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SWOT ANALYSIS ON THE IMPACT OF ENGINEERING WORKS FROM THE ARGES HYDROGRAPHIC BASIN ON THE FLUVIAL SYSTEMS

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Abstract

Arges river basin is one of the most engineered catchments of Romania, as evidenced by the multitude of existing hydro-technical works therein. In addition to their economical advantages, these "features" are, however, quantity, quality, ecological and hydro-geomorphologic pressure factors on the existing aquatic units, which reflect (directly or indirectly) negatively on society and ecosystems. According to the Water Framework Directive requirements, knowledge of anthropogenic pressure forms on water resources is highly imperative, in order to identify the quality of water bodies in order to adopt adequate measures to protect and conserve. The paper is a an inventory and a summary analysis of key engineering works from the Arges hydrographic basin (storage lakes, derivatives, river regulations, embankments and protection of the banks), performed on water courses for different purposes: (electricity generation, different water demands, defense against water destructive effects, control of excessive humidity, regulation of natural water flows) during different periods of time (daily, weekly, seasonal, annual, etc.). In order to quantify the impact of engineering works on fluvial systems, a SWOT analysis is of very much need. This method of analysis was applied on the area of the Arges Basin in order to identify, negative and positive effects of engineering works, opportunities and risks associated to these facilities, that should allow adopting strategies of water management so that the sustainable development concept is complied with.

Keywords: engineering works, fluvial systems, SWOT analysis, Argeş hydrographic basin.

1. INTRODUCTION

In the Arges hydrographic basin there is a high potential of water resources, potential which is exploited by numerous engineering works made for multiple purposes. These hydrotechnical works generate on rivers from the area of this theme, quantitative, qualitative, hydro-geomorphologic and ecological pressures, both positive and negative, with permanent or temporary effects.

This paper aims to be an inventory and an analysis of the main engineering works from the Arges hydrographic basin. In this respect there were valued a set of data and information from various annuals and synthesis prepared for the Arges hydrographic basin.

In order to quantify the impact of engineering works on fluvial systems, a SWOT analysis is of very much need. This analysis is important can identify positive and negative effects of engineering works, opportunities and risks associated to these works. Depending on the results of this analysis one can determine weaknesses, then identifying solutions leading to sustainable fluvial systems.

2. THE MAIN ENGINEERING WORKS FROM THE ARGES HYDROGRAPHIC BASIN AND THEIR ECONOMICAL IMPORTANCE

The main engineering works from the Arges hydrographic basin are represented by the following type of works: storage lakes, river regulations and embankments, derivatives, take-off and returns of significant waters (figure no. 1). These are carried on water courses for various purposes (electricity generation, different water demands, defense against water destructive effects, control of excessive humidity, regulation of natural water flows), with functional effects for human communities.

The storage lakes

According to the *Yearbook of water resources management for the Arges hydrographic basin*, 239 storage lakes were counted in the year of 2010, out of which 33 have a volume higher than 1,000,000 cubic meters. Of these the most important by total volumes and lenghts are: Vidraru, Mihăileşti, Goleşti, Budeasa, Vâlcele, Grădinari, Mărăcineni, Lacul Morii. The usages of the Arges basin storage lakes are diverse: energy, water supply, irrigation, leisure and complex as in the case of the lakes: Vidraru, Goleşti, Mihăileşti, Grădinari, etc.

