THE RESERVOIRS FROM ROMANIA -TYPOLOGY AND ACTUAL STATE.

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ABSTRACT. The reservoirs from Romania - typology and actual state. The topic addressed refers to one of the solutions applied to solve the shortage of fresh water caused by global warming. In the first part of the study, the notion of lacustrine ecosystem is defined and the consequences arising from the interrelationships between abiotic and biotic factors within the ecosystem. Particular attention was paid to the comprehension of newal index for reservoirs, based on which three categories of reservoirs were identified: oligodynamic, mesodynamic and polydynamic. The clogging of reservoirs and the risks that this process can generate on the operation and durability of hydrotechnical constructions, and the components of the surrounding environment constituted the study object of the fourth chapter. Finally, based on some dominant control factors (resistance index, erosion rate, hydrochemical type, degree of mineralization), several areas with different possibilities for setting up reservoirs were identified: degree I and II favorable, acceptable, and restrictive.

Keywords: reservoirs, lacustrine ecosystem, clogging, renewal index

1. INTRODUCTION

Among the effects of global warming, the reduction of freshwater resources has consequences in all areas of socio-economic activities (supplying drinking water to the population), industry (reduction of hydropower production), agriculture (reduction of irrigated areas), transport on inland waterways.

The improvement of reservoirs represents a solution used since ancient times and extended starting from the first decade of the 20-th century. Reservoirs with complex functions were frequently set up in mountain regions, with climatic and geomorphic conditions favorable for the construction of this type of lake. With all the unfavorable consequences that the construction of reservoirs causes on the environmental components, this solution has expanded a lot in the last decades of the last century. The construction of reservois and the way of using the accumulated water has caused conflict situations between different countries in the Middle East (Turkey and Syria on the one hand and Iraq on the other), from Central Asia (Afghanistan and Iran, Afghanistan and the republics of the former USSR - Uzbekistan, Turkmenistan, etc.), from East (China) and Southeast Asia (Myanmar, Thailand, Vietnam, etc.).

On the Roamnian territory***, mine pit*** were built even from the time of the Romans in the Apuseni Mountains, for the purpose of separating ***gold ores*** (***flotation*** - Roșia Montană) or for the exploitation of complex and ***iron ores*** (Dognecea, Ocna de Fier, Oravița), etc. Along with the development of industrial centers, lakes were created with the aim of accumulating water for industrial processes and feeding the population (Baia Mare, Hunedoara, Reșita).

In the regions with water deficit, reservoirs were built on the rivers – ***farm ponds*** being used for fish farming and local irrigation. These types of lakes are documented since the 15th century regarding the ponds of the Transylvanian Plain and the Moldavian Plain. ***Dimitrie Cantemir***, in his work ***Descriptio Moldavae***, mentions the large number of ***farm ponds*** in this historical province. In the Romanian Plain, ponds were built and are still found today on most of the smaller hydrographic arteries, for example on the rivers Călmățui, Vedea cu Teleorman, Neajlov-Argeș, and the most typical Mostiștea River, transformed into a ***network of farm ponds.***

Of particular importance in the use and management of water resources in Romania are the reservoirs with predominant use in hydropower but also for drinking water supply, irrigation and other related purposes.

After 1960, with the construction of the Izvorul Muntelui-Bicaz Lake, on Bistrița River, the number of this category of reservoirs increased on many hydrographic arteries, including the ***waterbief reservoirs*** (Bistrița, Argeș, Siret, Olt, Someșul Mic rivers, etc). It is estimated that, currently, there are about 1,975 reservoirs in this category, of which 400 store 15,549 million m^3 of water.

Among the larger reservoirs are those from Portile de Fier (Iron Gates) on Danube River (2,400 mil. m^3), Izvorul Muntelui-Bicaz on Bistrița River (1,130 mil. m^3), Stânca-Costești, on Prut River (735 mil. m^3), Vidraru, on Argeș River (469 mil. m^3), Vidra on Lotru River (340 mil. m^3). The installed power is estimated at 5,500 MW, representing 25% of the rivers'potential and 36% of Romania's energy production.

2. CONSIDERATIONS ON THE LAKE ECOSYSTEM

The lacustrine ecosystem, unlike the fluvial one, is characterized by a lower water dynamic, constituting the stage for energy and matter accumulation (organic and inorganic), which results in the tendency of the evolution of this aquatic ecosystem towards a specific biotic domain (Gâștescu, P., 1970).

In the case of reservoirs, the economic necessity requires the modification of the free flow by blocking the natural courses and creating reception basins corresponding to the volumes of water designed to accumulate. Under these conditions, the reservoirs have an ***azonal*** character in existence. Their presence and evolution is decisively related to human intervention, which must be continuously supported and adapted to the specific geographical conditions (Fig. 1).

