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CHANGE IN THE REPUBLIC OF ARMENIA WATER RESOURCES DUE TO GLOBAL CLIMATE CHANGE

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The impact of global climate change on the planet is already noticeable today. In recent years. many disasters occurring in different regions are one of his evidence. Climate change will primarily affect water resources. This article assesses the key elements of water balance that depend on global climate change in the Republic of Armenia. According to prognoses, it is expected that in the near perspective, already by 2030, the precipitation in Armenia will decrease by 2.6%; evaporation will increase by 0.95%; flow will decrease by 3.1%; and the country's water resources will decrease by 0.6 billion m3, i.e. 8.5%.

Key words: *water resource; global change; water balance; natural flow; trend.*

Introduction

The Republic of Armenia with its area of 30 thousand km^2 occupies the southern part of South Caucasus. Although the country's area is in the north of the subtropical zone, however, due to the mountainous landscape, it is influenced by the air masses from the temperate climatic zone where the western masses are predominating.

The average altitude in Armenia is 1830m above sea level. Although the rivers are short and not deep, however because of the high slopes they have a great hydro-energy potential, a considerable part of which is now already used. The dynamic resources of the river flow being formed in the country, according to the "RA National Water Program", make approximately 6.8 billion m^3 [1].

While the river network in the Republic of Armenia consists of approximately 9,500 small and medium rivers, only 379 of them are 10 and more km long. For a country with such a large number of rivers, Armenia is at the same time a arid country, with annual precipitation of only 620mm.

In the most densely populated sector – Ararat Valley, which has an altitude of 800m-1,000m – the annual total precipitation is around 220mm, while in high mountainous areas it can reach to 1,000mm and higher. A considerable part of rainfall occurs during April and May (about 37% of annual precipitation), while the share of December-February is only 17%-Á, and that of July and August is less than 10%.

Impact of global climate change on hydrometeorological factors in the Republic of Armenia.

Around 47% of the river flow in Armenia is formed from surface waters and 53% from underground waters [4]. River waters are largely used in different industries, especially in agriculture, where 76% of the total water withdrawal is used for irrigation purposes only [3].

Water resources are used also for utility-household and industrial supply, hydraulic energy, fishery and recreation.

Although Armenia has a very small impact on global greenhouse gas emission, however the living standards of the population, economic productivity, and the future economic development are in danger. It is a scientifically well grounded fact that climate change takes place and will take place as long as the volume of the greenhouse gases available in the air is larger than the processing capacity of the earth's natural cycles [2,3].

Studies conducted in Armenia over the recent years indicate [5] that, like other regions of the earth, a certain climate change is observed also in Armenia and is expressed by changes in air

temperature and precipitation, which in turn have their impact especially on river flow and its yearly distribution.

Conflict setting

These hydro-meteorological changes will be more obvious during the 21st century. As the studies conducted in the country have shown, according to the high greenhouse gas emission scenario, with only a few exceptions, most dry areas in Armenia will lose a considerable part of their precipitation due to the climate change, while the annual precipitation will increase to some extend in the rainiest areas.

Research results

Lower precipitation level and higher temperatures will increase evaporation rates and decrease the snow cover and therefore the flood flow and its surface component in particular. According to the mentioned forecasts, the minimum river flow in Armenia, even though it can increase in some river basins, however will decrease in Armenian rivers in general.

In the Figure, the average annual flow of Gomur river as well as the annual average temperature fluctuation tendencies in the Hrazdan meteorological station located in the Gomur river basin are brought in.

We suggest to use the obtained trend line equations for forecasting the perspective values of these two factors.

