

WATER RESOURCES MANAGEMENT IN THE LAND OF FĂGĂRAȘ

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ABSTRACT – The efficient management of water resources is vital for a community, because water is both a precious "good" and a strategic element in the process of spatial planning. It is not the abundance or scarcity of this resource that dictates the level of development in a territory, but the skills of local "actors" to participate to an adequate utilisation strategy, without compromising it. The aim of this study is to analyze the spatial distribution of the water resources in the regional system of the Land of Făgăraș, which are considered to be one of the most valuable natural resources in the territory. We focused our research on presenting the potential of the surface water, particularly the hydrographical network and the artificial lakes, but also the underground reservoirs, all in relation to access to the centralized supply system and the production of hydropower. Indicators of social welfare, such as the amount of water distributed for household needs per capita from the total amount of water distributed through the supply network were calculated in relation to household consumers. Finally, we concluded that an efficient management of water resources should necessarily involve partnerships between localities positioned above the same underground reservoirs or those using the same surface sources.

Keywords: water resources management, underground reservoir, regional planning, water consumption activities, hydropower

INTRODUCTION

The paper aims to analyse the hydrological component in the Land of Făgăraș from the point of view of water resources management. We focused our research on the potential of the water resources in this region, the existing water consumption activities outlining the areas characterized by scarcity of water and those which are defined by abundance of water.

It is well known that the Land of Făgăraș benefits from rich surface as well as underground water resources. In the scientific literature, this spatial entity is also named "The Land of the Olt", due to its location in the middle basin of the Olt. According to von Hasselbach (1997, p. 183), the toponym "the Land of the Olt", with a clear reference to the homonymous hydrographical axis, represents the popular name transmitted orally, by generations". In a recent research study conducted by Boamfă, the attention was drawn to the terms related to hydrographical characteristics of the land. The author associated local toponyms with the excessive humidity in the Olt river meadow, (e.g. "Balta Mare"). Rivers and rivulets that spring from the Făgăraș Mountains have vigorous flow, transposed in popular language. This is the case of the Sebeș, which means "fast" in Hungarian.

The land is crossed axially, from east to west, by the main collector, the Olt, which springs from Hășmașu Mare Massif at 1400 m altitude. In this context, the Olt corridor is regarded as a real "biunivocal gravitation axis" (Cocean, 2010) because it has assigned the major road and railway transportation route, the European highway E 68 and the main railway section M2, imposing the orientation of flows.

In terms of natural water resources, the Land of Făgăraș is characterized not only by a dense river network, but also by the varied surface and underground sources. Richness in freshwater has always represented one of the strengths attributed to this land, which had been the subject of interest for many researchers and also for a former leader of our country, Nicolae Ceaușescu, who had the

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intention to collect waters from this region and direct them into the Argeș, by digging a channel in the mountains (Modorcea, 2007).

The definition of “resource” given by the Dictionary of Human Geography (Erdeli et al., 1999, p. 274) emphasizes the relationship between the development level reached by a community and the usage of natural and anthropogenic resources: “finally, it becomes a cultural concept, the same elements can be taken into consideration by a society or, on the contrary, because of the underdevelopment of that society, the same elements can be neglected”. Therefore, we believe that knowledge of the typology of water resources in the studied region is mandatory, in order to be properly valued.

This paper is based on information collected from the local authorities, from the Olt Basin Branch Authority, from the National Institute of Statistics and from bibliographical sources. Cartographic sources consisting of ortho-images and topographic maps at scale 1:25 000 were analysed and processed in GIS environment. Indirect observation was correlated with field observation conducted during October 2011-July 2012.



Figure 1. *The Făgăraș Depression and the northern ridge of the Făgăraș Mountains*

LOCATION OF STUDY SITE

The Land of Făgăraș, situated in the centre of Romania, is “divided” between two neighbouring counties, Brașov and Sibiu. Administratively, the land consists of three urban localities, the towns of Făgăraș, Avrig and Victoria and twenty-six communes.

Geomorphologically, this land is located at the contact of the Făgăraș Depression with the Făgăraș and the Perșani Mountains. In the north-east, it widely communicates with the Hoghiz-Veneția Depression, while the western limit is represented by the Olt valley (Popescu, 1990). The geomorphologic personality of this space is defined by the great altitudinal difference which confers the region a much appreciated landscape value (Figure 1).

