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RIVER RUNOFF AS AN INDICATOR OF GLOBAL CLIMATE CHANGE

Abstract: The work introduces the analysis of the impact of possible climate change on river runoff in Armenia. For this reason, 10 river basins having different parameters and natural climatic conditions are selected. The natural runoff of these rivers is considerably disturbed (in some cases it is restored). In those basins average annual river runoff, precipitation and temperature are calculated. Multivariable correlation links have been established among the mentioned parameters. The present degree of runoff change and runoff changes expected in case of different versions of climate change have been evaluated. It's concluded, that in case of different versions of climate change river runoff will be reduced to 20% of the present one. However, it has not referred to the rest rivers in Armenia so far, as the role of local factors is very essential.

Key words: river runoff, temperature, precipitation, climate change, correlation, linear trend.

Among the global problems of environment, the global climate change is considered to be the latest and most disastrous. The most important peculiarity of climate change is temperature increase in troposphere, which causes global warming. According to the data of Intergovernmental Panel on Climate Change (IPCC), the average annual air temperature on the Earth increased in the last century by 0.3-0.6°C, and it still does; according to some predictions, temperature increase may reach 4.5°C by the end of 21st century (The Second Report of IPCC… 1995; IPCC European Regional… 1997; WCRP-107… 1999; WCRP-108… 1999). Certainly, it may impact somehow the environment and ecosystems, in different countries.

With this respect, IPCC technical guidelines, containing a number of models which present the dynamics of relations between climate and factors affecting it, are devised. It will help to evaluate climate change in different regions of the world (Technical Guidelines of IPCC… 1995).

Being a small mountainous country, Armenia has complex ecosystems which are peculiar by their dryness and small water resources. Thus, it is possible that the global warming of climate will have its negative impact on Armenia.

The goal of the work is to research and evaluate the possible impact of global climate change on the river runoff of Armenia in the past and future. For this purpose, 10 river basins in the territory of Armenia were chosen, with different physical-geographical conditions. In the river basins the observation posts are selected in such a way that the natural river runoffs above them are significantly disturbed. Those rivers are presented in Table 1, with several hydrometric, hydrological and climatic

Tab. 1. Several hydrometric, hydrological and climatic characteristics of rivers of Armenia, together with evaluation of impact of climate change.

N	River- Observation Post	Area of Drainage Basin, km^2	Average Height of Drainage area, m	Observation Period, year	Perennial Average Annual		
					Runoff, Q, m^3/sec	Precipitation, P, mm	Temperature, T^0C
1	Akhourian - Kaps	839	2710	1940-1987	7,24	566	4,5
2	Tashir-Saratovka	450	1810	1954-1998	2,65	662	6,1
3	Aghstev-Dilijan	303	2000	1950-1998	3,45	678	5,9
4	Marmarik-Hankavan	93,5	2430	1957-1994	1,65	758	4,0
5	Gegharot-Aragats	39,5	3100	1938-1998	0,96	802	1,1
6	Argidji-Getashen	366	2470	1930-1998	5,56	464	4,4
7	Arpa-Jermuk	180	2790	1960-1998	5,33	463	4,7
8	Vorotan-Borisovka	507	2630	1948-1997	7,36	845	3,0
9	Voghji-Kadjaran	120	2840	1960-1998	3,64	830	5,1
10	Meghriget-Meghri	274	2200	1951-1998	3,12	315	9,5

characteristics and observation periods. At first, the dynamics of long-term, permanent changes of selected river's runoff in Armenia was studied. For this reason, the dynamic changes of average annual runoff, as well as linear trend for the selected rivers were calculated (Fig. 1). As shows Figure 1, all river runoffs have cycles of certain periodicity. The graphs show that the runoffs of almost all the rivers have undergone certain changes in due time. E.g., the runoffs of the Tashir, the Aghstev, the Marmarik, the Gegharot, the Argidji and the Arpa rivers have increase tendency, while the runoffs of the Akhourian, the Vorotan, the Voghji and the Meghriget rivers - decrease. For these rectilinear trends of the runoffs equations with correlation coefficients and annual changes have been found (Tab. 2). Runoff change in relation with long-term average for all rivers has been little so far – 0.19-0.81%. Average multi-annual runoff, temperature and precipitation of selected river basins are also calculated (Tab. 1).

