 and whether the fear of a lack of drinking water has motivated water conservation. In the empirical section, data provided by the Centre for Research of Public Opinion was used, specifically microdata from questionnaire surveys (CVVM). CVVMs are conducted each year in May and 5,112 completed questionnaires were collected during the analysed 5-year period. This microdata was also supplemented with selected statistics at the regional level provided by the Czech Statistical Office (CZSO).

In the first step, an investigation was carried out into which environmental threats are considered by the Czech population to be the most serious and how these preferences have changed over time. CVVM questionnaires in 2014 and 2018 were used, and a total of 11 global problems were identified: forest loss; drinking water pollution and waste accumulation; operation of nuclear power plants; soil pollution; species decline; global warming; lack of drinking water; depletion of raw material resources; overpopulation; and cultivation of genetically modified food.

In the second step, statistical indicators from CZSO were evaluated. These indicators may indicate the scarcity of drinking water in regions (NUTS3). Factors that could influence the perception of water scarcity and willingness to conserve water in the region are important for this analysis. It can be assumed that residents will perceive water scarcity in their region in terms of its price, the amount of rainfall, the amount of supply and its availability, or the density of the water supply network. It would be useful to include the level of water pollution in the regions, but such data were not unfortunately available in sufficient detail. Four indicators were selected for this analysis: *w_price*; *rainfall*; *w_supply*; *w_conduit*. With these control factors, the amount of variance that was explained by regional level differences in the availability of water can be assessed. Based on these indicators, the indicator *CR2030* was constructed to identify regions at potential risk of drinking water shortages.

Furthermore, a central question was chosen to assess population preferences: How serious of a problem do you consider water scarcity to be? (Q1) and question (Q2): Do you conserve water for environmental reasons? (Q2). Using Gamma and Kendall's Tau for correlation between Q1–Q2 and logistic regression (eq. 1 and eq. 2), the hypothesis concerning whether the fear of lack of drinking water increases the willingness to save water was tested. Thus, finally, an econometric model was estimated to determine how selected socio-economic factors had an impact on the perception of drinking water scarcity and on saving water. The equations of the econometric model are as follows:

$$\mathrm{P}\left(Q_{it}^{1} = 1 \middle| \mathrm{X}\right) = \alpha + \beta_1 year_t + \beta_2 w\_price_{rt} + \beta_3 rainfall_{rt} + \beta_4 w\_supply_{rt} + \beta_5 w\_conduit_{rt} + \beta_6 CR2030_{rt} + \beta_7 children_{it} + \beta_8 married_{it} + \beta_9 gender_{it} + \beta_{10} income_{it} + \beta_{11} EA_{it} + \beta_{12} age_{it} + \beta_{13} edu_{it} + \beta_{14} politics_{it} + \mu_{it} \quad (1)$$

$$\mathrm{P}\left(Q_{it}^{2} = 1 \middle| \mathrm{X}\right) = \alpha + \beta_1 year_t + \beta_2 w\_price_{rt} + \beta_3 rainfall_{rt} + \beta_4 w\_supply_{rt} + \beta_5 w\_conduit_{rt} + \beta_6 CR2030_{rt} + \beta_7 children_{it} + \beta_8 married_{it} + \beta_9 gender_{it} + \beta_{10} income_{it} + \beta_{11} EA_{it} + \beta_{12} age_{it} + \beta_{13} edu_{it} + \beta_{14} politics_{it} + \mu_{it} \quad (2)$$

The index *t* represents the year in which the individual surveys were carried out (i.e. 2014–2018), the $year_t$ variable takes values from 1 to 5. The index $_r$ represents the regions (NUTS3); Index i represents each response; the total sample size (*n*) for eq. 1 is 2,494 and for eq. 2 is 2,989. Furthermore, μ_{it} stands for a random error component.

The model assumes that respondents' perceptions of drinking water scarcity were related to the current situation in the region (variables 3–6). An overview and description of the individual variables from the equations (eq. 1 and eq. 2) is given below (see Table 1).

As mentioned above, 5,112 completed questionnaires were obtained, but the final dataset for estimating the econometric equation had a smaller number of observations, which was due to the occurrence of missing values. The largest number of missing values occurred in the case of Q1; the questions on the evaluation of 11 global problems were missing in 2017, and therefore 1,084 observations had to be omitted from Model 1. For most variables the share of missing values did not exceed 2.5%. For the variable *politics*, the missing values were 9%; for the variable *income*, it was up to 36%. It can be assumed that although the questionnaire is anonymous, respondents have less willingness to disclose their income.

