STUDIA UBB GEOGRAPHIA, LIX, 2, 2014, pp. 87 - 98
(RECOMMENDED CITATION)

RELEVANT HYDROLOGY ELEMENTS IN TERMS OF REGIONAL GEOGRAPHY ANALYSIS. CASE STUDY: THE LAND OF HAŢEG

G. HOGNOGI[1], ROXANA VĂIDEAN[1]

ABSTRACT. – Relevant Hydrology Elements in Terms of Regional Geography Analysis. Case Study: the Land of Haţeg. By the diversity of the territorial system components that need to be analyzed, a regional geography study requires a continuous approach of the specific character of these components, which is also valid for the hydrological component. First, it is necessary to highlight the role of potamology, limnology and hydrogeology features in the evolution of the region, as related to three temporal levels (past, present and perspective). The change of population's notion of the extreme hydrological events by specific and/or general analyses of the changes occurred in the territory (hydrotehnical facilities, impoundment and drainage works). The graphical representation of the analyzed elements and phenomena, which varies in terms of scale and necessity, comes as a supplement and enforcement of the above statements.

Keywords: *region, potamology, limnology, hydrogeology, extreme hydrological events, water mills.*

1. INTRODUCTION

The Regional Geography study on the Land of Haţeg finds its purpose in the context of the existence of no less than 16 presented and/or published research works on the "land" type of regions in Romania and of other land use plans (at various levels), coordinated by professor Pompei Cocean, Ph.D. The former are mostly analyses of the existing state resulting from the evolution over time, without elaborating the evolution perspectives, which is not the case for the land use plans where the proposal part represents half of the materials. Both types of researches look for the specific elements of the territory supporting its development. The hydrology elements analysis perspectives vary depending on the author, but the potamology, limnology and hydrogeology features must be highlighted in temporal context (past, present and future), focusing on the extreme hydrological events and the quality of water resources.

[1] *PhD Students, Babeş-Bolyai University, Faculty of Geography, Cluj-Napoca, Romania, e-mails: gheorghehognogi@yahoo.com, roxana_vaidean@yahoo.com*

In order to improve the applicability of a research, the spatial representation (by GIS methods) of the quantitative and qualitative values characterizing these elements is more than necessary. The evolution of software facilitates the highly esthetical mapping of a wide range of geographic information (raster and vector spatial data, graphs, images, etc.), meant to support these statements and to improve understanding of these phenomena in other fields (i.e. administration). A high quality graphical material can be a way to summarize the information (even in the absence of a detailed data base), while the unfortunate or incomplete representation of some processes and phenomena does nothing more but helps the achievement of the quantitative standards, lacking a real scientific value. A frequent example in the regional Geography works is the flash flood graphic, together with the generating values (sometimes even of the levels), without any representation (map, elevation, image, etc.) of the section where it was measured. It is thus left to the reader to "imagine" the implications of the graphically represented value.

The values of the Land of Hațeg were considered particularly interesting by specialists in various fields. However, three authors are worth mentioning in terms of their approach of the hydrology elements: Vuia (1926), Popa (1999) and Margin Felicia (2011). The most recently published work is the only hydrological monograph of the Strei river basin, while the first two are models used to identify the interconnections established between the components of the territorial system.

2. MATERIALS AND METHODS

In order to highlight the temporal evolution, regardless of the area, the availability of cartographic resources is ideal, together with those of other nature (written, photographs and others). Starting from the assumption that cartographic resources are, especially for geographers, more than relevant, our purpose is to cartographically represent the researched phenomena and processes as completely as possible.

The oldest cartographic resources on the Land of Hațeg date back since the 18th century (the first land survey performed during the Hapsburg monarchy 1769-1773). In the 19th century there are the other two Hapsburg land surveys[2], while in the 20th century there are the Master Plans (1:20,000), the Soviet maps (1:50,000) and the topographic maps (1:25,000, 1:5,000). The relation to the present time is established based on the ortophotoplans (2005 and more recent).

All these cartographic resources have contributed, along with the field campaigns and study of other types of reference resources, to the final material, whose graphical part was performed by means of the Arc Gis10.1, Corel Draw X7 and Microsoft Office Excel 2013 programs.