EXISTING WATER RESOURCES AND WATER MANAGEMENT

Conceptual framework

The concept of integrated water management is defined as “the management that promotes the development and coordination of water, lands and its resources for optimizing the sustainability of economic and social development without compromising the ecosystems” (Integrated Water Management).

In accordance with the Water Law no. 107/1996 “the guiding scheme is the main instrument for planning, development and water management in the hydrographical basin district and comprises a Hydrographical Basin Development Plan - the quantitative management component and the Hydrographical Basin Management Plan - the qualitative management component”.

Due to the fact that the studied area consists of administrative units belonging to Sibiu and Brașov counties, the management authorities responsible with management activities are S.G.A. Brașov and S.G.A. Sibiu, both without legal statute, but subordinated to the Olt Basin Management Authority, which represents the legal frame of action and coordinates the management and exploitation of water resources for the Olt basin.

Surface water bodies

Analysing the water resources in the Land of Făgăraș, certain peculiarities have been revealed. First, the geological and geomorphological peculiarities favoured the emergence of a dense hydrographical network (that reaches values of 1.62 km/km² in the piedmont plain and 1.4 km/km² at regional level, compared to the national average which is 0.5 km/km²) on the left side of the Olt, but

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also of low density values on the right side of the Olt (in the Rodbav Plateau). Most of the streams originate from the glacial cirques of the Făgăraș Mountains, being fed constantly from the snow melting until mid summer, but also from heavy rainfall at high altitudes.

The general relief of the area is the outcome of the strong elevation of the mountain ridge and the successive accumulations of materials at the foot of these mountains.

The territory is grafted on the middle basin of the Olt and on a small surface on the Mureș hydrographical basin. The entire hydrographical network converges to the Olt, excepting several streams in the north that belong to the hydrographical basin of the Mureș.

Another characteristic is that the Land of Făgăraș has a transit hydrological network. The Olt crosses the region from East to West on a total length of 125 km while receiving most of its tributaries from the mountainous area. Consequently, the spatial distribution of the hydrographical systems, in relation to the main river, is asymmetrical (Fig. 2).

The important tributaries of the Olt from the left bank are Șercaia (Area=352 km², Length=42.6 km), Viștea (Area=42 km², Length=22.5 km), Ucea (Area=39 km², Length=21.9 km), Arpașul Mare (Area=83 km², Length=23 km), Porumbacu (Area=84 km², Length=24 km) Cibin (gathering its springs from the glacial cirques of the Căndrel Mountains) (Area=2237 km², Length=80.3 km), the last one flowing into the Olt North of Turnu Roșu. By assessing the water resources available through the river network, we can observe that there are inequalities caused by altitude and precipitations, between the left and the right tributaries of the Olt (especially rivers that drain the Hârțibaciu Plateau).

The exposition of the basins against the humid air masses produces heavy rainfalls of 1200-1400 mm/cm²/year, contributing to a vigorous flow for the rivers that spring from the Făgăraș Massif (Ujvari I., 1972), while on the right bank, the Olt receives small tributaries such as Felmer (with an average annual low flow of 0.07 m³/s in 2009, respectively 0.05 m³/s in the previous year) and Cincu fed by the rainfall solely.

Table 1. *Characteristics of hydrometric stations in the Land of Făgăraș*

River	Hydrometric station	Q med. Multiannual (m ³ /s/between 2005-2010)	Q min. (m ³ /s/year)	Q max. (m ³ /s/year)
Olt	Hoghiz	62.50	44.20/2009	86.00/2005
Șercaia	Șercaia	3.70	3.06/2008	5.43/2005
Felmer	Felmer	0.19 (2004-2009)	0.05/2007	0.43/2005
Racoviță	Făgăraș	2.33	2.15/2006	2.75/2005
Breaza	Breaza	1.56	1.31/2008	2.85/2005
Arpașu Mare	Arpașu de Sus	1.78	1.57/2008	2.36/2005
Arpășel	Arpașu de Sus	0.82	0.68/2008	1.06/2005
Pârâul Nou	Noul Român	1.07	0.63/2007	2.07/2005
Cârțișoara	Cârțișoara	2.18	1.93/2008	3.09/2005
Porumbacu	Porumbacu de Sus	1.89	1.51/2006	2.42/2005
Avrig	Avrig	1.66	1.29/2007	2.41/2005
Olt	Sebeș Olt	97.15	75.8/2009	131/2005

