



Consumption Analysis for Water Shortage Risk Estimation

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Abstract

Water is prime element of the environment and has important role in every biological process. Water is needed for almost all production processes. It has important role in industry, agriculture, transport, energetic, tourism, etc. It is renewable material, but limited, and society must ensure that water remains usable and in circulation in nature. Availability of water is limited by water reserves and conflicts can arise among end users, or water sources may dry up due over exploitation. In conditions of unstable or extreme weather events water shortage risk may arise. This paper shows quantitative method for water consumption analysis. For the territory of Vojvodina, water demands are calculated for the largest water users. Calculated water demands are then compared and put in relation to water supplies to estimate potential risk of water shortage.

Key words: Vojvodina, Water conflicts, Water consumption, Water shortage

1. INTRODUCTION

Agriculture contributes significantly to the economy in the region of Vojvodina. Vulnerability of a region can be used for prediction of possible consequences in terms of hazard and risk. In this sense, we can say that drought can create great material losses in the region of Vojvodina, due to economic dependence on agriculture. These losses may arise from the decrease of agricultural yield and quality of products.

Temperature and precipitation are the factors that could increase vulnerability to drought. From hydro-meteorological analysis of trends, it can be seen that there is a tendency of average temperature increasing, as well as reducing the amount of precipitation [1] [2]. If we consider the fact that almost all crops have high demand for water, especially in months with the least precipitation, than we can reasonably conclude that the crops are in high risk from drought during the vegetation period.

Despite the great water resources in Vojvodina, their utilization is extremely low. Economic circumstances represent one of the main reasons for minimal exploitation of water resources. If we analyse the

agricultural area in Vojvodina, we can conclude that only negligible small area is irrigated. There is a need for development of strategy for improvement of existing and construction of new irrigation systems in Vojvodina. Data on water consumption in Vojvodina indicate that water conflicts exist and that the number of conflicts will increase due to consumption trends and forecast about meteorological and water conditions [3]. The most noticeable conflict is between the consumption of water in agriculture (irrigation) and other consumption (mostly related to household consumption of water), which may occur in the summer period, during the vegetation period, when crops are irrigated. In this paper, irrigation and household water consumption in Vojvodina will be analysed.

2. WATER CONSUMPTION RATES

The Water Management Plan of the Republic of Serbia (WMP) as a base document provides a basic strategy for water use and water protection in the Republic of Serbia. The basic orientation of this strategy is: maintenance and development of a water regime which would provide the best and most appropriate technical,

financial and environmental solutions for a holistic water management, flood protection, preservation of water, and water use [4].

Water consumption rates are planned values that determine the required capacity of the water supply system and they are defined by the WMP. Consumption rates are determined on the basis of real data on the consumption of water in the observed area, theoretically determined by physiological and sanitation needs of population, and the specific characteristics and requirements of area. Also, the size of available resources and their cost have a large impact on these rates. The rates include:

- Consumption rates
- Coefficient of inequality of consumption (daily imbalances)

Water consumption rates are the average daily consumption of drinking water (according to WMP, high quality water) from the water system, adjusted to a single user (citizen) [4]. It is common that consumption rates cover the total need for drinking water, regardless of its purpose, which can be for:

- Household needs
- The needs of industry (like food industry)
- Public purposes (public institutions, hospitals, schools, hotels, restaurants)
- The needs of farm animals and agriculture.

The specific characteristics in Vojvodina should primarily include climatic characteristics. Hot summers, with relatively little precipitation (long-term average of 600 mm per year [5]) suggest that at least a minimal amount of water for irrigation should be planned into consumption rates. Another specificity of area includes social component and also influence on increase of water consumption in households. Low life standard, with noneconomic washing machines (large water consumers, hand washing instead dishwasher use, and finally very low price of water that does not encourage water saving.

A particular problem, which increases the needs for water, is dilapidation of the water supply network in the settlements, which causes big losses in the system. All of these factors can be influenced with suitable measures, but those require time and investments.

3. WATER DEMANDS IN HOUSEHOLDS

Proposal for household water consumption norms, for the region of Vojvodina, is based on experiences (domestic and European), consumptions trends in the countries that are in the final stages of the transition, consumption rates that are applied in the European Union, as well as the specifics of the Vojvodina area (climate, settlement structure, the habits of the population, the condition of the water supply network in the settlements, etc.).

