

**Czech University of Life Sciences Prague**

**Faculty of Economics and Management**

**Department of Economics**



**Bachelor Thesis**

**Water scarcity**

**Andrea Hovorková**

## BACHELOR THESIS ASSIGNMENT

Andrea Hovorková

Business Administration

Thesis title

**Water Scarcity**

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### Objectives of thesis

Goal of this thesis is to provide comprehensive outlook on water scarcity issue, evaluate current international situation and compare disposition in different parts of the world. Aim is also assess solutions and possibilities for sustainable development especially in Africa and other parts of the world where is situation the most alarming. I will try to make a predictions for the future progress and I will conduct survey about peoples opinion to water scarcity issue.

### Methodology

In theoretical part i will focus on basic knowledge about water scarcity, water stress, water usage and water renewability and purgation. Methods that are used for theoretical part of thesis are extraction, synthesis, induction and deduction.

For practical part methods of analysis will be employed same as basic statistical methods as average, maximum, minimum, median and mode. In thesis I will also try to predict future evolution of situation.

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Dr. Randy White, Water Management: The Decision Making Process, Author House LLC, 2014

Josefina Maestu, Water Trading and Global Water Scarcity: International Experiences, RFF press, 2013

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Postel Sandra, The Last Oasis: Facing Water Scarcity, Earthscan publications limited, 1992

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## **Declaration**

I declare that I have worked on my bachelor thesis titled "Water scarcity" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 15.3.2017

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# Nedostatek vody

## Souhrn

Smyslem této práce je poskytnout ucelený přehled o globálním problému nedostatku vody, zjistit závislost nedostatku vody na různých faktorech, pokusit se předpovědět možný vývoj v příštích desetiletích a navrhnout možná řešení nedostatku vody. V dnešní době lidstvo čelí stále prohlubujícím se nedostatku vody, přitom právě díky vodě jsme schopni žít na této planetě. Voda je klíčová složka našich těl a člověk bez jejího přísunu většinou nepřežije ani týden. V některých částech světa, především v Africe, lidé trpí akutním nedostatkem pitné vody, což má často za následek šíření nebezpečných nemocí, nedostatek jídla a vede až k úmrtí. Přesto, že voda je základní životní potřeba, světová populace není schopna ji zajistit pro všechny, nebo alespoň zabránit nadměrnému plýtvání s vodou a jejího znečištění. O to hůře, že nedostatek vody se stává větším a větším problémem každý rok a v některých oblastech světa hrozí, že dojdou zásoby vody za méně než 20 let. Když se rozhlédneme kolem sebe, uvědomíme si, že voda stojí za výrobou téměř všeho co vidíme kolem sebe. Průmyslová výroba roste a lidstvo se obklopuje věcmi, produkty, které ani nepotřebuje. Zemědělská produkce, která nám všem zajišťuje přísun jídla, spotřebovává největší část ze zdrojů vody. Rychle rostoucí populace klade stále větší nároky na zemědělství a obyvatelé vyspělejších zemí orientují svůj jídelníček na plodiny a potraviny náročnější na spotřebu vody, proto jsou zdroje vody ještě více zatěžovány. Nesmíme opomenout, že vzhledem ke globalizaci, problémy jedné země nebo oblasti nezdědka ovlivňují dění v jiných zemích světa, a vzhledem ke globalizaci je světová ekonomika více než kdy jindy ohrožena nedostatkem vody. Globální nedostatek takto základního elementu může způsobit závažné problémy celému lidstvu a proto je nutné o problému otevřeně mluvit, hledat řešení a změnit naše myšlení a chování. Protože, až jednou voda dojde, co bude následovat?

**Klíčová slova:** voda, sucho, zavlažování, nedostatek vody, globální problém

# Water scarcity

## Summary

The purpose of this thesis is to provide a comprehensive outlook of a global water scarcity issue. Nowadays, humankind is facing to scarcity of what allows us to live on this planet- water. Water is the key element of our bodies, more than half of our bodies is formed from water. It is hard and sometimes impossible to survive a week without water and in some parts of the world, especially in Africa, thousands of people die every year due to lack of safe water. Even that water is so basic need, the world population is not able to ensure it for everybody or at least stop overusing and polluting of water and decrease water scarcity. What is the worst, water scarcity is deepening every year, and in some areas, threat of running out of water is so close as in twenty years. Furthermore, global water scarcity is a complex problem, which affects us in several ways. All stuff we see around us were produced with use of water. Industrial production is increasing and we surround ourselves with things we do not even need. The agricultural sector from which comes all of our food consumes the most of water and our lives are dependent to them. Today's population is growing fast and also is oriented to more water thirsty crops and food, so water resources are under strong pressure. Also several socio-economic problems are connected- wars and conflicts are more often and global economy is sensitive to that. Due to globalization, what happens in one continent influences all others. Global water scarcity is a serious issue and it is necessary to make sharp changes in our thinking and behavior. Because, when water runs out, what are we going to do?

**Keywords:** water, drought, scarcity, irrigation, water stress, global issue

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# 1 Introduction

In last hundreds of years, the population of our planet increased significantly. Before that, when only small groups of people existed, even they were hunters and gatherers, the environmental burden was minimal and there was almost no stress to water resources. Since the population started growing this fast, interventions to nature and environment are being more frequent, significant and exploitation of water resources exceeds the level of possible resurgence (Pereira, Cordery, Iacovides, 2009).

Population growth, climate change, aridity, drought, water pollution, water overuse, globalization and poor water management belongs to key causes of water scarcity and it can't be any longer ignored because the impacts of water scarcity are too serious and definitive influences population of the whole world.

The public is not informed enough about this problematic and that is why people do not show interest and efforts to change or improve the situation. The purpose of this work is to summarize, evaluate and make the issue of water scarcity more understandable. Also, the goal is to define key causation and impacts, dependencies to different factors, approach the public opinion in the Czech Republic and offer some possible solutions to this serious problem.

## **2 Objectives and Methodology**

### **2.1 Objectives**

The goal of this thesis is to provide the comprehensive outlook on water scarcity issue, evaluate the current international situation and compare disposition in different parts of the world. The aim is also to assess solutions and possibilities for sustainable development especially in Africa and other parts of the world where is the situation the most alarming.

I will try to make predictions for the future progress and I will conduct a survey about people opinion to water scarcity issue.

### **2.2 Methodology**

In the theoretical part, I will focus on basic knowledge about water scarcity, water stress, water usage and water renewability and purgation. Methods that are used for theoretical part of the thesis are extraction, synthesis, induction and deduction.

For practical part methods of analysis will be employed same as basic statistical methods as average, maximum, minimum, median and mode. In the thesis, I will also try to predict the future evolution of the situation.

## **3 Literature Review**

### **3.1 Types of Water**

According to place of water origin we can generally divide water types to atmospheric, surface and underground water and according to chemical composition we distinguish freshwater and saltwater.

#### **3.1.1 Atmospheric Water**

When water evaporates from the surface, water steam is cumulated in the atmosphere in clouds. With decrease of temperature under certain level, water steam is transformed to atmospheric water which falls back to the surface in form of precipitation. For example: fog, rain, hoarfrost, ice or snow, all of them belongs to atmospheric water. Earth has huge supplies of water from this origin in glaciers. The biggest and the most famous iced water reservoirs are located around Antarctica, on Iceland and in Argentina's Perito Moreno Glacier.

#### **3.1.2 Surface Water**

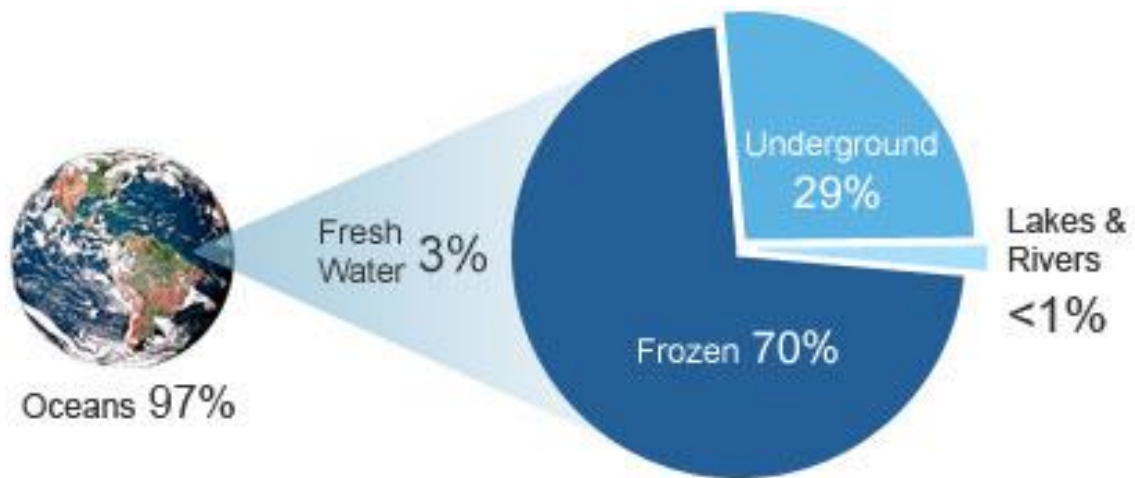
Rivers, lakes, ponds, wetlands, oceans and other water reservoirs located above the Earth's surface pertains to the category of surface water. These reservoirs are the easiest to access, so they create important water resource, but also the most endangered ones. Overuse of for example rivers is often a problem, same as water pollution. Surface water is used for producing electric energy, for irrigation in agriculture, for manufacturing of goods in industry and last but not least in supplying of municipals and settlements.

#### **3.1.3 Fresh Water**

In comparison, it is expected that only 2,5% of world's water is fresh water. This water contains only low or none amount of dissolved salts and other dissolved solids. The biggest part of fresh water is locked away in icebergs unavailable for human use, a big part is located under the ground as underground water and only a small part is kept in rivers, lakes and other surface reservoirs which are accessible to human use.

In the picture below, it is represented how water on Earth is distributed.

Figure 1: Distribution of water on Earth



Source: General Electric Company, 2016

## 3.2 Water Usage

While we realize that we use water at home, for bathing, cooking, cleaning, drinking, toilet flushing, gardening, swimming in pool and so on, we also use it indirectly- for manufacturing the most of the products we buy, for growing the food we eat, for producing electricity we use. Water is all around us and we use it every single day. It is expected that 69% of water supplies is used in agriculture, 19% in industry and last 12% is used in cities and households.

### 3.2.1 Water in Agriculture

It is known that the highest use of water is in agriculture. Since we started using irrigation to support agricultural yields, the water scarcity problem became very significant. Anyway, today's population is growing so fast, that without irrigation, the demand for food could not be satisfied. In developing countries the agricultural sector provides also the main source of income for the most of the people.

Huge amount of people is strongly dependent on water since it is not only necessary for life, but it is also directly connected to their source of income and needed for plating

their food. The uncertainty of water source do not allow people, who works in agriculture, fishery or similar sphere, to escape from poverty and risk of falling into destitution in case that rivers dry up and other water source are lost. (Molden, 2007)

Although we can say irrigation agriculture feeds the world, it is also source of huge water misuse, water waste and also water pollution. Currently, there is a big lack of water sources for irrigation because of water scarcity. Funding agencies and managers are continuously working on creating new solutions to help using water resources more efficiently, to improve irrigation in agriculture and to avoid negative impact of agriculture. They also want to increase yields and incomes of people working in agriculture. All at once, thanks to the progress in the field of economic management and engineering, there is a further focus to water use outside of an agriculture sector as in domestic consumption and sanitation and efforts to reduce water waste (Pereira, Cordery, Iacovides, 2009).

### 3.2.2 **Water in Industry**

Industry and companies are also consuming huge part of water supplies and *they even sometimes gets advantage* in using water resources ahead of agricultural and „common users“ purposes. An endangering fact is, that a big transnational companies, and not only them, are strongly overusing and abusing water resources to make profit, to the detriment of irrecoverable violation of hydrological cycle.

Maude Barlow and Tony Clarke shows in their book (2005) terrifying examples of it's impacts in factual parts of the world. "In the maquiladora zones of Mexico, for example, clean water is so scarce that babies and children drink Coca-Cola and Pepsi instead. During a drought crisis in northern Mexico in 1995, the government cut water supplies to local farmers while ensuring emergency supplies to the mostly foreign controlled industries of the region."