[2] *http://mapire.eu/en/map/collection/firstsurvey/?zoom=5&lat=47.89035&lon=14.76556*

3. RESULTS

3.1. Assessment of the Land of Hațeg water resources

The assessment of hydrological resources is the subject of extensive hydrology papers and especially in the case of a regional Geography research, it must capture the constant (in historic time, at least) of the water resource. In the selected research area, this is determined by the geological evolution in the given paleoclimate context and by the present result, the relief.

Located mainly in the middle (without the Șes River upstream of Corciova rivulet) and upper (without the sector upstream of Pravățului Valley) Strei basin, the Land of Hațeg has a dense hydrographical network (0.91 km/km^2). Beside the main collector, other significant water courses in terms of flow are the left-bank tributaries draining the Northern slope of the Retezat Mountains, the North-Eastern slope of the Țarcu Mountains and the South-Eastern slope of the Poiana Ruscă Mountains and mainly the Hațeg Depression: Râu Mare (with Sibișel, Râușor and Galbena), Râu Bărbat, and Râu Alb. The right-bank tributaries do not have large flows, but they do have impressive endo and exokarst formations generated in Jurassic limestones (caves, polje).

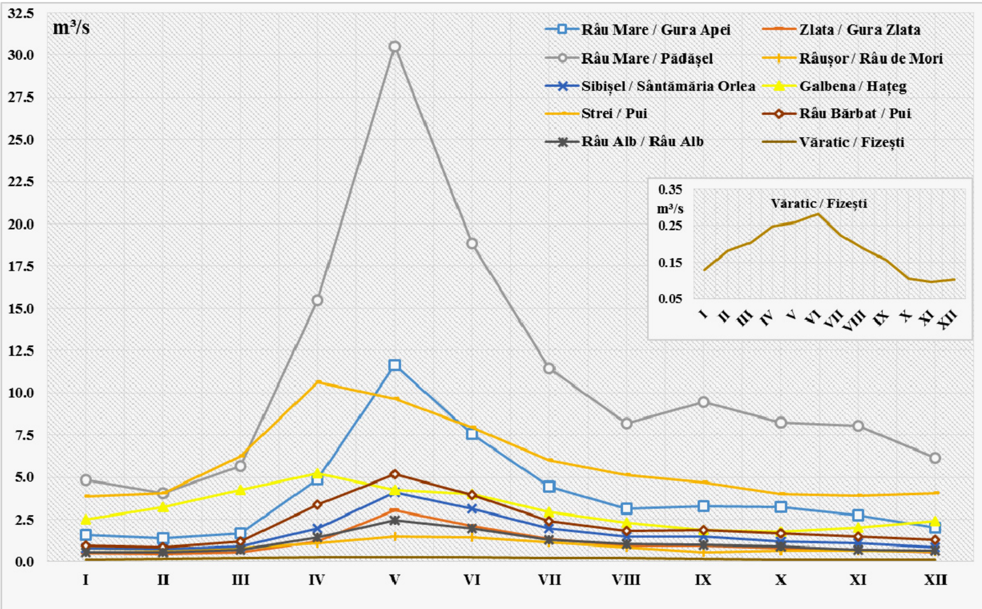


Fig. 1. The monthly average evolution of runoff in the middle and upper basin of the Strei River

The evolution of runoff has three types of regimes. One is specific to the rivers that drain the high Southern mountain area (Retezat, Godeanu and Țarcu Mountains) and presents two maxima and two minima. The main maximum is recorded in May (due to snow melting), and the secondary maximum is in October. The main minimum is recorded during winter, when rainfalls are stored at heights in solid form, and the second in August-September, when low rainfalls correlate with high evaporation and evapotranspiration (Fig.1). Until its confluence with Râu Bărbat and the right-bank tributary of the Râului Mare, Galbena, Strei River fits the second type of regime which presents a maximum in April, when snow is melting in the low mountains (Șureanu and Poiana Ruscă). In case of the Galbena River, one can notice an increase of flow also in June (which indicates the torrential character). Low runoff values are recorded during the autumn and at the beginning of winter (the minimum value in October – Galbena and January – Strei). One notices the low amplitude of runoff in case of the Strei River, mainly supported also by the retention of a significant volume of water in the existing endokarst formations. The hydrometric station on the Văratic is representative for the small rivers, where the maximum is given by the torrential rainfalls during the summer, while the minimum in November is caused by their absence in anticyclonic regime. The seasonal situation of runoff is represented in Figure 2, which is the reason we do not consider necessary to present it in more details.

