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# Ground water as water source opportunity at the fire front – case study at Bács-Kiskun County, Hungary

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**Abstract**

Almost without exceptions, in case of long time wildfires, the continuous water supply is always a logistic problem. One of the several reasons is obviously that most of the wildfires occur during droughts, when there is no rainfall and the natural water sources have low flows. Another problem with the water supply is that the frontline of fire and the water source are usually quite far apart from each other. In this case, firefighters are facing a logistical problem, where not only the limited number of fire trucks, but also the slow movement of these vehicles or even blocks have to be taken into account. The Hungarian example presented in the paper shows the use of local opportunities, just as the imaginative use of groundwater can provide a suitable water source at the fire site. With regard to the effective water transport, the question arises as to whether the average water flow that can be provided during a conventional long-distance water transport can also be provided by the water flow of wells drilled on the fire site. The research shows that, under certain conditions, the groundwater provided by drilled wells can be an alternative solution to the logistical difficulties of long-distance water transport.

## 1. Introduction

The generation of wildfires can be traced back to human negligence (Chas-Amilm 2010, Teknős and Debreceni 2022). In order to save human life and property, firefighters use several tactics to fight against wildfires (Restás 2003). They can use so-called hand tools for firefighting purposes, ground power machines, aircrafts for aerial firefighting or counter fire, but the most common solution is to extinguish the frontline of fire with water. One of the characteristics of wildfires is that forests ignite when the availability of water sources in wildland is already limited, i.e. during droughts (Bodnár et. al. 2019). In this case, the water required for firefighting can be replaced with artificial water sources. For this purpose, based on plans, we create artificial reservoirs, which we maintain and provide the right amount of water in them. The disadvantage of artificial water sources is that their construction and maintenance costs are high and their efficiency will only prevail if there is a wildfire nearby and they need to be used. Until they are used, the costs so far may seem unnecessary. Another characteristic of wildfires is that the frontlines are often far from the forest roads that can be used by heavy fire trucks, therefore the so-called long-distance water transport is also difficult (Bodnár 2016). On the one hand, traffic on dirt roads is rather slow, and on the other hand, the soil in the observation plot in the paper is rather sandy. As a result of this, heavy, water-filled fire trucks simply sank in the sand. The above mentioned problems can be justified by a number of examples, so it is clear that effective firefighting requires either a different firefighting method or a new solution to the water supply problem. Based on the above, the authors aimed how to provide the amount of water needed for firefighting in the most flammable area of Hungary (Bacs-Kiskun County) at the same time.

## 2. Methods

Authors have examined and analysed the relevant literatures focusing on the logistic problems of the firefighting and water supply. In addition, authors conducted discussions with the local firefighting experts on the subject. Case studies, made after the latest fires in the Bacs-Kiskun County, have also analysed focusing on the problem of water supply. Moreover, authors made a real experience in well drilling at a random place at the county and measured the water capacity of the well (flow rate) with using a simple water pump.

## 3. Results

The authors were able to prove that the area is high vulnerable with the help of previous case studies on large wildfires in Bács-Kiskun County (Gyapjas 2007). During firefighting, natural water sources are only available to a limited extent (Farkasinszky 2007a and 2007b) the so-called long-distance water transport is difficult and slow on dirt roads (Árpás 2007) and the risk of blocks are high. Study area is highly threatened by the climate change so suppressing fires in this area seems to be more and more difficult in the future (Teknős 2019, Kovács and Jakab 2021).