The situation will be in near future even worse in China, where the thread of water scarcity is alarming and which could influence global food security. Water scarcity initiate grain shortages so the level of China's demand for grain could be higher than it's available to import to China. What may not be so insolvable for China because of their strong economy, but that situation would cause higher grain price all over the world and that

would lead to social and political instability especially in countries of the third world and serious problems in global food security (Barlow, Clarke, 2005).

Maude Barlow and Tony Clarke (2005) alert about China's situation. "These shortages come at a time when China will see a population increase in the next 30 years greater than the entire population of the United States, when conservative estimates predict that annual industrial water use in China could grow from 52 billion tons to 269 billion tons in the same period, and when rising incomes are allowing millions of Chinese to install indoor plumbing with showers and flush toilets. The Worldwatch Institute predicts China will be the first country in the world that will have to literally restructure its economy to respond to water scarcity. "

### **3.3 Water resources**

#### **3.3.1 Groundwater**

Groundwater is significant water supply source for domestic, industrial and mostly agricultural use, especially in some parts of the world, because in some areas it can be the only water resource for long time period. Groundwater is important since it is stored under ground and provide supplies of water in case that no precipitation occurs and no other water resource is available and also deposits redundant water when high precipitation occurs. (Pereira, Cordery, Iacovides, 2009).

#### **3.3.2 Surface Water**

Speaking of surface water, we mean rivers, lakes, water reservoirs, waterfalls, icebergs and so on.

##### **3.3.2.1 Rivers**

Widely used resource of water are rivers. They are used for irrigation in agriculture, for manufacturing of products, for producing of electrical energy and we could continue with

this enumeration. In some cases, rivers may be overloading and that is where significant problem starts.

In some areas, water may be straightly taken from rivers to water supply system. In case that river stream stems high enough above inhabited areas, it is only required filtration and final disinfection of water. In other cases, the water from rivers must be treated, because without treating it would be huge health threat (World Health Organization, 2017).

### 3.3.2.2 Lakes

Another one of significant water resources are lakes. We can distinguish two types of lakes: artificial (with a dam) and natural. Water can be withdrawn from lakes for use, but before use it needs to be treated because of the pollution which would represent high possibility of some infection. In deep lakes, water is usually taken from 3-5 meters under the water level. In shallow lakes, water needs to be taken enough above bottom of the lake to prevent intake of dirt (n. d.). Retrieved from [http://www.who.int/water\\_sanitation\\_health/sanitation-waste/fs2\\_7.pdf?ua=1](http://www.who.int/water_sanitation_health/sanitation-waste/fs2_7.pdf?ua=1).

## 3.4 Water Scarcity

Water is definitely one of the most important and the most valuable resource on our planet. It is not coincidence that our planet is also called the “Blue planet”. It comes from the fact that around 70% of its surface is covered by water, which may sound strange in connection with water scarcity issue we have. The problem is, that only around 3% of total water supply is fresh water and even worse, 2% of it is inaccessible to us because it is in glaciers or differently remote, so we have available only about 1% of total water supply on our planet.

In their book (2009), Luis Santos Pereira, Ian Cordery and Iacovos Iacovides describe what is considered as water scarcity:

“Water scarcity is commonly defined as a situation when water availability in a country or in a region is below 1000 m<sup>3</sup>/person/year. However, many regions in



the world experience much more severe scarcity, living with less than 500 m<sup>3</sup>/person/year, which could be considered severe water scarcity. “

Postel Sandra (1992) supplement:

“In other words, water scarcity is the lack of clean water or insufficient supply of water to satisfy needs in given region. Although water is a renewable resource, it is also finite one.”

### **3.5 Types of Water Scarcity**

There are two types of water scarcity. We distinguish physical water scarcity and economic water scarcity.

When speaking about physical water scarcity, the lack is caused by the real “not having” enough water around and it can be caused by several reasons. Some of them are insufficient rain or extreme drought, but sometimes physical water scarcity can be man-made. An example of this is the Colorado river in the United States, where the water level is low because of overusing.

There are a lot of reasons of water scarcity, but we should not forget to mention policy failures and insufficient water management. Nowadays, countries and people as individuals overuse water. Countries consume more water than they have along with a rate of replenishment, which naturally has to lead to a huge ecological debt, which is inherited to next generations. The debt is deepening and water is more scarce also because of poor management and national accounting system. Pricing of water where the cost is underpriced or where the water is even for free makes easier to overuse water resources. Nice example could be Porsche cars: if Porsche cars come up to the market with give-away or extremely low price, there will be soon scarcity of them (Anton, Shelton, 2011).

Economic water scarcity is connected to insufficient investments to water infrastructure so that people have to even bring water from lakes and rivers, which are usually far from their home. Because of this, it is far more difficult to keep sanitation on a sufferable level and it is limiting for food production significantly.

Not only missing infrastructure is problem, also unequal distribution of water in a region is reason of water scarcity. For instance, Sub-Saharan Africa is an obvious example

of economic water scarcity, where development of sufficient infrastructure could decrease poverty in whole region (Molden, 2007).

### **3.6 Causes of Water Scarcity**

Scarcity of water could come from several reasons. It can be caused by natural occasion, by human infliction or could be combination of both causes (Pereira, Cordery, Iacovides, 2009).

#### **3.6.1 Population Growth**

Population size is expected to grow to 9 billion in 2050, that is why population growth is one of key causes of water scarcity. With the population growth are also connected other factors as change of dietary manners to more water-thirsty food, globalization, urbanization, higher power consumptions, biofuel crops planting to the detriment of food crops and others. Population growth rate is different in each part of the world, but paradoxically, population grow the fastest in countries with low water supplies, especially in developing countries.

J.A.A. Jones explains in his book (2010) how unsymmetric population growth is:

“The change in the geographical distribution of populations since middle-twentieth century is illustrated by the growth in Arab world. In 1950, the US population stood at 160 million, while Arab had a total population of just 60 million, almost equivalent to population of the UK in 2010. By 2000, the US stood at 284 million, but the Arab world had increased to over 240 million. From 2010 onwards, the Arab world is predicted to overtake America, possibly raising to 650 million by 2050 against America’s 400 million. Over the next 25 years, the population in Middle East is projected to double- the fastest growth rate outside the Africa.”

Growth of population straightly depends on developing and extending of urban areas which insure more working places and more stable environment for families. The

bigger population is, the higher stress occurs to water resources and infrastructure and threads areas with water scarcity. While population is constantly growing, the problem is going to be only bigger in the future (Pereira, Cordery, Iacovides, 2009).

### 3.6.2 **Climate Change**

Another source of water scarcity is climate change which is very likely caused by human actions.

Whole global trade is tapped to climate change which causes water scarcity. This is a bigger problem than it may look like, because for producing food and products for global trade, the key is water source, which is used and in the same time, natural water cycle is interrupted. Interruption of natural water cycle may have strong negative consequences to global climate. In future, regional and international cooperation will have to take into account climate change impact on transboundary waters (Libhaber, Orozco-Jaramillo, 2012).

### 3.6.3 **Aridity**

Aridity is caused by natural long-term disequilibrium of water distribution caused by low annual precipitation which results from insufficient soil moisture. In regions with high aridity, precipitation is permanently low and in some regions it is not exception that no rainfall occurs for several months. Flora in these areas is in arid parts steppe or desert and in semiarid parts savannah or chaparral. Agriculture is very limited in arid areas because of insufficient irrigation, but there is some chance for agriculture in semi arid regions with necessary condition of maximal and wise water use. To produce food, vegetable and crops in higher amount, it requires higher level of irrigation, which has been used for a hundreds years (Pereira, Cordery, Iacovides, 2009).

### 3.6.4 **Drought**

Drought can be described as unusually dry weather which persist for shorter or longer period and causes several problems as damage of crops, lack of water supplies and

dry out of soil. It can be caused by long term low precipitation and unusually high temperatures, so land and vegetation are dehydrated, but also it can be caused by human actions as overuse of water resources.

Actually, drought can be divided into four types:

- The first type is agricultural, when soil does not have enough moisture for planting.
- The second type is hydrological, when water reservoirs, such as lakes, rivers and ponds reach critically low level of water.
- The third is meteorological when low precipitations and high temperature occurs.
- And the fourth is socioeconomics when there is lack of water for drinking and running settlements and municipalities.

### 3.6.5 Water Pollution

Water quality is closely connected to water pollution. Water is called polluted when there is outbalance of negative qualities above positive qualities. Quality of water is denoted by physical, biological and chemical characteristic of water. The physical characteristic cover temperature, clarity of water and similar. Biological characteristic cover impact, identify and existence of organism in water. Chemical water characteristic refers to presence of substances in water and definition whether they are organic or inorganic and if they are bounded or dispersed in water. Simply, polluted water is water which was damaged, contaminated or differently depreciated so it is no longer suitable for usage (Agarwal, 2009).

Important source of poor water quality of surface and groundwater are man actions which leads to water shortages and causes desertification. Degradation of water quality is caused by contaminating with salts, by unfiltered municipal and industrial waste water with toxics and heavy metals, which creates demand for new water resources. Because of that pollution and depreciation of water, water scarcity is becoming bigger. It is possible to prevent man made water pollution and sequential water scarcity by better water management which ensures purifying of waste water and treating of toxics and heavy metals, which is more likely possible with surface water. As in case of groundwater, if avoiding degradation takes long term actions, desertification process may appear. It may be even task for several generations to restore water quality in some areas and in extreme

cases, it could be impossible, which leads to necessity to push ahead efforts to protect water and avoid man-made water scarcity (Pereira, Cordery, Iacovides, 2009).

Maude Barlow and Tony Clarke noted in their book (2001):

“The world's waterways are also struggling with the full range of modern industrial toxic pollution problems. Ninety percent of the developing world's waste water is still discharged untreated into local rivers and streams. “

### 3.6.6 **Water Overuse**

According to accessible information, it appears that water overuse by common users does not belong between the main reasons of water scarcity, because the biggest problem is overusing for industrial and agricultural purposes.

Big transnational companies are overusing water resources to increase their profits at the expense of ecological damage and global consequences. Overdraft of water resources especially rivers is interrupting natural cycle and restoring of sources is too slow to balance demand.

"The Nile in Egypt, the Ganges in South Asia, the Yellow River in China, and the Colorado River in America are among the major rivers that are so dammed, diverted, or overtapped that little or no fresh water reaches its final destination for significant stretches of time," writes Sandra Postel (1992).

### 3.6.7 **Globalization**

Maude Barlow and Tony Clarke (2005) explains:

“Once recognized as a basic human right, water is now denied to huge numbers of the human family. Wise conservation of water cannot take place until the reality of inequality is confronted—and the reality of inequality cannot be confronted until the tenets of economic globalization are rejected.“

Globalization is considered as one of sources of water scarcity. Why, that is very well described by Maude Barlow and Tony Clarke in their book (2005):

Problem of globalization is seen by world's governments and corporations as necessary in order to possess one single market with economic freedom and universal rules which are often set up in interests of transnational companies. Power to decide about economical and political situations is ripped out of national governments and is given to big transnational companies which do not take into account ecological or global impacts of their action but only their profit. The world is becoming a place, where everything is for sale, even goods which was not considered as tradable in past., such as education, health, culture, genetic codes and seeds and even water and air. Things which was considered as collective goods are now being dispensed.

Due to globalization, differences between rich and poor are getting bigger. We can actually say, that 225 of the world richest people have a combined wealth which is similar to the annual income of half of humanity.

Disparity of level of incomes is seen in fact that the richer half of world's population utilize 86% of world's goods and services in comparison with poorer half of the world's population, which obtains only about 14% of them.

As Maude Barlow and Tony Clarke (2005) continues,

“The Washington-based Institute for Policy Studies reports that the top two hundred corporations are now so big that their total sales surpass the combined economies of 182 countries and they have almost twice the economic clout of the poorest four-fifths of humanity. Of the 100 largest economies in the world, 53 are now transnational corporations. “

Disparity of income level and conditions for living play the main role in water scarcity in countries of the Third World. It is the reason why in some areas, every second family owns a swimming pool and in others people die because of water and food scarcity.

Another substantial fact is again described by Maude Barlow and Tony Clarke (2005), and shows how serious problems humans are facing:

“Americans and Europeans spend substantially more every year on pet food, reports the United Nations, than the total money needed to provide basic health and nutrition for everyone in the world. Americans spend more money on cosmetics every year than the total amount needed to provide basic universal education. “

### **3.6.8 Poor Water Management**

In some countries, one of the reasons of water scarcity may be the distance to water resources. The problem is unequal distribution of water resources and insufficient management.

