THE CONFLUENCE RATIO OF THE TRANSYLVANIAN BASIN RIVERS

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ABSTRACT. The confluence ratio of the Transylvanian Basin rivers. There are many possibilities to assess the hydrological and geomorphological evolution of a territory. Among them, one remarks the confluence ratio of the rivers belonging to different catchment areas. The values of this indicator may provide information regarding the stage of evolution of the fluvial landforms in the Transylvanian Basin. Also, the values may serve for the calculation of other parameters of catchment areas like: the degree of finishing of the drainage basin for its corresponding order, the density of river segments within a catchment area etc. To calculate the confluence ratio, 35 catchment areas of different orders have been selected. The confluence ratio varies between 3.04 and 6.07. The large range of values demonstrates the existence of a heterogeneous lithology and of morphological and hydrographical contrasts from one catchment area to the other. The existence of values above 5, correlated also with observations in the field, reveals an accelerated dynamics of the geomorphological processes in those catchment areas. This dynamic is mainly supported by the high landform fragmentation due to the first order rivers. In contrast, the catchment areas that have a confluence ratio below 5 are in a more advanced stage of evolution with stable slopes, unable to initiate new first order river segments.

Keywords: confluence ratio, drainage network, stream order.

1. INTRODUCTION

Within the Transylvanian Basin, one remarks the presence of a diverse fluvial morphology, as a result of the geomorphological evolution from the moment of its emergence until now. Even if other landforms conditioned by structure and lithology are found in the landscape, the morphology of the Transylvanian Basin is mainly the consequence of the activity of fluvial systems.

As a result of the process of deepening, to adapt to new base levels, they created specific landforms. Precisely for this reason, in this paper, the issue of geomorphological and hydrological evolution is approached starting from the existing situation at the level of catchment areas.

In this context, according to the values of the confluence ratio, stress will be laid on the effects of rather different values from one catchment area to another.

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2. METHODOLOGY

The assessment of the confluence ratio within a catchment area is based on the law of the number of streams in Horton-Strahler system.

Having a genetic basis, this law allows the execution of comparative studies, the statistical processing of data by value classes, as well as quantitative assessments of the stages of dynamic balance (Grecu and Palmentola, 2003).

As a result of the representation of data series values in semilogarithmic coordinates, Horton (1945, p. 291, quoted by Zăvoianu, 1978, p. 36) infers the law stating that *"the number of different order rivers in a given basin converges towards an inverted geometric progression, in which the first term is the unit, and the ratio is the bifurcation ratio"*.

$$R_b = \frac{N_u}{N_u + 1}$$

where: R_b – the bifurcation ratio; u – the order of the segment; N_u – the number of segments belonging to a certain order.

As a result of the analyses made on the drainage network of different basins, but mostly in Ialomiţa basin, and in order to use the confluence ratio instead of the bifurcation ratio (a stream of a certain order is formed after the confluence of two streams and not after their bifurcation), Zăvoianu (1978, p. 40) proposed the removal of the idiom "the first term is the unit" from Horton's law, which led to the reformulation of the law of the number of streams as following: *"the number of river segments belonging to consecutive orders in a given basin converges towards an inverted geometric progression, in which the first term (N_1) is given by the number of first order streams, while the ratio is the confluence ratio (R_c)"*.

The difference between the two laws is that "the first term" is not the unit, as in Horton's law, but the number of first order streams (Ichim et al. 1989).

The confluence ratio is computed as follows:

$$R_c = \frac{N_x}{N_x + 1}$$

where: R_c – the confluence ratio; N_x – the number of segments of x order;

One may determine the confluence ratio for every pair of segments:

$$R_{c_1} = \frac{N_1}{N_2}; \qquad R_{c_2} = \frac{N_2}{N_3}; \qquad R_{c_n} = \frac{N_n}{N_{n+1}}$$

where: R_{c_1} – the confluence ratio between the first and second order river segments; N_1 – the number of first order segments; N_2 – the number of second order segments.

In this case, the confluence ratio represent the arithmetic mean of the individual ratios:

$$R_c = \frac{R_{c_1} + R_{c_2} + R_{c_n}}{n}$$ where: n – the order of the stream.

The knowledge of the number of first and second order segments and of the confluence ratio provides the opportunity to compute the number of streams belonging to any *x* order (Zăvoianu, 1978), which represents nothing else than the ratio between the number of streams belonging to an immediately lower order and the confluence ratio (R_c).

$$N_x = \frac{N_x - 1}{R_c}$$

where: N_x – the number of segments belonging to x order; $N_{x\ -1}$ – the number of streams belonging to an immediately lower order.