In all hydrometric stations, spring is the season with the maximum runoff (Fig. 2). The situation is different when it comes to the minimum runoff, where there are differentiations depending on the water supply regime. This is the case with Galbena and Văratic Rivers, where autumn is the season with a minimum runoff value, not winter as in case of rivers supplied from the high mountain area. Moreover, in the first case, winter is the season with the second recorded runoff value. The reason for this is nothing else but the frequent melting of snow, the frequency of liquid or mixed rainfalls in the context of a much lower average altitude as compared to the other significant rivers in the Land of Hațeg and an alleged action of foehn. Strei River is in an intermediate position, with two seasons (autumn and winter), with close minimum values.

Having an ephemeral existence in terms of geologic time, lakes are well represented in the research area, by the 87 glacial lakes (79 in Retezat Mountains, 5 in Godeanu and 3 in Țarcu Mountains)[3]. Their presence was, among others, the reason for founding the first national park in Romania (Retezat Mountains National Park), some of these holding national records regarding various parameters (Bucura – area, Zănoaga – depth). Peșteana swamp is also included in the category of lakes. This swamp was originally a lake whose siltation process was accelerated by the anthropogenic factor by drainage and abundantly populated with a glacial relict (Drosera rotundifolia), which led to its declaration as a botanical reserve.

The spring of 1986 (Pop, 1996) represented a decisive moment in the typological diversification of lakes in the Land of Hațeg, by the development of the Gura Apelor Lake hydropower facility at the confluence of Lăpușnicul Mare and Râu Șes. Subsequently, other 3 reservoirs were developed on the Râul Mare, in the depression area (Ostrovul Mic, Păclișa and Hațeg). The latest presence in the lymnological landscape of the Hațeg area is the Sântămăria Orlea reservoir on the Strei River, where other "[...] 4 such reservoirs were planned" (Popa, 1999, fig. 14).