Even it may look like water crisis is caused primarily by the physical scarcity, the true is, that poor water resources management and low institutional participation takes a large part in origin of water crisis. Nowadays, in the most parts of the world, issues with water are not really about scarcity of water, but about incorrect water management and inefficient use of water resources, which could however lead to serious water scarcity in near future. Due to this, already around 1 billion people do not have access to safe water resource which would not threaten their lives and around 2,5 billion people can not keep proper sanitation (Libhaber, Orozco-Jaramillo, 2012).

## **3.7 Issues Connected to Water Scarcity**

### **3.7.1 Desertification**

As it has already been mentioned, water scarcity is often cause of desertification. Permanent lack of water in cooperation with man made degradation of soil, inappropriate use of land and water resources, higher soil salinity and other factors can lead to damages of local ecosystem and to process of desertification. Climate change and long term drought also takes part in this process, especially in arid, semi-arid and sub-humid climates (Pereira, Cordery, Iacovides, 2009).

Desertification is dangerous especially because people and animals in certain? region are impoverished of land to use for crop planting, animals loos their source of food and shelter and whole ecosystem is disrupted. Desertification is often a result of one another human action- deforestation.

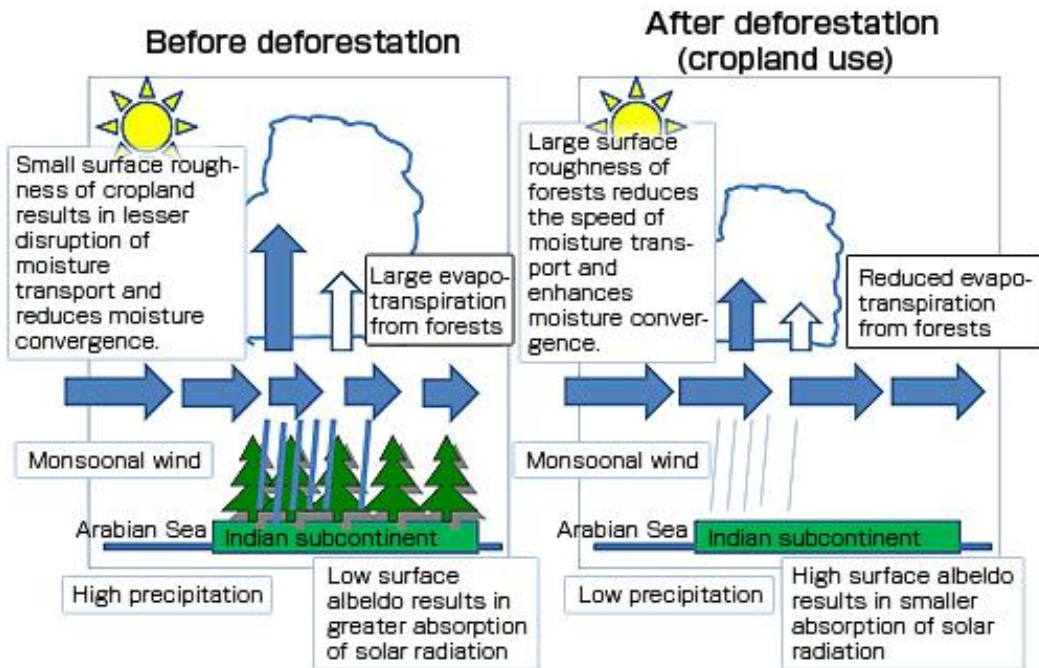
### 3.7.2 Deforestation

Richard Spilsbury (2012) describes deforestation as “clearing forests or woodlands to access resources such as timber and space for other activities including farming. “

Deforestation is connected to water scarcity because it influences, in better word harms, natural hydrologic cycle and cause water imbalance. Without forests, water, which falls on surface in form of precipitation, is not kept between vegetation and is not available for animals and other users, but is absorbed into the soil. Also, water is not evaporated to atmosphere in the same amount because without trees, important process called evapotranspiration, which means evaporation from plants leaves and other parts, is not involved.

In the picture below, it is explained how deforestation affects the hydrologic cycle.

Figure 2: Effects of deforestation



Sources: Jamsec, 2016



### 3.7.3 Diseases

Lack of water is the main precondition of spreading water born diseases. In regions with lack of water and insufficient sanitation, people are forced to use untreated and unsafe water which is often enriched of bacteria and other pathogenic microorganisms. Lack of sanitation cause transmission of infection from hands to mouth and also simple contact with infected water result in serious disease. Low education and ignorance of hygiene assist to spreading of diseases.

In countries of Asia, Africa and Latin America where contamination of water resources by waste coming from consumer societies is increasing, people are more threat by diseases as cholera or E. coli bacteria. In the Third World cities, local governments are unable to guarantee harmless water supplies and proper water treatment, not even basic treatment by chlorine. In these locations, people were used to solve problems with polluted water by using underground water from aquifers, but nowadays chemicals and other dangerous waste made underground water in many cases also unsafe or dangerous (Barlow, Clarke, 2005). Sandra Postel (1992) consider as one of the worst water born diseases dangerous bilharzia. Symptoms of bilharzia are blood losses and in further stage serious defects of vital organs as the liver, lungs, bladder and nervous system. It is spread widely in Africa, the Middle East and South America and access to save and clear water supplies could significantly decrease occurrence of this deadly disease.

### 3.7.4 Food Scarcity

Maude Barlow and Tony Clarke explains in their book (2005), that “irrigation for crop production claims 65 percent of all water used by humans, compared to 25 percent for industry and 10 percent for households and municipalities.”

Because the irrigation is essential in agriculture, water scarcity causes significant food scarcity. Insufficient water resources preclude planting of good quality crops and amount is then deficient in order to satisfy demand. With population growth, pressures to food supply and with that connected water supply are increasing and humanity will face still bigger problems with food scarcity.

### **3.8 Evaporation and Evapotransmission**

Evaporation is described as change of water state from liquid to gaseous vapors which ascend into the atmosphere. Water is evaporated from lakes, rivers, oceans and other water reservoirs, but the biggest part is evaporated right from the oceans because they take the largest part on the Earth's surface. In comparison, sublimation is when something solid change to gas, example of that is ice, and transpiration is change from liquid to gas but because of plant respiration, and water gets to the atmosphere as gas from leaves of plant. We can say that hydrologic cycle starts when sun directly or indirectly provides energy to change state of water. Indirectly by warming up of earth surface, the air, the water, the soil, and directly by radiant energy. That means, that hydrologic cycle, same as life on the Earth, is dependent on a sun (Thomson, 1999).

Condition for evaporation is water availability, and for evapotranspiration the condition is moisture soil and capacity of plants. Large amount of water which falls on the surface is returned into the atmosphere by evaporation or thanks to evapotranspiration from plants (Pereira, Cordery, Iacovides, 2009).

### **3.9 Water Management**

There is a lot of reasons and opinions about whether water is economic good or rather commodity to which everybody has natural rights. Protagonists, such as organizations and activists, promote the idea that everybody has right to water resources in limitless amount and that access to water resources should be provided and guaranteed by government, especially to those who are affected by poverty. They see water as fundamental human right, but on the other hand, this is the opposite of the other party, which stands to the opinion that water is commodity as any other and that it should be traded and apportioned only to those who can pay for it. That is where a big conflict starts (Figueres, Rockström, Tortajada, 2003).

Water management has several opportunities to improve water situation and to decrease water scarcity, but they are usually dependent on financial support or availability of financial funds for investment into water infrastructure. Mostly long term planning is

needed, what might be a problem because of inflexible attitudes of government. Significant change can be made only if perspective of problem is viewed widely and not only to specific short term problem (Pereira, Cordery, Iacovides, 2009).

Financial support is often very ineffective since only small part of financial aid heads straight to people in need and a big part of given money serves as instrument for corruption, purchasing weapons, financing wars and to satisfy private persons.

Example provided by J.A.A. Jones (2010) refers to poor governmental management of water and high stage of corruptions in some countries. As he describes in his book, situation is probably the worst in Africa, where money provided as aid are usually placed to pockets of private subjects and companies. In 1985, Ethiopia obtained financial support from organization Live Aid to help against hunger and undernourishment and the very next moment they engaged war on Eritrea.

In 1994, whole Indonesia was hit by serious drought which affected locals in several ways, especially by lack of water, but in comparisons, golf courses in Jakarta, which was used by rich tourists, still gained 1,000 cubic meters per course per day. In 1998 in Cyprus, rivers and aquifers were almost dried out because of 3 years drought, government decreased water supplies to local farmers of 50% while offering rich water supplies to two million tourist per year (Barlow, Clarke 2005).

Situations as these are the key problem in management of water and serious changes needs to be made.

### **3.10 Water Renewability**

There is a conflict about whether water is or isn't renewable resource. Probably the most accurate answer is: it depends. Naturally, water is renewable resource, because it is evaporated from oceans and other water areas into the atmosphere, where it is accumulated in clouds and then falls to the Earth's surface in form of precipitation. From surface, it continues back to dams, rivers, seas and also into the ground to refill aquifers. This creates cycle and water is renewing. But, important fact is, that for renewing, it is necessary to fulfill two conditions. 1) Water resource requires enough time to renew and 2) the replenishment rate needs to be faster or at least equal to rate of withdraw of water resource. In other words, we can not take out more water than nature is able to refill in particular time

period. From this, we get to key problem- since population is growing so fast, pressures and withdraws of water are higher and higher and exceeds replenishment rate several times in short time period. Then, water supplies are diminishing and water becomes non- renewable. Overuse can be considered as key problem, but also water pollution takes part. Due to chemicals and toxic substances in agricultural and industrial production, water is often being polluted irrecoverably. After the agricultural and industrial use, water is very little renewable. One of few cases that water is renewable is hydroelectric power production, where water can be used again without pollution.

As man made renewing of water could be considered desalination, which is removal of salts from the water.

Desalination can be used only in some countries (solely in coastal ones) and it is very expensive and difficult with huge consumption of fossil fuels, what makes it possible to do desalination only in countries with big sources of energy. Despite this, it would be big environmental burden in form of global warming, so it would be “solving” of one global issue to the detriment of worsening another one (Barlow, Clarke, 2005).

### **3.11 Conflicts Over Water**

It is generally known, that if there was the Third World War (and it will, sooner or later), it would be with high probability because of water. Water has limited resources, and we, as humans, are not using these resources very responsibly. What more, not only limited water volume is a problem, but also population, economic and industrial growth will result in water shortages, water scarcity and water conflicts in many countries. It is likely that wars will be started to occupy water resources and great migration to countries with better resources will happen. Water scarcity problematic is very complicated and it is hard to find reasonable and long-term solution, since population growth is excessively magnified and unstoppable, economy is growing, which may look good, but the result is, that more and more people can afford sanitation devices and flushing toilets, and also industrial growth is against water scarcity situation because it significantly contributes to water pollution.

At this time, several wars and conflicts has occurred. According to Patrick Johnson (2014), three of important water conflicts can be introduced:

### China- India: The Brahmaputra river

Brahmaputra river is an important river which stem in China and flows thru India and Bangladesh to the Bay of Bengal. China plentifully use the river for producing electric energy by hydroelectric plants, while do not consider impacts to India and Bangladesh. Environmental burden to the river cause decrease of flow and tenses situation in India and Bangladesh because regions in these countries are arid, overpopulated and agriculturally dependent on the river. While tendencies to create some treatments starts, it is usually long term and disadvantageous for China, there is a big potential of tensions.

### Ethiopia- Egypt: Grand Ethiopian Renaissance Dam and the Nile River

The Nile river is significant water resource for several countries. The conflict between Ethiopia and Egypt started in 2011, when Ethiopia announced construction of the Grand Ethiopian Renaissance Dam, which could produce electric energy not only for Ethiopia, but also for other countries. Problem is, that according to old treaties from 1929 and 1959, Egypt has right to 1/3 of Nile's water and also has the veto power to any upstream project, but Ethiopia ignores it and continues with a construction of a dam. Current situation is that upriver countries are against downriver countries as Egypt and Sudan, who wants to maintain their rights. Tension is region is increasing, because The Grand Ethiopian Renaissance Dam will be finished in 2017.