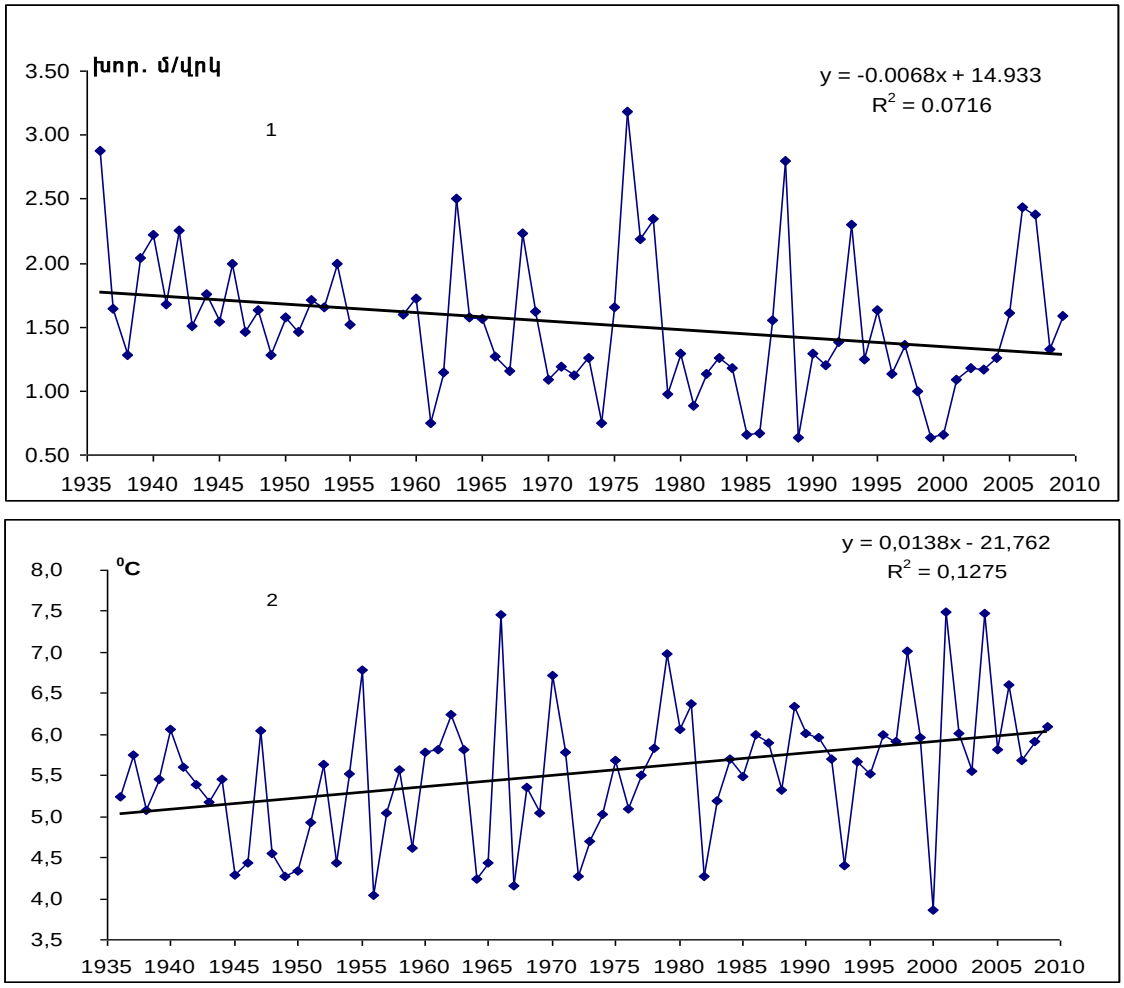

Fig.: Trends of annual flow in Meghradzor water inspection point on Gomur river (1) and Hrazdan meteorological station (2)

In the near future, most probably, the local climatic conditions will change: a warmer heat regime and strong winds are expected which in turn will contribute to the intensification of the evaporation process.

Given that the main feeding source for most of the annual flows of Armenian rivers are thaw and rain waters (for example, 35%-40% of the annual flow of rivers Akhuryan, Arpa, Azat, Hrazdan, and Kasakh is formed from thaw waters), and the forecasts say due to decrease in the winter precipitations and higher temperatures, lower snow cover and consequently decrease in water resource in snow is expected [3], therefore the average annual flow of the above mentioned rivers will decrease.

To assess the trends in the seasonal flow change, particularly in the spring flooding stage and summer-fall water shortage stage (when excess irrigation water is observed in the first case and a deficiency in the second case is observed), as a base we selected a number of small tributaries that have high balanced altitudes. Given that there is water withdrawal from these rivers or only insignificant part of their water is used by industries, then we can admit that the actual flow of those rivers is very close to the natural one and change in their regimes depends mainly the global climate change.

Comparative results of seasonal flow of certain rivers are brought in Table 1.