Source: data collected from the Olt Water Branch and processed by the author

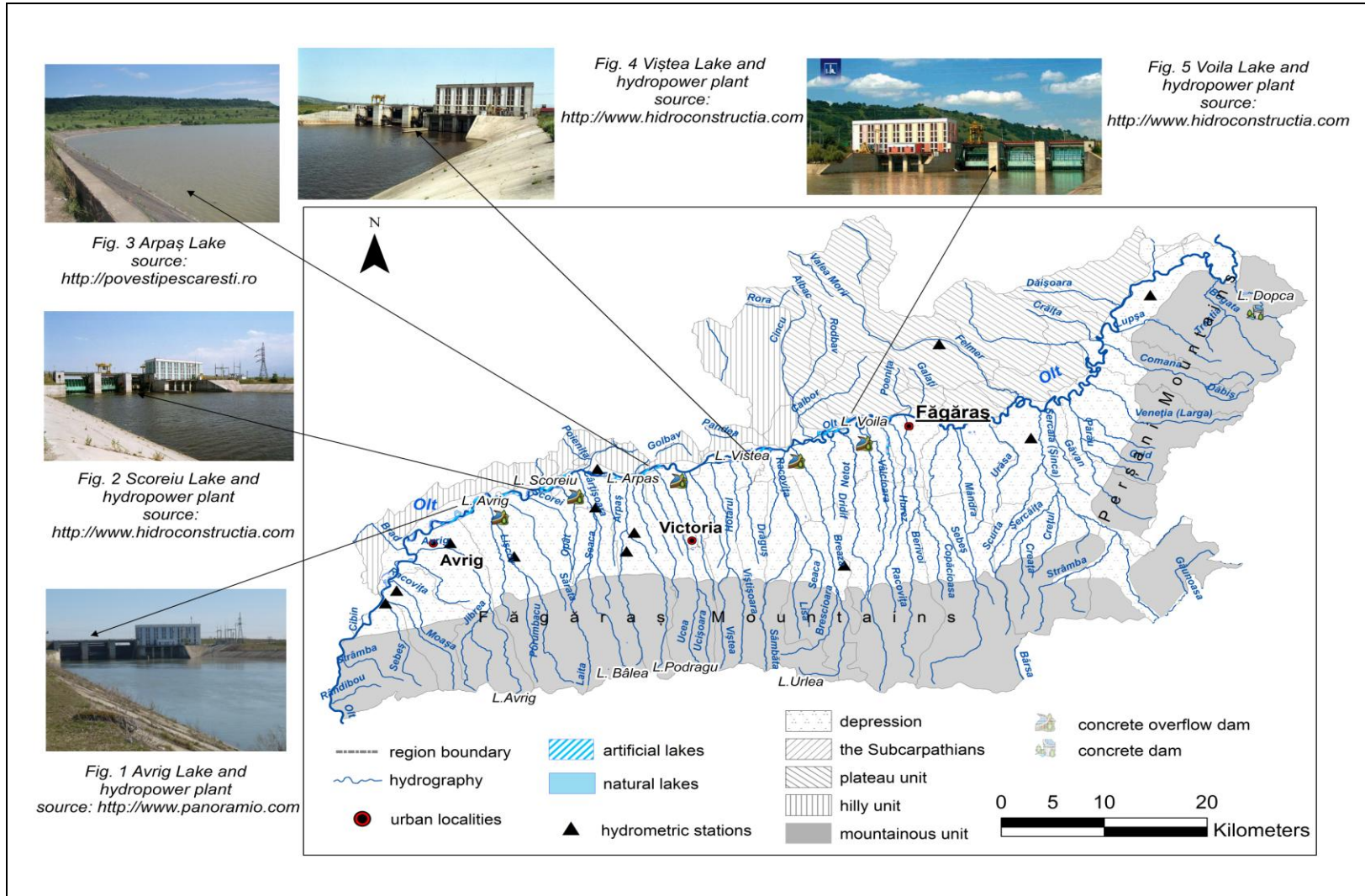


Figure 2. The Land of Făgăraș. River network. Lakes and reservoirs

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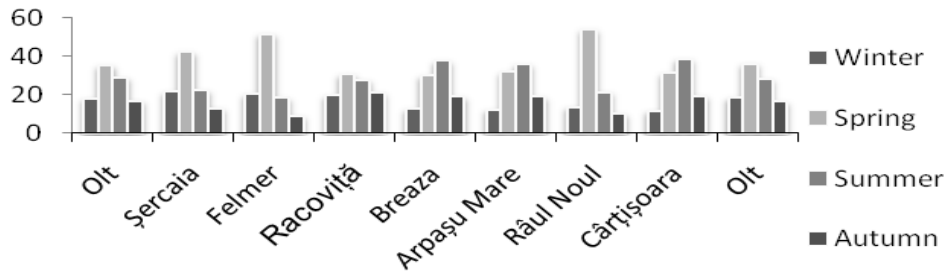


