

HISTORY OF BUILDING THE MAIN DAMS AND RESERVOIRS

Gheorghe Romanescu, Ana-Maria Romanescu¹, Gabriela Romanescu²

¹"Alexandru Ioan Cuza" University of Iasi, Faculty of Geography and Geology, Department of Geography, Carol I, 20A, 700505, Iasi, Romania, Email: romanescugheorghe@gmail.com

²School Nr. 22 Bogdan Petriceicu Hasdeu, Str. Ion Creanga, 27, 700317, Iasi, Romania

Abstract

The large dams and reservoirs have multiple functions: hydropower, supply with drinking or industrial water, irrigations, pisciculture, leisure, etc. The oldest reservoirs date to the Antiquity (circa 4,000 years ago) and they were built by the Arabs. The most numerous are constructed in the areas with rain deficit: Moldavia (with the largest pond, Dracsani), the Transylvanian Plain, Dobroudja. The ones in the mountainous areas are mainly used to obtain electricity (Izvorul Muntelui, Vidra, Vidraru, etc). The largest water bodies in Romania are found in the Tulcea County (considering the existence of the Danube Delta), Iași and Botoșani (with few precipitations, but with many ponds). Most dams were built in the period 1960-1990. The oldest reservoir in Romania (Taul Mare) was built in 1740 in the Metaliferi Mountains. The most numerous reservoirs are located in the Siret hydrographical basin. The Prut River comprises the largest reservoir built on the Romanian rivers (Stâncă-Costești). The oldest hydropower plant in Romania was built in 1890 on the Dâmbovită River (Bucharest). The Romanian territory has 246 large dams, more than half of which are less than 40 m high.

Keywords: manmade dams, reservoirs, hydropower potential, water resources

1. INTRODUCTION

According to the definition provided by Forel, (1892) lake is "a body of standing water occupying a basin and lacking continuity with the sea." The term lake applies to all natural or artificial depressions containing water, "with their own life and certain autonomy" (Dussart, 1992). According to the international treatises on limnology, lake is "an inland body of water of considerable size" (International Glossary of Hydrology, 1992) or "a sweet or salt water body which occupies a closed depression on the surface of a continent" (Dictionnaire Encyclopédique Alpha, 1983).

By their nature, lakes can be natural or manmade (artificial). Concerning the artificial lakes, the following characteristics are taken into account: purpose (hydropower, industrial or drinking water supply, irrigations, pisciculture, leisure, balneotherapy, waste settling, mineral flotation, etc); size (first, the water volume). The reservoirs in Romania comprise 13 billion m³ of water, which means 33% of the total water volume transited within a year by the rivers draining the country's territory (Jelev, 1992).

The category of artificial lakes tends to occupy a tremendous surface among all the lakes on Terra. Currently, 40 artificial lakes exceed 1,000 km² (a total of 114,000 km²) and their total volume is 1,675 km³. Among these gigantic lakes, almost half belong to Russia (Volgograd, Kuibâșev, Țimleask, Novosibirsk, Krasnoiarsk, Bratsk), while the rest to the USA (Mead, Glen Canyon, Fast Peak, Garrison, Oahe), to Canada (Pearce-Viuner Grew), to China (Three Gorges), to Argentina (Itaipu), to Egypt (Nasser), to Niger (Kandji), to Zambia (Kariba), etc (Romanescu et al., 2013). The largest manmade lake is Volta, in Sahel, Africa (8,730 km²), while the one with the greatest volume is Bratsk, on the Angara River, with 169.4 km³ (Billington et al., 2005; Biswas & Tortojada, 2001; Brandt & Hassan, 2000; Romanian Committee on Large Dams, 2000; Dăscălescu, 2000; International Commission on Large Dams, 1999, 2010; Mermel, 1989; Romanian National Committee on Large Dams, 2000; World Commission on Dams Regional Consultation, 1999; World Commission on Dams, 2000a,b).

