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# THE IMPORTANCE OF USING MULTIPLE WATER SOURCES AND BACK-UP SYSTEMS FOR WATER SECURITY – CLUJ-NAPOCA AREA

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**ABSTRACT**. This article examines the water sources and treatment techniques applied in the area of Cluj-Napoca, Romania. Alternative sources, including both surface and subsurface sources, are emphasized. The circumstances are compared with those of similar companies in Romania or abroad, to evaluate CAS's operational environment and its potential impact on water security. Additionally, the paper analyses the main legal provisions aimed at securing the groundwater harvesting system (including the one located between Florești and Cluj-Napoca. Finally, the author proposes measures to secure the water supply to consumers.

**Key words:** *water sources surface subsurface treatment.*

## INTRODUCTION

Water is an extremely important resource and a necessary condition for the social and economic development of the society. Pressure on the water sources is high, and it will continue to increase due to the population growth, improvement of the living standards, climate change, and other factors.

According to the US Geologycal Survey (2020), at a planetary level, water available for consumption is a very small percent compared to the total water volume of the hydrosphere, and it is unevenly distributed. Thus, needs are not met everywhere. Therefore, each water source needs protection and appropriate management.

The present work aims to make a contribution to increasing water security in Cluj-Napoca area and implicitly to contribute positively to the quality of life of the end-users that benefit of the water supplied by Someș Water Company (CAS). The availability of multiple water sources can restrain the gap between demand and supply (Elliott et al., 2019) and (Nel et al., 2017) attest that the use of multiple water sources is fundamental, particularly in developing countries, and, according to Van Koppen et al., (2020), is relevant not only in terms of water security but in global development and health issues.

In our view, water security is based on 3 pillars/coordinates: accessibility, quantity and quality (figure 1). Affecting any of the 3 elements involves risks for the users of this indispensable product for life. Stringer et al., (2021) have a similar view on the concept of water security, while Shrestha et al. (2018), have a more complex one. Leong (2016) states that defining water security is much more difficult to achieve because it can be viewed from different perspectives.

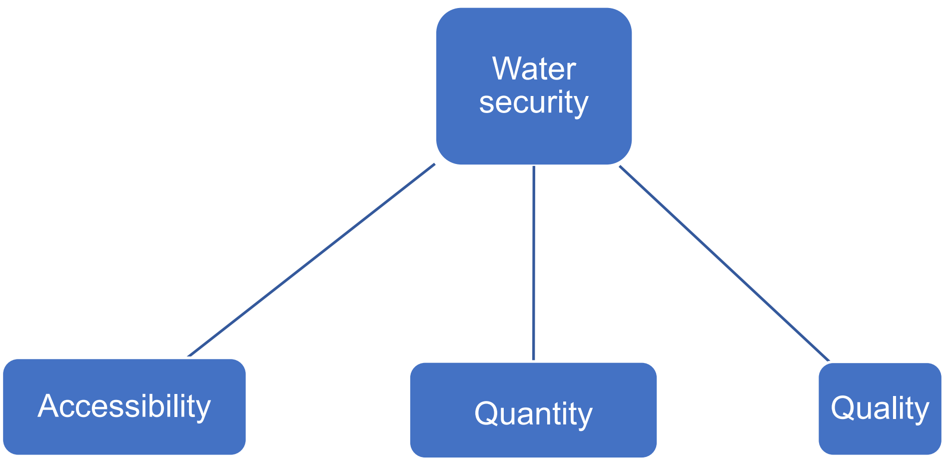


**Fig. 1.** *Author's concept regarding water security*

On the other hand, from the perspective of Zhou et al. (2023), water security is an interconnection between demand (caused by anthropogenic activities) and supply (generated by climate change and consumption reduction policies/technologies).

According to the previous authors, the following threats can affect water sources:

- climate change, terrorism and sabotage – may affect all of the 3 pillars (Gosling and Arnell, 2013; Falconer, 2022);
- lack of diversity of water sources – can affect the quantitative pillar;
- pollution or poor monitoring of water sources – can affect the quality pillar;
- corruption, political interests or legislative deficiencies – whose impact is more difficult to analyse.

This article focuses on the importance of having access to multiple water sources in the area of Cluj-Napoca, thus addressing the risks on the quantity, and, secondarily, on the accessibility of water sources that satisfy customer's needs.

## HYPOTHESES AND OBJECTIVES

Our approach is based on the hypothesis that the existence of multiple water sources increases the security of water supply to the customers.

The objectives of the work are:

a. To evaluate the importance of the groundwater source that supplies the municipality of Cluj-Napoca, and analyse of the main threats and the legislation that should address them.

b. Comparing the Someș Water Company's strategy with other companies from the same sector in Romania and abroad, regarding the plurality of water sources.

## METHODOLOGY

### Current situation review – Relevant case studies

In order to develop a pertinent analysis regarding the importance of water sources diversity in the municipality of Cluj-Napoca, a comparative analysis will be conducted to assess the current situation in this area and compare it with other regions in Romania and abroad.

### *The current situation in Cluj-Napoca*

Over time, as the population has increased, every public utility system has endeavoured to fulfil the requirements of its recipients. The water management system of Cluj city was also subject to this. According to the water supply operator Compania de apă Someș (2020), in 1882, when the city had a population of 35,000 residents, the Water and Sewerage Plant was established. It obtained its water supply from the “Bărnuțiului Garden”, which provided 1,700 m$^3$ per day, and the “Carolina” hospital reservoir, with a capacity of 140 m$^3$. The plant also had a water distribution network that spanned 4.4 kilometres, and a sewage network that covered 0.13 kilometres.

The “*Floresti*” groundwater source became operational in 1900, resulting in a production increase of 7,500 m$^3$/day. Furthermore, a reservoir with a capacity of 2,000 m$^3$ was also put into operation. The city’s water network reached a total length of 42.3 kilometres for distribution and 20.6 kilometres for sewerage pipes. After an interval of 19 years, the “Șapca verde” capture front was activated within the “*Florești*” groundwater harvesting area. The Water and Sewerage Plant was established as a Public Authority in 1930. Simultaneously, the Grigorescu Plant commenced operations, along with the *Captația I* capture front near Florești. In a period of 10 years, the city of Cluj has expanded its network to cover a total of 160 kilometres of distribution, 79 kilometres of sewerage, and has established 6,950 connections to accommodate its population of 116,500 individuals A daily production of 18,500 cubic metres of water was achieved.