[3] *http://retezat.ro/*

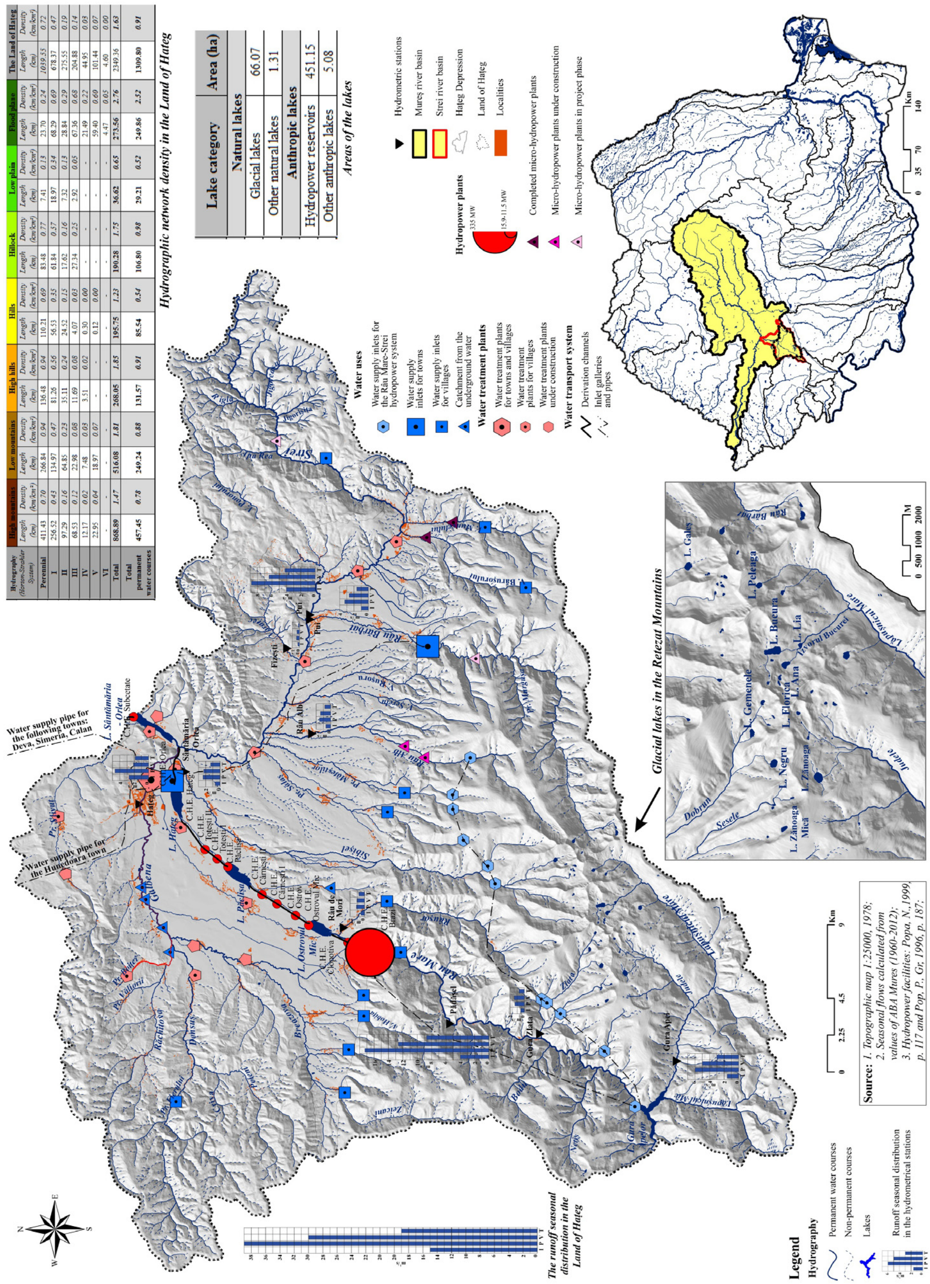


Fig. 2. The potamology and limnology features of the Land of Haţeg

The hydrogeological resources are quantitatively and qualitatively good, with no less than 7 groundwater bodies within the limits of the research area, some of these are included completely in this territory (Haţeg and Răchitova Depressions), others are mainly located in this area (Picuiu, Zeicani and Ohaba Ponor) or with less than 50% (Godeanu and Mureş corridor). The anthropogenic pressure has moderate to low values, the water bodies in the Haţeg Depression and Mureş Valley are the only ones with various ways of water use and with significant polluters (Fig. 3).

3.2. The role of hydrological elements in individualization of the Land of Haţeg

"A basic condition for the society to exist, as the main support of life, of hygiene and health" (Popa, 1999), water must have played one of the main roles in the occurrence and development of the habitats in this space where age and consistency of habitation represent one of the specificity elements. The result of the water action in a calcareous petrography context, the caves in the North-East of the Land of Haţeg: Cioclovina – Peştera Uscată (outside the borders of the region, Boşorod commune), Bordu Mare, Peştera de pe Scoruş, Ponor, Piatra Poienii developed as human habitats, starting with the middle Paleolithic, the many archaeological discoveries being proof in this regard[4].

In the context of the proximity of the religious and political – military centre in the Şureanu Mountains (1st century B.C. – 2nd century), we are entitled to imagine the importance of this depression area of Haţeg and the surrounding mountains, most probably together with the Mureş corridor in supporting the capital (agricultural products, soldiers, etc.) which offered peace at the same time. Exercising our imagination, "although one cannot imagine all" (Vulpe, 2012[5]), we could see permanent localities in the depression area whose inhabitants value the qualitatively superior lands, but also the proximity of the water courses.

The conquest of Dacia in 106 A.D. and the founding of the capital in the South-West of the depression requires significant amounts of water both for the capital and for the numerous "[...] pagus, vicus and villae rusticae of some landlords" (Tudor, 1968 cited by Popa, 1999), focused on agriculture. Since the times of Roman domination, we suspect the existence of Pârâul de Câmp and Odoraşniţa (Conea 1940, cited by Popa, 1999), branches of the Râului Mare within the piedmont plain. Together with supplementing the water necessary for agriculture, these two works have played a significant role in the drainage of the vast areas affected by sloughing and in taking over some flows, under flash floods circumstances, from the main course. Moreover, an aqueduct was identified on the present route of Odoraşniţa, which was presumed to supply the new capital from the Râul Mare, which was possible given the Romans' high water needs. In addition, the flow of the Hobiţa would not have been enough for 20 – 25,000 inhabitants, the water

[4] *http://map.cimec.ro*

[5] *http://www.historia.ro/exclusiv_web/general/articol/sintagma-stramosii-nostri-daci-ar-trebui-discutata*

inlet must have been located in the mountain area to meet the level difference necessary for the free fall of water, and the number of the catchments must have been large, as each vicus or villa rustica benefited of this facility.