The total number of river segments (N) belonging to any (x) order is computed with the ratio:

$$N = \frac{N_\Omega \left(1 - R_c^\Omega\right)}{1 - R_c}$$

where: N – the total number of segments; N_Ω– the order of the main stream; Ω – the order of the network.

3. RESULTS AND DISCUSSIONS

In order to calculate the values of the confluence ratio specific for the drainage basins of the Transylvanian Basin, 35 such territorial units have been chosen (three of the sixth order, nineteen of the fifth order and thirteen of the fourth order): Hârtibaciu, Fizeş, Dipşa, Almaş, Luduş, Visa, Comlod, Nadăş, Luţu, Secaşul Mic, Saschiz, Meleş, Borşa, Pârâul Nou, Luna, Sălătruc, Balta, Cincu, Laslea, Poiana, Brâglez, Unirea, Valea Mare, Fărău, Cuşmed, Şimişna, Olpret, Sărata, Felmer, Goagiu, Racilor, Ticuş, Pănade, Paloş and Veţca (Table 1 and Fig. 1).

The calculation of the confluence ratio values supposed first the determination of the number of rivers for each order, a fact which allowed also the checking of the law of the number of streams. As a consequence of the representation of the values in semilogarithmic coordinates, the corresponding regression lines have been obtained (fig. 2 and 3). Their analysis shows that the number of successive order segments form an inverted geometric progression, in which the first term (N_1) is given by the number of first order streams, while the ratio is represented by the confluence ratio. This means that the law of the number of streams is verified in the Transylvanian Basin (Grecu, 1992, Sandu, 1998, Roşian, 2011).

Then, by applying the calculation formula of the confluence ratio, different values have been obtained according to the characteristics of each catchment area (Tables 1 and 2).

Table 1. The catchment area, the order, the number of segments and the confluence ratio

Catchment area	**Horton-Strahler Order**	**Number of segments**							**The confluence ratio**
			N_1	N_2	N_3	N_4	N_5	N_6	Average R_c
Hârtibaciu	6	m*	929	214	38	9	3	1	4.03
		c**	862	213.9	53.1	9.4	2.2	0.7	
Fizeş	6	m	520	121	34	10	3	1	3.51
		c	423	120.7	34.4	9.6	2.8	0.85	
Dipşa	6	m	357	89	18	4	2	1	3.49
		c	310.5	88.9	25.5	5.15	1.1	0.57	
Almaş	5	m	952	196	43	11	1		6.07
		c	1186	195.4	32.2	7.0	1.8		
Luduş	5	m	464	99	21	4	1		4.63
		c	456.6	98.6	21.3	4.5	0.8		
Visa	5	m	494	111	20	4	1		4.75
		c	525.7	110.6	23.3	4.21	0.8		
Comlod	5	m	359	87	23	4	1		4.41
		c	383.1	86.8	19.7	5.2	0.9		
Nadăş	5	m	241	70	19	4	1		3.95
		c	276.1	69.9	17.7	4.8	1.0		
Luţu	5	m	326	76	18	4	1		4.25
		c	321.5	75.6	17.8	4.2	0.9		
Secaşul Mic	5	m	224	49	14	3	1		3.93
		c	191.5	48.7	12.4	3.5	0.7		
Saschiz	5	m	186	46	10	2	1		3.91
		c	178.8	45.7	11.7	2.5	0.5		
Meleş	5	m	247	48	13	4	1		4.02
		c	192.3	47.8	11.9	3.2	0.9		
Borşa	5	m	229	57	12	3	1		3.94
		c	223.5	56.7	14.4	3.0	0.7		
Pârâu Nou	5	m	240	54	10	3	1		4.04
		c	217.0	53.7	13.3	2.47	0.7		
Luna	5	m	159	32	10	2	1		3.54
		c	112.7	31.8	9.0	2.8	0.5		
Sălătruc	5	m	146	41	9	2	1		3.65
		c	149.2	40.8	11.2	2.4	0.54		
Balta	5	m	92	22	6	2	1		3.21
		c	70.0	21.8	6.8	1.8	0.6		
Cincu	5	m	135	29	6	2	1		3.62
		c	104.8	28.9	8.0	1.6	0.5		
Laslea	5	m	150	32	9	3	1		3.55
		c	113.4	31.9	9.0	2.5	0.8		
Poiana	5	m	128	27	9	2	1		3.56
		c	95.0	26.7	7.5	2.5	0.5		
Brâglez	5	m	143	29	7	2	1		3.64