With the establishment of the treatment plant at Gilău in 1973, Lake Gilău became the primary water source for the city, supplying approximately 60,000 cubic metres per day.

The official inauguration ceremony of the Tarnița raw water intake (figure 2) occurred on May 7, 2009. This event marked the transition of Lake Tarnița, which has a capacity of 70 million m$^3$, to become the primary source of raw water for the Cluj zonal system. As a result, lakes Gilău and Someșul Cald were designated as backup sources.

Upstream from the Cluj-Napoca municipality there is a string of 5 lakes (figure 3), with different volumes (Hidroconstructia 2020): Fântânele (212 mil. m$^3$), Tarnița (70 mil. m$^3$), Someșul Cald (7,5 mil. m$^3$), Gilău 4 mil. m$^3$ and Florești 2 (1 mil. m$^3$).

**Fig. 2**. *Tarnița raw water intake and its protective buoys*

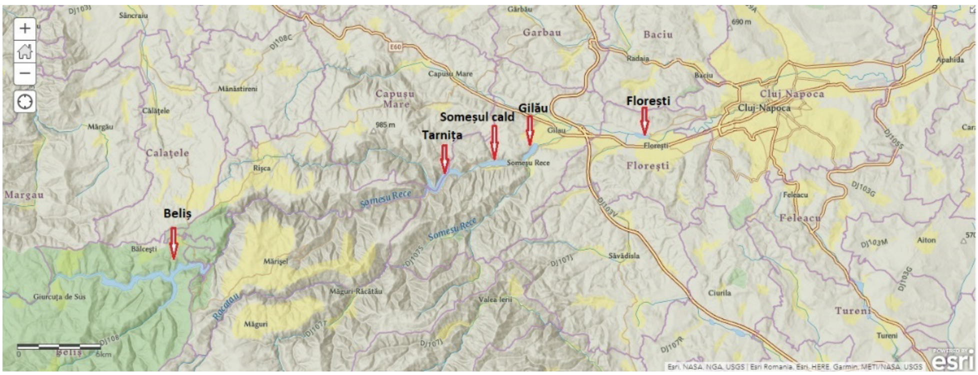


**Fig. 3.** *Lakes located upstream of the municipality of Cluj-Napoca (Hidroconstructia 2020)*

It is noteworthy that on October 14, 1992, the “Someş” Water Company (formerly referred to as the Cluj County Water-Sewerage Autonomous Administration) opened the first and only Water Museum in Romania. The museum is located in the groundwater collecting area near Florești. This source continues to supply water to the residents of Cluj-Napoca municipality. An approximate flow rate of 650-800 litres per second is acquired from this subterranean source. This product is then combined with water from the Gilău station at the Grigorescu pumping station.

The Someș Water Company primarily relies on the Lake Tarnița as its main water supply in the Cluj-Napoca region. The Gilău source is conserved as a reserve, while the Lake Someșul Cald serves as a backup for times when there is excessive turbidity or inadvertent pollution in the Gilău reservoir. In addition, the groundwater supply from Florești, where the Water Museum is located, is currently being utilised.

According to data from the CAS, the majority of water released to the beneficiaries in 2021 came from Lake Tarnița, ranging from 79.32% to 94.61%, as shown in figure 4. However, in September 2021, only little over 25% of the water was supplied from Lake Tarnița, with the remaining 70.4% coming from Lake Gilău. Moreover, water from this lake was used only in October 2021, accounting for 12.52% of the total usage, and in May 2021, accounting for 1.24%. The source of Someșul Cald is accessed on a monthly basis, albeit in limited quantities ranging from 1.69% to 11.69%. Its usage is most pronounced during the summer season. The Florești groundwater source consistently provides a minimal amount of water to the overall water supply of citizens, ranging from 1.29% to 2.71%.

According to the data received from the CAS (C. d. Someș 2024), the capacity of the Florești source is directly influenced by the amount of precipitation and the level of the Someș Mic River, and the yield may vary between 650-850 litres per second. Moreover, CAS states that the Florești source has an annually contributes of 25% to the total water supplied. Our conclusion is that the Florești source operates at a low level, but its potential is much higher, meaning that it can make a major contribution to securing the supply of water to the population.

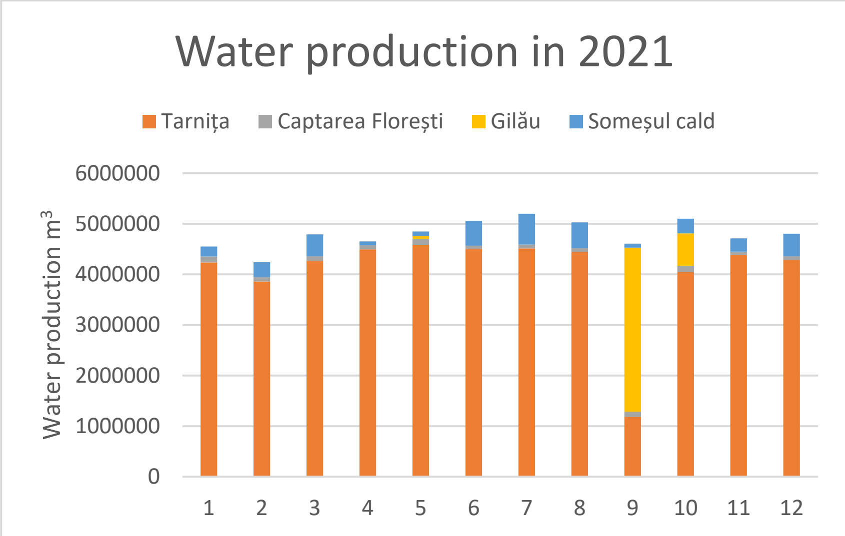


**Fig. 4.** *Water production 2021*

The Florești groundwater source is vulnerable to several threats. The mass-media (Monitorulcluj, 2017; Acualdecluj, 2020) has circulated ideas of changing the area into a park that can be accessed by citizens. Recently, the plans for the building of the upcoming road ring around Cluj-Napoca, which will be located adjacent to the sanitary protection zone, were initiated. Figure 5 depicts the trajectory of the forthcoming road. It is evident that, despite the challenging terrain, the route will adhere to the left side of the Someșul Mic River, so avoiding the designated protection area (highlighted in red). This approach aims, at least in theory, to comply with the current legal regulations.