For 3 regional variables — *rainfall*, *w_supply* and *w_conduit* — it can be assumed that with increasing value the probability that the respondent will have concerns about drinking water scarcity will decrease. As *rainfall* increases, there will be less concern about drinking water scarcity, and residents in regions with a higher water supply and higher percentage of inhabitants supplied with tap water in the region will also feel relatively less worried. In turn, this decrease in concerns about the scarcity of drinking water is likely to reduce the incentive to save water. On the other hand, for variable *w_price*, it can be assumed that as the price increases, the fear of the lack of drinking water will increase as well as the increase in motivation to save. For the *CR2030* indicator, it is expected that residents in regions at higher risk of water scarcity will be more worried and likely to be motivated to save more.

In general, people with children can be more worried about the lack of drinking water, as they may be worried about the future generation. Similarly, married people can be expected to feel more worried about their partners. In the case of gender, theoretically there is an uncertain dependence, but it may be possible that women are more sensitive and may have higher probability for concerns and motivation to save water. For variables income and *EA*, it is likely that economically active people with higher incomes may feel less motivated to save water, which could also mean lower concerns about drinking water scarcity. On the other hand, respondents that are economically active and have higher incomes may have higher education; in turn, it is likely that people with higher education will be more aware of the ecological situation and may be more concerned about the lack of drinking water and be more motivated to save water. The last variable *politics* represents the political perception of the respondent; usually left-wing political parties are focused more on environmental issues, and therefore an increase in concerns about drinking water can be expected among those who support the left-wing political spectrum more than the right.

Results

At first, the environmental problems that the inhabitants of the Czech Republic consider to be the most serious were evaluated. Respondents were asked to answer 11 questions and could choose from 4 options: very serious; fairly severe; not very serious; no problem at all. The analysis showed that in 2014 the accumulation of waste was seen to be the most serious problem (% frequency of response very serious — 60.2% of respondents), the second most serious problem was scarcity of drinking water (58.4%), and the third was pollution of drinking water (56.2%). The questions with the smallest share of answers of "very serious" were those that pointed to the following three problems: nuclear energy (19.8%); genetically modified food (26.5%) and global warming (31.0%). The order of the most pressing global problems changed in 2018, when respondents placed three problems in the following order: scarcity of drinking water (63.7%), accumulation of waste (63.2%) and pollution of drinking water (56.3%). From these statistics, it is evident that Czech respondents perceived the lack of drinking water and water quality as a very serious problem. The order of the least serious problems remained unchanged in 2018. The frequency of answers of "very serious" for the rest of the questions remained nearly unchanged;

only for the question on nuclear energy did the frequency slightly decrease (from 19.8% to 17.8%).

From an overview of the regional statistics on drinking water shortages in the Czech Republic, we can see that the highest average *rainfall* compared to the long-term average was in the Ústí Region (106%) and Karlovy Vary Region (103%). On the contrary, the least precipitation was in the Hradec Králové Region (86%) and Pardubice Region (89%); the average *rainfall* for the Czech Republic (96%) is smaller than the long-term average, which may lead to increasing concerns about water scarcity and lead to conserving water. The highest average consumption of water per capita was in Prague (0.08 m^3 per capita), followed by the Karlovy Vary Region (0.064 m^3 per capita), Moravian-Silesian Region (0.064 m^3 per capita) and Ústí Region (0.061 m3 per capita). In other regions, the consumption of water was around 0.05 m3 per capita.

The least urgent problem was identified in the Pilsen Region (48%), although less than 90% of inhabitants were supplied with tap water in this region and the average *rainfall* was below the long-term average (95%). These statistics suggest that the increasing fear of drinking water shortages does not always correspond to the values of indicators from CZSO, which has led to the addition of socio-economic variables into the econometric model. These factors may affect the perception of drinking water threats and willingness to save water. The regional overview of the possible threat of drinking water scarcity (CR2030 and CVVM) is listed below (see Figure 1).

It has been statistically tested whether there is a direct dependence between Q1 and Q2. Since Q1 and Q2 are ordinal variables, Gamma and Kendall's Tau were calculated to capture the correlation between these variables, and then the dependence test was performed. An overview of the combination of responses is listed below (see Table 2).