The first data related to the use of the hydrographic resources in the medieval period (271 – 1600) occur late, in the 16th century, in various donation documents of the kings of Hungary to the knyazes in the Land of Haţeg. The objects of these donations were among others "[…] meadows, […], underwoods, thornbush areas, hills, valleys, […], ponds, fishing places and mills, as well as places for mills, etc." (Lazăr and Tămaş, 2003). Even if the rural technique facilities occurred only later, the use of ichthyofauna, under natural or built conditions, cannot be denied. The "iron fishing hooks from Sarmizegetusa Regia" are proof in this regard (Glodariu and Iaroslavschi, 1979 cited by Bara et al., 2012).

In the modern age (1600 – 1821), the number of information on the hydrographic resources management increases, with the occurrence of the first unitary cartographic sources (the Josephine topographic survey – 1769 – 1773), which provides a clear image of the spatial distribution of the surface waters, fountains as an alternative of using groundwater as well as of the land use. It is possible to perform a spatial analysis of wetlands distribution, of the inhabited area/water course ratio, location of traditional industry facilities using water energy and so on. Along with this cartographic database we get much other written information which offers us an improved overview of the evolution of the manner man relates to water resources. The damages incurred to the access infrastructure by the hydrographic network stand out "[…] the bridge over the Strei River at Simeria Veche, which is often broken by the river strong current" (Bara et al., 2012, IV) or the damages to the agricultural yield: "The year 1771 was a poor year in terms of agriculture due to floods and hail" (Bara et al., 2012, IV); "the prolonged drought during 1813-1818 and the heavy rainfalls in short intervals have affected the cereal crops and have caused marked imbalances", which represents a real problem in the maintenance of the communication routes (Bara et al., 2012, IV).

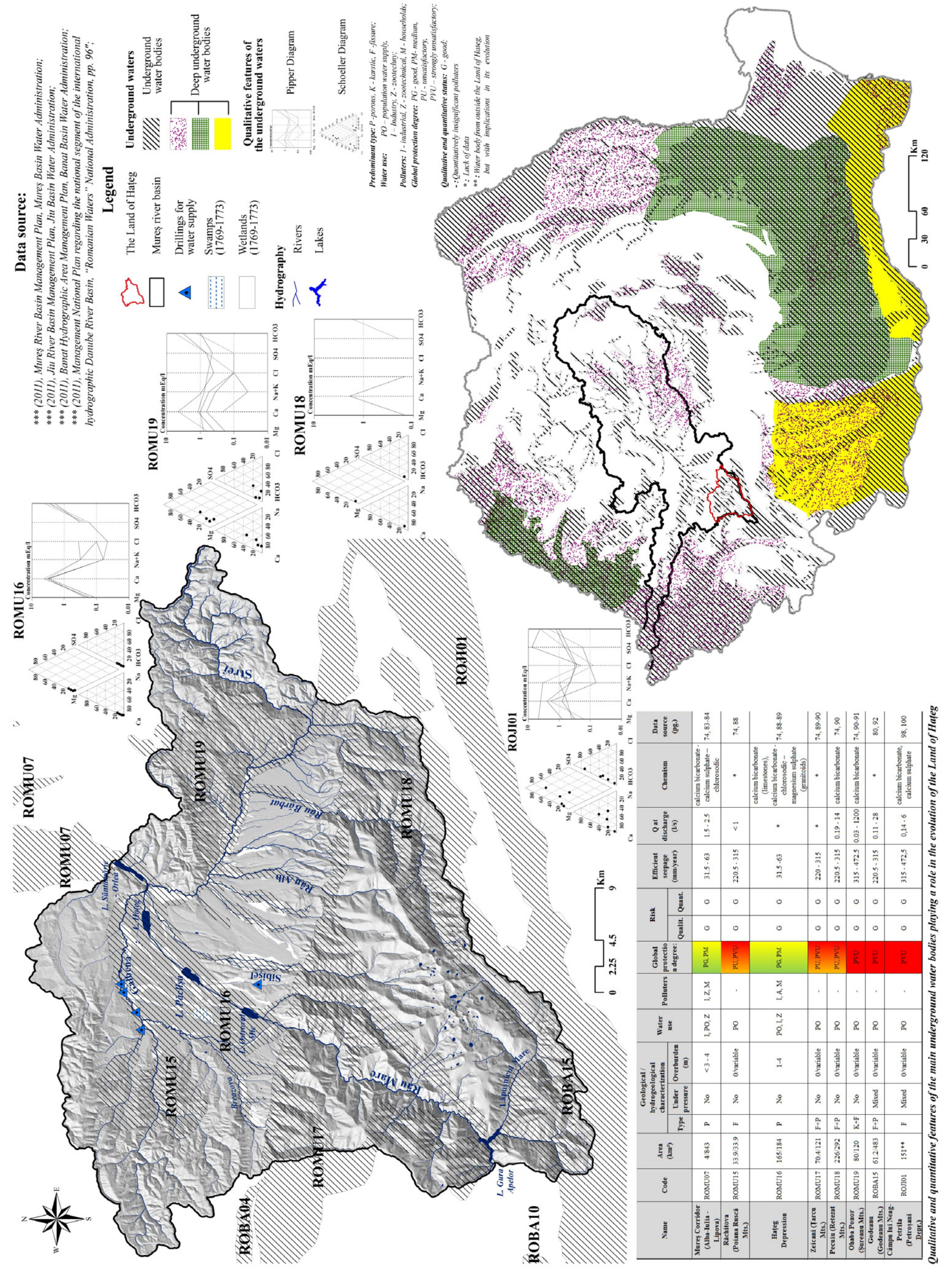
Regarding the use of river energy, we found that in 1785, on the Hobiţa, Sibişel and Paroş rivers, belonging to the localities Hobiţa (Sarmizegetusa), Nucşoara and Paroş, there were operating "saw mills" (Bara et al., 2012, IV) for wood processing. In a free or planned manner, the rivers were also used for timber rafting. These woods were intended for the production of charcoal used in the ore-based iron production facilities on the territory of Hunedoara domain. "[...] [private companies with heaps were mentioned in various locations, in our case in Petros" (Bara et al., 2012, IV). Also in the modern age there are mentioned, together with the "river species (several types of Salmonidae) and trout in the glacial lakes in Retezat used for fishing" (Benko, 1778 cited by Bara et al., 2012, IV). One of the environmental protection measures used by the authorities at that time might be considered the order of Transylvanian Governorate in August 28, 1767, which "[...] strictly prohibited under harsh punishment, the melting of hemp and flax directly into the river and lake waters in the Princedom"; to avoid the destruction of aquatic fauna, the inhabitants had to dig special holes near water courses (Benko, 1778 cited by Bara et al., 2012, IV).