### Turkey-Iraq: Ilisu Dam and the Tigris River

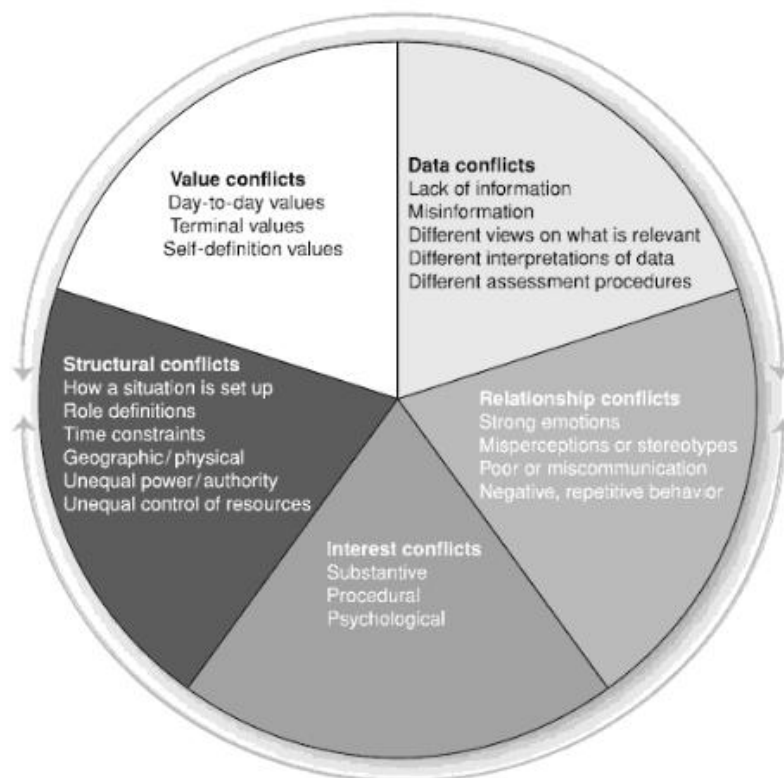
It has been several years since international conflicts started, and the reason is again in sharing the river. Turkey's The Southeastern Anatolian Project initiated construction of 22 dams and 19 hydroelectric plants in the Tigris-Euphrates basic, which was meant to be shared, but these dams and hydroelectric plant are significant interference into rivers flow. What more, after re-election of Erdogan, the new project, the Ilisu Dam on the Tigris River near the border of Syria has greater support, which means even bigger pressure to the rivers ecosystem. It is

expected, that around 2040, the flow will be so low, that it will not be able to reach the sea.

Jerome Delli Priscoli and Aaron T. Wolf (2009) describes causes of conflicts by the „Circle of Conflict“:

1. Disagreement over data
2. Problem with the people’s relationships
3. Perceived or actual incompatible interests
4. Problems with structural forces
5. Perceived or actual competing values

Figure 3: Circle of Conflict



Source: Delli Priscoli and Moore, (1985)

## 4 Practical Part

The goal of the practical part is to work with data and analyse influence of specific factors to water scarcity. Methods of analysis will be employed same as basic statistical methods as average, maximum, minimum, median and mode, and also future prediction and evolution of situation will be provided.

The subject of this work is to analyze data and find possible dependence between water scarcity and several factors in different selected countries. According to available data, dependency will be calculated with data from two years- 1990 and 2008, and also differences will be shown between rural and urban population.

Practical part will be based on table below, which contains data about access to safe water supplies in different countries in years 1990 and 2008. These years were chosen because it was hard to find other records about level of water scarcity in each country. It is possible to see progress and changes in access to water in these countries. The table is also divided into two parts- data from urban and from rural parts of chosen countries. Urban areas are those with high population, wide infrastructure and high density of people living in one place- in cities. Rural areas are places which are not so densely occupied and which are outside of cities- rural areas are villages and hamlets.

It is important to take into account these differences and inequalities, because some country could appear as developed in cities with great water infrastructure but in countryside people can suffer by water scarcity because of insufficient water infrastructure.

#### 4.1 Access to Safe Drinking Water and Dependence on Various Factors

In a table below, 29 countries were chosen for practical part of this work. These countries should represent situation on it's continent and differences between data from rural and urban parts within each country and also change between years 1990 and 2008. Data refer to percentage of population which has access to safe drinking water.

*Table 1: Access to safe drinking water*

	Access to safe drinking water in %				Time change	
	URBAN		RURAL		URBAN	RURAL
Country	1990	2008	1990	2008		
<b>Angola</b>	73	60	20	38	-13	18
<b>Congo, Dem.rep.</b>	68	80	24	28	12	16
<b>Ghana</b>	63	90	49	74	27	25
<b>Sierra Leone</b>	80	86	21	26	6	5
<b>Uganda</b>	60	91	30	64	31	34
<b>Barbados</b>	100	100	100	98	0	-2
<b>Belize</b>	95	99	100	100	4	0
<b>Guatemala</b>	92	98	45	90	6	45
<b>Haiti</b>	56	71	23	55	15	32
<b>Brazil</b>	95	99	31	55	4	24
<b>Ecuador</b>	63	97	44	88	34	44
<b>Guyana</b>	100	98	45	75	-2	30
<b>Afghanistan</b>	40	78	5	9	38	4
<b>Bangladesh</b>	39	85	89	78	46	11
<b>India</b>	86	96	69	84	10	15
<b>Indonesia</b>	35	89	33	71	54	38
<b>Iraq</b>	93	91	41	55	-2	14
<b>Jordan</b>	100	98	97	91	-2	-6
<b>Maldives</b>	77	99	68	86	12	20
<b>Nepal</b>	66	93	34	87	27	53
<b>Pakistan</b>	82	95	42	87	13	45



<b>Vietnam</b>	47	97	33	85	50	52
<b>Papua New Guinea</b>	94	87	17	70	-7	53
<b>Tonga</b>	92	100	98	100	8	2
<b>Solomon islands</b>	82	95	45	65	12	20
<b>Latvia</b>	100	100	98	100	0	2
<b>Slovakia</b>	100	100	100	100	0	0
<b>Russian federation</b>	99	100	89	96	1	7
<b>Netherlands</b>	100	100	100	100	0	0

*Source: Knoema, 2011*

According to the table, we can generally say that access to safe water supplies is significantly easier and more possible in urban parts of countries, where infrastructure is more developed and people live with higher living standards. Cities often use water resources such as rivers or undergrounds aquifers and are able to ensure purification so water is safe and clean. In comparison, in rural parts where people often live spread on bigger area, supplies of water are more far away, especially in developing countries, and water infrastructure is insufficient. People are then reliant on unpurified rivers or other resources.

Deep of water scarcity can be seen in data from urban areas, because there is always better infrastructure than in rural ones and usually more water supplies. So when water access is low even in urban areas, situation is serious. In a year 1990, the lowest percentage of population with access to safe water from chosen countries was (according to our table) in Indonesia (35%), Bangladesh (36%), Ecuador (63%) and Ghana (63%). In 2008, situation was the worst in Angola (60%), Haiti (71%) or in Afghanistan (78%), but generally, situation in urban areas of almost all chosen countries significantly improved, because of water infrastructure. However, growing population could move with these numbers downward in future.

On the other hand, situation was more critical in rural areas. In 1990, alarming situation was in Afghanistan (5%), Papua New Guinea (17%), Angola (20%), Sierra Leone (21%), Haiti (23%) or in Democratic Republic of Congo (24%). In the year 2008, percentage of population with access to safe water increased in the most of the countries, but in some of them, number was still extremely low. In Afghanistan (9%), Sierra Leone

(26%) or Democratic Republic of Congo (28%), two thirds of populations in rural areas did not have access to safe water resources so they were reliant to polluted and dangerous water, or they had to go very far away to get water. Percentage of people with access to safe water supplies was so low, that economies of these countries were paralyzed and precludes step out of this critical situation. It is necessary to note, that those areas with critical water scarcity in rural parts are often less inhabited, so for example when percentage of population is extremely low as 9% in Afghanistan, it does not mean that there is huge number of people living in these areas, because for example in Afghanistan, big part of its area is covered by desert.

Between years 1990 and 2008, there was a development in almost every country in the world. Access to safe water supplies became possible and easier for more and more people. In some countries such as Vietnam or Papua New Guinea, access to safe water resources in rural parts tripled and in the most of the countries from the table, percentage of population with access to safe water increased. On the other side, in some countries such as in Afghanistan or African countries as Angola, Sierra Leone or Ghana, people are often unable to gain safe and clean water and during almost twenty years between data collection did not change situation much. In other countries, especially those in Europe, percentage of population with access to water to safe water can be considered as 100%.

These data from year 2008 were collected almost 10 years ago, but are sufficient enough to show situation. Evolution of this problem is going to head to improving of water infrastructure in cities, so in urban areas access to water resources is going to be better, but in rural areas, water scarcity deepening occurs due to overusing of water resources by cities, population growth and pollution.

According to the table, average access to safe drinking water in urban areas in 1990 was 78,5% and in 2008 92,1%. In rural areas percentage was lower, 54,8% in 1990 and 74,3% in 2008. The average seems to be quite positive, but it is influenced by countries of Europe as Latvia, Slovakia and Netherlands, where almost 100% of population has access to safe water.

As written above, countries in Europe such as Latvia, Slovakia or Netherlands belongs between countries with maximal access to safe water resources. In these countries almost 100% percent of population has access to safe water resources.

In contrast, in urban areas, country with the lowest percentage of population with access to safe water is found to be Indonesia, in case of rural areas it is Afghanistan. These countries ended up with the lowest result according to table above.

According to the table with chosen model countries, median in urban areas in 1990 is 82% and in 2008 96%, and in rural areas in 1990 45% and in 2008 84%.

Mode, the most often appeared value in in both years and also in urban and rural areas 100%, because some countries from our table has 100% population with access to safe water.

#### 4.1.1 Dependence of Access to Safe Drinking Water on Local Annual Average Temperature

One of the goals of this work is to determine whether some dependence between access to safe water resource and local temperature in different countries exist. For purposes of finding this dependence, the Pearson's correlation coefficient is used.

Table 2: Table 2: Access to safe water and average temperature in country in 2008

Access to safe drinking water in %					Time change		Average temperature in country
Country	URBAN		RURAL		URBAN	RURAL	Temperature in °C
	1990	2008	1990	2008			2008
Angola	73	60	20	38	-13	18	25,1
Congo, Dem.rep.	68	80	24	28	12	16	24,6
Ghana	63	90	49	74	27	25	26
Sierra Leone	80	86	21	26	6	5	27,3
Uganda	60	91	30	64	31	34	26
Barbados	100	100	100	98	0	-2	27
Belize	95	99	100	100	4	0	25,8
Guatemala	92	98	45	90	6	45	21
Haiti	56	71	23	55	15	32	25,8

<b>Brazil</b>	95	99	31	55	4	24	27
<b>Ecuador</b>	63	97	44	88	34	44	17,8
<b>Guyana</b>	100	98	45	75	-2	30	25
<b>Afghanistan</b>	40	78	5	9	38	4	12
<b>Bangladesh</b>	39	85	89	78	46	11	26,1
<b>India</b>	86	96	69	84	10	15	24,1
<b>Indonesia</b>	35	89	33	71	54	38	27
<b>Iraq</b>	93	91	41	55	-2	14	15,6
<b>Jordan</b>	100	98	97	91	-2	-6	25,1
<b>Maldives</b>	77	99	68	86	12	20	28
<b>Nepal</b>	66	93	34	87	27	53	15
<b>Pakistan</b>	82	95	42	87	13	45	24,3
<b>Vietnam</b>	47	97	33	85	50	52	24
<b>Papua New Guinea</b>	94	87	17	70	-7	53	27
<b>Tonga</b>	92	100	98	100	8	2	23,6
<b>Solomon islands</b>	82	95	45	65	12	20	27
<b>Latvia</b>	100	100	98	100	0	2	6,2
<b>Slovakia</b>	100	100	100	100	0	0	10
<b>Russian federation</b>	99	100	89	96	1	7	0,1
<b>Netherlands</b>	100	100	100	100	0	0	10

*Source: Knoema, 2011*

The Pearson's correlation coefficient is statistical method used to determine relation between two variables and how significant it is. Correlation coefficient range between -1 and 1. When the result is close to -1, there is a strong negative (when higher variable A, then lower variable B) relationship between variables. When result is around 0, there is almost no significant relationship. When result is close to 1, strong positive (when higher variable A, then higher variable B) relationship exists.