Table 1

Seasonal flow of a number of rivers with natural flow, %

River-Inspection point	Watershed		Average seasonal flow before 1980,%		Average seasonal flow during 1981-2010, %		Difference,%	
	Surface, Km^2	Average altitude, m	III-VI	VII-XI	III-VI	VII-XI	III-VI	VII-XI
Dzoraget- Dzorakert	25.5	2220	66.7	22.6	72.9	20.2	6.2	-2.4
Marmarik-Hankavan	93.5	2430	77.5	16.1	79.7	14.6	2.2	-1.5
Gomur-Meghradzor	101	2430	79.1	16.4	80.6	13.1	1.5	-3.3
Dzknaget-Tsovagyugh	85.0	2220	81.6	13.9	82.1	13.1	0.5	-0.8
Arpa-Jermuk	180	2790	64.6	24.9	61.3	26.2	-3.3	2.0
Meghriget-Lichk	21.0	2950	53.5	41.2	63.3	34.1	9.8	-7.1
Voghji-Kajaran	120	2840	60.2	35.8	61.9	33.8	1.9	-2.0
Dzoraget-Katnarat	140	2320	60.3	30.9	58.0	32.8	-2.3	1.7

The Table shows that the flow of some of the rivers under study has increased in 1981-2010 versus the flow before 1980 during spring floods (III-VI), while during summer-fall shortage stages (VII-XI) it has decreased. In some rivers, given the overall growth in spring flood flow, even further decrease is observed in summer-fall water shortage flow.

1. **Assessment of RA water balance components according to IPCC scenes.**

According to the climate change scenarios suggested by IPCC and base period base period (1961-1990) we have carried out forecasts of the main elements for the water resource balance of Armenia for 2030, 2070 and 2100. The results calculated and obtained through these scenarios indicate that, compared with the base values, the water resources of the country will decrease by 0.6 billion m^3 by 2030, i.e. by 8.5%; by 1,2 billion m^3 by 2070, which will make 18,9% of the total; and by 1,8 billion m^3 by 2100, i.e. 25.4%.

The values of precipitation, evaporation, surface flows and undercurrent in the country according to different climatic scenarios are brought in Table 2.

Table 2

Forecast of the water balance elements in RA by climate change scenarios for 2030, 2070 and 2100

Climate change scenarios	Precipitation		Evaporation		Surface flow		Undercurrent	
	billion m^3	mm	billion m^3	mm	billion m^3	Mm	billion m^3	Mm
2030 (air temperature increases by 1.1° C, precipitation P decreases by 3.1 %)								
Base, 1961 - 1990	17.6	592	10.5	352	6.4	215	0.7	22
t + 1.1 ûC; P	17.1	575	10.6	357	6.2	208	0.3	10
2070. (air temperature increases by 2.7 ° C, precipitation P decreases by 5.9 %)								
t + 2.7 ûC; P	16.6	558	10.7	360	5.8	195	0.1	3
2100Ã. (air temperature increases by 4.4 ° C, precipitation P decreases by 8.7 %)								
t + 4.4 ûC; P	16.1	540	10.8	362	5.3	178	0	0

• By 2030, evaporation will increase by 0.1 billion m^3: 0.95%, while precipitation will decrease by 0.5 billion m^3: 2.84%.
• By 2070, evaporation will increase by 0.2 billion m^3: 1.91%, while precipitation will decrease by 1.0 billion m^3: 5.68%.
• By 2100, evaporation will increase by 0.3 billion m^3: 0.86%, while precipitation will decrease by 1.5 billion m^3: 8.52%.

Given that, according to forecasts, decrease in precipitation, and, on the opposite, increase in the air temperature meaning also increase in evaporation, is expected in most river basins, it is already necessary to develop measures that will make it possible to mitigate to some extend the expected water deficit in the country.

Studies show that in certain locations of the country the natural conditions will become unfavorable for growing a number of crops caused by increased river flow in spring and decreased flow in summer. In countries like Armenia, where agriculture has a large share in the GDP (with direct agricultural produce making 20% and the food processing industry making 10% of the GDP). Since agriculture largely depends on the irrigation water coming from rivers, therefore the climate change can seriously impact on agriculture as well as on other industries [3].

Conclusions

Currently, water supply in 40% of Armenia's irrigated land areas is carried out by pump stations, which pump water with the help of electricity up to 500m high. 9% of electricity use is the share of pumping stations pumping water for water management and household use. Given that currently only less than half of lands needing irrigation is irrigated, it is already necessary to develop adaptability measures.