The local authorities have signed a financing agreement to enhance the efficiency of the groundwater source. This agreement entails the refurbishment of more than 100 wells, over 19 kilometres of drainage and piping, the renovation of the chlorination system, and the implementation of a new SCADA monitoring and control system for the Florești groundwater collection system.

The majority of the funding for this project comes from European sources, and the project is scheduled to be completed by 2024 (zcj.ro, 2022). According to the beneficiary (C. d. Someș 2024), these works will not result in an augmentation of production capacity. Furthermore, the Someș Water Company operates according to a strategic plan that seeks to enhance the distribution and sewerage networks. Utilising a mathematical model and informatic tool as decision support can be highly advantageous for water resource management, particularly in cases where there is a combination of surface and groundwater resources (Pacheco and Pissarra, 2023; Yin et al., 2023).

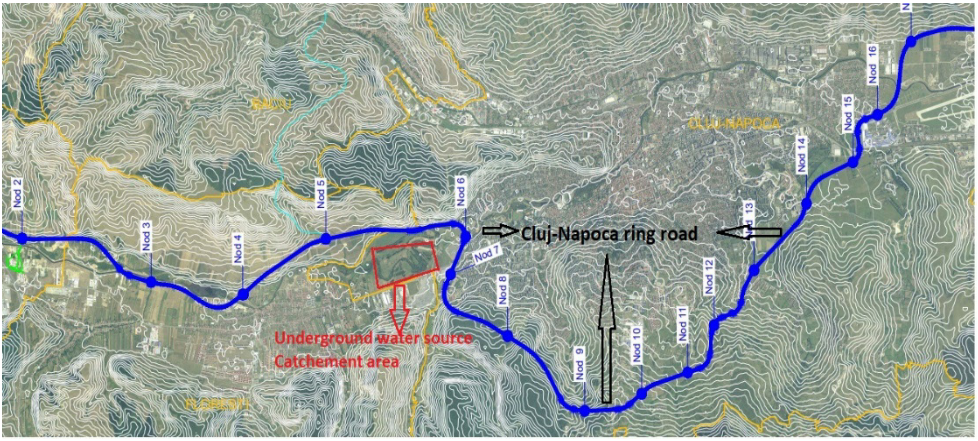


**Fig. *5.*** *Cluj-Napoca ring road* (G4media.ro, 2019) *vs. Floresti groundwater collection area*

## Regulatory system

The water regulatory framework in Romania consists of a series of laws, Government Decisions, EU directives, and other related regulations. Among the most relevant are the Water Law 107/1996 and HG 930 of August 11, 2005 for the approval of the Special Norms regarding the nature and size of sanitary and hydrogeological protection zones.

By decision of the Cluj County Council no. 147 of 15.11.1994, Lake Tarnița was declared a protected natural area. Additionally, by order 951 of July 5, 2021 issued by the Ministry of Transport and Infrastructure, the use of boats that use fossil fuels directly or indirectly (generators) is prohibited. Furthermore, it is prohibited to sail within 200 m of the dam (which includes the area of the water intake tower).

The extension of the protection zones is established according to Annex no. 2, which is an integral part of the law 107/1996. Relevant data for the analysed area can be found in table 1.

**Table 1.** *Protection zones extension*

| | | | |
|---|---|---|---|
| Protection zone extension along water courses | | | |
| Watercourse width (m) | 10-50 | 51-500 | Above 500 |
| Protection zone width (m) | 15 | 30 | 50 |
| Protection zone extension in lakes | | | |
| radially, on the shore | | | (100 m) |
| radially, on the shore where the outlet is located | | | 25 (m) |

Regarding the groundwater collection system from Florești and the projects that could influence it, it's worth mentioning some of the most important legal regulations in force designed to ensure its protection against such intentions. Acting in accordance with 107/1996 and HG 930/2005 (especially Art. 26 and 27), building the Cluj Metropolitan Ring Road within the groundwater collection area is not allowed. Although some similar areas in the Netherlands (a country subject to the same legal provisions established by European legislators) also fulfil the function of a relaxation area, this area cannot be transformed into a recreational area, with pedestrian or bicycle lanes, located at safe distances (minimum 20 m) from the collection wells, as required by the National Administration of Romanian Waters (2017). The high number of wells and their layout make the sanitary protection zones overlap, resulting in an extended area that must be protected against external interventions.

**Case studies (from Romania and abroad*)***

***Apanova – Bucharest*** is 73% owned by the French company Veolia (Apanova, 2020).

Surface sources: multiple catchments on Dâmbovița and Argeş Rivers. Treat the water in the three treatment stations:

- Arcuda station – source: River Dâmbovița, commissioned in 1892 – capacity 650,000 $m^3$/day.

- Roșu Station – source: River Argeș, put into operation in 1970 – capacity of 520,000 $m^3$/day.

- Crivina Station – source: River Argeș, commissioned in 2006 – capacity of 260,000 $m^3$/day.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Ozonation, Chlorination.

Compared to the Someș Water Company, Apanova only uses surface sources. It should be noted that, in order to secure their supply, two sources are being used and the water is treated in several stations.

***Brașov Water Company*** - owned by the Municipality of Brașov and the County of Brașov, with 42% each, the rest being owned by the cities of Rupea, Ghimbav and the communes of Apața, Hălchiu, Harman and Sânpetru (Compania de Apă Brașov, 2020).