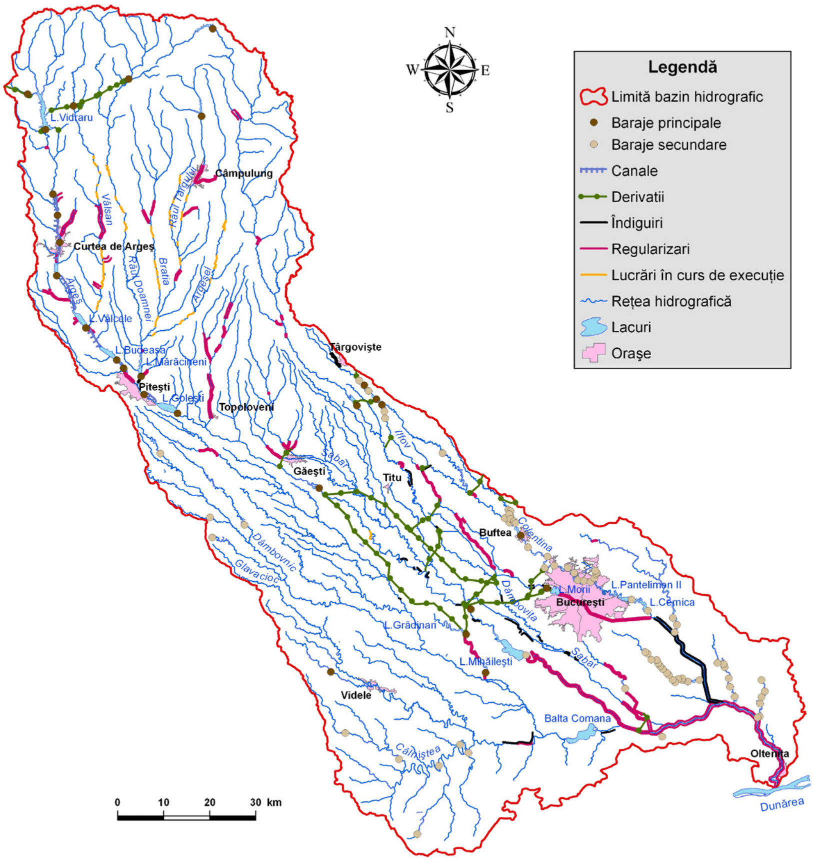


Figure no. 1 Engineering works in the Arges hydrographic basin (Source INHGA)

River regulations and embankments

In the Arges hydrographic basin, according to the *Yearbook of water resources management for the Arges hydrographic basin* , (2010), it have been counted 213 bed river regulations on a length of 10,700.06 km, 261 of protection of the banks over a length of 523.72 km, and 67 embankments. In 2010, the humidity excess was removed through 20 drainage systems on a total area of 92,715 ha, being evacuated a total of 94,905.112 thousand cubic meters.

Derivatives

The derivatives are made in order to supplement the volumes of water for usage or flood protection by transferring water from one river to another, in the high water, low water and medium water conditions.

The derivative works on the tributary stream of the upper basin of the Arges river are to supplement the amount of water for hydropower, while in the lower basin the derivatives are connected to the water supply, flood protection and ecological improvement of rivers.

In the Arges river hydrographic basin was done and it is functional an important network of basinal water transfer. In 2010, there have been identified 20 derivatives (Yearbook for management of water resources for the Arges hydrographic basin), of which the longest is the Argeș/Ciorogârla/CA2 derivation (L = 30.7 km), followed by the Arges / Ilfovăț/CA1 derivations which derives from a river with Vtransit of 12040.0 thousand cubic meters, respectively Doamnei/Lac Vidraru, each having a length of 19.2 km. The highest volume by-passed, in the year 2010 was 377,770 thousand cubic meters, corresponding to the Dâmbovița/Ciorogârla/Joița derivation.

Take-off/returns of significant waters

In the Arges hydrographic basin the main significant water take-off generators of pressure on the fluvial systems, according to the *Arges-Vedea Basin Management Plan*, are represented by the Crivina - Ogrezeni (on the Arges River) with a take-off flow of 5.75 cm / s and Arcuda (on the Dambovita river) with a take-off flow of 4.64 cm / s. Significant water take-off is done by the economical units as well: SC APA CANAL 2000 SA Pitesti (Qtake-off = 0.78 m / s), SC Aquaterm Arges (Qtake-off = 0.073 m / s), SC EDIL CAMPULUNG (Qtake-off = 0 , 18 cm / s). The water take-off mentioned aim the alimentation with potable and industrial water of the cities: Bucharest, Pitesti, Campulung and Curtea de Arges.

Significant water returns from the Arges hydrographic basin, which represent from the quantitative point of view a hydromorphological pressures, are generated by economic units, such as SC Apa Nova

Bucharest SA (Qoutflow = 11.70 cm / s), PETROM OMV-ARPECHIM Piteşti (Qoutflow=0,806 cm/s) and SC AUTOMOBILE DACIA (Qoutflow=0,036 cm/s).

Other major take-off are achieved by the economic units SCP NUCET-P. NUCET and SC PISCICOLA SA GIURGIU, their purpose being the pisciculture and the take-off rivers are Ilfov and Neajlov.

3. SWOT ANALYSIS

In order to quantify the impact of the engineering works on the fluvial systems, a SWOT analysis is very useful. The SWOT analysis is a method of analysis leading to the identification, both of the negative and the positive effects of the engineering works, and hence the solutions in the form of water management strategies so that the concept of sustainable development is respected.