Figure 3. Seasonal flow rate between 2005 and 2010 (% from the average annual flow rate)
Source: data collected from the Olt Water Branch and processed by the author

Favourable features of the hydrographical network arise from the constant flow throughout the year due to the Southern Carpathian flow regime with a maximum in spring-summer (usually in May) – which allows the utilisation of water on a large scale. Its importance in everyday activities is maintained by the consumption rate within the area. Nevertheless, based on data from 2010, only 80% of the localities in the region were connected to the centralized supply system. In the same year, administrative units that are connected to the centralized supply water system share the need for water according to household, industrial, agricultural activities. For the analyzed year, high consumption rate in the other fields of activity, except household activities, are correlated with the industry (it is the case of Făgăraș 24%, Victoria 16%, Hoghiz 16%), or agricultural farms (Arpașu de Jos 23%, Viștea 14%, Comana 16%). High consumption rates in other fields of activity that could not be explained by the industrial or agricultural use, for instance in Racovița (78%), are the result of low connections to the public water supply system.

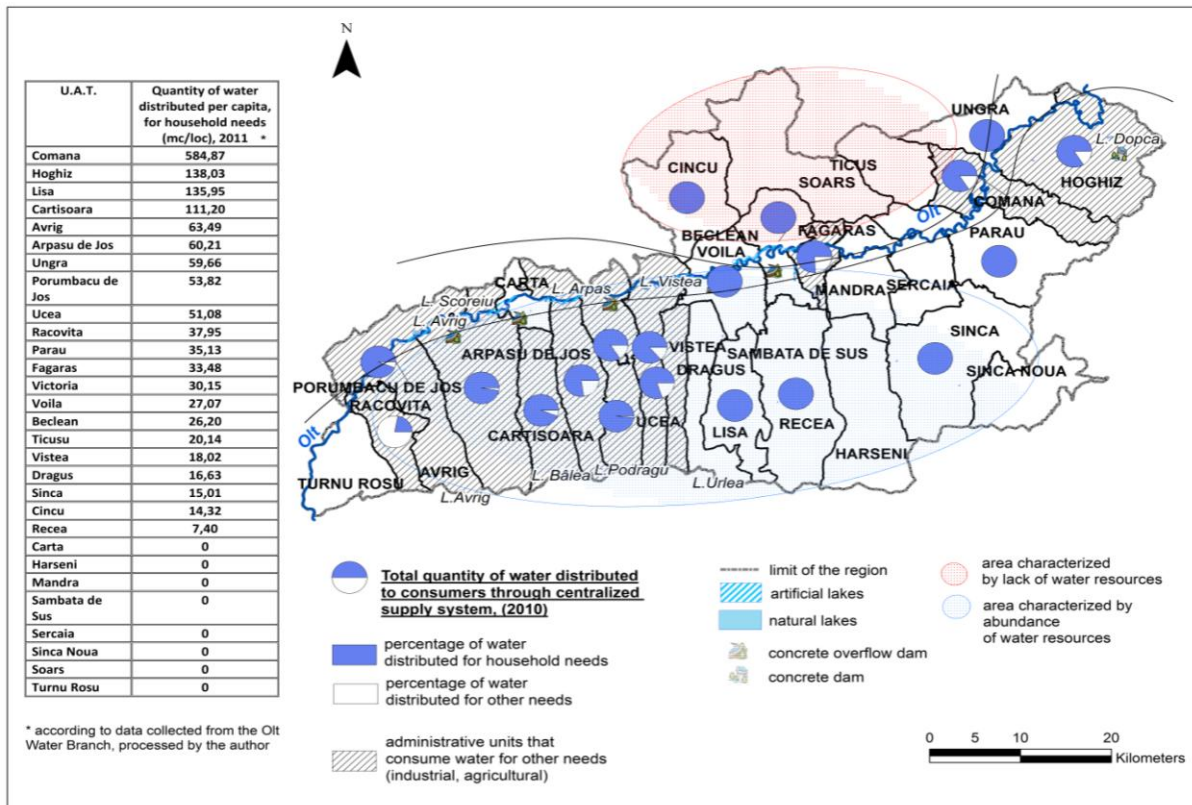


Figure 4. Water distributed to consumers for household needs

The water consumption per capita was calculated with reference to the quantity of water distributed for household needs in 2010. It can be noticed that the highest values are specific for Comana, which has a value of 584 m³/year. Other settlements situated above the amount of water according to the European norms (meaning above 36 m³/year which is the equivalent of 100 litres/day/person) are Racovița, Ucea, Porumbacu de Jos, Ungra, Arpașu de Jos, Avrig, Cârțișoara, Lisa, Hoghiz. These high consumption values can be related to the proximity of surface water sources, many of the rivers that are used as primary sources are entirely located inside the administrative boundaries of the localities. However, minimum values (below 100 litres/day/person) are recorded in the urban units of Făgăraș and Victoria, as well as rural units of Părău, Voila, Beclean, Ticuș, Viștea, Drăguș, Șinca, Cincu, Recea.

As regards the major water withdrawals, these are made from springs and the destination is either industrial, or agricultural. Preferred sources are Breaza, Brescioara, Lisa, Sâmbăta, Viștea, Viștișoara, Ucea, Ucișoara, Arpașul Mare, Arpășel, Cârțișoara. Lisa catchment functions as seasonal source, while permanent sources (Arpășel catchment and Bâlea catchment) ensure an average capitalized discharge of 11,221 l/s. More than 80% of the water captured from these streams is used for technological needs and only a small amount is used as drinking water. In this respect, Dopca lake represents one of the artificial water bodies used exclusively for drinking water, with a usable volume of 0.617 million m³ and an ecological discharge of 0.092 m³/s.