Surface sources:

Lake Târlung, the most important source that covers more than 90% of the supply system; Lake Dopca, the water supply source for consumers in the Rupea, Racoș, Dopca area.

Groundwater:

• the Harman – Prejmer groundwater collection area: it includes 45 wells that operate at a depth of 40 m and are equipped with submersible pumps, with a total capacity of 1900 l/s (property of the Brașov National Land Improvement Agency);

• Măgurele groundwater collection area: with 3 deep wells, serving only Poiana Brașov;

• the Ghimbav groundwater collection area: includes 3 wells drilled at a depth of 45 m, with a total capacity of 26 l/s;

• the Stupini-Sânpetru-Hărman groundwater collection area: includes 30 wells operating at a depth of 150 m, with a total capacity of 810 l/s.

Treatment process: Pre-treatment, Chemical dosing, Sand bed filtration, Chlorination.

Comparing the Brașov Water Company with the one in Cluj, certain similarities can be noted: the existence of a main surface accumulation type source (Lake Târlung vs. Lake Tarnița) as well as a groundwater collection system (with a higher flow rate than Florești).

***Apa Canal Sibiu SA*** – 99.89% owned by Sibiu Local Council, the rest being owned by 29 other local councils (Apă Canal Sibiu S.A., 2020).

Groundwater:

The groundwater collection system from Lunca Ştezii started to operate in 1879, with a yield of 900 litres/minute, enough to cover the consumption of the approximately 20,000 inhabitants of Sibiu at that time.

In 1909, the aqueduct from Păltiniș was put into operation, transporting water from an array of springs in the Şanta area. The network was developed in 1922 and 1928, when the springs from the Dăgneasa and Cotorăşti area were captured.

Surface sources:

In 1965, a reservoir was built on River Cibin, upstream from the town of Gura Râului, and also a water treatment station near the town, close to Poplaca. The treatment capacity of the “Dumbrava” plant was 480 l/second, being increased, following further expansion works, in 1977, to 900 l/second.

Surface water accumulations:

In 1979, a new adduction with water coming from the Gura Râului Reservoir, a hydropower complex that could store 15.5 million $m^3$ of water, was put into operation.

Compared to the situation in Cluj, the one in Sibiu evolved in a similar way. Although springs were used at the beginning, later on, a surface source of accumulation type + hydropower complex was put in place.

***Alba Water Company*** – SC APA CTTA SA ALBA (SC APA CTTA SA Alba, 2020); the company’s shareholders are the Alba County Council and the local councils from the 11 municipalities and towns of Alba County (Alba Iulia, Abrud, Aiud, Baia de Aries, Blaj, Câmpeni, Cugir, Teiuș, Zlatna, Ocna Mureș, Sebeș).

Surface sources:

Surface water facilities:

Obrejii de Căpâlna reservoir (River Sebeș) (3,000,000 $m^3$/capacity).

Petrești treatment plant, with a total capacity of about 75,000 $m^3$/day works at about 23% of capacity. It provides water to approximately 30% of the residents in the municipality of Alba Iulia.

Sebeşel treatment plant has a total capacity of 86,400 $m^3$/day, and it is working at about 40% of capacity. It supplies water to approximately 44% of the population of the municipality of Alba Iulia, 89% of the municipality of Blaj, 56% of the municipality of Aiud, 60% of the city of Ocna Mureș and 70% of the city of Teiuș.

Mihoiesti reservoir (on River Aries), and Mihoiesti Câmpeni treatment plant, has a total capacity of 11,232 $m^3$/day, and it is working at about 38% of capacity. It supplies water to approximately 55% of the population of Campeni.

The Râul Mare Cugir treatment plant, with a total capacity of 35,510 $m^3$/day, works at 28% of capacity. It supplies water to approximately 65% of the population of Cugir.

Buninginea – Abrud treatment plant has a total capacity of 2,851 $m^3$/day, and it works at 28% of its capacity. It supplies water to approximately 67% of the population of Abrud.

The Zlatna treatment plant – total capacity of 57,024 $m^3$/day – is operating at 3% of capacity. Powers approx. 63% of the population of Zlatna.

The Hărmăneasa – Baia de Ariesș treatment plant - total capacity of 432 $m^3$/day - is working at 39% of capacity. Powers approx. 9% of the population of Baia de Aries.

The Tarina – Baia de Arieș treatment plant - total capacity of 1,720 $m^3$/day - is working at 29% of capacity. Powers approx. 37% of the population of Baia de Aries

Compared to the CAS, the counterpart in Alba treats the water needed by the municipality of Alba Iulia in two stations, also fed from a surface reservoir, this being the only source for the respective area.

***Oradea Water Company*** (SC Compania de Apă Oradea SA, 2020).

Groundwater:

The company uses 5 water plants located on the two banks of the River Crișul Repede, in the northeastern part of the city, with a total installed pumping capacity of 2,100 l/s. The raw water is collected from the shallow aquifer through drains. In order to enrich the underground water layer, the 23 basins fed by River Crișul Repede through the adduction pipes from the catchments are used.

The existing technology also allows the use of surface water, captured from the River Crișul Repede and then treated accordingly. This solution is a backup one, preferring underground water, which is also of better quality and cheaper, requiring only chlorination as treatment.

The entire catchment system, water adductions, enrichment basins, infiltration fields, water plants are located in a protection zone with a severe regime with an area of approximately 280 ha.

Compared to CAS, Oradea Water Company has a totally different approach. Although it has only one source, which is of underground type (or, if necessary, of the underground/surface hybrid type), the security of the supply is ensured by 5 treatment stations.

***APASERV Satu Mare SA*** was established in 2004, being a joint stock company. The shares are owned by 52 administrative-territorial units from Satu Mare county, the majority shareholder of the company being the municipality of Satu Mare (Apaservsm, 2020).

Groundwater:

Currently, the drinking water supply for the municipality of Satu Mare is provided by the groundwater contained in the alluvial cone of the River Someș through the existing catchments.

Groundwater collection is carried out by pumping from the Mărtinești-Noroieni-Micula collection system, composed of 60 wells (46 of which are usable) - with a maximum collection capacity of approximately 850-900 l/s.