The disadvantages of reservoirs have often been underlined by the specialized literature, because the anthropic activity does not always have positive outcomes: it produces alterations in the natural flow regime of rivers and it presents a high impact on the environment by modifying the ecosystems, etc (Touchart, 2006). By building the dam of Assouan, on the valley of the Nile, its floodplain and delta no longer receive enough alluvia. Because part of the waters of Don and Kuban are retained, the Sea of Azov receives a smaller amount of water.

2. METHODOLOGY

The consultation of the specialized literature within international publications. The positioning of the large dams and of reservoirs on a general map and comparing them by size, shape, utility, etc. The largest

dams and reservoirs in Romania were included into types and compared to the other ones in the world. In the field of hydrotechnical works, Romania ranks high on a global scale, with a total of 246 large dams.

3. RESULTS AND DISCUSSIONS

The dam represents any hydrotechnical work with an existing or proposed structure, capable of ensuring the permanent or temporary accumulation of water, of liquid or solid industrial waste deposited underwater (from the chemical or energetic industry and from the mud settling ponds of the mining industry), whose breaking can produce the uncontrolled loss of the accumulated content, with highly significant negative effects upon the social, economic and/or natural environment (definition comprised in the Emergency Ordinance no. 244/2000 on the safety of the dams – republished).

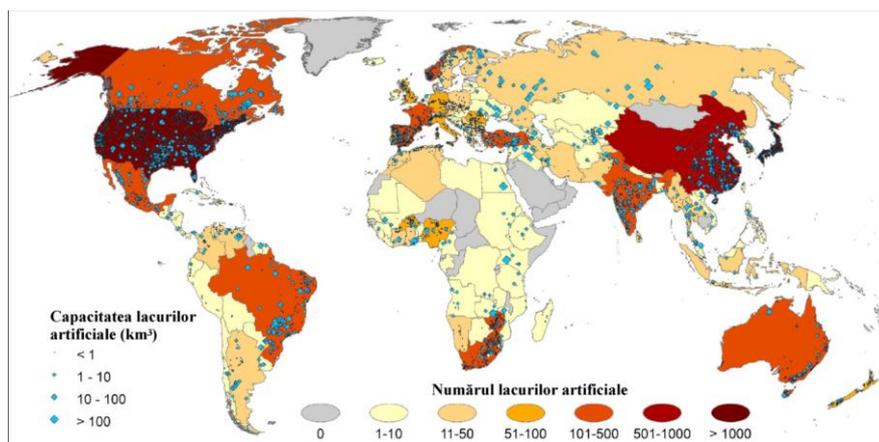


Figure 1. Distribution of large reservoirs and of the number corresponding to each State (after Lehner et al., 2010)

The countries with an aggravated precipitation deficit – and liquid flow, implicitly – on the hydrographical arteries are forced to build dams and reservoirs. The necessity of building dams in Romania is due to the fact that 95% of the rivers are less than 50 km long. Only four Romanian rivers exceed 500 km in length: Siret, Prut, Mureş and Olt. The mean multiannual flow of the Romanian rivers only reaches 1,172 m³/s, which means a volume of 37 million m³. The territorial repartition and the unequal flow regime determine the rivers to supply an annual volume of only 5-6 million m³/s (Gâştescu, 1971; Gâştescu & Rusu, 1980; Rădoane & Rădoane, 2004; Romanescu, 2006; Şerban et al., 1989).