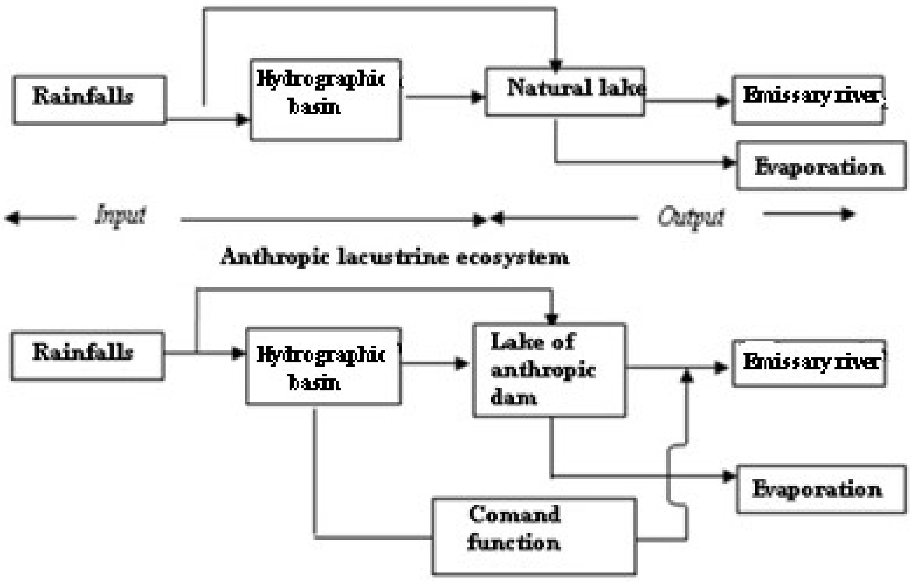

Fig.1. The lacustrine ecosystem (natural and anthropogenic)
(Source: P. Gâștescu, B. Driga,1996)

In the case of reservoirs, the control function is decisive in the evolution of the accumulated water volume.Thus, the water requirements for irrigation are manifested prominently in summer (sometimes also in spring and autumn), fish farming requiring the preservation of certain volumes of water throughout the year in relation to the development of the fish population|; the hydropower requirements are permanent, but with certain peaks during a diurnal and seasonal cycle. Since currently most reservoirs have a complex profile of use, it is understandable the need to develop optimal exploitation models in relation to the climatic conditions, the water stock and the priority of the functions, without neglecting the ecological and aesthetic aspect of the lake itself, also of the surrounding area.

Between the main abiotic and biotic factors acting in the lacustrine ecosystem, there are interrelations that contribute to the production of some processes (bank abrasion and lake clogging), which affect the nature of the substrate, the composition and dynamics of the benthos (Fig. 2).

Given the main function of reservoirs to retain a volume of water and to be returned in relation to socio-economic requirements, a rhythm of transit and therefore replacement of the water volume in a certain time results (period). This transit rate was called ***relative water exchange***, although we think it would be more appropriate to call it the ***index of renewal or replacement of the***

volume of water (including precipitation received by the lake surface), compared to its volume.

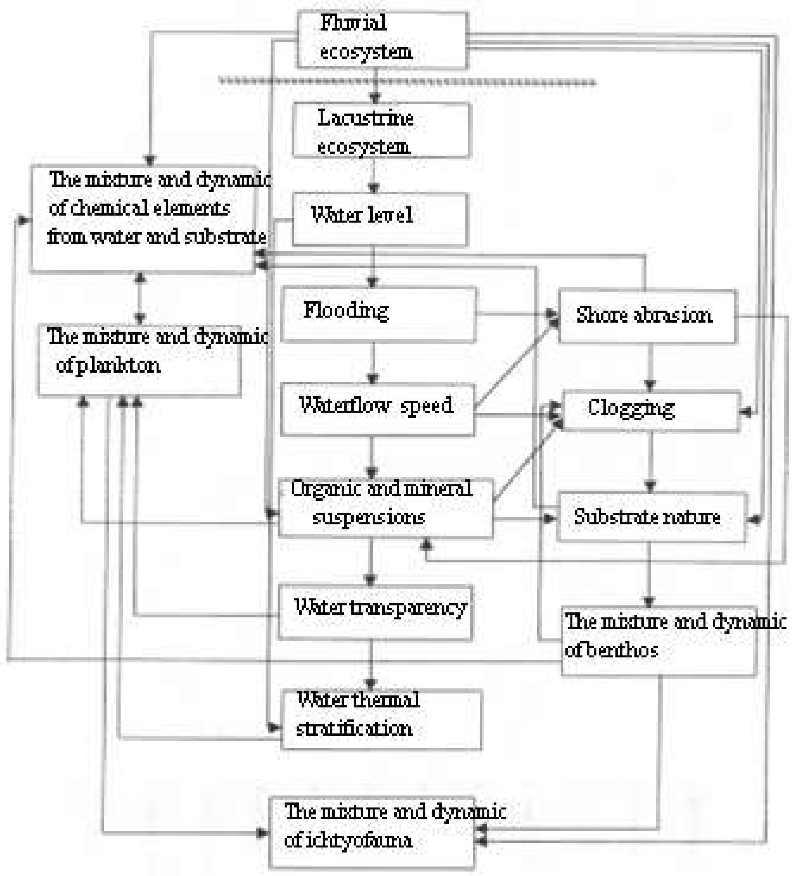

Fig.2. The interrelationships between abiotic and biotic factors in the ecosystem of reservoirs (*Source: P. Gâștescu, B. Driga,1996).*

The renewal index of the water volume (Ipr) from the reservoir can be defined as the ratio between the annual volume entering lake (resulting from the liquid runoff from the own hydrographic basin and that brought by derivations from other neighboring basins -***Vi***, on one part, and the total average volume of the lake –***Vlak***e, i.e. ***Ipr = Vi/Vlake***). Depending on the value of ***Ipr***, reservoir can be grouped into three distinct types.

Oligodynamic lakes (Ipr<0.5), in which the total volume of the lake is primed (replaced) in a maximum proportion of 50%, in one year. As a rule, this type is closest to the natural lake ecosystem. Here, a vertical thermal stratification is achieved, with floristic and faunal associations specific to the lacustrine environment.

