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INTEGRATED WATER RESOURCES MANAGEMENT CHALLENGES IN ARMENIA IN THE CONTEXT OF THE GLOBAL CLIMATE AND WATER CRISIS

A. A. ARAKELYAN [1*], L. A. MARGARYAN [2**]

[1] *Institute of Geological Sciences NAS of the RA, Armenia*
[2] *Chair of Inorganic and Analytical Chemistry, YSU, Armenia*

Under the conditions of climate change, efficient use and protection of natural water resources are one of the key challenges in water resources management. Armenia is one of the countries where the climate changes in recent decades are evident. Historical records of air temperature in Armenia indicate a significant upward trend over the past decades. The results of assessment of climate change impact on water resources quantity and quality for the rivers in Armenia are presented in this paper. The projections and discussion of climate change impact on natural river flow were done using various methods and models. It was revealed, that adequate adaptation measures need to be developed and embedded into the national and regional water strategies and basin management plans to address the adverse impacts of climate change in water resources in Armenia.

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***Keywords*:** climate change, impact assessment, adaptation, water resources, vulnerability, projection, chemical composition.

Introduction. Around two billion people worldwide today do not have access to safe drinking water, and approximately half of the world's population experiences severe water scarcity at least some months of the year [1]. These are expected to increase, exacerbated by climate change and population growth. Water reserves stored in glaciers and snowpack are projected to continue to decline, thus reducing water availability during the hot and dry seasons of the year in meltwater-fed regions that are currently home to more than one–sixth of the world's population [2–3]. Exacerbating water scarcity due to climate change and population growth will put pressure on the food supply chain, as most of the fresh water used, about 70 percent on average, is used in agriculture [4].

Armenia is one of the countries where the climate changes in recent decades are evident. Historical records of air temperature in Armenia indicate a significant upward trend over the past decades [5]. Meteorological observations have been

[*] E–mail: alex.arakelyan@outlook.com
[**] E–mail: l.margaryan@ysu.am

ongoing since 1929, and during various periods, the annual mean temperature experienced notable increases: from 1929 to 1996, it rose by 0.4℃; from 1929 to 2007, by 0.85℃; from 1929 to 2012, by 1.03℃; and from 1929 to 2016, by 1.23℃ [6]. Particularly noteworthy is the rise in summer temperatures, which increased by approximately 1.3℃ from 1966 to 2016. The last 20 years have witnessed extremely hot summers in Armenia, indicating a tendency toward a more continental climate with significant seasonal temperature variations.

As for precipitation, observations reveal a decline in average annual rainfall. Between 1935 and 1996, the average annual precipitation decreased by 6%, and from 1935 to 2016, it decreased by approximately 9%. Precipitation distribution across Armenia exhibits irregular patterns. Over the same period (1935–2016), the climate in the north, south, and central regions of the country became more arid, while the Shirak plain, Lake Sevan basin, Aparan, and Hrazdan regions experienced an increase in precipitation [7–10].

Climate change will inevitably influence not only quantity of water resources, but also on its' quality, adding indirect "natural" pollution. At the result, it will lead to total destruction of water reserves and be not able for water usage. Moreover, in case of quantitative and qualitative changes of surface water (river, lakes, etc.), it also will be started destroying water ecosystems [11–12].

Hydrometeorological disasters have become more frequent and intense. Between 1975 and 2016, the total number of observed hazardous phenomena increased by about 40 cases compared to the average from 1961 to 1990 (168 cases) [13]. Hailstorms were most prevalent in the Shirak plain, while Tashir and Ijevan regions had the highest number of heavy rainfall incidents. Frosts are common in the Ararat valley and foothill regions. Drought indices reveal an increase in the number of days with strong and very strong droughts from 2000 to 2017, with 33 more days compared to the 1961–1990 average (87 days). In recent years, the upper boundary of the drought zone has expanded to include mountainous areas, with droughts starting earlier [13].

Materials and Methods. The hydrogeological and hydrochemical measurements were performed according to ISO and State standards [14, 15]. Monthly, the water temperature and flow rate were measured in selected monitoring points [16]. The flow rate of the river was measured by the "flow–cross–secional area" method [17].

In the water samples, we measured pH, BOD5, and concentrations of dissolved oxygen and general ions. The salinity of water was calculated by the sum of the general ions concentrations (calcium, manganese, potassium, sodium, sulfate, chloride, hydrocarbonate) [15]. The total hardness of water was calculated as the equivalent sum of calcium and manganese [15].