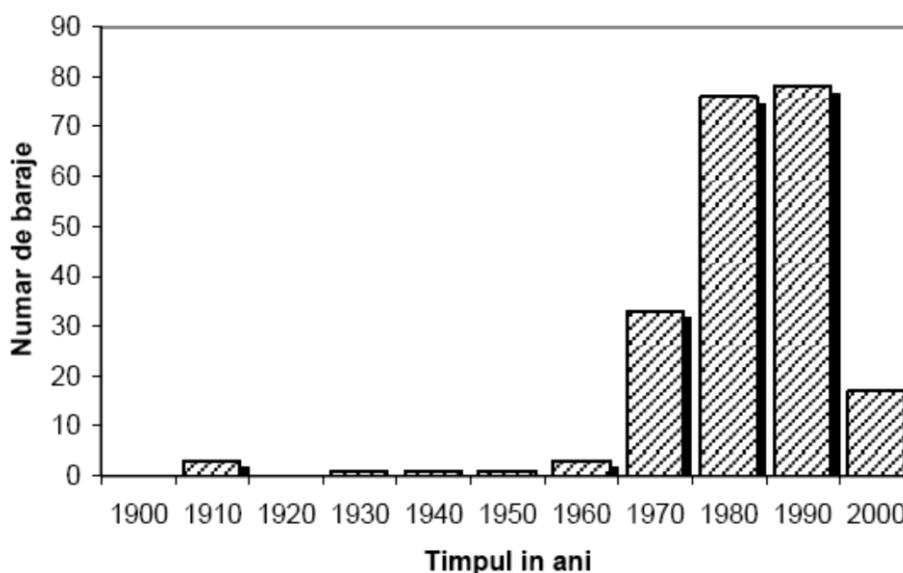


Figure 2. Rhythm of dams building on the Romanian territory (after Rădoane & Rădoane, 2004)

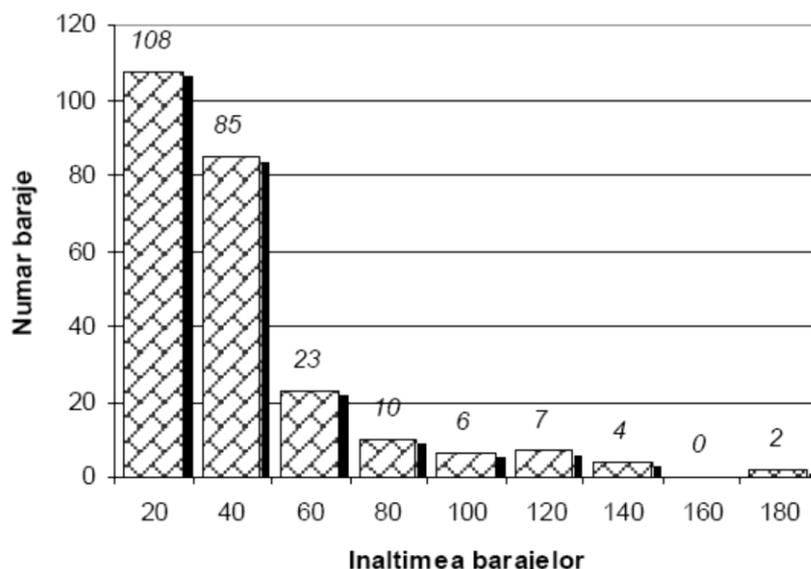


Figure 3. Number of the dams and their height, on the Romanian territory (after Romanian Committee on Large Dams, 2000)

Most rivers in the Moldavian Plateau, Dobroudja and the Romanian Plain dry out in the summer and they have no flow in the winter because waters are frozen. Only the rivers larger the fourth order – according to the Horton-Strahler classification system – have a permanent flow (Romanescu, 2012). The first (artificial) reservoirs were constructed during Antiquity; however, an intense increase in their number has been registered in the past 60 years (Fig. 1). Most dams were built in the period 1980-1990. After the year 1990, no dams were built on the Romanian territory. Most dams in Romania have a height under 20 m (108), while only two are more than 180 m high (Fig. 2). The most numerous reservoirs are situated in the Siret hydrographical basin, followed at great distance by Olt, Argeş, Ialomiţa, Mureş, Jiu-Cerna, Someş, Crişuri, etc (Fig. 3, 4). On the Prut River – the Romanian sector – only one dam was built: Stânca-Costeşti.