Strengths:

The main engineering works in the Arges hydrographic basin (storage lakes, derivatives, river regulations, embankments and protection of the banks), made on the water courses for various purposes, generate in the SWOT analysis a series of "strengths" from which the most important as follows:

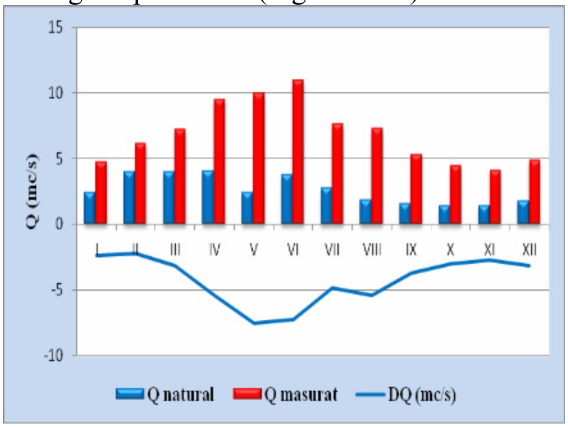
-*electricity generation*, renewable, clean through hydroelectric power plants located in the Arges hydrographic basin, has positive, beneficial and permanent effects. Of these, according to the *Yearbook of water resources management for the Arges hydrographic basin*, (2010), the most important from the installed capacity are: Vidraru (220 MW), Clăbucet (64 MW), Rucăr (23 MW), Leresti (19 MW), Valcele and Baiculesti (15.4 MW), Oeşti, Albeşti, Cerbureni, Valea Iaşului (15 MW).

Case study – The Arges hydrographic basin

STRENGTHS – S	WEAKNESSES – W
Electricity generation Flood mitigation Flow regulations Providing the water sources for usage Minor or major river beds regulations Changing the hidric regime of some lands Protection of the banks (including of the riverain lands and constructions) Facilitate the shipment Fishy exploitation Tourism development Birds habitats development	Change of water quality Change of bed morphology Change of the natural flow regime Change of landscape Land occupancy Change of aquatic flora and fauna
OPPORTUNITIES – O	**THREATS – T**
Hydroenergetic potential Tourism, leisure (especially near the storage lakes) and water sports Fishing sport and fisheries The emergence of new cities, new occupations and professions, infrastructure, electrical networks, hospitals, schools etc Increase in the land quality Increase in the life quality	Silting (in lake and beds) and eutrophication (nutrients) due to changes in the water quality Earthquake and dams break risk Damage of areas of communitary importance (sites of communitary interest – SCI and special avifaunistic protection areas SPA) Change in bed morphology Change in flora and fauna Risk of landslides Damage of archaeological, historical and cultural sites Reduction in the area of agricultural land

- *flow regulation* by maintaining of minimum acceptable flows in rivers during periods of prolonged dryness, based on water stocks held in the storage lakes or by removing the excess water and mitigating floodings, because of heavy rainfall. Flow regulations can be distinguished by the difference between the natural flow regime and the one measured (ie accumulated and dezaccumulated flows) expressed in cm/s.

In the Arges hydrographic basin at the hydrometric station Vidra on Sabar river (1978-2005), the measured flows are superior to those natural ones, which reveals clearly the regulation of the drainage by compensation of the minimum flows (Figure no. 2). A similar situation is found and at the hydrometric station Poenari on the Sabar river for the period 1978-2005, the difference being that the flow regulation is achieved by reducing the peak flow (Figure no. 3).



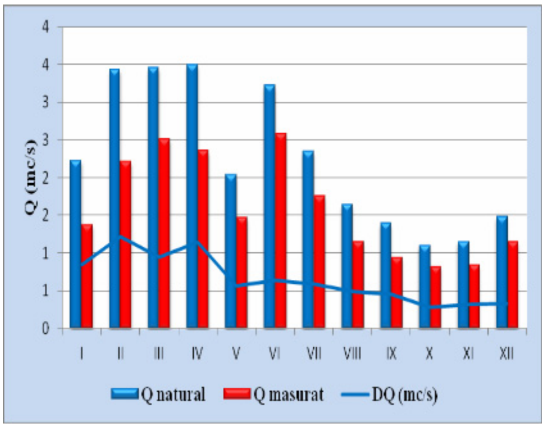


Figure no. 2 (left) Variation of mean monthly flows measured and natural at the hydrometric Vidra station on the Sabar river (1978-2005), Fig. 3 (right) Variation of mean monthly flow measured and natural at the hydrometric Poenari station on the Sabar river (1978-2005)