Water consumption in households is considered as individual personal consumption for physiological,

hygienic and sanitary purposes. The variable is dependent on the number of residents in the settlement. For further calculation of household water consumption, norms proposed by WMP were used, presented in Table 1. The coefficient of inequality of consumption was not applied for calculation of annual water consumption, as it shows daily variation in water supply and does not affect the cumulative water consumption.

Table 1. Rates of water consumption in households [4]

<i>Number of inhabitants</i>	<i>Unit consumption (l/capita/day)</i>
up to 2.000	110
from 2.000 to 5.000	120
from 5.000 to 10.000	130
from 10.000 to 20.000	140
over 20.000	150

Total calculated water demand in households on the territory of Vojvodina is presented in Table 2, based on the census of 2012 [6]. Territory of Vojvodina is divided into three municipalities, namely Bačka, Banat, and Srem.

Table 2. Total calculated water demand for household needs in Vojvodina

	<i>Bačka</i>	<i>Banat</i>	<i>Srem</i>	<i>Vojvodina</i>
Total population:	1.592.039	1.222.333	312.278	1.933.851
Total consumption (m³/d):	136.686	83.182	41.007	260.875
Total consumption (l/s):	1.582	963	475	3.019

4. WATER DEMANDS FOR AGRICULTURE

4.1 Crop Water Needs

Based on its properties, the soil in Vojvodina is among the best soils in Europe. In total, Vojvodina covers 2.150.600ha, with agricultural land covering 1.747.000ha, or 81.26%, while the percentage size of arable land is 74.6%. According to the use of the land, Vojvodina is predominately an agricultural area [7].

According to the Agricultural Census of 2012, cereals, with 69% of total production, are the most common group of crops on arable land in Vojvodina. Behind them are industrial plants (25%), fodder (3.26%), fruit (1.55%) and vegetables (1.26%) [7]

Out of all crops grown, the most common are corn, wheat and soybeans [7]. All crops have annual water requirements. Their needs vary depending on the vegetation period, climate, temperature and other factors. Annual water needs for crops in Vojvodina are less than the expected average of 611mm. However, wheat, as one of the most common varieties, is the only

cereal that cannot meet its annual need of average precipitation and needs to be irrigated [8].

There are five basic types of industrial plants that are grown in Vojvodina. Out of the total sown area of industrial crops, sunflower and sugar beet take up 95%. Hops, tobacco and rapeseed are planted in the remaining 5% of the land under industrial plants. Maximum water needs of rapeseed and sunflower cannot be met by the average annual rainfall [8].

4.2 Water Demands for Irrigation

One form of preparedness for prevention and mitigation of drought in food production is the installation of irrigation systems on agricultural land. This measure prevents crop losses, which solves the problem of food scarcity.

Irrigation may be defined as a supplement to natural precipitation in order to achieve optimal water content in the soil during the vegetation period, which is a prerequisite for a successful cultivation of crops. Quantities of water needed for intensive crop production during the growing season, are determined by the climatic conditions and planned production on the irrigated surface. Irrigation is carried out during a part of the growing season or during the entire vegetation period.

Agricultural production in Vojvodina is limited by the amount and distribution of precipitation. In recent years, there has been a trend of shifts between extreme wet and extreme dry years, which affect the normal development of economy in general and agriculture particularly. According to the WMP of Serbia, the area that is irrigated in Vojvodina covers about 120.000ha. Around 60.000ha are supplied with water from regional systems, mainly from the hydrosystem Danube-Tisa-Danube, 55,000ha from groundwater and 5,000ha from accumulations. In total, less than 8% of arable land in Vojvodina is irrigated. [4]

Table 3. Estimated amount of water used for irrigation in Vojvodina

	<i>Bačka</i>	<i>Banat</i>	<i>Srem</i>	<i>Vojvodina</i>
Total consumption (m3/year) :	138.697.752	73.571.808	62.836.767	226.479.927
Total consumption (m3/day) :	1.507.584	799.694	683.008	2.461.738

Census of Agriculture in Vojvodina recorded the following [7]:

- The types of crops that are irrigated the most are vegetables, melons, and strawberries which cover about 1.5% of the total planted area in Vojvodina.
- As the main source of water for irrigation 44.9% of agricultural holdings indicated groundwater on the holding. Surface water outside the holding is used by 40.2% of holdings. Surface water on the holding

is used by 5.2% of holdings. Water from water supply system is used by 5.1% of holdings.