Analyzing the reservoirs in Romania, we find that few of them can be considered as lacustrine ecosystems, given their main function (hydropower and supply of potable and industrial water) which implies a use, a continuous intake during the year, of significant volumes of water. Reservoirs with a predominantly fish-farming function and lakes present conditions for creating a lacustrine environment, even if the depth is less (of the order of meters). In reservoirs with a predominant function for irrigation, from which the water is used only in a certain period of the year, the conditions of a lacustrine environment are also achieved. In Romania, reservoirs with an agro-fishing function are small ones, such as ***ponds and pools***, as well as ***recreational*** ones near cities.

The mesodynamic lakes (05< Ipr<5.0) present conditions for achieving the lacustrine environment depending on the depth and the water usage schedule. Among the reservoirs in Romania, a special position is held by those with a large water volume, where its restoration is carried out, depending on the climatic conditions, at least every six months. These reservoirs located in the upper courses of the rivers are called ***head dam (peak) lakes***. The most typical in this sense are Vidraru on Argeş, Vidra on Lotru, Oașa on Sebeş, Valea lui Iovan on Cerna, Gura Apelor on Râul Mare, Fântânele on Someş Cald, Colibița on Bistrița, Poiana Uzului on Uz-Trotuș, etc. Others can be included in the category of these lakes, such as Izvorul Muntelui - Bicaz, located on Bistrita River in its middle course, but with a large storage capacity (around 1 km^3) and which also presents a "dead" volume of water well highlighted. Analyzing through the prism of the renewal index (***Ipr)*** of Vidraru Reservoir, it is found that its total volume is achieved in a proportion of 55.1%, i.e., 256.4 mil.m^3 compared to the maximum capacity of 465 mil.m^3. At the same time, the average incoming volume is 634 million m^3, so Ipr =2.47, which means that the volume of the lake is refilled once every 4.85 months or 148 days (mesodynamic lake).

Polydynamic lakes (Ipr.>5.0), in which the conditions of the lacustrine environment are achieved, are extremely limited in time, but possible to achieve in some bays that are protected from the transit of the water volume. In this category, the most typical example is the Porțile de Fier Reservoir, where the volume entered in one year (respectively the flow of the Danube) is 170 km^3, and the total volume of the dam lake is 5 km^3, resulting in an Ipr =34. However, in the Porțile de Fier Reservoir there are lacustrine environmental conditions in the side bays from Dubova, Ieselnița and, especially, in the one from Orşova. The same cannot be said about the ***waterbief reservoirs*** such as those on Olt River- between Gura Lotrului and Izbiceni, on Argeş River - between Vidraru and Golești, on Bistrița - between Izvorul Muntelui and Bacău, which have small depths (rarely 10 – 20 m) and small storage capacities (the largest being 202.7 mil. m^3 – Strejești Reservoir on Olt River), in relation to the volumes of water transited. In these reservoirs, quite exceptionally, on extremely small surfaces and under abnormal operating conditions, lacustrine environments can be created. Analyzing the waterbief reservoirs on Argeș River for the same period (1970 – 1981), taking as input volume, the machined (turbine) volume from Vidraru Reservoir (608 mil. m^3/year) and the total volumes of the downstream reservoires, we will find indices of of 10.4 for Golești (downstream Pitești), 21.9 for Budeasa. For the system of waterbief reservoirs on the Olt, the water balance for one year (1986) was analyzed, starting with Turnu from the gorge and up to and including Slatina. In the calculation of the impoundment index of the cascading lakes on the Olt River for the year 1986, the reduction of the storage capacity compared to the initial (designed) one through the clogging process was taken into account for each lake. Also, depending on the geographical position in the system, intakes and losses along the way were taken into account, according to the balance sheet model (Fig. 3).

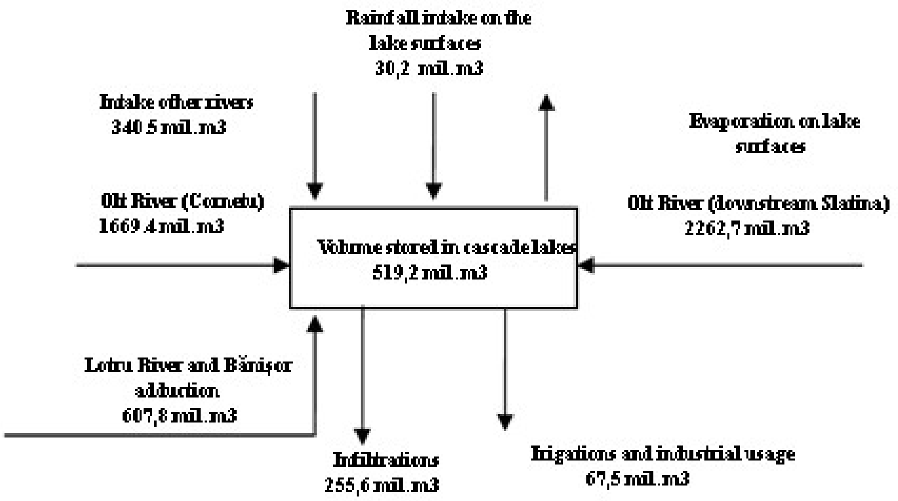

Fig.3. The water balance model of Olt between Turn and Slatina in 1986
(Source: P. Gâștescu, B. Driga,1996).

The rate of replenishment of the water volume from the lakes varies between 567.3 (once every 14.4 hours) for the Călimănești Lake and 11.8 (once every 31 days) for the Strejești Lake (Table 1).

Table 1. Renewal index (Ipr) at the cascading lakes on the Olt River (Source: P. Gâstescu, B. Driga, 1996).