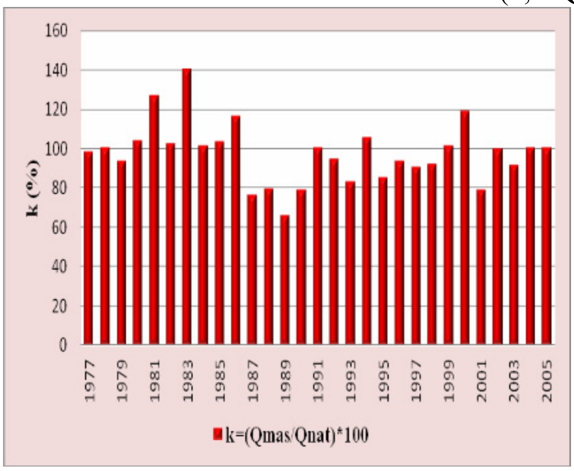
- *providing water sources for usage* is achieved by storing and regulating flows in existing engineering works. In the Arges hydrographic basin, the takings for different uses, according to the *Yearbook of water resources management for the Arges hydrographic basin*, (2010), there were distributed as follows: 220,487 mil.cm for population, 201,361 million cubic meters for industry, 1183 million m³ for zooculture, 2786 million cubic meters for irrigation, 45,201 for fisheries.
- *regulations and bed defense works* of minor or major river beds leading to protection against erosion and degradation by alluviation of the riverain lands. (the number of bed adjustments have been mentioned in point 2).
- *change in the hydric regime of lands* generates implicitly their quality change with the economic value, as well as the emergence of new settlements and occupations; in the Arges hydrographic basin, in the year 2010, the change of the hydric regime of land was made for a total of 20 drainage systems, through which the excess moisture was removed from a total surface of 92,715 hectares, being evacuated a total volume of 94,905.112 thousand cubic meters.
- *protection of margins* in the Arges hydrographic basin, in the year 2010, was achieved by 261 works of protection of the banks on a length of 523.72 km.
- *facilitation of shippment* will be done by implementing the project "Development of the Dâmbovița and Arges rivers for navigation and other uses" through this project, one of the great benefits is linking Bucharest with the Danube River, respectively the Trans-European Transport Corridor no. VII, by a waterway transport with a capacity of 24 million t/year.
- *fishy exploitation* - according to the Ministry of Environment, in 2008, the hydrographic basin had a total number of 224 small reservoirs with fish use, recreation or local interest, of categories C and D, subject to GEO. 138/2005, as amended and supplemented.
- *tourism development* - because of a large number of storage lakes in the Arges hydrographic basin there are obvious effects of the development of tourism and leisure activities such as general social benefits, benefits for the engineering works administrator and for associated tourism organizations, local economic growth, positive environmental effects by eliminating poaching.
- *development of habitats for birds* occurs because of the existing lake surfaces at the level of the Arges hydrographic basin; these lakes are part of the special avifaunistic protected areas (SPA) (eg ROSPA0062 storage lakes on Arges, ROSPA0038 Danube - Oltenita).

Weaknesses:

-*changes in water quality* is the result of physico-chemical parameters fluctuations, biological and bacteriological, as well because of: high temperature, due to thermal stratification and isolation; reduction of the amount of dissolved oxygen, salinity increase due to concentration processes, precipitation, evaporation, dissolution of some substances of the cuvette, turbidity decrease which increases the biologically active area, accumulation of organic and or chemicals substances, with often unpredictable effects (ecologically). In this context, for example, in the Arges hydrographic basin, according to the *Annual synthesis on quality of the water resources from the Arges hydrographic basin* (2009), the *Targ River* under the macroozobentos saprobity index, on the section area Câmpulung –

Doamnei river confluence, presents a deterioration of the water quality, moving from class I to II (on a length of 43 km), due to restitution of urban waste waters of SC Edilul Câmpulung Muscel. Also, in case of Doamnei river on Dărmăneşti section - Arges confluence, water quality is getting worse (grade III), due to Mioveni household sewage and industrial wastewater restitution of the SC Automobile Dacia SA . Neajlov River, on the village bridge section Broşteni - Vadu Lat shows a deterioration of water quality (Class III) due to Dâmbovnic water, charged with restitution of wastewater from OMV Petrom - Arpechim Pitesti. Dambovita River, downstream section restitution from sewage discharge from SC Apa Nova Bucharest - Arges confluence (on a length of 30km) shows V grade quality. Arges River, on the reservoir section Zăvoiul Orbului - Ogrezeni reservoir entrance is characterized by deterioration of water quality (class IV) due to riverbed morphology where water stagnates in gravel pits, and on the downstream Dâmboviţa confluence – Danube confluence the water quality is of grade V, due to Dambovita untreated waters.