Implementing empirical statistical and genetic theoretical models (Rozhdestvensky A.V., Chebotarev A.I. 1974), multivariable regression links between

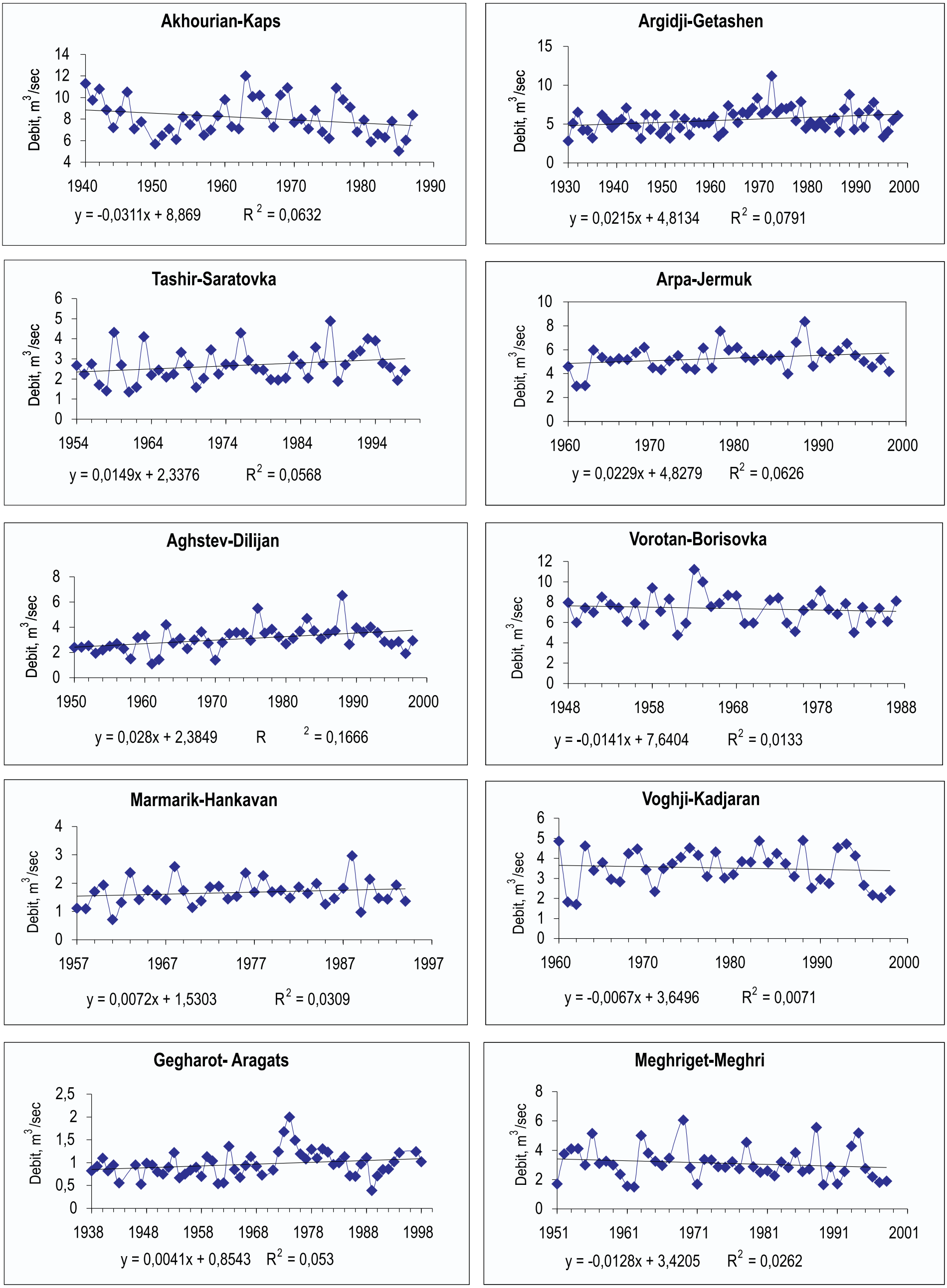

Fig. 1. Dynamics of changes of average annual runoff of rivers in Armenia (1930-1998).

Tab. 2. Trend equations of selected river runoffs with due parameters.

N S/P	River	Trend Equation	Change of Annual Runoff		Correlation Coefficient
			m^3/sec	%	R
1	Akhourian	y=-0,0311x+8,869	-0,031	-0,43	-0,25
2	Tashir	y=0,0149x+2,338	0,015	0,57	0,24
3	Aghstev	y=0,028x+2,385	0,028	0,81	0,41
4	Marmarik	y=0,007x+1,530	0,007	0,43	0,18
5	Gegharot	y=0,004x+0,854	0,004	0,42	0,23
6	Argidji	y=0,0215x+4,813	0,022	0,39	0,28
7	Arpa	y=0,0229x+4,828	0,023	0,43	0,25
8	Vorotan	y=-0,0141x+7,640	-0,014	-0,19	-0,12
9	Voghdji	y=-0,0067x+3,650	-0,007	-0,19	-0,08
10	Meghriget	y=-0,0128x+3,420	-0,013	-0,42	-0,17

average annual river runoff (Q), average annual precipitation (P) of river basin and temperature (T) were established. For those links it is necessary to have multi-annual observations. However, the standard period was acknowledged by World Meteorological Organization to be 1961-1990. The observations were done for many-year period and the standard period (1961-1990) which is taken as basis for future forecasts.