Lake name	Initial volume (mil.m^3)	Volume in 1986 (mil.m^3)	V_i	$I_{pr.}$	No. of days for volume replacement
Turnu	19,1	16,2	2.280,3	140,7	2,6
Călimănești	4,57	3,56	2.076,5	567,3	0,6
Dăești	11,2	6,72	1.893,4	281,7	1,3
Rm. Vâlcea	19,2	9,1	1,953,4	214,6	1,7
Râureni	7,3	6,4	1.578,5	246,6	1,5
Govora	18,5	13,88	1,950,2	140,5	2,6
Băbeni	59,65	54,88	2.501,9	45,6	8,0
Srejești	202,7	196,6	2.316,9	11,8	31

3. MORPHOMETRIC CHARACTERISTICS OF THE RESERVOIRS

In Romania, the reservoirs are located in all major relief units (Carpathians and Subcarpathians, plateaus and plains), represented by several morphological types of lake depressions, depending on the purposes of using the accumulated water, from those from abandoned salt mines, to those for flotation of auro-argentiferous ores, at ponds and fish ponds and local irrigation, until the most recent ones starting from the 20th century, especially for hydropower. The anthropogenic reservoirs in Romania, valued at 2147, total a volume of 13.3 billion m^3. The reservoirs with capitalization, first of all, energetic and then complex, each larger than 1 mil.m^3, located on the most important rivers. There are about 400 lakes in operation with a volume each greater than 1 mil. m^3. Following the distribution of reservoirs on the main relief steps, it is found that the largest are found in the mountain region, having complex functions (predominantly energetic). Of the total reservoirs with surfaces over 30 ha, the Southern Carpathians own 37%, followed by the Western Carpathians with 33% and the Eastern Carpathians with 30% (Table 2).

Table 2. Reservoirs in the Carpathians Mountains (*processing according to data published on the Internet, 2024*).

Name			Altitude (m)	Surface (ha)	Max. depth (m)
Lake	Mountain	Hydrographic basin			
Eastern Carpathians					
Izvorul Muntelui -Bicaz	Ceahlău	Bistrița	513	3000	90
Colibița	Căliman	Bistrița	900	314	92
Bâtca Doamnei	Tarcău	Bistrița	324	235	16
Călinești	Oaș	Turulung	150	160	9
Pângărați	_Tarcău	Bistrița	369	155	15
Poiana Uzului	Ciucului	Trotuș	550	135	75
Săcele	Bârsei	Tărlung	745	123	45
Vaduri	Tarcău	Bistrița	360	115	15
Firiza	Gutâi	Săsar	370	110	37.5

Southern Carpathians					
Pucioasa	Bucegi	Ialomița	400	105	30
Vidra	Parâng	Lotru	1289	1035	109
Vidraru	Făgăraș	Argeș	830	893	155
Oașa	Șureanu	Sebeș	1260	453	90
Valea lui Iovan	Godeanu	Cerna	685	296	107
Sadu V	Cindrel	Sadu	1150	72	68
Gura Râului	Cindrel	Râul Mare	658	65	17
Mălaia	Parîng	Lotru	480	46	22
Oiești	Făgăraș	Argeș	505	40	4.5
Oiești	Făgăraș	Argeș	505	40	4.5
Valea de Pești	Vîlcan	Jiu de Vest	830	31	53
Western Carpathians					
Fântânele	Gilău	Someșu Mic	900	980	92
Surduc	Poiana Ruscă	Gladna	195	460	20
Cinciș	Poiana Ruscă	Cerna	300	261	40
Tarnița	Gilău	Someșu Mic	620	215	97
Leșu	Bihor	V.Iadului	560	147	56
Secu	Semenic	Bârzava	350	105	30
Gilău	Gilău	Someșu Mic	410	70	9
Gozna	Semenic	Bârzava	610	66	40
Trei Ape	Semenic	Timiș	835	53	30

In hilly and lowland regions, the reservoirs have small surfaces and functions predominantly for fishing, agriculture (irrigation) and even energy (those located in cascades) and water supply for the population.

From the analysis of reservoirs on first-order hydrographic basins, it can be seen that most of them have complex functions, their order being: energetic, water supply, irrigation (Fig. 4).

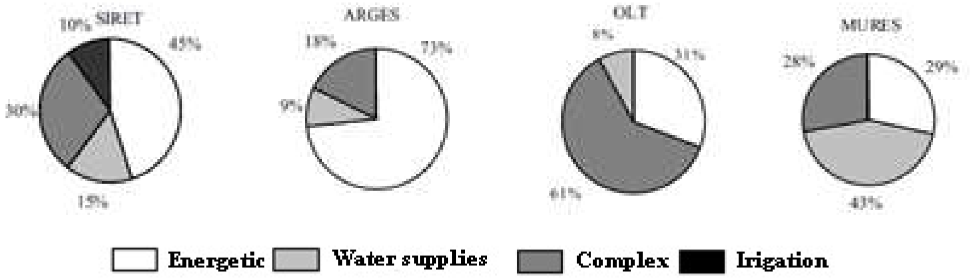

Fig. 4. The share of reservoir functions on the main river basins
(after P. Gîștescu, B. Driga, Maria Sandu, 2003)

4. CLOGGING OF THE RESERVOIRS

The effects of lake clogging are multiple and can influence the safety of construction exploitation, the reduction of characteristic volumes, especially the useful volume with implications on uses. Clogging of reservoirs has negative effects on water quality and accelerates the process of bed degradation downstream of dams. Several indicators are used to assess the level of reservoir clogging (rhythm, rate, intensity and duration of clogging, as well as the degree of retention of alluvium).