Correlation can be also divided to more detailed stages:

Figure 4: The Pearson Correlation of Coefficient

r value =	
+0.70 or higher	Very strong positive relationship
+0.40 to +0.69	Strong positive relationship
+0.30 to +0.39	Moderate positive relationship
+0.20 to +0.29	weak positive relationship
+0.01 to +0.19	No or negligible relationship
0	No relationship [zero order correlation]
-0.01 to -0.19	No or negligible relationship
-0.20 to -0.29	weak negative relationship
-0.30 to -0.39	Moderate negative relationship
-0.40 to -0.69	Strong negative relationship
-0.70 or higher	Very strong negative relationship

Source: *Statistics How To*, 2015

Here are correlation coefficients from different variables:

Percentage of population with access to safe water in 1990 in urban areas and local temperature in country

$r = -0,244489691$

Percentage of population with access to safe water in 1990 in rural areas and local temperature in country

$r = -0,314272662$

Percentage of population with access to safe water in 2008 in urban areas and local temperature in country

$r = -0,232067183$

Percentage of population with access to safe water in 1990 in rural areas and local temperature in country

$r = -0,234237741$

According to results, we can expect that only weak negative relationship between variables exist. It means that there is some little dependence between local temperature in each country and percentage of population with access to safe water resources, but it is not significant. When temperature in country is higher, there is a weak dependence that access to water resources will be lower. That also means, that theoretically when country has a hot weather in most of the year, low percentage of its population has access to safe water resources. Some countries from Africa could be example of this expectation, despite this, correlation coefficient proved that there is no significant dependence between these two variables.

#### 4.1.2 Dependence of Access to Safe Drinking Water on GDP

The Pearson's correlation coefficient will be suitable also for determining whether there is some dependence of access to safe water and GDP of a country. In this part year 2008 will be used, to have a younger data.

Table 3: Access to safe water and GDP in 2008

Access to safe drinking water in %					Time change		GDP per capita in USD
	URBAN		RURAL		URBAN	RURAL	
Country	1990	2008	1990	2008			2008
Angola	73	60	20	38	-13	18	3924,7
Congo, Dem.rep.	68	80	24	28	12	16	326,5
Ghana	63	90	49	74	27	25	1,234
Sierra Leone	80	86	21	26	6	5	453
Uganda	60	91	30	64	31	34	448
Barbados	100	100	100	98	0	-2	16358
Belize	95	99	100	100	4	0	4662
Guatemala	92	98	45	90	6	45	2867
Haiti	56	71	23	55	15	32	680
Brazil	95	99	31	55	4	24	8622

<b>Ecuador</b>	63	97	44	88	34	44	4255
<b>Guyana</b>	100	98	45	75	-2	30	2478
<b>Afghanistan</b>	40	78	5	9	38	4	377
<b>Bangladesh</b>	39	85	89	78	46	11	619
<b>India</b>	86	96	69	84	10	15	1042
<b>Indonesia</b>	35	89	33	71	54	38	2178
<b>Iraq</b>	93	91	41	55	-2	14	4472
<b>Jordan</b>	100	98	97	91	-2	-6	3797
<b>Maldives</b>	77	99	68	86	12	20	6027
<b>Nepal</b>	66	93	34	87	27	53	478
<b>Pakistan</b>	82	95	42	87	13	45	1018
<b>Vietnam</b>	47	97	33	85	50	52	1164
<b>Papua New Guinea</b>	94	87	17	70	-7	53	1222
<b>Tonga</b>	92	100	98	100	8	2	3369
<b>Solomon islands</b>	82	95	45	65	12	20	1208
<b>Latvia</b>	100	100	98	100	0	2	15463
<b>Slovakia</b>	100	100	100	100	0	0	18558
<b>Russian federation</b>	99	100	89	96	1	7	11699
<b>Netherlands</b>	100	100	100	100	0	0	56630

Source: Knoema, 2011

Here are correlation coefficients from different variables:

Percentage of population with access to safe water in 2008 in urban areas and GDP of the country

$r = 0,336108753$

Percentage of population with access to safe water in 2008 in rural areas and GDP of the country

$r = 0,388796115$

According to results, there is only moderate positive relationship between percentage of population with access to safe water GDP of the country. It means, what lower GDP, that lower the percentage of population with access to safe water. Also when

country has higher GDP, then there is higher possibility of higher percentage of population with access to safe water. Dependence is almost the same in rural and in urban areas. Results shows dependence, which is not so strong but can not be neglect. As reason why these variables are at least little dependent we can consider water infrastructure, which is more developed in countries with higher GDP than in those with lower one.

#### 4.1.3 Dependence of Water Scarcity Level on Population Density

As last, the goal is to determine whether there is some relationship between percentage of population with access to safe water in 2008 and density of population in 2008.

Table 4: Access to safe water and density of population in 2008

Access to safe drinking water in %					Time change		Density of population
Country	URBAN		RURAL		URBAN	RURAL	(people per sq. km of land area)
	1990	2008	1990	2008			2008
Angola	73	60	20	38	-13	18	15,9
Congo, Dem.rep.	68	80	24	28	12	16	27,3
Ghana	63	90	49	74	27	25	101,59
Sierra Leone	80	86	21	26	6	5	76,5
Uganda	60	91	30	64	31	34	155,2
Barbados	100	100	100	98	0	-2	644,9
Belize	95	99	100	100	4	0	13,4
Guatemala	92	98	45	90	6	45	131,6
Haiti	56	71	23	55	15	32	352,1
Brazil	95	99	31	55	4	24	23,3
Ecuador	63	97	44	88	34	44	58,17
Guyana	100	98	45	75	-2	30	3,8
Afghanistan	40	78	5	9	38	4	40,6



<b>Bangladesh</b>	39	85	89	78	46	11	1138,9
<b>India</b>	86	96	69	84	10	15	380
<b>Indonesia</b>	35	89	33	71	54	38	129,9
<b>Iraq</b>	93	91	41	55	-2	14	66,7
<b>Jordan</b>	100	98	97	91	-2	-6	68,1
<b>Maldives</b>	77	99	68	86	12	20	1206
<b>Nepal</b>	66	93	34	87	27	53	183,6
<b>Pakistan</b>	82	95	42	87	13	45	52
<b>Vietnam</b>	47	97	33	85	50	52	274,5
<b>Papua New Guinea</b>	94	87	17	70	-7	53	14,4
<b>Tonga</b>	92	100	98	100	8	2	142,8
<b>Solomon islands</b>	82	95	45	65	12	20	18
<b>Latvia</b>	100	100	98	100	0	2	35
<b>Slovakia</b>	100	100	100	100	0	0	111,8
<b>Russian federation</b>	99	100	89	96	1	7	8,74
<b>Netherlands</b>	100	100	100	100	0	0	489,9

Source: Knoema, 2011

Here are correlation coefficients from different variables:

Percentage population with access to safe water in urban areas in 2008 and density of population in 2008

$r = 0,071337839$

Percentage of population with access to safe water in rural areas in 2008 and density of population in 2008

$r = 0,227175787$

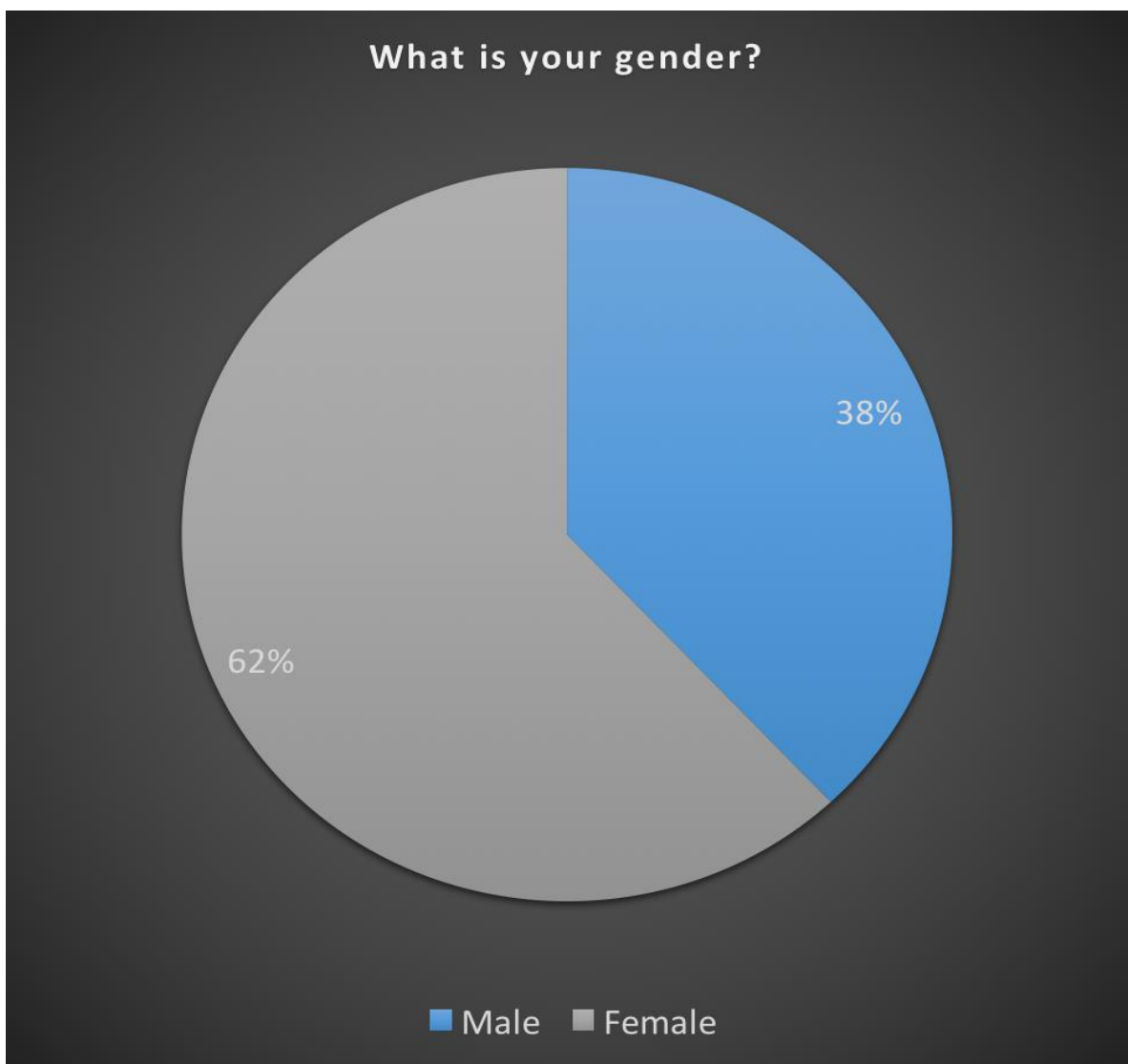
Results about dependence of percentage of population with access to safe water in 2008 and density of population in 2008 vary, generally there does not exist really significant dependence, but in rural areas there is a weak positive relationship in comparison with urban areas where no relationship exists. In rural areas, we could consider small probability that when density of population is higher, the percentage of population with access to safe water resources is higher.

## 4.2 Survey about Water Scarcity Issue

I decided to create a survey about public opinion to global water scarcity issue in order to delineate the point of view of Czech citizens and evaluate their behavior and dependency to water scarcity issue. Online survey was used for easier distribution and for wider range of different people. The survey was attended by 200 people, which is not a big sample, but is quite balanced and reflects approximately what people think.