Based on the results, it may be concluded that there is a statistically significant direct dependence between the variables (Gamma = 0.2882; ASE = 0.049; Kendall's Tau-b = 0.0901; p-value = 0.0000). Therefore, it might be assumed that, with growing concern over the scarcity of drinking water, the willingness to conserve water increases, and this correlation may be reflected in the results of the regression analysis (the same +/- signs for the estimated coefficients). Two econometric models were estimated, logistic estimation was used, and results have been presented below (see Table 3).

The coefficient year from Table 3 shows whether the fear of scarcity of drinking water or the willingness to save water has changed over time. For Q1, the coefficient is positive ($\beta Q1 = 0.040$), which indicates that over time the fear of drinking water scarcity has increased; this also corresponds to the comparison between 2014 and 2018, when the proportion of respondents who viewed drinking water scarcity as very serious increased by 5.3 pp. For Q2, the coefficient is negative (βQ2 = -0.016). This indicated that the willingness to conserve water had declined over the years.

There was an expectation that an increasing *w_price* would increase fear of lack of drinking water and would also likely be a motivating factor for water conservation. Both coefficients are positive (βQ1 = 0.010; βQ2 = 0.039), which indicates the confirmation of our assumptions. For the coefficient *rainfall*, it has been expected that with increasing *rainfall*, the fear of lack of drinking water will decrease as well as the willingness to save water. Our assumption was supported by the results of both estimated coefficients (βQ1 = -0.030; βQ2 = -0.567). The variable *w_supply* reflects the supply and consumption of water in a given region. If there is a relatively high supply of water in the region, it can be assumed that there will be a decline in the fear of lack of drinking water as well as the level of willingness to save water. This assumption was also supported by the values of both estimated coefficients (βQ1 = -8.994; βQ2 = -9.175). For variable *w_conduit*, it is possible to assume a rather indirect dependence with Q1 — if the share of *w_conduit* increases, the fear of scarcity of drinking water should decrease and motivation for saving water may decrease as well. According to the results, the increasing proportion of inhabitants supplied with tap water in the region did not reduce concerns about the lack of drinking water (βQ1 = 0.633), but decreased the willingness to save water (βQ2 = -0.130). According to the *CR2030* variable, the regions were divided into three groups in accordance with the level of possible scarcity of drinking water. It can be assumed that if the level of scarcity increases, there will be an increase in concerns about the scarcity of drinking water and the rate of water saving will also increase. This assumption was supported only in the case of Q1 (βQ1 = 0.423).

The rest of the variables in the model are socio-economic factors. An increasing number of children (βQ1 = 0.059; βQ2 = 0.005) increased the fear of scarcity of drinking water and increased the willingness to save water; these results were similar for *education* (βQ1 = 0.223; βQ2 = 0.287), *age* (βQ1 = 0.094; βQ2 = 0.170) and *income* (βQ1 = 0.342; βQ2 = 0.013). Economically active people will be more concerned about drinking water scarcity and will save more than those who are economically inactive (βQ1 = 0.208; βQ2 = 0.198). Despite our assumption, married people were less often afraid of lack of drinking water, but on the contrary have a higher willingness to save water (βQ1 = -0.245; βQ2 = 0.114). People who have more left-wing political beliefs tend to be more worried about the lack of drinking water (βQ1 = 0.101) and, on the other hand, people who have more right-wing political beliefs tend to save water more (βQ2 = -0.066).

Both models M1 and M2 were statistically significant (p-value = 0.0001; p-value = 0.0000). The t-tests show that only some estimated coefficients were statistically significant, which could be due to a relatively high number of missing values. The next step was to omit the *income* variable and estimate the two models again, but the statistical significance of the coefficients did not improve. In addition, the *income* variable was statistically significant for the original M1 and M2, and thus the procedure omitting the *income* variable did not seem appropriate. In order to improve the estimates, it would probably be appropriate to obtain a complete time series and eliminate the occurrence of missing values.