- 38.7% of households apply surface irrigation, 36.2% drop by drop, 25% of households use sprinkling as a way of irrigation.

The current state of irrigation in Vojvodina, viewed through total number of irrigation systems, or surfaces on which they have been built in and used, is not satisfactory in terms of capacity, technical characteristics and utilization level of irrigation systems.

4.3 Irrigation Rates

Water needs of crops depend on the stage of vegetation growth and development, climate and hydrological conditions, breeding sites... Quantity of available water in the soil is variable. In our environmental conditions, for most crops, water content in the soil is often contrary to the water needs of plants. In periods of the highest water demands for plant, water inflow into the soil is the lowest.

For the most common cultures in Vojvodina water needs - irrigation rates for period from April to September, with 80% of provision are: wheat (1750-2100) m3/ha, maize (3500-4200) m3/ha, sugar beet (4250-5100) m3/ha, alfalfa (4450-5300) m3/ha and other cultures (3500-4250) m3/ha. [4]

Based on these irrigation rates, sowing structure, water source, methods of water extraction, water distribution requirements to the system and by the system (5 -15% loss), irrigation hydromodule is usually between 0.5-0.6 l/s per ha. [4]

For the purpose of this research, the assumed rate of irrigation is 0.5 l/s per hectare and the irrigated period is three months a year (June, July and August). Based on this postulations and data on irrigated areas, total estimated amount of water consumed for irrigation in Vojvodina equals 226.479.927m3/yr. The following table shows the estimated water needs for irrigation in Vojvodina.

5. COMPARATIVE ANALYSIS OF WATER CONSUMPTION AND POSSIBLE CONFLICT

For purposes of detecting possible conflicts related to water consumption in Vojvodina, characteristic loads of water consumption and thickness of water-supply layers have been recognized. As indicators of water resource loads, average household consumption and consumption for the purpose of irrigation have been analyzed.

Visualizing water consumption, it is quick and easy to notice municipalities which consume the groundwater the most. For that purpose was used Geographical Information System (Q-GIS). To identify a potential conflict zone, water consumption data and water availability data are put into the spatial context and risk maps are created.

Water consumption for household needs on the municipality level is presented in the following map of Vojvodina (Figure 1).

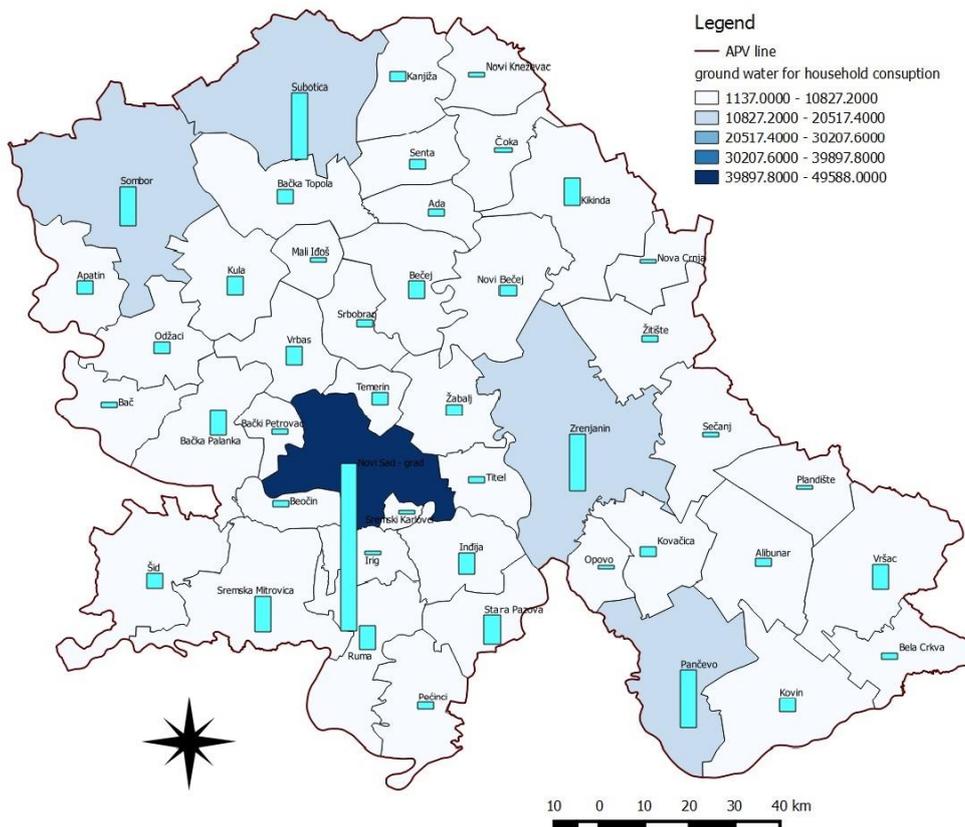


Figure 1. Household ground water consumption

The highest water consumption for household needs is in the following municipalities: Novi Sad, Subotica, Pančevo and Zrenjanin.