Below questions and output of survey are displayed:

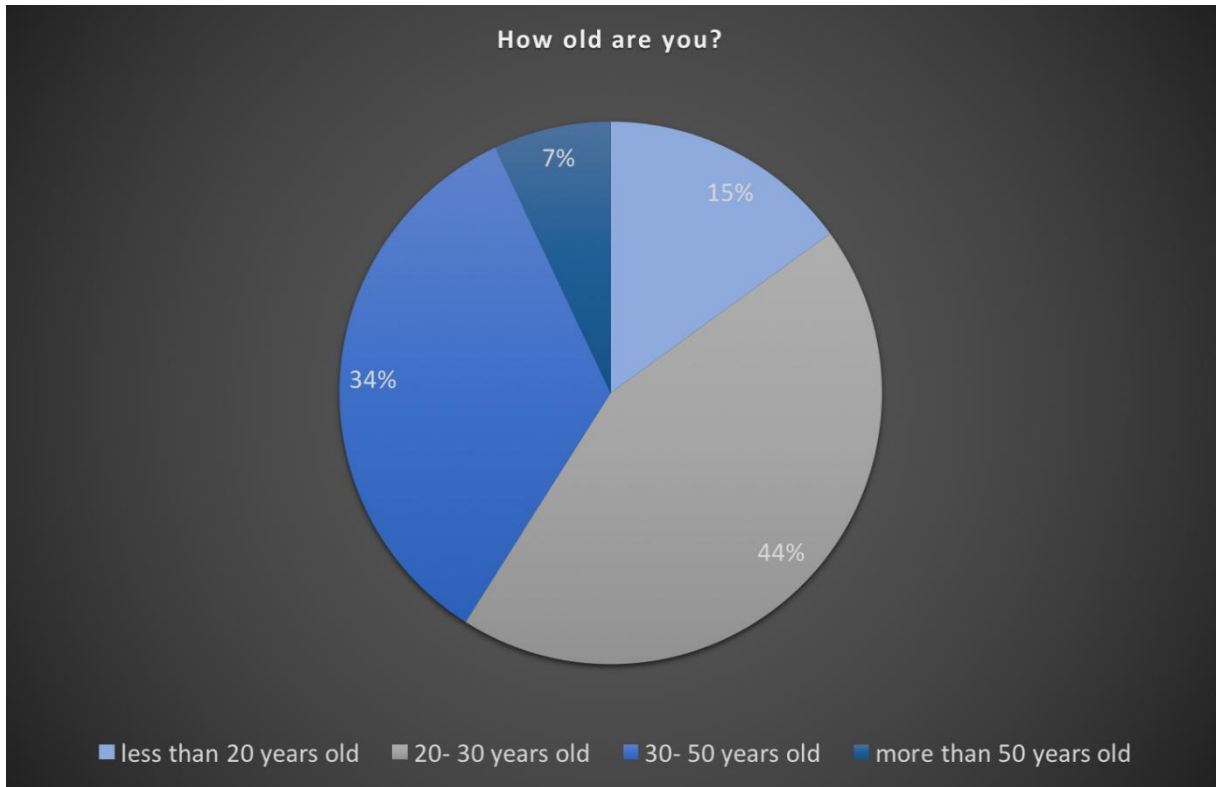
*Figure 5: Gender of respondents*



*Source: Own survey, 2016*

In survey, 62% of attended participants were females and 38% of attended were males.

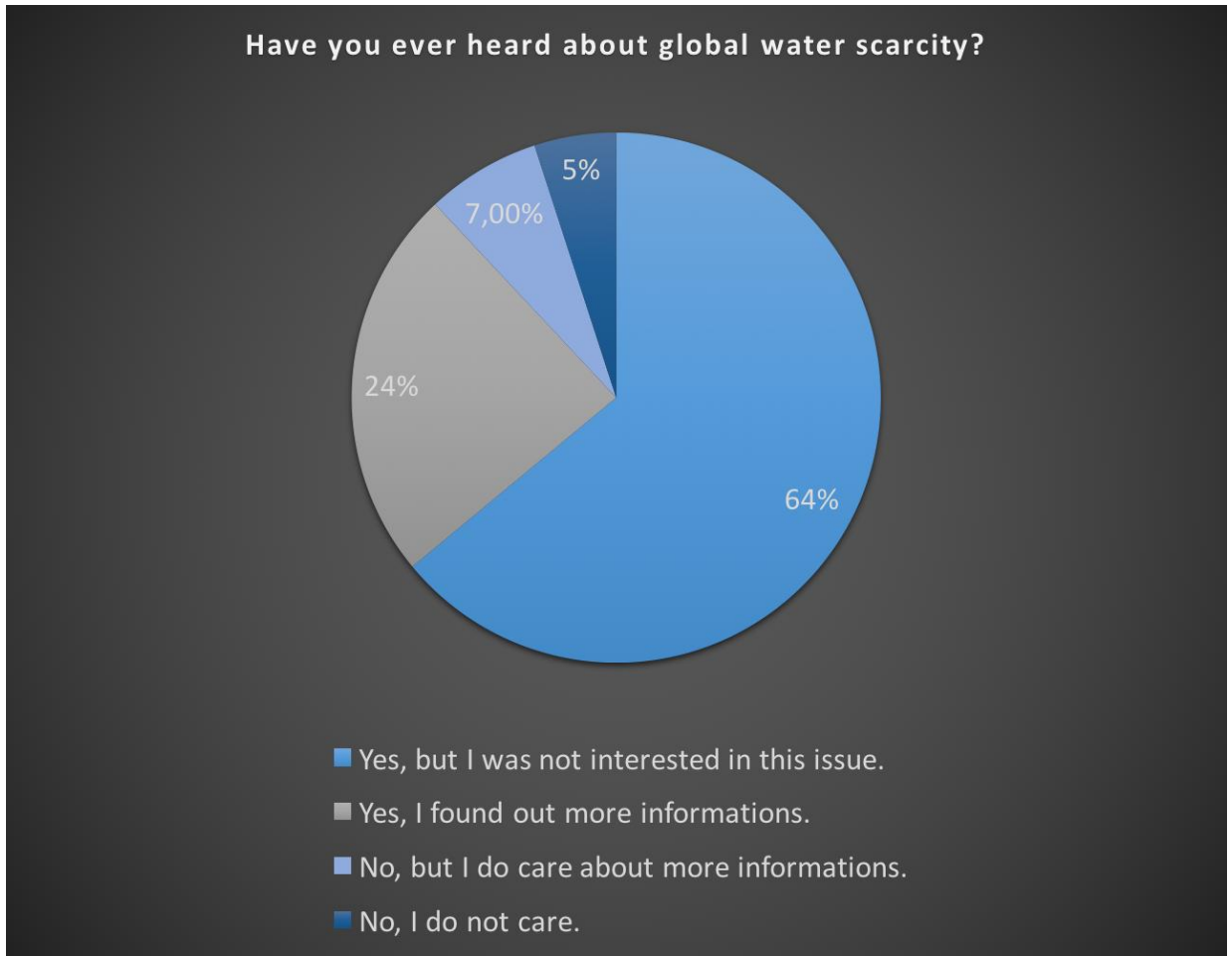
Figure 6: Age of respondents



Source: Own survey, 2016

Respondents were mostly in middle age, highest percentage were people between 20-50 years old and only 7% percent were older than 50 years old.

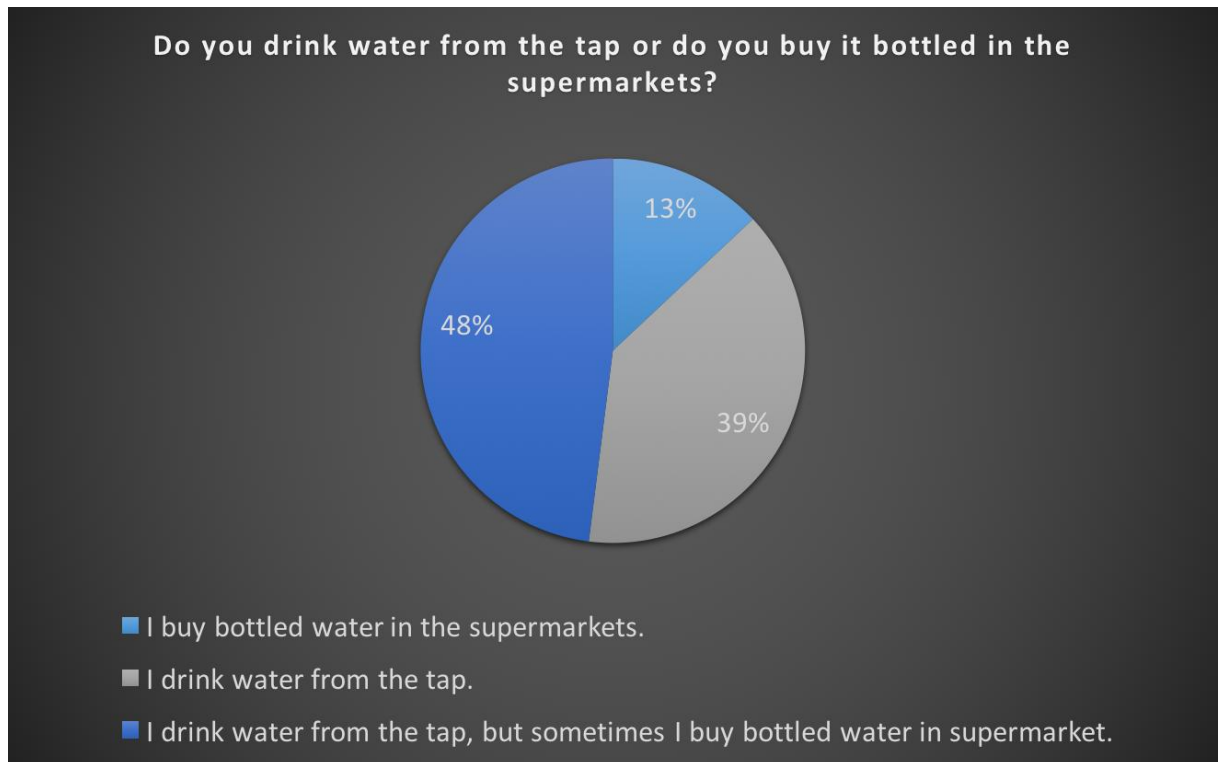
Figure 7: Water scarcity



Source: Own survey, 2016

From the graph above imply, that 64% of respondents heard about the issue of water scarcity, but they were not really interested in finding more information. This fact is quite negative but understandable, because when people are not touched by the issue, they do likely ignore it. Same with other world's problems, as wars, hunger, insufficient education and health care, people care only when they, or their families, are affected by that problem. It is anyway good that the most of the people at least know about water scarcity, but it should be more propagated and public debate should be more significant in order to decrease water scarcity and avoid it's deepening.

Figure 8: Bottled water in supermarket



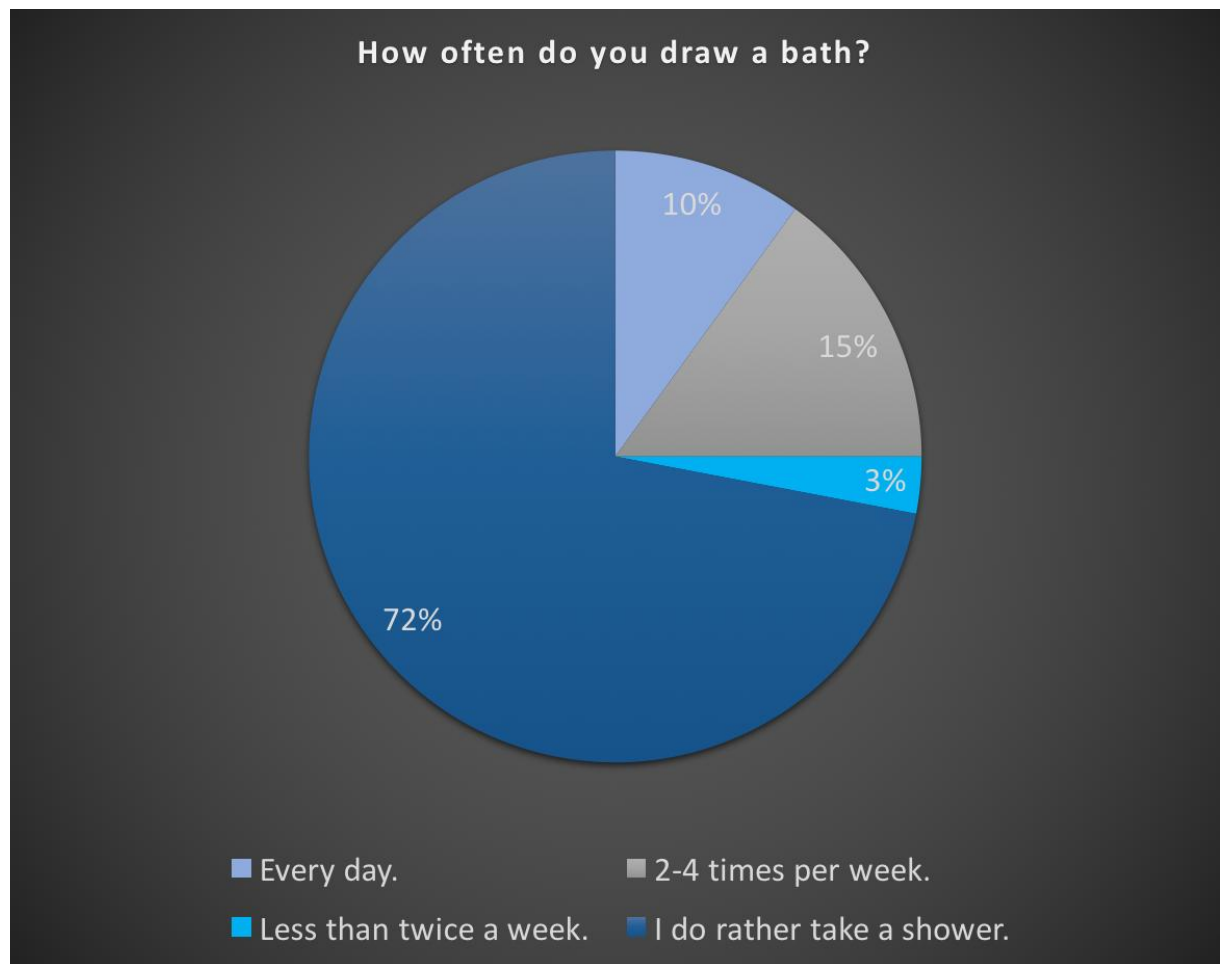
Source: Own survey, 2016

It is considered that first commercial trading with bottled water started in 18<sup>th</sup> century in the USA, when company Jackson's Spa decided to sell bottled mineral water which was supposed to have therapeutic impacts to health. From that time, bottling of water extended from curative mineral water to bottling of all liquids you can think of, bottled water can be found in every corner.