The degree of clogging depends on the size of the reservoir capacity, the volume of water stored, the position the reservoir occupies within the basin, the balance profile presented by the sector between two reservoirs, etc. An important role in the clogging of lakes is also played by the anthropogenic factor, which through various activities contributes to the enrichment of alluvium sources in the reservoir. In this sense, the first place is held by the use and processing of land use and the deforestation carried out in mountain and hilly regions.

In order to assess the level of clogging of reservoirs in Romania, a correlative analysis was carried out between different parameters (accumulation coefficient and clogging time) and the morphodynamic features of the hydrographic basin, reaching the following conclusions:

– in an average period of 15 years, about 200 mil.m^3 of alluvium was deposited in the reservoirs on the inland rivers, with an annual rate of 13.4 mil. m^3, which represents 27% of the total multiannual average alluvium transport;

- the reservoirs on Argeş River had the most important anual clogging rates (Pitești 15.7%, Bascov 11.7%, Oiești 9.5%, Cerbureni 7.3%, Curtea de Argeş 5.3%), and from Siret River (Galbeni 10.6%);

- average annual rates of fast clogging were also recorded at the first lakes built on Olt River (Govora 8.27%, Râmnicu Vîlcea 5.63% and Dăeşti 4.90%), Bistrita (Pângarați 3.45%) and Ialomița River (Pucioasa 2.58%);

- small rates of clogging are recorded in the large reservoirs: Izvoru Muntelui (0.03%) and Vidraru (0.04%).

According to the mentioned authors, the situation of damming of reservoirs in Romania is as follows:

- very serious for a number of 15 reservoirs, with average sizes below 8 mil. m^3 and with a clogging time between 2 and 10 years;

- serious for 30 reservoirs located in the area of high specific production of alluvium (250 t/km^2/ year), with average capacities of 35 mil. m^3 and the time of clogging between 10 and 50 years (the waterbief reservoirsw of on Olt, Argeş, Buzău and Bistrița rivers, and those in the Bârlad Basin);

- difficult for 13 reservoirs located, as a rule, in the area with specific production of alluvium of 200 t/km^2/year and the time of clogging under 100 years (Rogojeşti on Siret, Izbiceni on Olt, Bacău on Bistriţa, Văliug on Bârzava) (Rădoane Maria, Rădoane N, 2003).

Regarding the stage of clogging of reservoirs in Romania, at the level of the 1980, in the research done by several authors mentioned in the bibliography, it results that the lowest values of the anual rhythm of clogging correspond to large reservoirs in the mountain region (Vidraru on Argeş 0.039% and Leşu on Iad 0.060%) and the highest anual rate of clogging was recorded on the reservoirs of the Subcarpathian and Piedmont region, the Argeş River (Table 3).

Table 3. The situation of the clogging of the main reservoirs in Romania *(Source: Gâştescu, P., Driga, B., Sandu, Maria, 2003).*

No. crt.	River	Lake name	Volume (mil. m^3)	Accumu -lation coef.	Clogging degree (%)	Clogging duration (years)	Annual average clogging rhythm (%)
1.	Argeş	Vidraru	465,0	1,31	0,43	11	0,039
2.	Argeş	Zigoneni	13,3	0,027	23,7	13	1,82
3.	Argeş	Vâlcele	41,5	0,107	8,42	11	0,76
4.	Argeş	Budeasa	30,8	0,058	8,30	8	1,04
5	Argeş	Bascov	5,24	0,009	87,6	7,5	11,7
6.	Argeş	Piteşti	4,48	0,003	97,4	6,2	15,7
7.	Argeş	Goleşti	107,9	0,045	1,95	6	0,32
8.	Olt	Dăieşti	11,7	0,001	39,1	8	4,90
9.	Olt	RmVâlcea	21,4	0,002	73,2	13	5.63
10.	Olt	Râureni	10,9	0,002	11,7	8	1,46
11.	Olt	Govora	18,5	0,002	24,8	3	8,27
12.	Olt	Băbeni	59,6	0,007	8,36	5	1,67
13.	Olt	Ioneşti	24,9	0,003	1,98	6	0,33
14.	Olt	Zăvideni	51,2	0,008	2,18	6	0,36
15.	Olt	Drăgăşani	66,6	0,011	1,28	6	0,21
16.	Olt	Străjeţşti	202,7	0,027	3,21	5	0,64
17.	Vaslueţ	Soleşti	52,7	0,573	1,14	11	0,10
18	Siret	Bucecea	10,6	0,023	17,6	9	1,95
19.	Siret	Galbeni	39,4	0,009	31,7	3	10,6
20.	Tazlău	Belci	14,6	0,034	83,3	25	3,33
21.	Prut	Stânca	1 400,0	0,178	2,5	8	0,31
22.	Bistriţa	Izv Muntelui.	1.220.0	0.688	0.929	27	0.034
23.	Bistriţa	Pângăraţi	5,62	0,002	44,8	13	3,45
24.	Doftana	Paltinu	63,0	0,302	3,47	17	0,20
25	Holod	Vida	0,294	0,008	27,9	16	1,74
26.	Iad	Leşu	28,3	0,003	0.060	1	0,060
27.	Iaomiţa	Pucioasa	10,8	0,043	33,5	13	2,58
28.	Cerna	Cinciú	43,5	0,275	4,11	21	0,196
29.	Gladna	Surduc	50,0	0,525	2,40	9	0,27
30.	Firiza	Firiza	16,9	0,111	1,42	17	0,083
31.	Tur	Călineşti	10,5	0,027	11,0	17	0,65
32.	Uz	Poiana Uzului	90,0	0,674	5,11	20	0.25
33.	Târlung	Săcele	14,6	0,113	6,02	12	0,50
34.	Crasna	Vârrşolţ	21,5	0,334	9,10	12	0,76

A completely special situation is presented by the cascading lakes on the Olt River located in the Subcarpathian and Piedmont regions, where the annual clogging rhythms are reduced from those in the upstream to those in the downstream.