In the studied area, the “actors” that facilitate the access to running water through the centralized supply system are the water company SC Apă-Canal S.A. Sibiu, the Făgăraș Branch and Avrig Branch, and the local administrations. Investments, as part of the Sectorial Operational Programme Environment 2007-2013, Priority Axis 1- Water/Wastewater, were approved for extending and rehabilitating the distribution network in Avrig, Mârșa, Făgăraș, Feldioara, the upgrading of Avrig water treatment plant, the rehabilitation of the catchment and connections in Făgăraș municipality. Regionalisation of water services represented the main condition to implement the proposed strategy via the first priority axis. That is the reason why the Water Company Sibiu and the Water Company Brașov were created; they are the inter-community development associations which are specialized in carrying out common projects in order to access European funds. Particularly, waste water is collected from Făgăraș and treated by SC Apă-Canal S.A Sibiu Water Company.

Hydropower potential

As far as the hydropower potential is concerned, the Land of Făgăraș has the advantage of being located in a mountain region with steep slopes, over 100 m/km in some areas, with a dense hydrographical network that could fulfil the energy purposes. Given the hydraulic potential, we could show some examples of arrangements, for instance those that have been undertaken down the Cârțișoara river. Meanwhile, the construction of other small hydropower plant down the Sâmbăta valley, at the initiative of local authorities in collaboration with foreign investors, is expected to begin. The small hydropower plant will be located on the territories of Drăguș and Sâmbăta de Sus communes. The existing hydropower arrangement down the Cârțișoara will be completed by the construction of the second small hydropower plant projected on the right bank of Cârțișoara, downstream from Bâlea challet, at 772 m altitude. Special attention was required for this project due to its localisation in the Natura 2000 Site of Făgăraș Piedmont and Făgăraș Mountains.



Figure 5. Ucea river, left-bank tributary of the Olt

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Grigor P. Pop analyzed the hydropower potential of the hydrographical network in Romania and revealed the fact that the Olt possesses a technical potential of 3 billion kWh/year, out of which, 560 kWh/km are characteristic in the Făgăraș- Turnu Roșu sector. According to the same author, the first initiatives regarding the possibilities to capitalize the hydraulic energy of the Olt were accomplished between 1960 and 1968, when the complex arrangement scheme for the Făgăraș-Danube sector was drawn up. It proposed the construction of 34 hydropower plants in a sector with a total fall of 426.5 m which allowed an installed capacity of 1103.9 MW.