The latest archaeological excavations have brought to light vestiges of dams circa 4,000 years old. They were built in the places with precipitation deficit, mainly in the Arab countries. They were used for the water supply of settlements and for irrigations. Marib of Yemen is the best-preserved dam and it was built in 750 B.C. (Fig. 5, 6). The building process took around 100 years. The dam was 4 m high and it was made of stone and clay. The ancient dam was elevated in the year 1968; currently, it is 38 m high. The lake accumulates a water volume of 398 million m³.

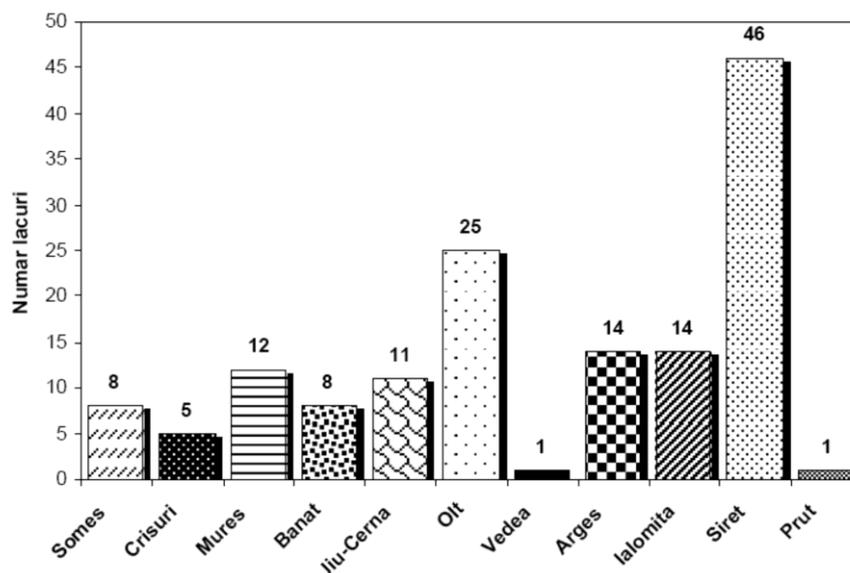


Figure 4. Number of reservoirs in Romania on hydrographical basins (after Rădoane & Rădoane, 2004)



Figure 5. Dam of the Marib Lake in Yemen, reconstructed in 1968 (after www.icold-cigb.org, 2013)



Figure 6. Inscriptions on the original stone of the Marib Dam, built in 750 B.C. (after www.icold-cigb.org, 2013)

The reservoirs had the primordial role of supplying with water the human settlements in the droughty period of the year. The oldest dam still in function was made of ripraps, in A.D. 1350, on the Syrian territory, today Iran (Ben-e-Golestan) (Fig. 7). In 2280 B.C., a complicated system of dams and channels – unusable today, unfortunately – was built on the Chinese territory.

The Sayamaike dam is the oldest on the Japanese territory, as it was constructed in the 7th century A.D. (Fig. 8). It has suffered important alterations throughout the time, but it has always preserved its complex use. On the territory of Sri Lanka, there are numerous inscriptions and chronicles attesting the existence of the dams starting with the 6th century B.C. Most of them were destined to irrigations. One of the largest dams (Nachchaduwa) was built during the reign of King Mahasen (A.D. 276-303), but it was destructed in 1900. It was restored in 1901 and it is still active (Fig. 9). On the territory of Sri Lanka, over 50 old dams were restored.



Figure 7. The Ben-e-Golestan Dam in Iran, built in A.D. 1350 (after www.icold-cigb.org, 2013)



Figure 8. Aerial image of the Sayamaike Lake in Japan, built in the 7th century A.D. (after www.icold-cigb.org, 2013)

The old system of building the dams – with sloping walls and weir for high waters – was preserved until the contemporary period (Fig. 10, 11, 12). Unfortunately, the material used has not always been the best, reason for which certain dams broke. The Roman system of dam building was based on the small heights of the crest. The most famous dam is Cornalbo, in Spain: it was 24 m (78 feet) high and 185 m (606 feet) long.