		c	104.6	28.7	7.9	1.9	0.5			
Unirea	5	m	73	21	5	2	1			3.04
		c	63.7	20.9	6.9	1.6	0.6			
Valea Mare	4	m	163	38	8	1				5.67
		c	215.3	37.9	6.7	1.4				
Calva	4	m	184	40	6	1				5.75
		c	228.1	39.6	6.9	1.0				
Fărău	4	m	80	17	3	1				4.45
		c	75.2	16.9	3.8	0.6				
Cuşmed	4	m	169	32	7	1				5.61
		c	179.3	31.9	5.7	1.2				
Şimişna	4	m	198	40	7	1				5.88
		c	235.1	39.9	6.8	1.1				
Olpret	4	m	137	34	4	1				5.50
		c	184.5	33.5	6.1	0.7				
Sărata	4	m	100	28	6	1				4.74
		c	132.5	27.9	5.9	1.2				
Felmer	4	m	116	35	7	1				5.10
		c	176.4	34.6	6.8	1.3				
Goagiu	4	m	81	18	4	1				4.33
		c	76.8	17.7	4.1	0.9				
Racilor	4	m	75	17	4	1				4.22
		c	71.2	16.8	4.0	0.9				
Ticuş	4	m	74	19	3	1				4.40
		c	83.2	18.9	4.3	0.6				
Pănade	4	m	33	10	3	1				3.21
		c	31.9	9.9	3.1	0.9				
Paloş	4	m	41	9	2	1				3.60
		c	32.4	9.0	2.5	0.5				
Veţca	4	m	111	23	6	1				4.88
		c	111.9	22.9	4.7	1.22				

*m – measured; **c – calculated.

The analysis of the confluence ratio (Table 1 and Fig. 1) shows a higher frequency of the values comprised between 3.00 and 3.99 specific for the catchment areas of Poiana, Sălătruc, Brâglez, Luna, Borşa, Nadăş, Sărata, Fizeş, Dipşa, Unirea, Pănade, Balta, Secaşul Mic, Laslea, Saschiz, Paloş, Cincu, followed by the category of values between 4.00 and 4.99 (Meleş, Luduş, Comlod, Luţu, Racilor, Fărău, Veţca, Goagiu, Visa, Hârtibaciu, Pârâu Nou, Ticuş), while values over 5.00 are found in the case of the catchment areas of Almaş, Şimişna, Olpret, Cuşmed, Valea Mare and Felmer. The higher values indicate an accelerated dynamics of the geomorphological processes in these latter catchment areas, mainly maintained by the high morphological fragmentation compared to the situation of those catchment areas where the R_c has values below 5. In the Transylvanian Plain, for example, in the case of R_c values below 4.63, one notices the existence of a more advanced stage of evolution, with relatively stable slopes from the point of view of slope processes modelling.