- *change in beds morphology* occurs in longitudinal and transverse profile modification of rivers, expressed in increased height due to the accumulation of sediment (behind dams) and widening of river beds (downstream of dams), as well the change in the profile of equilibrium. In this respect, the Arges River in the montan sector it has a lateral erosion of the riverbed (upstream of accumulations), while in the plain sector (downstream of reservoirs) to be specific the erosion depth. Thus, lowering the Arges river bed in downstream of the Golesti reservoir with 11m from its inception (1977) by 2008 it has several causes, namely: reducing the amount of sediments brought in the riverbed as a result of their detention in the accumulation and regulation of exploitation which requires removal of some relatively high flow and with similar speed s. In a single year, 2002-2003, th thalweg share fell 2m, for the remaining years the deepening rate being approx. 1m/an. (Laura Ana Mititelu, 2010). According to the speciality literature (Rosca and Theodor, 1990), the migration distance of the deepening processes in downstream of the Golesti lake on the Arges river was sent up to approx. 100 km downstream of it.
- *change in the natural flow regime* can be evidenced through the various parameters such as the flow difference between natural and measured (k, DQ).



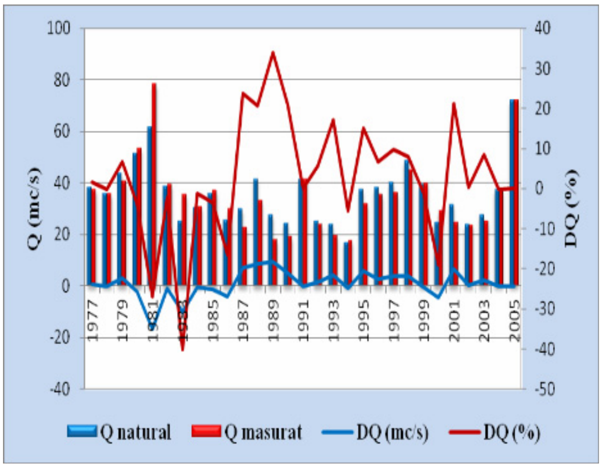


Figure no. 4 (Left) The degree of damage of the average annual flow at the hydrometric station Căteasca on the Arges River (1977-2005), Figure no.5 (right) Variation of average annual flow measured and natural at the hydrometric station Căteasca on the Arges River (1977-2005).

The affectation degree of the global annual mean drainage at the hydrometric station Căteasca the Arges river, shows that, during the lowest K coefficient values years, the water consumption of usages were the highest and the years in which was considered necessary the reconstitution correction, ie 1987, 1988, 1989, 1990, 2001 (figure no. 4). For example, in 1987, the K coefficient has a value of 76.34%, which is the proportion of measured flow from the reconstituted natural flow. The weight of the reconstitution correction was 23.65% requiring that the reconstitution operations of the natural flow regime to be strictly necessary (figure no. 5). These values show that, in 1987, the modifier factors have expressed their influence over the medium drainage area, in the hydrometric station Căteasca section. Moreover, the observed and reconstructed medium flows were below average annual values, fact that indicates a higher degree of affectation of the medium drainage due to water consumption by facilities.

- *change in landscape* by building engineering works (appearance of a new habitat), plus: lakes at low levels, margin with no vegetation, dry river beds downstream of dams, poorly fit final constructions (concrete construction , walls without vegetation, unclean designed and built roads), temporary buildings (quarries and gravel pits, technological and social site organization platforms) abandoned without adequate facilities (Stefann I., 2001)

- *land occupancy* for engineering works it is required the change of the initial use of land by suspending them of their agrarian or sylvan circuit.
- *change in the aquatic flora and fauna* by the very appearance of storage lakes requiring species to adapt to the new habitat conditions, as well through different faulty operations on hydraulic washings of the accumulations (eg, washing Valsan Lake in 1984 resulted in low water processes siltation in the downstream, endangering endemic fish species, namely aspretele (Romanichtys valsanicola).