In this sense, the role of the volume and position of the lake, the particularities of the substratum in the hydrographic basin related to the lake unit, is noteworthy. For example, the clogged volume decreases with the increase in lake size from 7-8% for lakes with an initial volume between 100 and 200 mil. m³ to 0-1% for lakes with an initial volume over 1000 mil. m³.

The position of the lakes within the cascade system and the particularities of the substrate in the basin related to the lake introduce changes in the mentioned legality. Thus, in the case of dam lakes with related hydrographic basins in which hard rocks predominate, the clogged volume is lower (Gura Apelor 1%, Vidra 5% and Vidraru 5%) than in those where the substratum of the related hydrographic basin is made up of rocks less rough (Răcăciuni, 14%, Cerna 14%). The lowest annual clogging rate (0.039) corresponds to Vidraru Lake located in the mountain region, followed by Leșu Lake (0.060), and the highest values were assessed on the lakes at the exit from the Subcarpathian and Piedmont areas on the Argeş River (Table 3).

The position of the lake within the cascade system has an important role in differentiating the degree of clogging and is very well highlighted within the cascade system of the lakes on Argeş and Olt rivers (Table 4).

Table 4. The characteristic volumes of the cascading dam lakes on the Argeş and Olt rivers. (under 100 mil.m^3) (*Sorocovschi,2021*)

River	Lake name	Initial volume	Actual volume	Clogged volume	Period of measure ments
Argeş	Oieşti	1,770	0,090	95	2003
	Cerbureni	1,620	0,080	95	2003
	Curtea de Argeş	1,050	0,315	70	2003
	Zigoneni	13,300	8,045	39	2007
	Doamnei	0,585	0,234	60	2003
	Vâlsan	0,175	0,081	54	2003
	Cumpăna	0,262	0,139	47	2003
Olt	Dăiești	11,700	5,440	54	2007
	Rm. Vâlcea	21,400	10,000	53	2005
	Râureni	10,900	6,240	43	2007
	Govora	21,400	13,580	37	2005
	Băbeni	62,200	43,750	30	2005
	Ioneşti	25,280	23,340	8	2006
	Zăvideni	52,750	52,750	0	2008

Studying the silting of lakes in the Transylvanian Depression,states that the degree of pond clogging is influenced by the size of the hydrographic basins related to each lacustrine unit and by the morphometric characteristics of the ponds. Thus, the most intense rate of clogging was recorded in ponds with smaller surfaces (Sucutard I, Geaca II and III)(Sorocovchi,V.,1998,1999,2005; ,Șerban,Gh.,1999,2007; Bătinaș,R.,1999).

Water depth also influences the clogging process, which is more intense in ponds with shallower depths. The ponds in the Fizeş basin located upstream of the Mociu stream flow show the lowest degree of clogging, below 50% (30.7 at Tău Popii and 46.6% at Cătina), and those located downstream of the mentioned confluence show percentage values of over 70 % (73% Sucutard II and 95.3% Sucutard I). The average annual rate of clogging is higher at Sucutard I (3.67%) and Geaca III (3.1%) and lower at Tău Popii (0.99%) and Cătina (1.50%). In the other ponds, the values of the average rate of clogging are maintained between 2 and 3% (Table 5).

Table 5. The characteristic volumes, degree and average annual rate of clogging of ponds in the upper Fizeş basin (*V. Sorocovschi, 2005*).

Pond / **Average volume and rythm**			**Cătina**	**T. Popii**	**Geaca I**	**Geaca II**	**Geaca III**	**Sucutard I**	**Sucutard II**
Total volume (Talveg - - N. M. R.)	Effective (mil. m^3)	1966 /*71	2,053	0,997	0,640	0,341	0,322	0,878	1,000
		1997	2,025	0,997	0,252	0,113	0,111	0,345	0,492
	Clogged	(mil. m^3)	0,028	0	0,388	0,208	0,211	0,533	0,508
		(%)	1,36	0	60,62	61,00	65,53	60,71	50,80
	Annual average rythm	(mil. m^3)	0,001	0	0,012	0,007	0,008	0,020	0,016
		(%)	0,04	0	1,96	1,97	2,52	2,34	1,64
Gross volume (Talweg - - N. N. R.)	Effective (mil. m^3)	1966 /*71	0,880	0,400	0,284	0,192	0,175	0,380	0,806
		1997	0,523	0,314	0,142	0,035	0,034	0,036	0,218
	Clogged	(mil. m^3)	0,357	0,086	0,142	0,157	0,141	0,344	0,588
		(%)	40,57	21,50	50,00	81,77	80,57	90,53	72,95
	Annual average rythm	(mil. m^3)	0,012	0,003	0,005	0,005	0,005	0,013	0,019
		(%)	1,31	0,69	1,61	2,64	3,10	3,48	2,35
Fish volume (Talweg - -N. Ex. P.)	Effective (mil. m^3)	1966 /*71	0,690	0,290	0,242	0,160	0,170	0,300	0,608
		1997	0,368	0,201	0,058	0,023	0,033	0,014	0,164
	Clogged	(mil. m^3)	0,322	0,089	0,184	0,137	0,137	0,286	0,444
		(%)	46,67	30,69	76,03	85,62	80,59	95,33	73,03
	Annual average rythm	(mil. m^3)	0,010	0,003	0,006	0,004	0,005	0,011	0,014
		(%)	1,50	0,99	2,45	2,76	3,1	3,67	2,36