After the Roman period, for a relatively long time, in Spain only small-sized dams were built, while large dams began to be built starting with the 16th century. In the 19th century, the European engineers managed to build dams 45-60 m high (150-200 feet).



Figure 9. The Nachchaduwa Dam in Sri Lanka, built in the period A.D. 531-551 (after http://en.wikipedia.org/wiki/Three_Gorges_Dam, 2013)



Figure 10. The stone placement in the Giritale Dam in Sri Lanka, built in the period A.D. 608-618 (after www.icold-cigb.org, 2013)

The old dams were built for the water supply of localities, for irrigations and flood mitigation. It was only after 1800 that the energetic and sailing functions were added. The touristic or leisure function is relatively new and in full development. Most of the dams built lately have complex functions. The first mentions in documents of the dams on the Romanian territory date to the 12th century, when the ponds of Saard and Cristural near Turda were built (Fig. 13).



Figure 11. The ancient Minneriya tower built in the period A.D. 276 -303 in Sri Lanka. It was restored in 1901 and it is destined to irrigations (after www.icold-cigb.org, 2013)

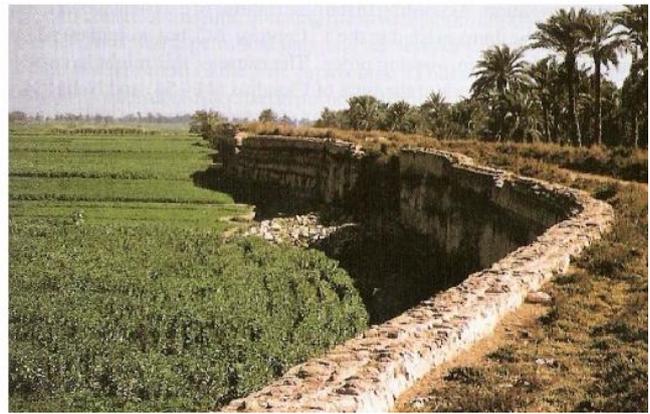


Figure 12. Ancient dam in Egypt, destined to irrigations (after www.icold-cigb.org, 2013)



Figure 13. Construction of the first reservoirs (Antiquity and Middle Ages) on the Romanian territory (after Dăscălescu, 2000)

The oldest reservoir (Tăul Mare), still in function, dates to 1740 and it was built in the Metaliferi Mountains, for the gold mines. The first ponds for felt mills date to the year 1448 and they were quite numerous in the Braşov area. In the period 1503-1550, there were 28 ponds. The ponds in Moldavia are mentioned in documents starting with the 15th-16th centuries. The first ponds mentioned in documents are the following: Hârlău, Belceşti, Şipote, Diniscean, etc. During the reign of Vasile Lupu, Lake Dracşani was extended; it is the largest such pond in Romania, with a surface of 486 ha and a volume of 5.5 million m³. On Bawr's map, (1781-1797) there were 134 ponds, while on the one of Oztellowitz (1790) – 372 ponds. On the Russian map – edited in 1850 – 126 ponds were represented, while the map of 1850-1900 already included 1,144 ponds (Băican, 1970).