Table 2. *Characteristics of proposed hydropower plant on Cârțișoara*

Small hydropower plant	No. of turbines and type	Net power/turbine [MW]	Installed discharge (Qi) (m ³ /s)	Raw fall (Hb) (m)	Net fall (Hn) (m)
MHC2	Qi*Pelton	1.615	0.525	435	387

Source: www.arpmsb.anpm.ro

The present cascade hydropower arrangement of the Olt in the research area includes the hydropower plants from Voila, Viștea, Arpașu, Scoreiu, Avrig and the associated water reservoirs (Table 3) and Voila, Viștea, Arpașu, Scoreiu, Avrig and Veneția dams administrated by the trading company producing electric power in hydropower plants which is Hidroelectrica SA. This company is owned 80% by the state through the Ministry of Economy Trade and Business and 20% by a closed type investment company S.C. Fondul Proprietatea S.A. Each of the artificial lakes has an installed capacity of 14.2 MW and a total average output of 204.5 GWh/year, which is introduced in the national energy system.

Table 3. *Artificial lakes that fulfill energy purposes in the Land of Făgăraș, 2009*

Artificial lake	Water course	Location	Total volume (mil.m ³)	Usable volume (mil.m ³)	Lake surface NNR (ha)	Use	Installed capacity (MW)	Commissioning year	Total fall (m)
Voila	Olt	Voila-jud Brasov	13.74	2.46	332	energy	14.2	1989	10
Vistea	Olt	Vistea-jud Brasov	9.45	0.9	192	energy	14.2	1989	10
Arpas	Olt	Arpas-jud Sibiu	7.35	1.2	255	energy	14.2	1991	10
Scorei	Olt	Scorei-jud Sibiu	5.2	0.9	190	energy	14.2	1992	10
Avrig	Olt	Avrig-jud Sibiu	10.8	1.6	330	energy	14.2	1996	10
The Land of Făgăraș	-	-	46.54	7.06	1299	energy	71	-	-

Source: Olt Water Branch

Within the national trend imposed by the most important Romanian hydropower producer, Hidroelectrica Company, the hydrographical sources are the second most important sources of hydropower in Romania because 27% of the total electrical power produced is hydropower. Hidroelectrica's plan to increase the production of electric energy in the middle basin of the Olt comprises the construction of the hydropower plant Racovița, that is expected to be operational in 2013 and will have an installed power of 31.5 MW.

Underground water

The Făgăraș Depression consists of piedmont glaciis and terraced glaciis covered by gravels, sands and alluvial sheets (Popescu, 1990). Litho-stratigraphical conditions favoured the accumulation of deep underground waters and shallow underground waters, which generated in the territory a high density of localities that settled on alluvial-proluvial fans, e.g. Avrig, Arpaș, Sâmbăta de Sus, Lisa communes. Underground water resources in the research area have been divided into deep underground water stored in the conglomerates and Cretaceous limestone of Perșani Mountains and shallow underground waters stored in the fluvio-glacial fans of Făgăraș Depression. The two hydrogeological entities delineated by the Olt Water Branch Authority (Figure 8) are the Făgăraș Depression water body (ROOT07) and the Perșani Mountains water body (ROOT03); the latter does not lie entirely within the studied area.



Figure 6. *Voila hydropower plant*



Figure 7. *Voila Lake*

The phreatic waters located in the Făgăraș Depression, organized as a compact water body with a surface of 1172 km², have a major importance at regional level. They are preferred in terms of quantity and quality for the drinking supply system of the localities. Exploitation of the Făgăraș Depression reservoir is done under optimal conditions, drilling wells operate at a 50 m depth, the piezometric level is situated at 1-5 m depth, excepting Voila-Turnu Roșu sector where it is situated at 10 m depth. Both hydrogeological entities ensure a discharge of up to 20 l/s and are covered by a 0.5-1 m thick deposit. The water taken from the underground source ROOT07 Făgăraș Depression through Pojorta-Sâmbăta de Sus frontage area is operated by SC Apă-Canal S.A. Sibiu within 45 drilling wells and serves as drinking water for the town of Făgăraș and the communes of Lisa, Recea and Beclean, Cincu, Șoarș. Other sources used for domestic needs are Cârțișoara, Avrig and Arpașu de Jos rivers. The total volume capitalized annually by this company from the Făgăraș Depression groundwater is 1880 thousand m³.