Water treatment is done by: aeration, filtration for demanganization and deferrization, chlorination.

The situation in Satu Mare is different from that in Cluj-Napoca, as groundwater only is used.

***SC VITAL SA Baia Mare*** was established as a commercial company in the summer of 1997, following the reorganization of RASP URBIS Baia Mare, keeping the same activity profile: the provision of water and sewage services to users in the area of operation (Vital, 2020).

Surface sources:

Surface water accumulations:

The treatment plant of Baia Mare (950 l/s capacity) is supplied with raw water from the Strâmtori-Firiza reservoir through the Berdu buffer lake downstream of the dam. In addition, the Ferneziu micro-plant and the Blidari treatment plant are also used.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Chlorination.

Compared to CAS, VITAL SA uses raw water from two reservoirs, which is treated in a single station.

***SC Aquabis S.A*** – Bistrita is mostly owned (89.9%) by the Bistrita County Council, together with 12 local councils in the county (Aquabis, 2020).

Surface sources:

Surface water accumulations: Colibiţa reservoir.

Running water sources: the Rivers Bistrita Ardeleană, Anies, Rebra, Someșul Mare.

Treatment process: filtration (grating), coagulation/flocculation, filtration through sand basins, chlorination.

Compared to Cluj, there is no groundwater source in use.

***APA PROD S.A.*** Deva was established in 2001. The company manages 19 water collection stations, 15 water treatment stations, 4 chlorination stations, 54 water storage complexes and 51 water pumping stations. The length of the supply mains is 184.5 km, and the distribution networks exceed 1090 km (Apaprod Deva, 2020).

Groundwater:

In 1941, the construction of a water plant began - the Horogos Water Source, located north of Deva. The source was built in two stages: the first in 1941, and the second in 1962. Water capture at this source was done from a phreatic aquifer, by means of 14 drilled, shallow wells.

Surface sources:

Running water collection

In 1963, it was decided to create a new water supply source in the village of Batiz, on the left bank of the River Strei.

Surface water accumulations:

In the period 1984-1985, the Orlea Water Source was built, having its intake on the Hațeg reservoir.

Treatment process: Filtration (grating), Coagulation/flocculation, Sand bed filtration, Chlorination

Compared to their counterparts in Cluj-Napoca, Apa Prod Deva had a similar evolution of raw water capture. If initially groundwater was used, currently the main source is surface accumulation.

***The Aquatim*** – Timișoara company is owned by the Timișoara Local Council (99%) as well as by other local councils or the County Council (Aquatim, 2020).

Groundwater:

In 1914, the water plant no. 1 (currently - Urseni water treatment station) which treats and distributes water collected from underground – 600 l/s.

In 1991, the Water Plant no. 5 (currently - Ronat Water Treatment Station), as a secondary source of deep water.

Surface sources:

In 1959, the water plant no. 2, captures and treats water from River Bega at the (initial) capacity of 115.7 l/s. – currently 1,380 l/s

In 1982 - Plant no. 2 is expanded by building in the same location the Plant no. 2-4 (currently the Bega Water Treatment Plant) – 900 l/s.

Compared to CAS, which uses raw water from an accumulation, the counterparts in Timișoara capture water from River Bega. For technical reasons, they have several treatment plants, compared to those in Cluj who have only one. The only similarity is given by the capture from underground sources as well.

From abroad:

***PWN – The Kingdom of the Netherlands*** (PWN, 2020)**.**

Surface sources:

Lake Ijessel - where the River Rhine flows.

Groundwater:

The sand dune area – underground slow filters Heemskerk area – which provides 45% of the water needed by the customers.

Annually, the company supplies 112 million $m^3$ of water to its 1.7 million customers.

The company uses 4 treatment plants: Andijk, Heemskerk, Bergen and Wijk aan Zee.

- the one from Andijk (Ijessel source), which uses the treatment scheme: grates coarse filtration - the use of resin that absorbs organic material and $NO^3$/Ceramic membrane microfiltration (this represents a pretreatment that replaces the classic coagulation/flocculation/sand basin filtration technology) - advanced oxidation ($H_2O_2$+UV) - filtration through biologically activated carbon.

- The one in Heemskerk (Ijessel source, 50 km away) which uses the treatment scheme: coagulation/flocculation/filtering + biologically active carbon (as well as pretreatment) - advanced oxidation ($H_2O_2$+UV) - infiltration through dunes. In parallel, there is an ultrafiltration/reverse osmosis line (Kamp et al., 2000). Once the water is excessively purified, it is mixed with water that is collected from the nearby dunes, so that it can be consumed by the beneficiaries (edie.net, 2011).

Slow filtration through the sand dunes (approx. 30 days) – a natural area (Natura 2000 site) of approx. 7300 ha, of which only 5% is used for filtration. Although the dunes represent only 0.5% of the surface of the Netherlands, over 50% of the country's biodiversity can be found in this area (Dutchnews, 2018). The water infiltrated into the dunes also comes from Lake Ijssel.

Compared to CAS, the Dutch from PWN use only one source of water, Lake Ijssel, but the treatment process takes place in 4 stations, and the technology used is clearly advanced to that applied in Cluj-Napoca.

***Waternet – The Kingdom of the Netherlands*** (Waternet, 2020)**.**

Surface sources:

The Bethune polder – from where the pumped water is treated at the station in Loenderveen. In cases of drought, water is supplied from the Amsterdam-Rhine canal.

Lek Canal – Bethunepolder catchment area near Maarssen. The canal is fed by the River Rhine. After a coagulation/flocculation/sand bed type pretreatment, the water is pumped into the dune system (slow filters) Amsterdamse Waterleidingduinen – filtration time approx. 3 months (near Haarlem), refiltered through sand to remove algae, then pumped to the Leiduin treatment plant. Here, the water is subjected to a treatment process by ozonation (15 minutes), softening (up to 7.8 German degrees) and filtration through biologically activated carbon. Annually, 70 million $m^3$ of water is filtered through the respective dunes.