Opportunities:

- *hydroenergetic potential* of the Arges hydrographic basin is significant, as demonstrated by the wealth of existing surface waters (theoretical resources in 2007, according to the Arges-Vedea Basinal Management Plan were 1960 million cubic meters / year, while the expendable resources according to assurance grade of the hydrographic basin reached 1671.654 million cubic meters / year).
- *tourism, leisure and water sports activities* are appropriate for the Arges hydrographic basin, favored also by the potential of the fluvial systems specific to the site, activities which obviously generate jobs.
- *fishing sport and fisheries* are also encouraged by the potential of surface water resources, being important the design of an organized system, such as Oieşti trout farm (supplied with water from the storage lake Oieşti) and Brătioara trout farm.
- *The emergence of new cities, new occupations and professions, infrastructure, electrical networks, hospitals, schools etc* due to the emergence of potential new engineering works, which will increase the quality of life.
- *increase in the land quality* can be achieved by changing their hydric system with the help of some drainage systems through which to remove excess moisture, irrigation, development of land for recreation (with very high value).

Threats:

- *eutrophication* is the result of water quality deterioration, namely the physico-chemical, biological and bacteriological characteristics expressed through temperature, turbidity, oxygen concentration, digestion, taste, smell, with the consequences: clogged filters for the treatment plants with organic solids in suspension, affecting recreational activities (odor, cloudy water), damage to fishing potential, etc.
- *silting of the storage lakes* leads to affection of dams utility by reducing the accumulation of useful volumes. According to the specialty literature (Rădoane Maria, Rădoane N., 2003, and Teodor S., 1999), on the Arges River to a total of 13 reservoirs, the silted volume ranges between 10.3% at Budeasa and and 100% at Ogrezeni. In the next period, if hydraulic washing measures are not taken, it is evident that silting lakes will increase, and they will lose their functions for which they were built; *silting of the downstream riverbeds* (between the dam and the first emissary) without fluid flow (derived through adductions) carry the risks of outfall fan that no longer wash appearance, appearance of vegetation in the minor riverbed, reduced transport capacity of liquid flow waters, with the possibility of flooding.
- *dam break risk* is due to earthquakes, landslides, seepage, wear of construction materials, explosions, non-compliant exploitation system, hydromechanical equipment wear, etc.. Dam break probability is reduced as maintenance, repair and surveillance is operating according to regulations. According to the Basinal flood protection plan (2011), the most negative scenario is the one on breaking the Vidraru dam, the emergency flow beng of approximately 500 million cubic meters, the consequence consisting in the dams downstream damage and flooding of some large areas.
- *Damage of areas of communitary importance (Sites of Communitary Interest - SCI and special avifaunistic protection areas SPA)* occurs when the interest of these protected areas is applied with mismanagement sometimes with irreversible implications on ecosystems (eg hydraulic washings of accumulations that generates downstream siltation, endangering species and their habitats).
- *change in bed morphology* occurs either through agraduation processes (sediment accumulation in upstream, at the lake bottom), or by degradation processes (downstream, due to the alluviations)
- *change in flora and fauna* is reflected by the emergence of new habitats due to lake level changes affecting flora development, migration and reproduction ichthyofauna
- *risk of landslides* due to changes in the lacustrine level, flooding of sensitive softening layers, base versants erosion or excavation works without support works, revetment or drainage and induced seismicity and production of explosions during construction of the engineering works (Ştefan, I. 2001).
- *Damage of archaeological, historical and cultural sites, of the possibility of exploitation of natural resources* may be threats of the engineering works at the stage of their execution, in the absence of archaeological, historical, cultural and natural existing potential research, completed and anticipated

- *Reduction in the area of agricultural or sylvan land* due to engineering works construction, and which involves expropriation of land for different categories of use, in this context, the clearing of land may favore occurrence of floods.

CONCLUSIONS

The significant potential for surface water resources, as well the high requirements for multiple uses from the Arges river hydrographic basin, lead to one of the most landscaped basins of Romania, as evidenced by the multitude of existing engineering works therein. According to the SWOT method of analysis there have been identified positive and negative effects of the hydrotechnical facilities, opportunities and risks associated with them. The positive effects are expressed by the following aspects: the production of clean electricity, providing water sources for usage, flood mitigation, natural water flow regulation, regulation of river beds, fishery exploitation, recreational, etc.. The negative effects manifest themselves by altering the natural flow regimes, changing bed morphology, water quality, aquatic flora and fauna, etc.. These effects generate positive or negative significant changes on surface water resources, the most important being clearly the positive effects for society, and at the same time, altering the balance of the fluvial systems, which is why it is urgently necessary the addoption of water management strategies, so that the concept of sustainable development be respected.

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