The largest consumption of ground water for purpose of agriculture is in the territories of: Vrbas, Zrenjanin, Bečeј, B. Palanka, Kula and Apatin (Figure 2).

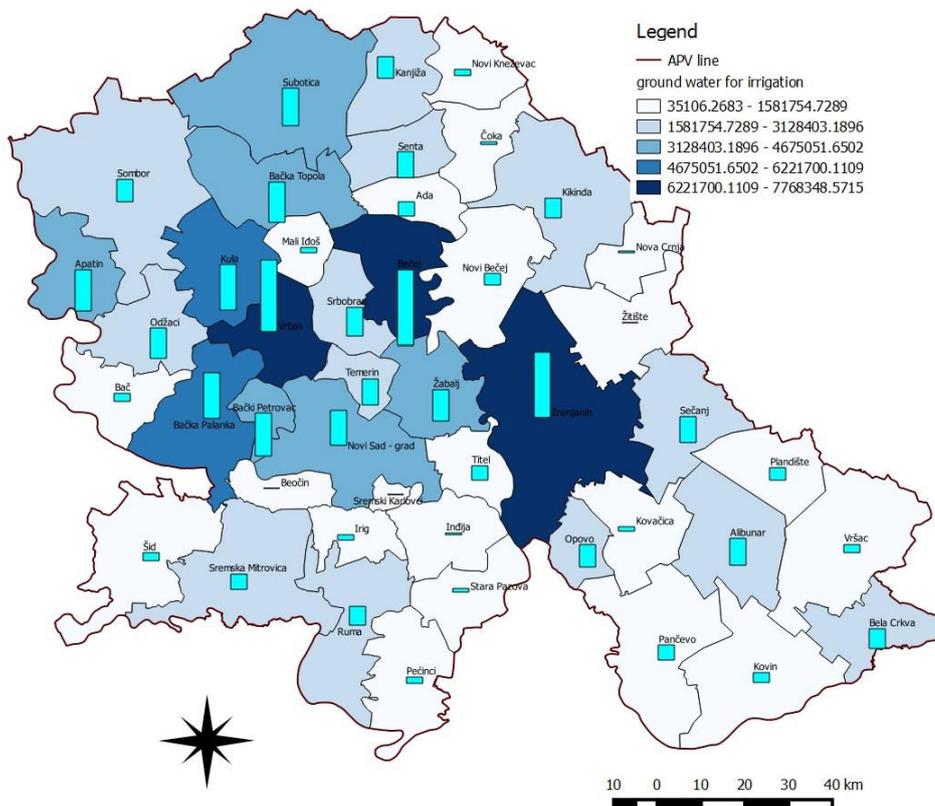


Figure 2. Groundwater consumption for irrigation

Territories with the cumulative highest observed consumption are: Zrenjanin, Bečej, Vrbas, Kula and Bačka Palanka. It is followed by high consumption of groundwater in territories of: Subotica, Bačka Topola, Apatin, Novi Sad, Žabalj i Bački Petrovac.

In territories with the highest observed consumption, water conflicts may arise among these consumers. Conflicts are possible during the growing season, or during the irrigation season. Since higher consumption of water for irrigation, and reduced groundwater levels due to over-exploitation are expected in the future, this kind of conflict is inevitable.

Thickness of water-supply layers, available to Vojvodina, are sorted into 5 categories: less than 20 m, 20-35m, 35-50m, 50-100m and more than 100m. Figure 3 presents the spatial distribution of individual thicknesses of water-supply layers.

Based on the thickness of water-supply layers, we can estimate the quantity of water available for exploitation and thus recognize spatially-based conflicts. By proportion of water consumption and thickness of water-supply layer, the biggest conflict is in municipalities on water-supply layers less than 20

meters. On the bases on calculated consumptions and water supply layers, those municipalities are: Nova Crnja, Vršac, Alibunar, Inđija, Sremska Mitrovica, Irig and Beočin.