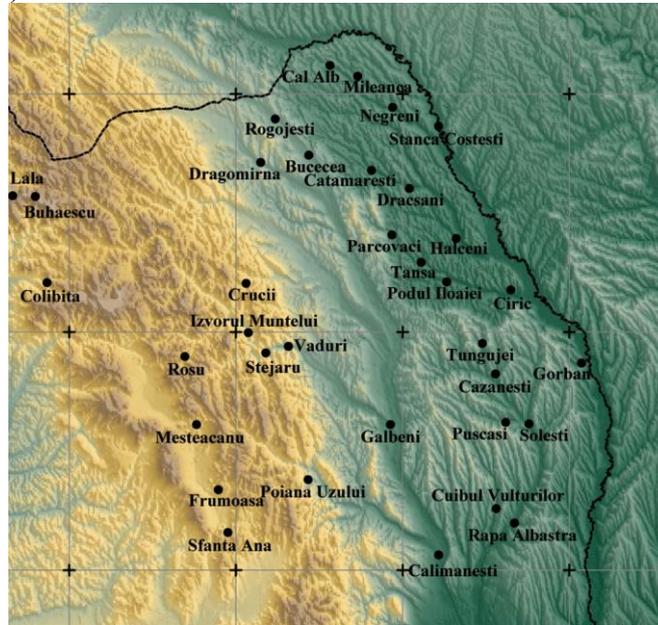


Figure 14. Distribution by area of the large-sized lakes in Moldavia

The first hydropower plants were built at the end of the 19th century: Bucharest (1890) on Dâmboviţa; Sadu (1896) in the Sibiu County. Until 1940, 128 hydropower plants were built. The largest reservoirs began being constructed in 1960, when the hydropower plant of Stejaru, on the Bistriţa River, was inaugurated (it includes the reservoir Izvorul Muntelui). The climax of the hydropower hydrotechnical works was recorded in the period 1980-1990, when 78 hydropower plants were inaugurated.

The tradition of hydrotechnical works and the value of the Romanian school in the field have been acknowledged by the International Commission on Large Dams, which includes 80 countries. Romania ranks the 19th by total number of the dams and the ninth in Europe (Romanescu et al., 2013). On the Romanian territory, there are 246 large dams, of which half are less than 40 m high. The highest dam on the Romanian territory is Gura Apelor, on Pârâul Mare, in the Retezat Mountains: 168 m. Other 1,500 dams are less than 15 m high, while the reservoirs comprise a volume below 1 million m³ (Rădoane and Rădoane, 2004, 2005). Most large-sized lakes in Moldavia are manmade, only a few are natural (Lala, Buhăescu, Red Lake, Crucii, St Ana) (Fig. 14).

4. CONCLUSIONS

The dams and reservoirs have been built for multiple purposes: supply with drinking or industrial water, irrigations, water for animals, pisciculture, hydropower, transport, leisure, etc. The first reservoirs were built in the Near and Middle East, because of the water deficit. The first ponds on the Romanian territory were constructed in the Moldavian Plain and they were mentioned in documents as early as the reign of Stephen the Great. The most numerous and the largest ponds in Romania are situated in the Moldavian Plain (counties of Botoşani and Iaşi) and in the Transylvanian Plain (counties of Cluj and Mureş).

The current reservoirs are large-sized and they have complex functions. The largest are used mainly for hydropower. They are built in mountainous or isolated areas because they occupy significant surfaces (North America, Asia, South America, etc). On the Romanian territory, there are 246 large-sized dams which harbour reservoirs comprising important water reserves.

Acknowledgments. *Our thanks go to the Geo-archaeology Laboratory within the Faculty of Geography and Geology, “Alexandru Ioan Cuza” University of Iasi, which provided the tools and carried out the processing of the data.*