The most profitable of these, in our opinion, is first of all accumulation of excess water in high mountainous regions by establishing new small reservoirs to accumulate excess spring water, which will enable to mitigate to a certain extend the current as well as expected water deficiency through gravity irrigation in summer time.

The suggested reservoir system, together with existing reservoirs, will enable to regulate up to 3.0-3.5 billion m^3 of the river flow formed in the country, which makes 45% of the annual river flow. This can resolve a number of strategic problems: expansion of irrigated land areas up to 450 thousand hectares; substitution of most of the mechanical irrigation systems with gravity system; additional new capacities for energy system; protection against flooding of coastal areas; establishment of nature protection and recreation zones, etc.

References

1. ՀՀ օրենքը «Ջրի ազգային ծրագրի մասին», Երևան, 2006թ., ՀՕ-232-Ն.
2. Second National Statement on Climate Change; based on UN Framework Convention on Climate Change, Yerevan 2010, 112 p.
3. Socioeconomic Impact of Climate Change in Armenia, Yerevan, 2009, 157 p.
4. Մնացականյան Բ.Պ. Հայաստանի ջրային հաշվեկշիռը //Եր., “Զանգակ-97”, 2005, 194 էջ:
5. Саргсян В.О. Воды Армении //Ер., 2008, 208с.

References

1. RA law “On National Water Program”, Yerevan, 2006., HO-232-N.
2. Second National Statement on Climate Change; based on UN Framework Convention on Climate Change, Yerevan 2010, 112 p.
3. Socioeconomic Impact of Climate Change in Armenia, Yerevan, 2009, 157 p.
4. Mnatsakanyan, B.P. Water Balance in Armenia // Yerevan, “Zangak-97”, 2005, 194 p.
5. Sargsyan, V.H., Waters of Armenia, Yerevan, 2008, 208p.

ԿԼԻՄԱՅԻ ԳԼՈԲԱԼ ՓՈՓՈԽՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ ՀԱՅԱՍՏԱՆԻ ՀԱՆՐԱՊԵՏՈՒԹՅՈՒՆՈՒՄ ՋՐԱՅԻՆ ՌԵՍՈՒՐՍՆԵՐԻ ՓՈՓՈԽՈՒԹՅՈՒՆԸ

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Կլիմայի գլոբալ փոփոխության ազդեցությունը երկրագնդի վրա նկատվում է արդեն այսօր: Վերջին տարիներին տարբեր տարածաշրջաններում տեղի ունեցող բազմաթիվ կատակլիզմները դրա ապացույցներից է: Կլիմայի փոփոխությունը, առաջին հերթին, իր ազդեցությունը կունենա ջրային ռեսուրսների վրա: Սույն աշխատանքում գնահատվել են ջրային հաշվեկշռի հիմնական տարրերը, որոնք կախված են Հայաստանի Հանրապետությունում կլիմայի գլոբալ փոփոխության հետ: Կանխատեսումների համաձայն ակնկալվում է, որ արդեն 2030 թ., Հայաստանում տեղումների քանակը

կկրճատվի 2,6% -ով, գոլորշիացումը կավելանա 0,95% -ով, հոսքը կկրճատվի 3,1% -ով, իսկ երկրի ջրային ռեսուրսները կկրճատվեն 0,6 մլրդ խ.մ.-ով, այսինքն՝ 8,5% -ով:

Բանալի բառեր: ջրային ռեսուրսներ, կլիմայի գլոբալ փոփոխություն, ջրային հաշվեկշիռ, բնական հոսք:

ИЗМЕНЕНИЕ ВОДНЫХ РЕСУРСОВ РЕСПУБЛИКИ АРМЕНИЯ В УСЛОВИЯХ ИЗМЕНЕНИЯ КЛИМАТА

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Влияние глобального изменения климата на планету заметно уже сегодня. Доказательством этому - многочисленные катаклизмы происходящие в последние годы в разных регионах. Изменение климата в первую очередь повлияет на водны ресурсы.
В данной работе оценены основные элементы водного баланса Республики Армения в условиях глобального изменения климата. По прогнозам, ожидается, что к 2030 году количество осадков в Армении уменьшится на 2,6%, испарение увеличится на 0,95%, сток уменьшится на 3,1%, а водные ресурсы страны уменьшатся на 0,6 млрд кубометров. то есть на 8,5%.

Ключевые слова: водные ресурсы; глобальные изменения климата; водный баланс; естественный сток.

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