The contemporary period (1821 – present time) brings the most important changes in the management of the hydrological potential of the Land of Haţeg, whose evolution can be traced in the cartographic, photographic, written resources and/or the local memory, which makes it possible to faithfully restore the territorial system at each component level. Three types of attitudes can be distinguished in terms of the water resources management: before 1947, between 1947 – 1990, and after 1990. Until 1947, there is an increase of community attention on the aquatic resource, which is why we find cases where "[...] local communities rent the fishing rights on a given period of time to supplement incomes" (Bara et al., 2012, IV). Starting with the second half of the 19^{th} century, "the intensive fishing practices (use of dynamite and natural poisons), expansion of poaching, numerous traditional industry facilities" (Bara et al., 2012, IV) and timber rafting (this is widespread also on Râul Mare after 1850) drastically reduce the diversity and amount of the ichthyofauna.

The inhabitants of the villages in Haţeg begin to be aware of the hydrological risk events, due to the magnitude and frequency of these events. Relevant examples in this direction could be the objection of the representatives of the communes General Berthelot, submitted to the state representative in 1919 concerning the prices of lands on the banks of the Galbena River "[...] the rent for the 15 yokes on the river bank is too high, because it is exposed to floods" (Bara et al., 2012, IV) or the statements of the inhabitants of Clopotiva, which confirm the frequency and damages caused by the flash floods on the Râu Mare: "When the high mountains (Retezat, Godeanu, Ţarcu) roar, heavy rain comes and Râu Mare overflows. One year, there came a large flood that filled the corn fields with dead fish and mud. One summer, it flooded the field and the hemp; it causes much damage when it overflows" (Conea, 2010). In the same paper, referring to the quality of soils, one resident mentions the occurrence of extreme hydrological events: "[...] it is sandy soil, brought by the flood". The local memory mentions flash floods causing material damages "Sălaş River […] is almost dry during the summer, and in spring […] it carries everything in its way […] It breaks all bridges and carries them away, as if they had never been there" (Pocanschi, 1967), sometimes also human victims (Strei Valley, Muncel).