REFERENCES

- Băican, V. (1970), *Iazurile din partea de est a României oglindite în documentele istorice și cartografice din sec. XV-XIX*. Scientific Annals of the Alexandru Ioan Cuza University, II, XVI.
- Billington, D.P., Jackson, D.C., Melosi, M.V. (2005), *The history of large federal dams: planning, design, and construction in the era of big dams*. U.S. Department of the Interior, Denver, Colorado.
- Biswas, K. & Tortojada, C. (2001), *Development and Large Dams: A Global Perspective*. Water Resources Development, 17(1):9-21.
- Brandt, S.A. & Hassan, F. (2000), *Dams and Cultural Heritage Management*. World Commission on Dams, Cape Town.
- Dăscălescu, N. (2000), *History of Dam Construction in Romania*. Romanian National Committee on Large Dams, Bucharest, 16-26.
- Dictionnaire Encyclopédique Alpha. (1983), *Dictionnaire Encyclopédique Alpha*, vol.1-24. Editions Grammont S.A. Lausanne.
- Dussart, B. (1992), *Limnologie. L'étude des eaux continentales*. Editions Boubee, Paris
- Forel, F.A. (1892), *Le Lemane: monographie limnologique*. Tome I. Bull. Soc. Vaud. Sci. Nat. Lausanne, 10.
- Gâștescu, P. (1971), *Lacurile din România – limnologie regională*. Romanian Academy Publishing House, Bucharest.
- Gâștescu, P. & Rusu, C. (1980), *Evaluarea resurselor de apă din râuri și amenajarea bazinelor hidrografice în România*. Terra, XII(XXXII), 2.
- International Commission on Large Dams. (1999), *Benefits and Concerns About Dams*. Committee on Public Awareness and Education.
- International Commission on Large Dams. (2010), *Dams and the World's Water*. Paris.
- International Glossary of Hydrology. (1992), *International Glossary of Hydrology*. World Meteorological Organization.
- Jelev, I. (1992), *Conferința Națiunilor Unite pentru mediu și dezvoltare, Rio de Janeiro, June 1992*. Mediul Înconjurător, III(3): 3-8.
- Lehner, B., Reidy Liermann, C., Revenga, C., Vörösmarty, C., Fekete, B., Crouzet, P., Döll, P., Endejan, M., Frenken, K., Magome, J., Nilsson, C., Robertson, J., Rödel, R., Sindorf, N., Wissler, D. (2010), *High resolution mapping of the world's reservoirs and dams for sustainable river flow management*. GWSP-GCI Workshop, The Global Dimensions of Change in River Basins, Bonn, 2010.
- Mermel, T.M. (1989), *Major Dams of the World-1989*. Water Power and Dam Construction Hand Book, 50-56.
- Rădoane, N. & Rădoane, M. (2004), *Lacurile de baraj din bazinul râului Siret*. Annals of the “Ștefan cel Mare” University, 13: 77-88.
- Rădoane, M. & Rădoane, N. (2005), *Dams, sediment sources and reservoir silting in Romania*. Geomorphology, 71: 112-125.
- Romanescu, G. & Lasserre, F. (2006), *Le potentiel hydraulique et sa mise en valeur en Moldavie Roumaine*. In: Politiques de l'eau. Grands principes et réalités locales, Eds. A. Brun, F. Lassere. Presses de l'Université du Québec, 325-346.
- Romanescu, G., Stoleriu, C.C. & Enea, A. (2013), *Limnology of the Red Lake, Romania. An Interdisciplinary Study*. Springer, Dordrecht.
- Romanian Committee on Large Dams. (2000), *Dams in Romania*. Romanian National Committee on Large Dams, Bucharest.
- Romanian National Committee on Large Dams. (2000), *Dams in Romania*. Romanian Waters National Administration, Bucharest.
- Șerban, G., Sorocovschi, V. & Fodorean, I. (2004). *Riscuri induse de amenajarea hidrotehnica a iazurilor de pe Valea Șesului (Campia Transilvaniei)*. Risks and catastrophes, 1: 159-172.
- Touchart, L. (2006), *Lacs et risques. Un essai de typologie*. Risks and catastrophes, 5(3): 13-20.
- World Commission on Dams Regional Consultation. (1999), *Large Dams and Their Alternatives in Latin America, Experiences and Lessons Learned*. World Commission on Dams.

World Commission on Dams. (2000a), *Dams and Cultural Heritage Management. Final Report*. Vlaeberg, Cape Town, South Africa.

World Commission on Dams. (2000b), *Dams and Development: a new framework for decision-making*. Earthscan Publications Ltd., London.

http://en.wikipedia.org/wiki/Three_Gorges_Dam, 2013

www.icold-cigb.org, 2013