The equation of multivariable regression links, their correlation coefficients and the values of runoff changes are presented in Table 3. The links are poorly expressed (correlation coefficients vary from 0.2 to 0.65), which, we believe, is caused by complex climatic and geological conditions of the region. Together with the equation of multivariable regression the values of precipitation and temperature, the changes of river runoff were evaluated.

According to IPCC calculations, in Southern Europe (where Armenia is situated) in 2030 temperature will increase by 2-3°C, and precipitation will decrease by 5-15%, in case the greenhouse gases are emitted at the constant rate (The Regional Program IPCC … 1997).

Taking into consideration that Armenia is a country of complex natural and climatic conditions, different versions of change of climatic components were chosen:

1) T+ 1.0°C; 0.9 P   2) T+2.0°C; 1.1 P   3) T+2.0°C; 0.9 P

Runoff changes of the selected rivers have been evaluated on the basis of these climate change predictions (Tab. 3). River runoff will be reduced in general by 20%, but in some cases (T+2.0°C; 1.1P) it may even increase by 10-15% (the Akhourian, the Aghstev and the Argidji rivers). Thus, the runoff of selected rivers in Armenia has undergone insignificant changes so far, but according to different climate change predictions it may decrease to 20%.

Tab. 3. Evaluation of river runoff change in case of different climate change predictions.

River	Equation of Multifactor Regression Link	Correlation Coefficient	Versions of Climate Change	River Runoff, m^3/sec	Runoff Change	
		R			m^3/sec	%
Akhourian	Q=0,0076P+0,151T+2,26	0,4	basis	7,24	0	0
			T+1,0⁰C,0,9P	6,96	-0,28	-3,9
			T+2,0⁰C,1,1P	7,97	0,73	10,1
			T+2,0⁰C,0,9P	7,11	-0,13	-1,8
Tashir	Q=0,003P-0,224T+2,02	0,65	basis	2,65	0	0
			T+1,0⁰C,0,9P	2,22	-0,43	-16,2
			T+2,0⁰C,1,1P	2,40	-0,25	-9,43
			T+2,0⁰C,0,9P	2,00	-0,65	-24,5
Aghstev	Q=0,0078P-0,021T-1,697	0,4	basis	3,45	0	0
			T+1,0⁰C,0,9P	2,92	-0,53	-15,4
			T+2,0⁰C,1,1P	3,95	0,50	14,5
			T+2,0⁰C,0,9P	2,89	-0,55	-16,0
Marmarik	Q=0,0008P-0,057T+1,27	0,45	basis	1,65	0	0
			T+1,0⁰C,0,9P	1,53	-0,12	-7,3
			T+2,0⁰C,1,1P	1,60	-0,05	-3,0
			T+2,0⁰C,0,9P	1,47	-0,18	-10,9
Gegharot	Q=0,00013P - 0,0011T+0,87	0,2	basis	0,96	0	0
			T+1,0⁰C,0,9P	0,94	-0,02	-2,1
			T+2,0⁰C,1,1P	0,95	-0,01	-1,0
			T+2,0⁰C,0,9P	0,96	0	0
Argidji	Q=0,0074P+0,138T+1,53	0,4	basis	5,56	0	0
			T+1,0⁰C,0,9P	5,36	-0,20	-3,6
			T+2,0⁰C,1,1P	6,19	0,63	11,3
			T+2,0⁰C,0,9P	5,50	-0,06	-1,1
Arpa	Q=0,0026P-0,149T+4,83	0,4	basis	5,33	0	0
			T+1,0⁰C,0,9P	5,06	-0,27	-5,1
			T+2,0⁰C,1,1P	5,15	-0,18	-3,4
			T+2,0⁰C,0,9P	4,91	-0,42	-7,9
Voghdji	Q=0,001P-0,335T+4,52	0,65	basis	3,64	0	0
			T+1,0⁰C,0,9P	3,23	-0,41	-11,3
			T+2,0⁰C,1,1P	3,05	-0,59	-16,2
			T+2,0⁰C,0,9P	2,89	-0,75	-20,6

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