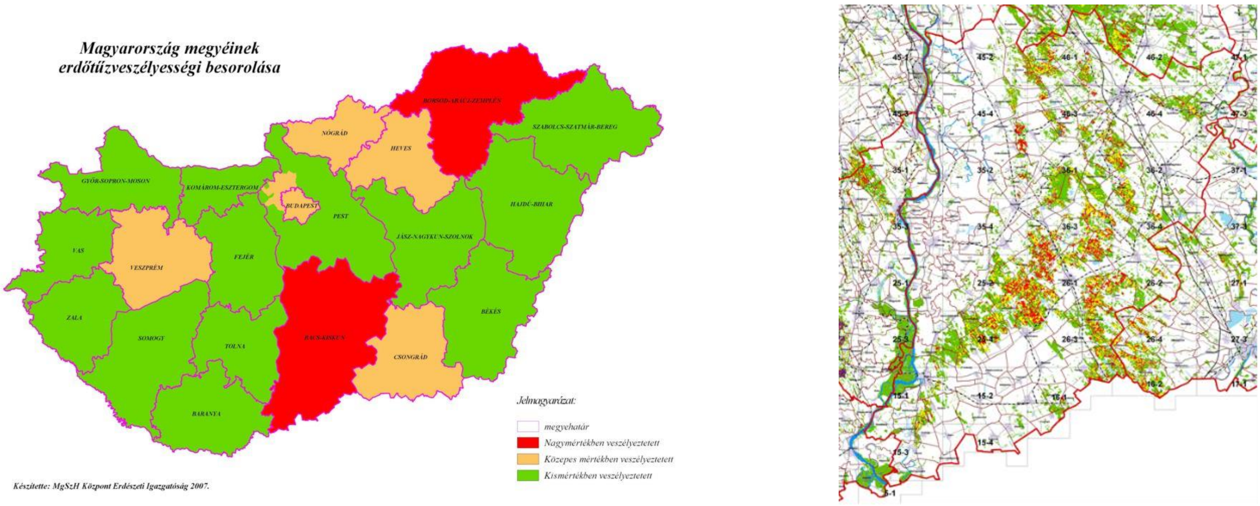


***Figure 1. Fire danger classification of counties in Hungary (left) and the fire danger classification of forests at Bacs-Kiskun County (right) (Gyapjas 2007)***


***Figure 2. Water transport vehicles trapped in sandy dirt road (Gyapjas 2007).***

Based on the geographical analysis, it can be stated that Bacs-Kiskun County is basically a flat area (plain), without significant prominence, but the surface is covered with sand in many places. During the search for water sources, local firefighters suggested that wells used for irrigation of agricultural land should also be considered as potential water sources. Based on experience, these simple wells can be created in a short time, and their water flow appears to be relatively stable even at the order of a few hundred litres per minute (Higuera 2015). Based on the above, the authors first reviewed the area of the observation plot and then the whole country in terms of groundwater availability. For this purpose, the official groundwater map of Hungary (MBFSz maps 2022) and other relevant literatures were analysed (Grundwaters in Hungary 2006; Kovács and Jakab 2021). According to it, there is a water layer a few meters below the wildland area of Bács-Kiskun County, which can be easily reached with the help of a well drilled, due to the sandy soil (Fig. 3). Based on it, the authors conducted an experiment to drill a well at a random selected spot in the county.

The experiment had several purposes.

- First, the authors wanted to prove that the well could be drilled easily and quickly on the soil that characterized the county.
- Another objective of the experiment was for the authors to be able to demonstrate that the water flow provided by the well is stable, so it can provide the same amount of water for at least 24 hours.
- Third objective of the study was to create graphics on which we can find the tipping points where drilled well able to supply as much water as tradition solution.

***Figure 3. Ground water level in Hungary below the surface (left) (MBFSZ maps) and measuring the water flow after drilling (archive of authors).***

The authors involved in the experiment the Municipality Fire Brigade of Szabadszállás and a well drill master. The well drilling master did the professional part of the work (well drilling), the firefighters helped with the preparation and setup of the pump after drilling. During the experiment, the water layer was available in less than 2 hours, slightly deeper than expected, at approximately 5 metres deep. The preparation of the well with 60 mm diameter of well tube, the setting of the pump and the further preparatory works took an additional 1 hour. The water flow, which was then measured for 1 hour, reached 400 $lmin^{-1}$, which appeared to be completely stable. Drilling master stated also that drilled wells can produce stable water amounts after about 1 hour usage. It is proved on the selected place drilling wells can supply firefighters with stable water flow. Based on the results of the experiment, authors calculated the assumption that in case of drilling 2 wells after professional preparation, firefighters can be able to provide a water flow of 800 $lmin^{-1}$ after 3 hours of the arrival of the fire forces. The authors went on to find out whether this amount of water (from the well) competes with the amount that can be provided by long-distance water transport.

In case of long-distance water transport, the following can be expected: the average speed of the water transporter is considered to be 30 $kmh^{-1}$. Based on it, the vehicle travels a distance of 5 km in 10 minutes and returns in another 10 minutes, thus making a total of 10 km in 20 minutes in both directions. As a result of it, the average flow rate of a 10,000 litre tank is 250 $lmin^{-1}$ (Fig. 4 left). The maximum value of the water flow is obtained when the vehicle is not moving, so it is filled and then emptied locally. In this case, the water flow is maximum (500 $lmin^{-1}$). The water flow increases in a straight line with increasing the average speed, while it is inversely proportional to the distance (Fig. 4 right).