Compared to Compania de Apa Someș, Waternet, like PWN, uses water from River Rhine. They have two sources, and the treatment process is different, much more advanced than the one in Romania.

***New York*** table (New York City water supply system, 2020).

It consists of 2 lake arrays:

- Croton, east of the Hudson River – composed of the following lakes: Boyds Corner, West Branch, Glaneida, Gilead, Middle Branch, Bog Brook, East Branch, Diverting, Craton Falls, Titicus, Kirk, Amawalk, Muscoot, Cross River, New Croton and Kensico.

- Catskill/Delaware west of the Hutson River – composed of the following lakes: Cannonsville, Pepacton, Schoharie, neversink, Rondout, Boys Corner, West Branch and Ashokan.

From the two rivers, water reaches the city through three aqueducts: Croton, Catskill and Delaware. The water company delivers daily over 3.75 million $m^3$ to 10 million customers.

Its treatment consists of: coagulation/flocculation, sand filtration and a double disinfection: chlorination and UV.

It is of interest that until 2007, a water supply system consisting of 67 wells, from where the water reached 43 stations and several storage tanks, also operated in the SE of Queens. The system was put into operation in 1887, until 1996 it was owned by the private Jamaica Water Supply Company (JWS).

## RESULTS AND SUGGESTIONS

Someș Water Company is an entity that has undergone changes over time, aiming to meet the specific demands of its consumers and adhere to legislative regulations concerning water quality.

From a quantitative point of view – supply security is ensured using raw water from the Lake Tarnița, with the Lakes Gilău and Someșul Cald as reserves. Underground catchments have not been abandoned, although their contribution is low. On the other hand, their potential is higher, being able to provide up to 25% of the water requirement, at least for short periods. The groundwater collection area between Florești and Cluj-Napoca, although comparable to the dune area in Holland, must remain restricted to the public, due to water quality protection and safety reasons. The legislation in force protects this area against building initiatives.

Analysing the raw water sources and the number of treatment stations, the Someș Water Company's strategy compared to that of other similar companies in Romania, can be classified as follows:

- similar: Brașov Water Company (using a lake as the main source and groundwater as a secondary source), SC. Apa Prod SA Deva (initially they captured water from underground sources, later from a well, and finally, from a reservoir).

- partly similar: Apa Canal Sibiu (using a lake as the main source and springs as secondary sources), SC APA CTTA SA Alba (uses water from only one lake to supply the municipality of Alba Iulia, without secondary sources; on the other hand, the treatment takes place in two stations), VITAL SA Baia Mare uses raw water from two reservoirs, which is treated in one station, Aquabis (uses raw water from a reservoir for the municipality of Bistrita, without groundwater extraction).

- different: Apanova Bucharest (takes water from two rivers, using 3 treatment stations), Oradea Water Company (takes groundwater from the banks of the River Criș, but purifies it in 5 stations), SC. APASERV Satu Mare SA (has only one groundwater source), Aquatim Timișoara uses both surface and groundwater, and 5 treatment stations are in operation.

As shown by the previous comparison, most water companies in Romania use an existing reservoir from their area as their main water source, especially in the hilly/mountainous area, where such hydrotechnical constructions are easier to build. The three examples that do not benefit from such a source are in lowland areas.

Another important aspect is that 4 of them have two or more treatment plants, which is a big plus for the supply security in case one of them should fail. A possible breakdown of the Gilău water treatment station would represent an absolutely critical situation for CAS, which would not be able to deliver the necessary water using only the Florești source. As for the treatment process, it is identical, except for Apanova, which also applies ozonation. For economic reasons, the treatment process must be chosen according to the raw water quality. Thus, water from a higher quality source requires a less intrusive treatment process.

Before comparing the Someș Water Company with the foreign counterparts listed in the previous chapter, it should be noted that these are much larger companies (in terms of number of end-users), and some are true pioneers in terms of the technology.

Thus, it can be seen that the counterparts in New York have abandoned groundwater, focusing strictly on the lakes from the upstream area. The existence of 3 water aqueducts that supply hundreds of treatment stations ensures the continuity of the supply in case one of these elements is taken out of use. As for the treatment process, it is similar to the one in Bucharest, having an ozonation step in addition to what the Romanian companies generally use.

On the other hand, as far as Dutch companies are concerned, the situation differs almost entirely. Since chlorination is no longer used as a disinfection method in the Netherlands, the relevant companies have adapted their treatment technology and modernized the distribution systems. Thus, PWN was the first company in Europe to implement processes such as ultra-filtration/reverse osmosis, advanced oxidation such as $H_2O_2$/UV or filtration through resins (to reduce organic material and nitrate)/micro – filtration through ceramic membranes.

Both PWN and Waternet utilises River Rhine (which ends up in either Lake Ijssel or the canal) as their main water source. In order to secure the water supply, treatment takes place in several stations. Complementary to the technological process itself, a large amount of water is infiltrated into sand dunes where it is naturally purified for several tens of days, thus increasing its quality in a cheap and non-invasive manner. The treatment process utilised in Romania is also used by the Dutch companies as a pre-treatment stage for the rest of the technological process. Because water culture is deeply rooted in the Dutch tradition, water companies continuously invest in research in order to develop innovative technologies. At the same time, it keeps the old treatment plants as backup options in case the new plants would fail.

In the process of optimizing/developing new treatment technologies, companies try to look to the future to understand what challenges might arise. Representative in this sense is the vision of PWN, which in their 2019 activity report expressed their concern about how global warming will affect the quality of the water source from Lake Ijessel, due to salinity increase. At the same time, a pilot process to build floating solar panel farms on Lake Ijssel to produce renewable energy was started. Romania’s advantage in this sense is given by the fact that most of the hydrotechnical constructions are also equipped with turbines, thus the lakes are water sources and also green energy sources. Regarding the disinfection component of the treatment process, the use of chlorine can have beneficial effects in force majeure situations such as anthrax contamination (Raber and Burklund, 2010) because such spores can also be transmitted through drinking water (CDC, 2023).

It is important to mention that these companies operate in a country with a strong economy, which can afford to invest in technology in order to provide their citizens with a high-quality product.