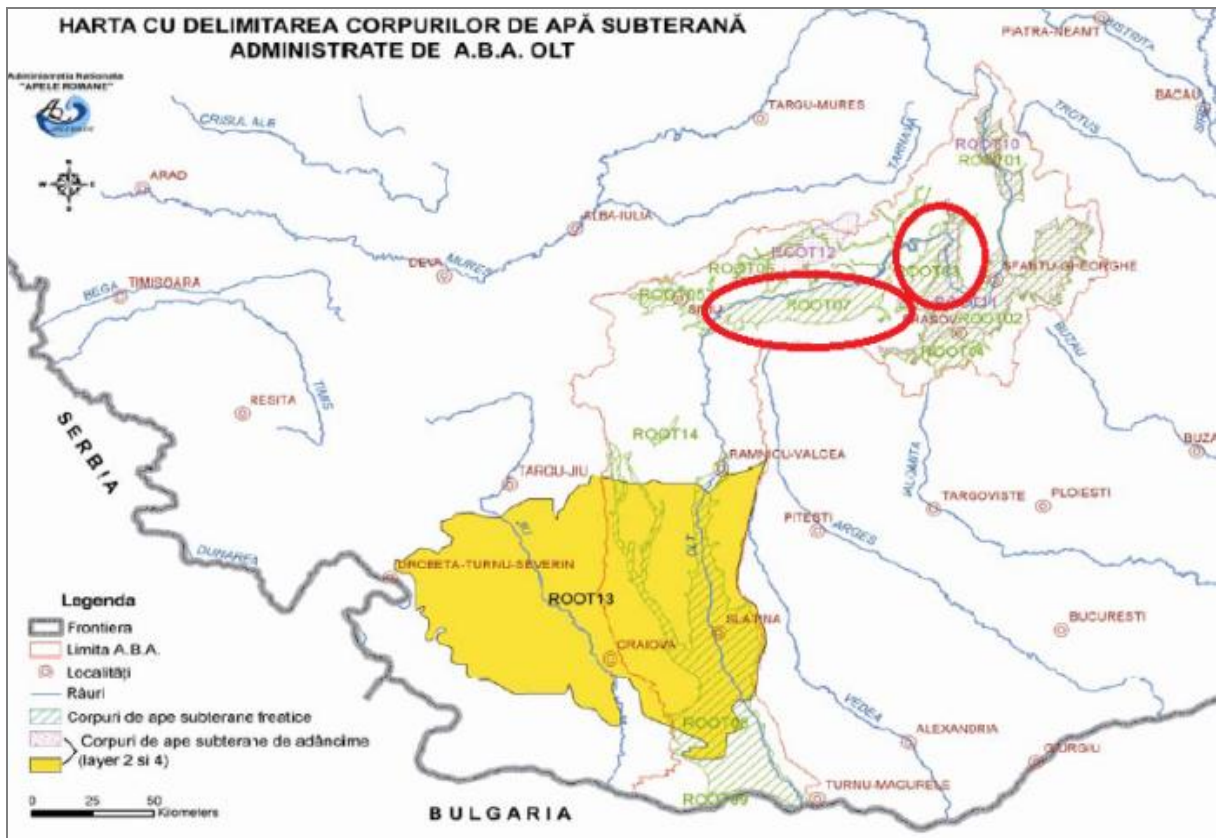


Figure 8. *Underground water bodies within the Olt catchment area. Circled with red, the underground reservoirs in the Land of Făgăraș*

Source: according to the Management Plan for the Olt Basin

Studying the area of restrictiveness regarding the quantity and quality of underground reservoirs in relation to the access to drinking water, some dysfunctions were revealed:

- The shallow underground water located under Cincu, Șoarș and Ticuș communes (all situated on the right bank of the Olt within the Rodbav Plateau) does not provide sufficient discharge for the localities. Presently, Ticuș commune is supplied from wells fed by the shallow underground water with a discharge of 0.15-0.20 l/s. The wells are in the proximity of the waste water storage tank which favours infiltrations of untreated water into the drinking water. Water captured by drains is transported via a damaged pipeline causing leakage.

- Some studies concerning the centralized water supply system for Cincu were initiated in 1998, evolving slowly until 2012, partially due to the scarcity of water resources (deep underground reservoirs with low discharges) and also to the role played by local decision factors. Cincu commune is now connected to the culvert pipeline of Făgăraș supplied by Pojorta-Sâmbăta de Sus frontage, but not all households are connected to the distribution network.