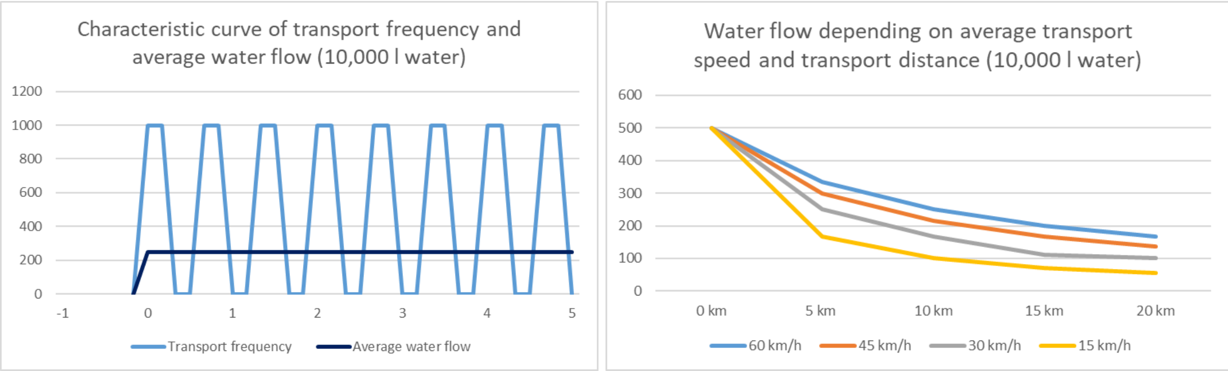


***Figure 4. Characteristic curve depending on transport frequency and average water flow in case of 30 kmh$^{-1}$ average transport speed and 5 km transport distance (left) and water flow rate depending on average transport speed and transport distance in case of 10,000 l water capacity (right).***

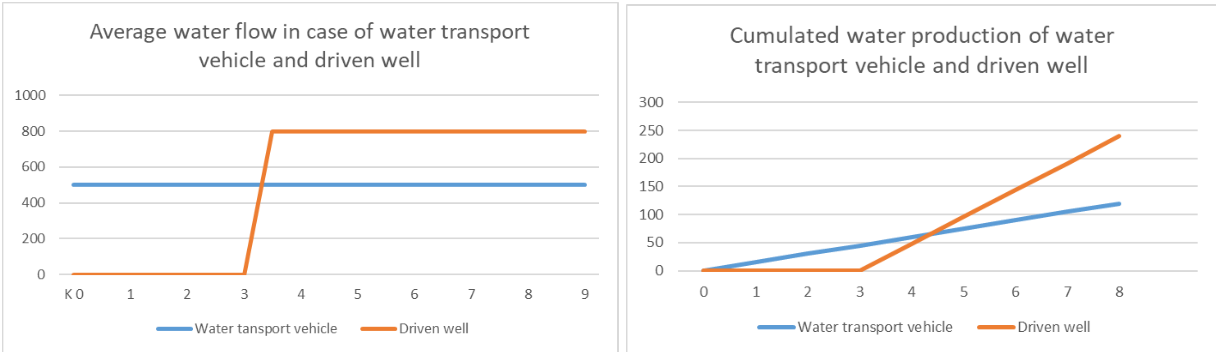


***Figure 5. Average water flow in case of water transport vehicle and driven well (left) and cumulated water production of water transport vehicle and driven well in optimal cases (0 km) (right).***

## 4. Conclusion

The results show that water transporters can be replaced by drilled wells after about 3 hours. The results also show that the farther the water has to be transported, the more difficult it is to transport the water, and the more difficult (slower) is the fire site to approach. The diagrams also show when the cumulative amount of water in drilled wells with higher water flows reaches or exceeds the amount of water provided by water transporters. According to the above, authors considering that during a long firefighting, water transporters can also be replaced or their capability can complete by drilled wells, depending on the given conditions. The authors suggest further research into the international applicability of this method. Example, based on the ground water map of Europe (GWM of Europe 2022) the fire departments could measure their responsible area where ground water can be acceptable by reasonable efforts especially focusing on the forest fire threatened areas, like Mediterranean region. Even if the study area has a good capacity using ground water for supporting firefighters, as a new method it can be an option in other places too. In order to compare the efficiency of the two methods from an economic point of view further research is also required.

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