A final important factor to consider is the particularity of the water sources. Whether we are talking about CAS, the counterparts from Romania or abroad, they are obliged by the existing regulations to supply a product that falls within the quality parameters. As a rule of thumb, the quality is good in the case of groundwater sources, but gaining access to it requires more resources.

## Suggestions

Taking into account all the above-mentioned aspects (the existing situation in the area served by the CAS, as well as the policy pursued by some of its counterparts), the author proposes a series of measures, intended to contribute to strengthening the concept of water security, from the supply perspective. They will be grouped into 3 major directions: water sources, treatment and distribution (see table 2).

**Table 2.** *Measures proposed by the author*

| Target item | Proposed measures |
|---|---|
| Water sources | - creation of supplementary intakes in the other available lakes<br>- modernization and expansion of groundwater sources<br>- keeping remote sources as backup sources<br>- protecting the sources against external threats |
| Treatment | - construction of secondary stations<br>- creation of new, parallel flows<br>- modernization and expansion of existing treatment plants<br>- increasing station security |
| Distribution | - the construction of secondary aqueducts.<br>- securing the existing water aqueducts<br>- classify the distribution network as a state-secret<br>- efficient and innovative management<br>- building large distribution basins along the network |

The duality or plurality of water sources ensures the necessary volume in exceptional or *force majeure* situations. Regarding surface sources, the status of Lakes Gilău and Someșul Cald (as reserve water sources) significantly contributes to securing supply. They contribute to the accessibility and quantity pillars. We believe that the implementation of water intakes in each lake would not only increase the volume of water available, but would give the operator the opportunity to opt for the water that has the best quality at a given time, avoiding thus the limitations given by changes in the physical/chemical/biological parameters of a source at a given time, changes that would make water treatment inappropriate, or would involve high costs. Moreover, a larger volume would ensure water for the future customers of CAS, given the expansion of the distribution network in Sălaj county as well. Last but not least, according to the specialists from The Royal United Services Institute (2010) the availability of a large volume of water helps protect customers in the event of chemical or biological terrorist attacks, according to the principle "the solution is dilution".

Underground sources must continue to be a back-up solution, even if their contribution is reduced. In the case of CAS, this is important as there is no dependence of the Florești source on the Gilău water treatment plant, the only one operating in the area. Underground sources should be upgraded and expanded where possible. Additionally, new groundwater collection areas can be identified, especially in isolated areas, where there are no distribution systems or prospects for expanding the existing ones. Currently, such sources provide water to the towns of Jibou and Cehu Silvaniei (C. d. Someș, Casasomes.ro 2023).

Although the water main towards Sălaj county is under construction, we believe the Vârsolț source, which currently supplies the municipality of Zalău and the town of Șimleul Silvaniei, must be maintained as a reserve source in the future. Despite the fact that the water from this reservoir does not have the same quality as that from Lake Tarnița, it is the only major source in the area, which can be used in case the future main aqueduct suffers a major failure.

The existence of a sufficient number of water sources, or the construction of new ones, is the first condition for securing water supply. Furthermore, they must be subject to advanced protection measures to protect them from threats such as: pollution, terrorism or sabotage. The authorities should implement additional measures to reduce the risk of accidental or intentional pollution of water sources (e.g. securing and expanding sanitary protection zones, improving waste and wastewater collection systems in the vicinity of water sources, increasing controls, awareness activities, etc.). The war in Ukraine highlighted the importance of protecting critical civil infrastructures (energy or water), which are often the target of armed attacks or sabotage. Thus, the author believes that the water infrastructure must be considered a strategic objective, and thus benefit from increased protection: armed guard and video surveillance. In addition, the intelligence services must constantly watch over threats (hybrid or terrorist), which can target such objectives.

## CONCLUSIONS

The existence of several water sources is an element that significantly contributes to securing the supply of beneficiaries. Groundwater collection systems are important backup options in case of major damage to the main systems. Regarding the Someș Water Company, the main vulnerability identified would be the existence of a single water main, which supplies the only existing treatment plant. A failure of any of these two elements would leave a large part of the Cluj-Napoca population without water.

For these reasons, the author proposes a series of measures, intended to contribute to strengthening the concept of water security, clustered in 3 major directions: water sources, treatment and distribution.

The Someș Water Company managed to adapt to local conditions (raw water sources, their quality, the supplied population, etc.). Despite the identified vulnerabilities, the company brilliantly fulfils its mission to provide its customers with safe water that complies with the national quality norms. Moreover, through the distribution network modernization programs, it is intended to reduce losses and maintain optimal water quality throughout the system.

## REFERENCES

Actualdecluj, 2020. *Actualdecluj.ro.* 23 July. https://actualdecluj.ro/arhitectii-si-activistii-au-iesit-cu-caiacul-pe-somes-sa-militeze-pentru-un-parc-natural-de-200-de-hectare-care-ar-putea-functiona-intre-floresti-si-cluj-napoca/. (accessed 17.04.2023)

Administrația Națională Apele Române, 2017, *Planul de management actualizat aferent porțiunii naționale a bazinului hidrografic internațional al fluviului Dunărea.* Ministerul Mediului Apelor și Pădurilor.

Apă Canal Sibiu S.A., 2020, https://www.apacansb.ro/ (accessed 20.06.2020).

Apanova, 2020, https://www.apanovabucuresti.ro/ (accessed 13.06.2020).

Apaservsm, 2020, https://www.apaservsm.ro/ (accessed 14.06.2020).

Aquabis, 2020, http://www.aquabis.ro/ (accessed 14.06.2020).

Aquatim, 2020, https://www.aquatim.ro/ (accessed 15.06.2020).

CDC, 2023. CDC.gov, https://www.cdc.gov/anthrax/transmission/index.html (accessed 15.11.2023).

Compania de Apă Brașov, 2020, https://www.apabrasov.ro/ (accessed 15.06.2020).

Compania de Apă Someș, 2020, https://www.casomes.ro/?page_id=1805, https://www.casomes.ro/?page_id=1527 (accessed 23.03.2023).

Compania de apă Someș, 2024, Data request no 9152 from March 18, 2024.