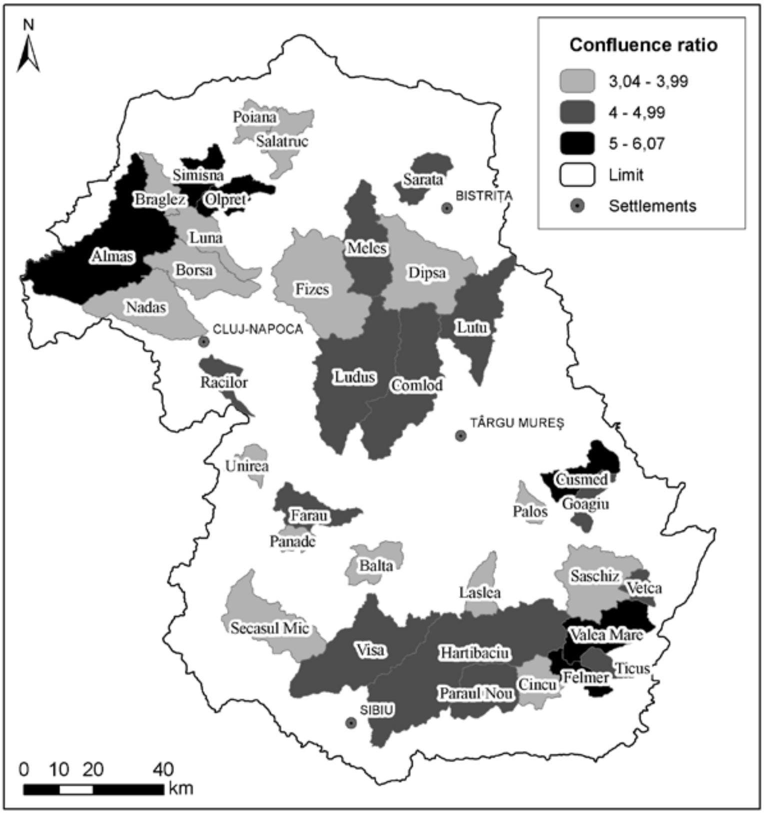

Fig. 1. The confluence ratio specific for catchment areas

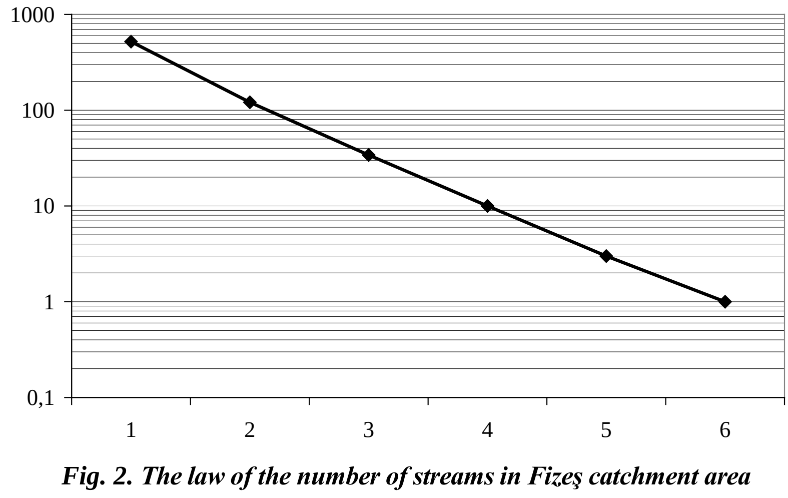

Fig. 2. The law of the number of streams in Fizeş catchment area

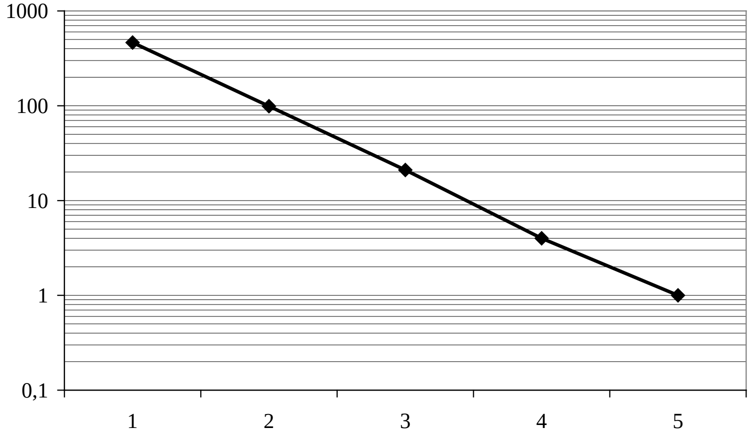

Fig. 3. The law of the number of streams in Luduş catchment area

The field observations and the interpretation of resulted regression lines shows the progressive increase of the ramification degree from maximal order segments to those of the first and second order. The variation of the confluence ratio between 3.04 and 6.07 highlights two aspects: on one hand, the large variation range demonstrates the existence of a heterogeneous lithological support, and on the other hand, the morphological and hydrological contrasts from one catchment area to another.

4. CONCLUSIONS

The assessment of the values of this indicator is able to provide information on the stage of evolution of the fluvial landforms in the Transylvanian Basin. Also, the values obtained may provide the basis for the calculation of other parameters of catchment areas, like: the degree of finishing of the basin for its corresponding order, the density of stream segments within a catchment area etc.

Analyzing the regression lines obtained after the data representation in semilogarithmic coordinates, one notices that the law of the number of streams is verified. The number of successive order segments form an inverted geometric progression, in which the first term (N_1) is given by the number of first order streams, while the ratio is represented by the confluence ratio.

The results thus obtained must be confronted with the existing situation in the field. Such an approach is necessary to demonstrate that catchment areas with high values of the confluence ratio also have higher values of areas affected by active geromorphological processes, especially those related to water flow on slopes.

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