For the gross volume of the ponds, the degree of clogging is lower, the percentage values being between 21.5% at Tău Popii and 90.5% at Sucutard I (Table 5). The values are lower at the Tău Popii (21.5%) and Cătina (40.5%) ponds and higher at those located downstream of the confluence with the Mociu stream (50% at Geaca I, between 70 and 80% at Sucutard, Geaca II and Geaca III and 90.5% at Sucutard I). The average annual rate of clogging has values close to those mentioned in the case of fish volume (table 5). In the case of the ponds in the Pârâului de Câmpie basin, the silting dam of the ponds located in the two sectors (upstream and downstream of the confluence with the Șesului

Valley) is different. In all analyzed ponds, the fish volume decreased to the greatest extent, the percentage values being between 7.79% at Zau de Câmpie and 32.76% at Bujor II. The total volume is the least decreased. There are contrasting differences between the ponds located in the upstream sector (Miheş I and Miheş II), where the clogging was more intense (11 – 11.5 %) and those downstream (between 0 and 4 %). The ponds located downstream of the mentioned confluence have a total volume almost unaffected by this phenomenon (below 1%). The situation is similar to the average annual clogging rate. The sharp reduction of the lower volumes, especially the fish volume, denotes the fact that the ponds have operated for a long time at the level of fish exploitation, the alluvium transported by the tributaries sedimenting especially below this level (Table 6).

Table 6. The characteristic volumes, the degree and the average annual rate of clogging of the ponds in the middle basin of the Pârău de Câmpie (*V. Sorocovschi, 2005)*.

Average volume and rythm / Pond			Miheş I*	Miheş II*	Miheş III*	Bujor I	Bujor II	Zau de Câmpie
Total volume (Talweg - - N. M. E.)	Effective (mil. m^3)	1966/ 71	0,142	0,062	0,101	0,232	0,241	3,38
		1998	0,126	0,055	0,097	0,230	0,241	3,38
	Clogged	(mil. M^3)	0,016	0,007	0,004	0,002	0	0
		(%)	11,27	11,29	3,96	0,86	0	0
	Annual average rythm	(mil. M^3)	0,0005	0,0002	0,0001	0,0000	0	0
		(%)	0,42	0,42	0,15	0,03	0	0
Gross volume (Talweg - - N. N. R.)	Effective (mil. m^3)	1966 /71	0,115	0,052	0,079	0,165	0,096	2,188
		1998	0,092	0,044	0,070	0,150	0,095	2,070
	Clogged	(mil. M^3)	0,023	0,008	0,009	0,015	0,001	0,118
		(%)	20,00	15,38	11,39	9,09	1,04	5,39
	Annual average rythm	(mil. M^3)	0,0008	0,0003	0,0003	0,0005	0,0000	0,004
		(%)	0,74	0,57	0,42	0,28	0,03	0,17
Fish volume (Talweg - -N. Ex. P.)	Effective (mil. m^3)	1966 /71	0,089	0,041	0,060	0,128	0,058	1,90
		1998	0,060	0,030	0,046	0,103	0,039	1,752
	Clogged	(mil. M^3)	0,029	0,011	0,014	0,025	0,019	0,148
		(%)	32,58	26,83	23,33	19,53	32,76	7,79
	Anual average rythm	(mil. M^3)	0,001	0,0004	0,0005	0,0008	0,0006	0,005
		(%)	1,21	0,99	0,86	0,61	1,02	0,24

* Ponds in controlled exploitation since 1971

5. GEOGRAPHICAL CONDITIONS CONCERNING THE CONSTRUCTION OF RESERVOIRS

In order to avoid the risks that may occur in the construction of reservoirs, it is particularly important to know the abiotic and biotic components of the environment within the hydrographic basins provided for the development of reservoirs.

Based on several control factors ***(Ir - the rock resistance index; Re - the erosion rate; Th-the hydrochemical type; Gm - the degree of mineralization)*** the outline of the territory of Romania regarding the opportunity to build reservoirs was created, on which the areas with different degrees of favorability and restrictiveness (Fig. 5).