Between 1957 – 1990, the hydrographic elements underwent the most significant changes. The large hydrotechnical works on Strei River or its tributaries, especially on Râul Mare but also on upstream tributaries stand out. Generally speaking, this system is composed of 4 reservoirs on the Râul Mare and one on the Strei river, a pipe taking over a part of the water flow of rivers on the Northern slope of the Retezat Mountains to supplement the volume of Gura Apelor Lake, 11 hydropower plants with a total power of 495.5 MW[6], water inlets to supply rural and/or urban localities and many pipes and channels. The implications of these reservoirs are diverse, from flood risk reduction, especially on the Râul Mare (however, events like that from July 11, 1999 is difficult, if not impossible to avoid). A significant anthropogenic intervention was represented by "[...] the drainage works affecting the Western compartment of the depression and the Valea Lupului – Valea Verde interfluve between 1970-1985" (Popa, 1999), increasing the production potential of these lands (Fig. 3).

[6] *http://www.hidroelectrica.ro/Details.aspx?page=38*



Name	Code	Area (km²)	Geological / hydrogeological characterization			Water use	Polluters	Global protection degree:	Risk		Efficient seepage (mm/year)	Q at discharge (l/s)	Chemism	Data source (pg.)
			Type	Under pressure	Overburden (m)				Qualit.	Quant.				
Mureș Corridor (Alba-Iulia - Lipova)	ROMU07	4/843	P	No	< 3 - 4	I, PO, Z	I, Z, M	PG, PM	G	G	31.5 - 63	1.5 - 2.5	calcium bicarbonate - calcium sulphate – chlorosodic	74, 83-84
Răchitova (Poiana Ruscă Mts.)	ROMU15	33.9/33.9	F	No	0/variable	PO	-	PU, PVU	G	G	220.5 - 315	< 1	*	74, 88
Hațeg Depression	ROMU16	165/184	P	No	1-4	PO, I, Z	I, A, M	PG, PM	G	G	31.5 -63	*	calcium bicarbonate (limestones), calcium bicarbonate - chlorosodic – magnesium sulphate (granitoids)	74, 88-89
Zeicani (Țarcu Mts.)	ROMU17	70.4/121	F+P	No	0/variable	PO	-	PU, PVU	G	G	220 - 315	*	*	74, 89-90
Pecuiu (Retezat Mts.)	ROMU18	226/292	F+P	No	0/variable	PO	-	PU, PVU	G	G	220.5 - 315	0.19 - 14	calcium bicarbonate	74, 90
Ohaba Ponor (Șureanu Mts.)	ROMU19	80/120	K+F	No	0/variable	PO	-	PVU	G	G	315 - 472.5	0.03 - 1200	calcium bicarbonate	74, 90-91
Godeanu (Godeanu Mts.)	ROBA15	61.2/483	F+P	Mixed	0/variable	PO	-	PVU	G	G	220.5 - 315	0.11 - 28	*	80, 92
Câmpu lui Neag-Petrila (Petroșani Depr.)	ROJI01	151**	F	Mixed	0/variable	PO	-	PVU	G	G	315 - 472,5	0,14 - 6	calcium bicarbonate, calcium sulphate	98, 100

Qualitative and quantitative features of the main underground water bodies playing a role in the evolution of the Land of Hațeg

Fig. 3. The hydrogeological features of the Land of Hațeg

The pressure on the underground water becomes higher as agricultural activities require significant water volumes, while they become representative polluters in the surrounding areas. Starting with 1953, an important polluter occurs on the Boița valley, the pyrite mine. Even if the activity is ceased, this site continues to damage the quality of the Galbena River, as the treatment plant cannot cope with the concentration or the flow. As an example of the water quality importance in the life of the communities, we mention "water hardness and the lack of iodine and fluorine as causes of endemic thyreopathic dystrophy – endemic goitre – in the Paroș and Peștera villages until the first half of the 20th century. This time, the cause was a natural one, the presence of limestones at the contact of the depression with the Retezat Mountains.

After 1990, the polluting activities (mining exploitations, intensive agricultural activities and other industrial activities) reduce significantly. Local administrations access funds for the development of mostly local water supply systems (one or more villages), whose sources are represented by the nearby rivers or underground water bodies (communes Răchitova and General Berthelot). In this context, the sewage systems, frequently unfinished, become polluters of the surface hydrographic network.