Discussion

Although the Czech Republic is not among the most vulnerable countries in terms of the lack of drinking water (WHO, 2017), the Czech population considered this problem to be one of the greatest global threats. This is consistent with the assumption of some studies that without improved water resource management, water shortages are predicted to affect two–thirds of humanity by 2025 (Kemp, 2012). On the other hand, finding new water resources and managing water scarcity can enhance the economy and social development (Hallowes *et al*., 2018; Garcia *et al*., 2015). It turns out that Czech citizens with higher concerns about the lack of drinking water had a higher willingness to conserve water. However, it can be assumed that a higher rate of water conservation (i.e. overall conservation of water across the population) may then reduce the fear of drinking water scarcity. This may be supported by the study from Garcia–Cuerva *et al*. (2016), which was performed in the United States. The study found that a small percentage of the population was concerned about water shortages, but the majority of the population practiced some level of water conservation, and a substantial percentage of the population supported the use of reclaimed water. Responsible behavior with water consumption might be positively influenced by social awareness about water consumption, i.e. knowledge about e.g. the Water Footprint Indicator or information about the nexus between urban services and water uses (Zhuo *et al*., 2016; Gómez–Llanos *et al*., 2020). Implementing European Union environmental law in the new member states in the area of the Urban Waste Water Treatment Directive is also intended to contribute to better water management and the prevention of water scarcity; however, it appears that administrative shortcomings in the

Czech Republic and Poland have problems that stem from the multilevel nature of the implementation process, which places heavy administrative and financial burdens on municipalities and requires cooperation between national and local government authorities (Marek *et al*., 2017). Increasing the willingness to conserve water and the perception of water scarcity is related not only to socio-economic factors (as mentioned in the Results section) and awareness of water scarcity in society, but also to the ability of countries and municipalities to implement measures to contribute to better water management.

Even though the research to date about the influence of socio-economic factors on the perception of water scarcity and water conservation has been contested (Buyukkamaci & Alkan, 2013; Gu *et al*., 2015; Garcia–Cuerva *et al*., 2016) and while some socio-demographic associations were proposed in the 1970s and 1980s, these assumptions may not be valid today (Marks, 2003; Garcia–Cuerva *et al*., 2016). Some studies go even further and show the important role of pre-cognitive affective reactions (Smith *et al*., 2018); however, such a research design goes beyond the aim of the study that has been defined here. The findings from the analytical section show that socio-economic factors such as income, gender, age or education may have influenced the perception of water scarcity and water conservation. These findings are consistent e.g. with Nauges and Thomas (2000) or Matos *et al*. (2014) that older people develop wider saving attitudes than younger people by taking fewer showers and laundering less frequently. The elderly are used to living in less comfortable conditions, and this may be the case in the Czech Republic, as the elderly are among those at the greatest risk of poverty and are probably more vulnerable to water price mechanisms. A direct relationship between the price of water and the willingness to conserve water was also observed in the results of logistic regression. Household dynamics may also influence water consumption and environmental impacts and social factors such as lower fertility rates may affect water consumption (Liu *et al*., 2003; Hummel & Lux, 2007). However, according to results from logistic regression, the influence of the number of children or marital status on the perception of water scarcity and water conservation was not indicated.

Conclusions

Water scarcity is a very current and important topic. Water is a basic element of all life on our planet. Therefore, water scarcity also naturally plays a major role in socio-economic development. Water resource management is crucial for changing wet and dry periods, which makes water an even more precious resource. Water scarcity is a rapidly growing global concern and for these reasons it is necessary to instate better water management and governance for water scarcity conditions (Liu *et al*., 2017; Mekonnen & Hoekstra, 2016; Kummu *et al*., 2010).

Problems such as water scarcity and problems caused by drought are growing phenomena that have many impacts on environmental, economic and social areas. There are many research studies and analyses that focus on problems of water scarcity, and we can find many strategic documents focusing on this area in the world and naturally also on Europe and the Czech Republic. Some of these studies and approaches have been presented in this paper.

The purpose of this study was to investigate to what degree environmental problems — especially the issue of drinking water scarcity — have been evaluated in the Czech Republic from 2014 to 2018 and whether the fear of a lack of drinking water has motivated water conservation. The results showed that the problem of drinking water scarcity in the Czech Republic was assessed as the most serious problem in 2018, which led to a more detailed regional analysis. It has been found that if there is an increased concern about the lack of drinking water, the likelihood of water conservation increases, but the dependence is relatively weak (Gamma = 0.2882; ASE = 0.049; Kendall's Tau-b = 0.0901; p-value = 0.0000). The authors have highlighted some changes and other problems related to reporting in the realized surveys that led to the higher frequency of missing values of some variables. But, due to the sufficiently large sample size, this is expected to have a rather small effect on the estimated results.