Also, water supplies in the following category of water-supply layers, 20m to 35m, although bigger than the above mentioned, in spatial proportion with a particularly big consumption indicate conflict of managing water resources of a certain municipality: Subotica, Zrenjanin, Novi Sad and Pančevo

On the basis of previous conclusions, it can be said that, territorially speaking, approximately half of Vojvodina has a conflict between reserves and water consumption. Viewed through population size, it can be concluded that:

- Number of inhabitants in the zone of high conflict is: 179.399,
- Number of inhabitants in the zone of conflict is: 729.955.

Total number of inhabitants under conflict in Vojvodina is 909.354, approximately half of the total population.

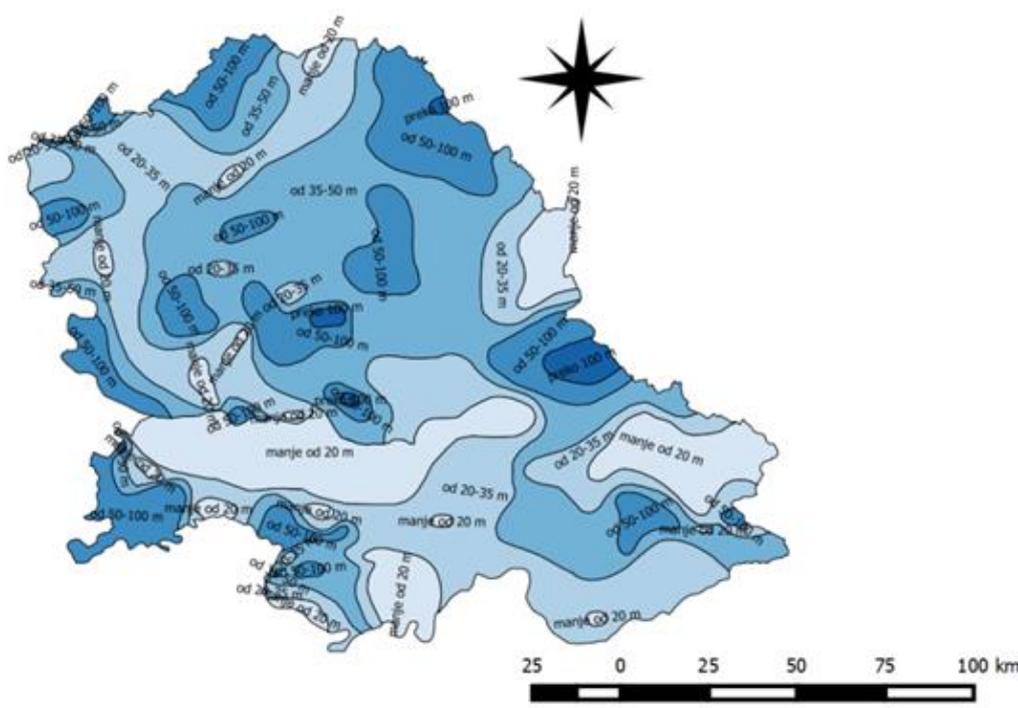


Figure 3. Spatial distribution of individual thicknesses of water-supply layers

6. CONCLUSION

Households, public sector, industry, and cattle breeders use high quality drinking water obtained by exploitation of groundwater. Among them, households are the highest water consumers. Surface water should be used for agricultural needs. In spite of that, farmers mainly use groundwater for this purpose, due to neglected hydro systems, low quality of water, and poor economic situation. Consequently, there may be a conflict in water usage among users, especially in the

irrigation season when water consumption becomes extremely high.

In this paper we showed that irrigation practice in Vojvodina is not on adequate level. It is expected that water consumption in agriculture will increase in future, due to negative effects of drought. Increase in water consumption is necessary to insure stable food production and to exploit the most of Vojvodina agricultural potential. Therefore, escalation of water consumption problem can be expected in near future, if

farmers do not start to exploit surface water in a greater extent.

Also, excessive exploitation and insufficient precipitation in dry periods could cause current water sources to dry up. Risk of drying up of groundwater sources (artesian wells on farms) should make farmers more aware of the necessity to use surface water for irrigation purposes in greater extent. In situations in which surface water use for irrigation purposes is not possible, risks related to drought should be transferred to professionals (e.g. insurance companies).

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