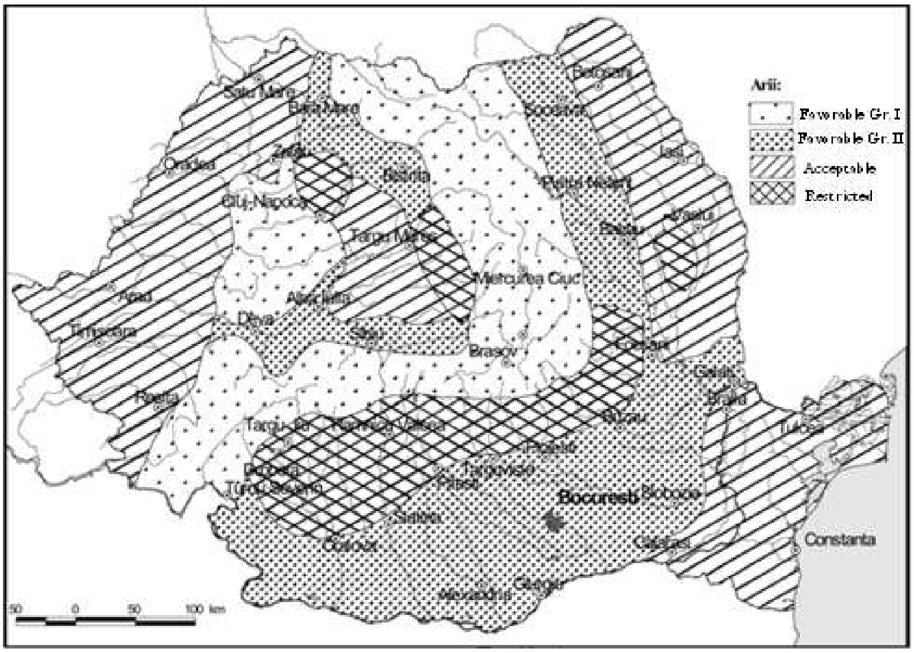

Fig. 5. The sketch map of the Romanian territory with the areas of opportunity for the construction of reservoirs *(Source: Gâștescu, P., Sandu, Maria,1991)*

The area with the first degree of favorability includes the Carpathian Mountain, consisting of a varied lithological range but with a high resistance to erosion, a fact that also determines a solid flow in suspension reduced (<1t/ha.year). Both the relief energy and the specific liquid and solid discharge are favorable for the creation of reservoirs. Added to these are the low degree of mineralization (below 200 mg/1) and the calcium bicarbonate hydrochemical type.

The only drawback of this area is that the average values of the flow discharge are quite low, on the order of a few m^3/s and rarely above 10 m^3/s. This situation is due to the fact that the Carpathian Mountain represents the spring of most of the hydrographic rivers and as such on its periphery the rivers, although they have a high specific discharge, do not have large volumes of water. An exception to this situation is the rivers that cross the Carpathian Mountain (Olt, Mureș, Jiu, Bistrița and obviously, the Danube).

The only solution by which a larger volume of water can be achieved, i.e. a flow rate of 20-30 m^3/s, is the capture of several higher courses of the neighboring hydrographic rivers, as was done in the case of Vidraru-Argeș, Vidra-Lotru lakes and so on.

The reservoirs in this area mainly have energy and water supply functions. Due to the favorable conditions found in the Carpathian Mountain under this aspect and the fact that 65% of the water resources of the Romanian rivers are formed (regenerated) here, a series of restrictions are imposed to preserve the quality of this natural wealth. The idea of establishing some hydroreserves on distinct Carpathian Mountain is even being advanced.

The area with grade II favorability includes the Suceava Tableland, a part of the Someșan Tableland, the Moldavian Subcarpathians, the Bistrița and Năsăud Hills from the Transylvanian Depression and the Romanian Plain as a whole, geographical units with a varied relief lithology and energy and even with liquid and solid drainage, also differentiated.

In the mentioned Subcarpathian subunits, liquid and solid runoff are higher than in the plain. The common element of these subunits is the presence of transient hydrographic arteries (allochthonous) with flow rates of the order of tens of m^3/s and therefore the possibility of building reservoirs, not with large volumes but with a high level of traffic. The cascade lake system is for rent.

Among the disadvantages of the Subcarpathian units, we mention the higher rate of clogging compared to the one in the mountains and in the plains and the existence of saline areas that lead to an increase in the degree of mineralization (sometimes over 1,000 mg/l) and the type of sodium chloride. In the Suceva Tableland, the above inconveniences are absent and therefore this represents a more favorable area for reservoirs in the presence of hydrographic arteries such as Siret, Suceava and Moldova rivers. As for the Romanian Plain, it was included in the area of favorability of gr. II, due to the fact that here the soil erosion is very low due to the low relief energy and the rather low specific liquid runoff (around 1 l/s. km^2) and as such also of the solid sub 0.5t/ha.year).

The presence of large hydrographic arteries (Jiu, Olt, Argeș, Ialomița) with appreciable flows allow the construction of reservoirs with a predominant function for irrigation, fish farming and hydropower subsidiary. Small lakes of agro-fishing interest (ponds) are built on the secondary hydrographic network of the Romanian Plain, due to low water flows, especially seasonal runoff.

The acceptable area - for the construction of the reservoirs, the geographical units of the plateau and the plain were identified (Bârlad and Corvului Tableland, Moldova Plain, Dobrogea, Târnavelor Hills with specific liquid and solid discharge (under 2 l/s km^2, in the eastern part of the country just below 1 l/s km^2 and respectively below 0.5 t/ha.year) with the exception of Dobrogea where the difference in solid discharge is greater (0.5 – 2.5 t/ha.year).

The hydrographic rvers in these areas, apart from the allochthonous ones (Someș, Crișuri, Mureș, Bega, Timiș, Târnava, Prut), are of small extent, have low liquid flows and varying degrees of mineralization (over 500 mg/l). As a hydrochemical type, sodium bicarbonate prevails, except for the Moldavian Plain, where sulfate prevails. Frequent reservoirs are the farm ponds ones (Moldova Plain, Transylvanian Plain, West Plain -farm ponds, Bârlad and Corvului Plateau, and even in Dobrogea).

Restrictive areas in terms of the construction of reservoirs. The following geographical units are included in this category: Curvature and Getic Subcarpathians, Getic Tableland, a part of the Transylvanian Subcarpathians (between Mureș and Olt rivers), a small area in the center of the Bârlad Tableland and the Someșan Tableland. The determining factor in considering these restrictive geographical areas for the construction of reservoirs is the high specific solid runoff (over 5 t/ha.km^2).

In these conditions, the lifetime of some reservoirs is very short, and the investments for the development of the related drainage basins are very high. Added to this aspect of the specific solid runoff is the presence of salt masses that are washed away by the waters and load the river waters with sodium chloride.

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