The idea of building micro-hydropower plants is very current and full of perspectives, not favorable to the environment, communities or the state, but beneficial only to the project owners. Bărușor and Alb Rivers are already affected by such facilities, while Râu Bărbat and Strei River are about to meet the impact of such criminal ideas.

4. CONCLUSIONS

The Land of Hațeg holds a significant quantitative and qualitative hydrologic potential, which facilitated its continuous habitation since Paleolithic. It was considered more appropriate that this potential was better highlighted graphically than in writing, as the second option was used to accentuate the manner in which the hydrological elements have contributed over time to the individualization of the territorial system.

The settlements system could not be built without the existence of a transport network during the modern period, which became widespread mostly along the valleys. The "plotting" of the access routes along the main valleys represents nothing else but the overlapping of the anthropogenic axes with the already existing natural ones. Two main axes are thus highlighted: one from the East (on the Strei Valley) and another one from the West (on the Breazova Valley and the high piedmont plain), which combine in the North, where the main collector leaves the depression. These two main axes sent in all directions secondary axes which often enter the mountain area, with direct implications in the systemic cooperation between the depression and the mountain areas. The evolution may also be represented graphically, but mostly by case studies and only if cartographic resources are available (in our case barely from 1769 – 1773), otherwise only geologic studies on the river bed deposits, the archaeological evidences, the written information help us imagine the overall state over a longer period of time (several centuries).

Each of the three hydrologic elements categories, by certain features, improves the specificity degree of the Land of Haţeg, as follows:

- potamology: the rivers supplied from the Southern high mountain area generated, by their large flow, fluvial relief forms highlighted in the landscape (granite fields), chosen to be the location for the inhabited areas of the settlements;
- limnology: the inheritance left by the Quaternary mountain glaciers to the mountain areas, consisting in 87 glacial lakes and the Râu Mare – Strei hydropower system, by its technical features and the impact on the territory;
- hydrogeology: the Ohaba Ponor water body has carved in the Jurassic deposits a complex karst system which developed into a human habitat ever since the Paleolithic.

Acknowledgement

This paper was financially supported by the project entitled "Doctoral and post-doctoral excellence programs for the training of highly qualified human resources in the research fields of Life, Environmental and Earth Sciences", POSDRU/159/1.5/S/133391, funded by the European Social Found and Romanian Government.

R E F E R E N C E S

1. Bara I.S., Toma, D., Lazăr I., coord (2012), *Judeţul Hunedoara, Monografie*, II, Editura Emia, Deva.
2. Bara I.S., Balasz, Marcela, Dobrei, F., Ioanaş, V., Lazăr I., Lazăr, L., Popa, Paulina, Toma, Denisa, coord. (2012), *Judeţul Hunedoara, Monografie*, IV, Editura Emia, Deva.
3. Conea I. (2010), *Clopotiva, un sat din Haţeg*, Ediţia a II-a, Editura Academiei Române, Bucureşti.
4. Lazăr, I., Tămaş I.P. (2003), *Monografia comunei Baru Mare*, Editura Emia, Deva.
5. Margin, Felicia (2011), *Bazinul hidrografic al Streiului. Monografie hidrologică*, Timişoara.
6. Pocanschi N., (1967), *Sălaşul de Sus – aşezare străveche românească*, manuscris.
7. Pop, P.G. (1996), *România. Geografie hidroenergetică*, Editura Presa Universitară Clujeană, Cluj-Napoca.
8. Popa, N. (1999), *Ţara Haţegului. Potenţialul de dezvoltare al aşezărilor omeneşti. Studiu de geografie rurală*, Editura Brumar, Timişoara.
9. Vuia, R. (1926), *Ţara Haţegului şi Regiunea Pădurenilor*, Editura Institutul de Arte Grafice „Ardealul", Cluj-Napoca.
10. *http://map.cimec.ro, 2.VIII.2014.*
11. *http://www.historia.ro/exclusiv_web/general/articol/sintagma-stramosii-nostri-daci-ar-trebui-discutata, 2.VIII.2014.*

12. *http://mapire.eu/en/, 1.VIII.2014.*
13. *http://www.hidroelectrica.ro/Details.aspx?page=38, 4.VIII.2014*.
14. *http://retezat.ro/, 4.VIII.2014.*