CONCLUSIONS

In the researched region, water is regarded as one of the most important resources, because of both quantitative and qualitative aspects. From the existing situation presented in the study, we reclaim that the Land of Făgăraș is a region with excessive freshwater resources. However, the availability of water is not even. It can be noticed that the region is divided into two areas: an area with a dense hydrographical network and large underground reservoirs situated on the left side of the Olt and the

right area, with permanent problems regarding the water resources, which induced a crisis situation into the rural communities of Cincu, Șoarș and Ticuș. On the left side of the Olt, the hydrographical network is equally distributed through the territory which proved to be a favourable condition for assuring households and the local economy with the amount of necessary water. Not only are the surface sources of water highly accessible in the territory, but they also provide relatively considerable and constant discharge throughout the year.

Although water resources are sufficient and could satisfy all requirements, also considering the underground reservoirs, there are administrative units that are not entirely connected to the centralized water supply system, especially the rural localities. To improve the living standards of the rural population in some particular areas, the households have to be connected to the main supply network. The desiderata of connecting all the households to the centralized supply system should also consider equipping them with the sanitary installation, based on the fact that the cost of introducing the pipelines for the distribution network would be reduced (sources are located on the territory of the communes and cities), which would allow investments the indoor facilities. In the studied area, the amount of water consumed per capita from the total amount of water distributed for household needs shows that there is great difference between the localities supplied from the same type of sources (584 m³/year for Comana, compared with the desirable 36 m³/year, which is the equivalent of 100 litres/day). One has to consider calculating the water requirements for each administrative unit. Moreover, the pipelines in the distribution network have a high degree of wear, which causes water loss through leakage. Unfortunately, projects undertaken at communal level give minimum importance to water loss and funds are accessed for the introduction of water supply networks. The implementation of a viable strategy that could reduce leakage is compulsory, for example, monitoring the quantity of water which entered the system and the quantity of water evacuated from the system and replacing the highly worn pipelines in accordance to the period designated for usage.

In order to safeguard the existing resources of the Land of Făgăraș and to improve the access to running water, collaboration between localities depending on the same sources is vital. For instance, the exploitations of Cârțișoara, Arpășel, Avrig sources have to be the object of concern for several communes within inter-communal projects in which they could develop an exploitation scheme. A unitary utilisation strategy should also be taken into consideration from another perspective: local administrations could promote partnerships between settlements located within the same hydrographical basin according to the principle of the watershed “a sustainable management of water resources will integrate water users in the same hydrographical basin” or the same supply source according to the principle of solidarity “planning and development of water resources requires collaboration between all actors implicated in the water sector” (Integrated Management of Water Resources, pp. 1-2) , serving the aim of creating local water companies subordinated to the regional ones. The advantages driven by these associations are of financial nature. The local taxes demanded by the water supplier (in this case the local administrations in collaboration with other specialized companies) may be used to support the costs of technical infrastructure instead. Dependence in exploiting the water resources is more related to the surface water resources -settlements that share the same stream as a source of supply, and less related to underground sources, due to the localisation of built-up area on the fluvio-glacial fans of the Făgăraș Depression.

The water supply in the northern part of the region is considered critical because the scarcity of drinking water and the physical conditions, which caused dysfunctions in the economic development of the localities. To remedy this weakness Șoarș and Ticuș communes need to find allochthonous sources such as those located on the left bank of the Olt.

The artificial lakes situated along the Olt river and the mountain streams are important from the economical point of view, being valued for the production of hydropower. In this context, the hydropower industry in the Land of Făgăraș has rapidly developed in the last five years with the construction of small power plants in the mountain area at the initiative of foreign investors. These investments are beneficial because they input a certain amount of capital into the regional system, but they should be implemented at the initiative of local administrations.

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As a conclusion, water resources management in the Land of Făgăraș should be referred to regionally, taking into consideration two facts: one is the important surface water resources which lie entirely in the studied region (the complex network of streams that spring from the Făgăraș and the Perșani Mountains); this particular alignment favours the unitary management considering multiple uses, such as hydropower, drinking water, water for industrial and agricultural use. The second argument is the existence of rich underground reservoirs which are completely within the limits of the territory- Făgăraș Depression Water Body- contributing to local partnerships between localities that are served by the same sources or are located above them.

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