Bottling of water brought extensive advantages, such as possibility to distribute and transfer water almost everywhere, possibility to carry water everywhere you go, even to places where you can not find any other resources. Bottled water is also pretty safe because of standards which guarantee that water is not contaminated or polluted. On the other hand, bottled water also has significant disadvantages, such as price of water which is quite high, especially in some countries, then also consequences of using plastic bottles to our health, because they contains life- threatening compounds as for example bisphenol A (BPA), and last but not least the impact to the environment is gigantic, because waste is significant environmental burden since nature is not able to disassemble plastic, or it is, but in hundreds years.

In a survey, the aim was to find out the public behavior with water using and to investigate how people use tap water in comparison with buying water in supermarkets. The result according to the survey is that 13% of people regularly buy bottled water in supermarkets, which is not so much percent, but it is significant for environment and also needless, when tap water is available almost everywhere in Czech republic. Positive is, that according to the survey, 39% of respondents confirmed that they drink water only from the tap and another 48% buy water in supermarkets only occasionally. If we could apply results of this survey to whole population of Czech republic, then the situation about plastic waste from bottled water could be considered as acceptable.

Figure 9: Frequency of drawing a bath

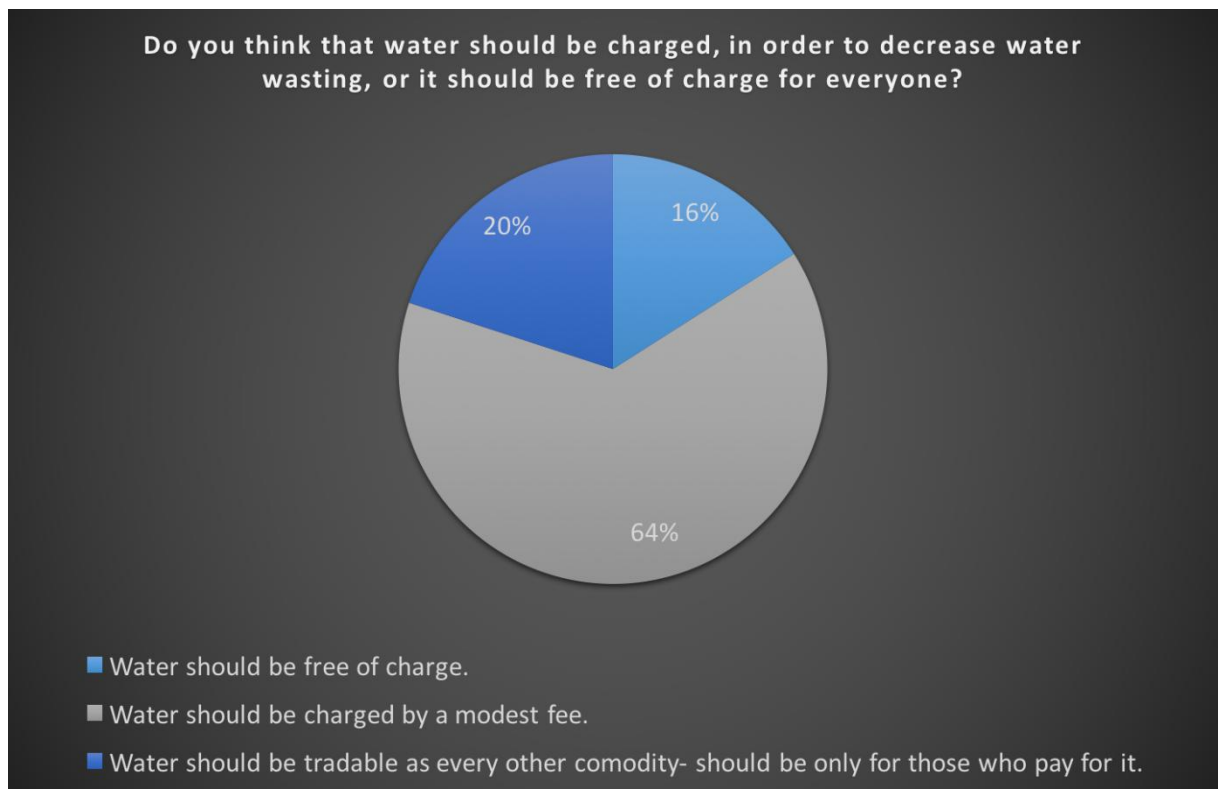


Source: Own survey, 2016

The aim of the next question in the survey, “how often do you draw a bath”, was to quantify water wasting in Czech households regarding to drawing a bath instead of taking a shower.

According to the answers of 200 respondents, 72% of them do rather take shower, which is surprising and positive, because by taking a shower instead of drawing bath, consumption of water is decreasing and wasting of water is lower. Only 10% of respondents draw a bath every day, what is quite acceptable percentage and even they draw a bath every day, it does not mean that they draw a full bath.

Figure 10: Charges for water



Source: Own survey, 2016

As mentioned in the theoretical part, water pricing belongs between key questions in the water scarcity issue. Basically, one opinion is, that water is in collective ownership, and that everybody has same right to water resources, but it is hard to define which part of resource belongs to particular country, even worse particular human. On the other hand, contrasting opinion is that water could be traded as every other commodity and should be for those who pay for it. Giving a water price tag could avoid overusing and wasting, but

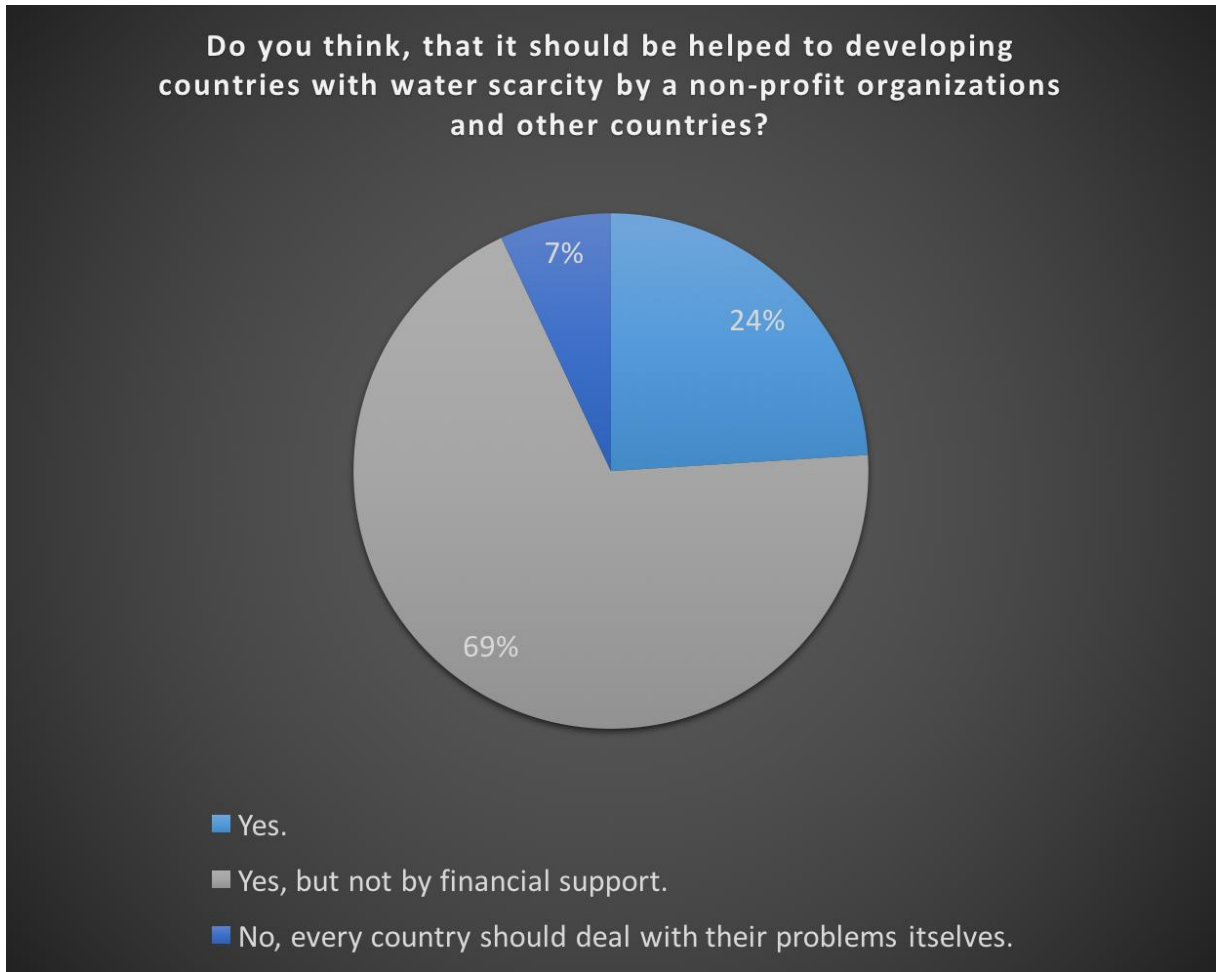
also is quite immorally and water should not be withheld to those who need it but can not afford it.

Resulting from a survey, 64% of respondents stands by opinion that water should be kind of tradable, but the fee should be regulated in order to sustain affordable price level for everybody. This seems like a compromise between to extremes, but can (as it is) applicate in Czech Republic, but in other countries, especially those in poverty and high water scarcity it would be a bad solution.

20% of respondents agreed with opinion of trading water and paying for it, what could be all right on one hand, but on the other hand, privatization of water is very dangerous instrument given to hands of people who only see the profit. An example of privatization is case from Bolivia. Bolivia is a developing country and its citizens often live on the edge of poverty. In the end of 20<sup>th</sup> century, Bolivian government sold some of its public property and businesses to international investors in order to help the economy. One of sold was also the water system and resource of Cochabamba city, which had serious consequences. In Cochabamba, soon the price of water increased into “breakneck” high, so some families end up with paying the half of their monthly income for water. This case shows that the border between what is right and wrong is very thin since everything could be abused. Last 16% of respondents answered that they think water should be free and for everybody. The truth is, that this may be necessary in developing countries where people live in poverty and basic right as access to water resources should not be denied, on the other hand, if water was free of charge in developed countries, it would probably lead to bigger and bigger overuse of water and countries would ran out of water much faster.