Apaprod Deva, 2020, https://apaprod.ro/ (accessed 15.06.2020).
Dutchnews, 2018, https://www.dutchnews.nl/features/2018/07/the-dutch-dunes-are-more-than-just-sand-theyre-a-source-of-drinking-water/ (accessed 10.06.2023).
edie.net, 2011, https://www.edie.net/library/Innovation-harnessed-in-Dutch-water-treatment/6009 (accessed 07.09.2023).
Elliott M., Foster T., MacDonald M.C., Harris A.R., Schwab K.J., Hadwen W.L., 2019, Addressing how multiple household water sources and uses build water resilience and support sustainable development. *npj Clean Water*, **2** (6), 5 p, https://doi.org/10.1038/s41545-019-0031-4.
Falconer R. A., 2022. Water Security: Why We Need Global Solutions. *Engineering* **16**, pp. 13-15. DOI:10.1016/j.eng.2021.10.009
G4media.ro, 2019. *www.g4media.ro.* 13 November. https://www.g4media.ro/care-este-traseul-final-al-centurii-cluj-in-regim-de-autostrada-primaria-a-preluat-proiectul-de-la-guvern-si-vrea-sa-descongestioneze-traficul-in-oras-si-in-floresti.html. (accessed 17.04.2023)
Gosling S., Arnell N., 2016, A global assessment of the impact of climate change on water scarcity. *Climatic change, Springer*, **134**, pp. 371-385.
Hidroconstrucția, 2020, http://www.hidroconstructia.com/dyn/2pub/proiecte_det.php?id=119&pg=28 (accessed 15.06.2020).
Yin J., Xia J., Liu Z., Ji S., Cai W., Wang Q., Liu X., Zu J., Wang Y., Xu K., 2023, Impact assessment of cascade freshwater reservoir using the ecological security assessment (ESA) model across a four-year timescale. *Ecological Indicators*, **154**, 110907, https://doi.org/10.1016/j.ecolind.2023.110907.
Leong C., 2016, Resilience to climate change events: The paradox of water (In)-security. *Sustainable Cities and Society,* **27**, pp. 439-447, https://doi.org/10.1016/j.scs.2016.06.023.
Monitorulcluj.ro, 2017. *Monitorulcluj.ro.* http://www.monitorulcj.ro/actualitate/58373-muzeul-apei-se-transforma-in-parc-compania-de-apa-somes-nici-nu-vrea-sa-auda-de-ambitiile-lui-boc#sthash.j8Um2itP.dpbs. (accessed 17.04.2023)
Nel N., Heinz E. J., Loubser C., Kobus (JA) Du P., 2017, Supplementary household water sources to augment potable municipal supply in South Africa. *Water SA.* 43 (4), pp. 553-562, DOI:10.4314/wsa.v43i3.01.
New York City water supply system, 2020, https://www1.nyc.gov/site/dep/water/water-supply.page (accessed 18.06.2020).
Pacheco F.A.L., Pissarra T.C.T., 2023, Groundwater security indicators and their drivers: An assessment made in a region of tropical climate (Paraopeba River basin, Brazil). *Science of the Total Environment,* **901**, 165919, 18 p., https://doi.org/10.1016/j.scitotenv.2023.165919.
Kamp P. C., Kruithof J. C., Folmer H. C., 2000, UF/RO treatment plant Heemskerk: from challenge to full scale application. *Desalination,* **131** (1-3), pp. 27-35, https://doi.org/10.1016/S0011-9164(00)90003-1.
PWN, 2020. https://www.pwn.nl/ (accessed 18.06.2020).

Raber E., Burklund A., 2010, Decontamination Options for Bacillus anthracis-Contaminated Drinking Water Determined from Spore Surrogate Studies. *Applied and Environmental Microbiology,* **76** (19), pp. 6631-6638.

RUSI, The Royal United Services Institute, 2010, *Keeping our drinking water safe.* https://rusi.org/publication/keeping-our-drinking-water-safe.

SC Compania de Apă Oradea SA, 2020, http://www.apaoradea.ro (accessed 20.06.2020).

SC APA CTTA SA Alba, 2020, https://apaalba.ro/ (accessed 13.06.2020).

Shrestha S, Aihara Y, Bhattarai AP, Bista N, Kondo N, Futaba K, Nishida K, Shindo J., 2018, Development of an objective water security index and assessment of its association with quality of life in urban areas of developing countries. *SSM Popul Health*., **19** (6), pp. 276-285. doi: 10.1016/j.ssmph.2018.10.007.

Stringer L. C., Mirzabaev A., Benjaminsen T.A., Harris R. M.B., Jafari M., Lissner T. K., Stevens N., Tirado-von der Pahlen C., 2021, Climate change impacts on water security in global drylands. *One Earth,* **4** (6), pp. 851-864, https://doi.org/10.1016/j.oneear.2021.05.010.

Survey, U.S. Geological, 2020, https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_objects (accessed 21.06.2020).

Van Koppen B., Hofstetter M., Edward Nesamvuni A., Chiluwe Q., 2020, Integrated management of multiple water sources for multiple uses: rural communities in Limpopo Province, South Africa. *Water SA,* **46** (1), pp. 1-11, http://dx.doi.org/10.17159/wsa/2020.v46.i1.7870.

Vital, 2020. https://www.vitalmm.ro/ (accessed 22.06.2020).

Water Thames, 2020, https://www.thameswater.co.uk/ (accessed 22.06.2020).

Waternet, 2020, https://www.waternet.nl/ (accessed 23.06.2020).

zcj.ro, 2022, https://www.zcj.ro/administratie/incep-lucrarile-de-modernizare-a-sursei-de-apa-subterana-floresti-investitie-de-66-mi-lei-fonduri-europene--235191.html (accessed April 17, 2023).

Zhou Y., Nan L., Haitang H., Bojie F., 2023, Water resource security assessment and prediction in a changing natural and social environment: Case study of the Yanhe Watershed, China. *Ecological Indicators,* **154**, 110594, https://doi.org/10.1016/j.ecolind.2023.110594