Furthermore, it has been shown that the perception of drinking water shortages is not only influenced by indicators representing the volume and price of water in each region, but can also be determined by other socio-economic factors such as income, gender, age and education. Increasing the willingness to conserve water and the perception of water scarcity is related not only to socio-economic factors and awareness about water scarcity in society, but also to the ability of countries and municipalities to implement measures to contribute to better water management.

In the future, the analysis could be extended to include the issue of drinking water quality, as the respondents considered this problem to be the second most serious in 2018. Unfortunately, such regional data are not available in sufficient detail at present, and therefore it would be necessary to find an appropriate proxy variable for future research.

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Annex

Table 1. Variable and description

Variable	Description	Note	Source
Q1	Scarcity of drinking water	missing: year 2017	CVVM
Q2	Conservation of water for environmental reasons	2014–2018	
w_price	Average price per m3 of billed water in region	CZK/m3	
rainfall	Total rainfall in year (t-1) as a percentage of the long-term rainfall average in region	rainfall/long-term rainfall average	CZSO
w_supply	Production of drinking water per inhabitant in region	m3/inhabitant	
w_conduit	Percentage of inhabitants supplied with tap water in region	<0.9; (0.9–1); 1	
CR2030	Endangered region according to CR2030 and selected indicators	scores threat: 1–3	own based CZSO
children	Number of children	0;1;2;3 (and more)	
married	Marital status	married =1	
gender	Respondent's gender	female = 1	
income	Range of household income in thousands of CZK	< 17.5; (17.5–32.5); > 32.5	
EA	Economically active	if non EA=0	CVVM
age	Range of years	15–29; 30–44 45–59; 60+	
edu	Highest educational levels reached	elementary; secondary; university	
politics	Left–right political spectrum	right=1; center=2; left=3	

Source: own source based on the Institute of Sociology of the Czech Academy of Sciences (2014–2018), Czech Statistical Office (2014–2018).

Table 2. Crosstab Q1 and Q2

Q1/Q2	0	1	Total
0	224	178	402
1	1 449	2 084	3 533
Total	1 673	2 262	3 935

Source: own source based on the Institute of Sociology of the Czech Academy of Sciences (2014–2018).

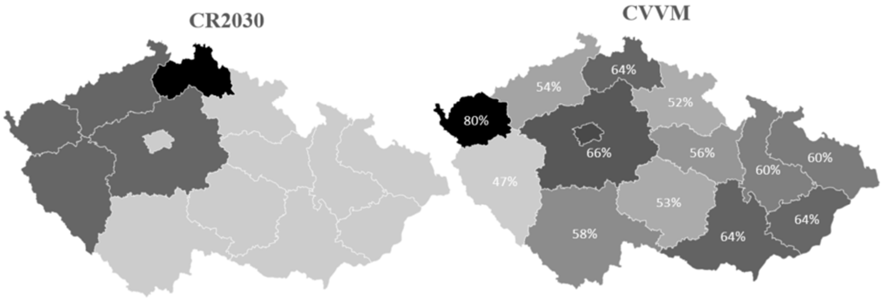
Table 3. Logistic regression results for Q1(Scarcity of drinking water) and Q2 (Conservation of water for environmental reasons)

	Model 1 [Q1]		Model 2 [Q2]	
	coef	**se**	**coef**	**se**
intercept	-80.691	108.611	32.002	60.518
year	0.040	0.054	-0.016	0.030
w_price	0.010	0.016	0.039***	0.010
rainfall	-0.030	0.511	-0.567*	0.304
w_supply	-8.994	9.843	-9.175	5.882
w_conduit	0.633***	0.199	-0.130	0.115
CR2030	0.423**	0.168	-0.094	0.086
children	0.059	0.096	0.005	0.053
married	-0.245	0.163	0.114	0.092
gender	0.258*	0.135	0.279***	0.076
income	0.342***	0.116	0.013	0.066
EA	0.208	0.162	0.198**	0.092
age	0.094	0.078	0.170***	0.045
edu	0.223*	0.127	0.287***	0.072
politics	0.101	0.094	-0.066	0.054
N		2 494		2 989
missing		year 2017		-
chi2		41.65		99.08
p-value		0.0001		0.0000

Note: .01 - ***; .05 - **; .1 - *;

Source: own source based on the Institute of Sociology of the Czech Academy of Sciences (2014–2018).

Figure 1. Regional indicator CR2030 and CVVM (average 2014–2018)



Source: own source based on the Institute of Sociology of the Czech Academy of Sciences (2014–2018), Czech Statistical Office (2014–2018).