Figure 11: Aid to developing countries



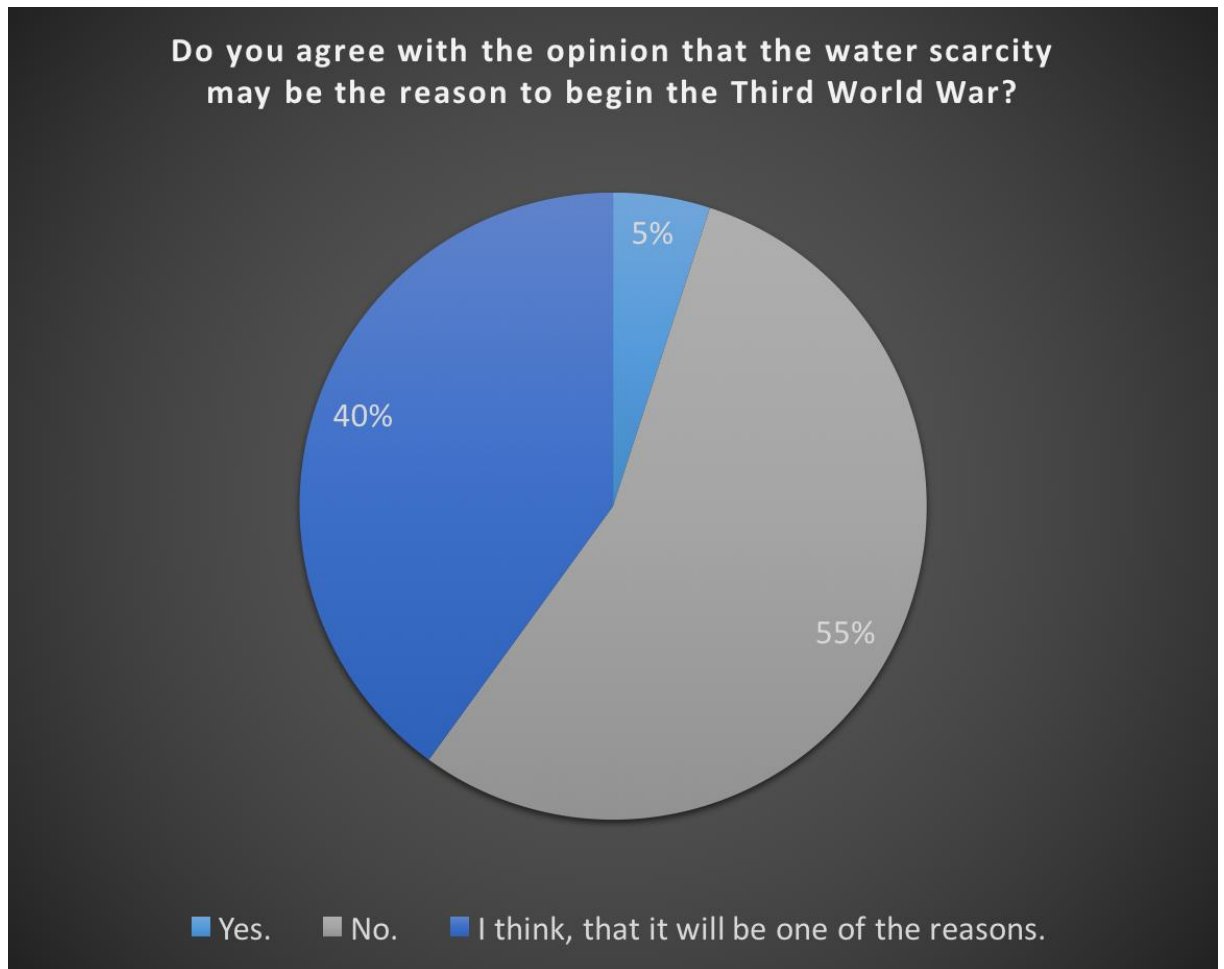
Source: Own survey, 2016

A part of the survey was a humanitarian pointed question, about whether it should be helped to developing countries or not, in order to show what respondent consider as a right solution.

The biggest part, 69% of respondents are identified with idea that we (countries, organizations,..) should be solidary and should offer aid to these countries in need, but not financial aid, since as is mentioned in the theoretical part, it is often spent for corruption, purchasing guns and initiation of wars, instead of real help to people in need.

Another 24% of respondents think that we definitely should help to these countries, with every possible resources, including financial aid, and only 7% stands by opinion that these countries should help themselves alone.

Figure 12: Water scarcity as reason of conflicts



Source: Own survey, 2016

Water scarcity is considered as one of possible causation of the Third World War, if it occurs, since there is already several conflicts in the world and some countries *are running* out of water faster than we could think.

From a survey, it appears that opinions are quite half to half, because 55% do not agree with idea that water scarcity will cause the Third World War, which could be a bit misleading since in a question above, respondents answer that they do not know anything/ much about water scarcity so they are not really able to imagine its consequences.

Another half are people who agree with the opinion that water scarcity will be one of causation of the Third World War (40%), or it will be the main reason of it (5%).

## **5 Results and Discussion**

### **5.1 Suggested Solutions to Water scarcity**

To find a solution to this serious issue, whole world population would have to take part, especially big companies and corporations. The question is if it is even possible to find a solution to water scarcity. According to population growth and people needs, we are not really able to avoid water scarcity, but we can fight against it and decrease it significantly. There are a several ways how to do it.

At first, the most necessary is to avoid overusing of water, especially in industry and agriculture. The goal and also solution is to make both more efficient. Human population, especially in developed countries, is now oriented to more water thirsty food, which increases water consumption. Water resources are overused in agriculture. Problem is, that population growth is the biggest in developing countries with low water infrastructure, what cause lack of water supplies and the number of people affected by water scarcity is increasing. In developing countries, one possible solution could be seen in the education of locals, to make them more productive to develop the country, infrastructure and to realize, that having a high number of children is unsustainable and lead to higher stress to water resources.

The industry is also consuming a big part of world supplies. Factories all over the world are producing billions of products which significantly damage the environment and for manufacturing these products is used the huge amount of water. Humans should stop producing so many useless goods and companies should be more regulated by the state to care about the environment, not overuse water resources and ensure sufficient purification of water.

Consumption in households is only small part of whole world water consumption, so trying to stop overusing of water by an individual is not so efficient. However, everybody can help to decrease water scarcity. Taking shower instead of drawing a bath, turning off the tap while brushing our teeth or dish washing, or drinking water from the tap instead of buying it in the stores, all these little things can save some water and make a difference.

Main liability is in hands of governments, to make steps to ensure the adequate price of water so everybody could afford it, but not to give it for free in order to avoid overusing. Also, governments should avoid privatization of water resources and protect them against

overusing and pollution.

The modern world of technologies is making the water scarcity worse, but also better. Technologies help us to use water more efficiently. Eco houses are built and systems for water usage are more advanced.

A rainwater tank is a reservoir which is nowadays installed into houses to decrease water consumption. They catch rainwater which is then used for flushing toilet, for gardening, in washing machines, and to similar purposes, what safe clean drinking water only for necessary purposes. This system is the nice example of how people and companies started realizing that water is a precious resource which is not infinite. These rainwater tanks and similar products are often possible to purchase thanks to the subsidies from the government, and in the Czech Republic, it will be available also for natural persons from the second half of 2017. The price in the Czech Republic without subsidies is around 20000 CZK, what is quite high, but savings in several years can cover the price.

Another important thing is cleaning and recycling of water. Water is often left untreated after use, also after use in the industry where chemicals and heavy metals contaminate water and nature are not able to renew it by itself. Improving cleaning processes, higher regulation of water pollution for industrial purpose and avoiding water pollution is the way how to help decrease water scarcity.

## **5.2 Results of Bachelor Thesis**

The subject of this thesis was to collect comprehensive overview about water scarcity, to find out whether there is any dependence between the level of water scarcity and make the small survey about public opinion to this issues.

The world is nowadays facing to serious water scarcity, which is mainly caused by population growth, overusing of water resources, pollution of water, climate change, drought, globalization, privatization and so on. Problem is, that since the population is growing very fast, water resources are under higher stress, and in view of several decades, some parts of the world are going to be almost without safe water supplies. The threat of water scarcity is also connected to several other issues. Since production of food is directly dependent on water, food scarcity is going with water scarcity hand in hand. Insufficient supply of safe water causes deadly diseases, which are spreading due to insufficient

sanitation and kills millions of people every year. Also, there is a threat of conflict between countries and within the country itself. Inequality is always causing a problem in every sphere of life, but in the case of water, which is necessary for life, conflicts are threatening more than ever. Nowadays, the planet is connected because of globalization, so every conflict or unrest could move with the whole world economy and affect people in other countries.

The purpose of this thesis was also to find out, whether there is a relationship between access to safe water supplies and factors as the temperature in a country, GDP and population density. To this purposes, data from 29 different countries were selected and the Pearson's correlation coefficient was used in this thesis. According to the results it seems, that access to safe water resources is not significantly dependent on any of these factors. The result can not be considered as 100% because data from all countries are not available, however, they provide an answer whether there is a relationship between access to safe water supplies and these factors. Data used in this thesis are older, from the year 1990 and 2008, but we can compare change between these years and also Pearson's correlation coefficient is more exact, because the difference is not so high within these years.

First researched factor was the local average temperature of the country in 2008. According to results, we can expect that only weak negative relationship between variables exists. It means that there is some little dependence between the local temperature in each country and percentage of the population with access to safe water resources, but it is not significant. When the temperature in the country is higher, there is a weak dependence that access to water resources will be lower. That also means, that theoretically when the country has a hot weather in most of the year, low percentage of its population has access to safe water resources. Some countries from Africa could be an example of this expectation, despite this, correlation coefficient proved that there is no significant dependence between these two variables.

Next researched factor was GDP of the country in 2008. The correlation coefficient in rural part in 2008 was  $r= 0,389$ , and in urban part  $r= 0,336$ . Results say, that there is the only moderate positive relationship between the percentage of the population with access to safe water GDP of the country. It means, what lower GDP, that lower the percentage of the population with access to safe water. Also when the country has higher GDP, then there is a higher possibility of a higher percentage of a population with access to safe water.

Dependence is almost the same in rural and in urban areas. Results show dependence, which is not so strong but can not be neglected. As the reason why these variables are at least little dependent, we can consider water infrastructure, which is more developed in countries with higher GDP than in those with a lower one.

The last one factor was population density. Results about the dependence of percentage of the population with access to safe water in 2008 and density of population in 2008 vary, correlation coefficient showed up to be 0,227 in rural areas and 0,0713 in urban areas.

Generally, there does not exist really significant dependence, but in rural areas, there is a weak positive relationship in comparison with urban areas where no relationship exists. In rural areas, we could consider the small probability that when the density of population is higher, the percentage of the population with access to safe water resources is higher, but in general, it can not be taken into account because the Pearson's coefficient did not prove the dependence.

To complete this thesis, the survey about water scarcity was employed in order to reveal approximate public opinion. 200 participants answered in an online questionnaire to questions about water scarcity. It is necessary to mention, that scope is very limited and more people would have to be asked in order to make the more proper interpretation, but it is important because water scarcity is becoming a problem in the Czech Republic and also in the whole world.

Respondents were mostly in middle age, highest percentage were people between 20-50 years old and only 7% percent were older than 50 years old. According to the result of this survey, the most of the people know about water scarcity but are not interested, what is alarming so public awareness should be increased. The most of the people drink water from the tap, what was quite surprising and positive finding, same as information, that 72% of respondents in this survey answered that they prefer to take a shower rather than drawing a bath. Resulting from a survey, 64% of respondents stands by the opinion that water should be kind of tradable, but the fee should be regulated in order to sustain affordable price level for everybody. This seems like a compromise between to extremes, but can (as it is) applicate in the Czech Republic, but in other countries, especially those in poverty and high water scarcity it would be a bad solution. The most of the people also agree with helping to developing countries by nonprofit organizations, but with different that financial support. The last one question was about Third World War, whether people think there is some

possibility that it will be caused by water scarcity, and opinions are different. 55% respondents answered that they don't think that the cause will be water scarcity and another half of people agreed with the opinion that water scarcity will be one of causation of the Third World War (40%), or it will be the main reason of it (5%). It is necessary to mention that according to results above, people do not have enough information about water scarcity to make own opinion properly.

## 6 Conclusion

The purpose of bachelor thesis was to collect comprehensive outlook of water scarcity issue, to find data about the situation in several countries from the whole world and find out whether there exist some dependence between water scarcity level and factors as the temperature in a country, GDP or population density. Also, the purpose was to approach public opinion about water scarcity in the Czech Republic by the survey.

This work summarizes, how serious problem the world is facing. Water scarcity is deepening, but still kind of ignored by the world, even with the fact, that due to the globalization and global trade, events in one country significantly affects other countries, especially their economies. The scarcity of one of the most important element- water, is causing several connected problems as food scarcity, diseases, conflicts and others.

The governments of some countries are capable of selling own water resources to the companies and exposing the own population to high fees for water which used to be considered as public ownership accessible for everybody. Time changed and we are becoming the part of the society where only money can allow you to survive. In countries where the income of a big percentage of the population is around \$1 a day, people are reliant on unsafe resources where the high possibility of infection exists. Nowadays, even we are in the 21th century, millions of people are dying because of water scarcity and along walking problems, despite the fact that Americans spent every year more money for pet food than would be necessary for providing the basic health care and nutrition for everybody in the world.

A lot of books were written on this topic, but essential steps were not made. It is important to spread awareness about this situation since water scarcity is mainly deepening because of the population growth which creates higher demand for water and for food production. As we know, the population growth is unstoppable, so it is necessary to find a solution in the better management of water resources and in changing our ways of thinking and behaving.



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