Results and Discussion. As for projections on future changes, according to the latest results [18] obtained through METRAS model [19], the average annual temperature in the territory of Armenia will increase by up to 1.6℃ by 2040, by 3.3℃ – by 2070 and by 4.7℃ – by 2100 (relative to the baseline annual average (5.5℃) for 1961–1990). As for atmospheric precipitation, these are projected to decline by up to 2.7% by 2040, 5.4% – by 2070 and 8.3% – by 2100 (relative to the baseline annual average (592 *mm*) for 1961–1990) (UNFCCC, 2020).

Impact of Climate Change on the Water Resources in Armenia. There are different studies on the impact of projected climatic changes on the water resources in Armenia using various methods and models. The smallest decrease in annual total river flow by 2100 for Armenia was calculated within the First National Communication (15–20%) (UNFCCC, 1998), the biggest decrease – in the latest study (UNDP/GEF, 2020) – 39% according to the RCP8.5 scenario (IPCC, 2007) using METRAS model (Fig. 1).

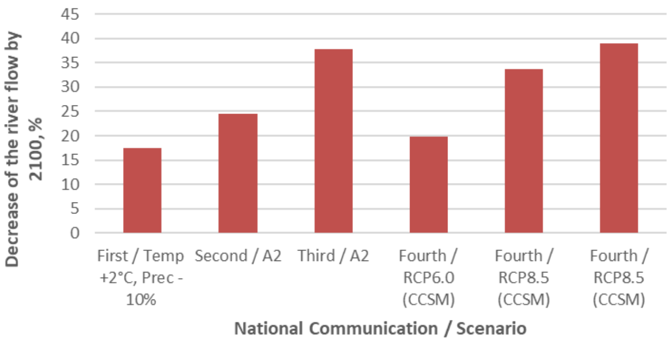

Fig. 1. Changes in the River Flow in Armenia by 2100 against the Baseline Period Average according to the National Communications of Armenia to the UNFCCC.

Here, the results of the studies that used METRAS model have been analyzed and summarized to create a comprehensive basin–level vulnerability map for Armenia (Tab. 1).

As we can see in Fig. 2, the areas in Armenia that are most vulnerable to the climate change are in the basins of rivers Debed, Hakhum, Voghji, and Lake Sevan basin.

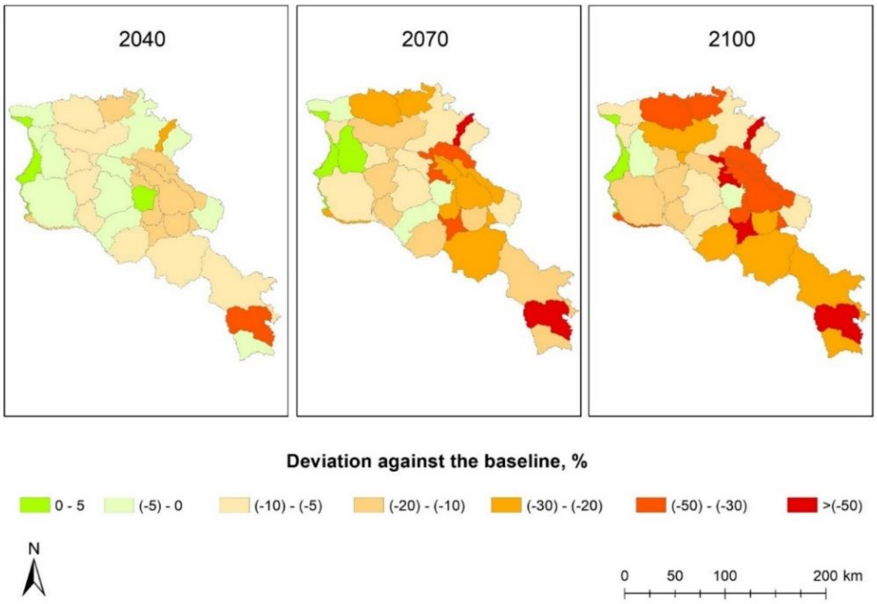

Fig. 2. Water Resources Vulnerability due to Climate Change, IPCC RCP8.5 Scenario, METRAS Model (UNDP/GCF, 2020).

Table 1

Vulnerability of Water Resources in Armenia due to the Climate Change
(IPCC RCP8.5 Scenario, METRAS Model)

BMA	Basin/Watershed Area	2040	2070	2100
Akhuryan	R. Sevjur	–4.2	–9.3	–13.6
Akhuryan	R. Araks	–12.6	–26.1	–37.8
Akhuryan	Lower flow of Akhuryan River	1.6	3.7	5
Akhuryan	Middle flow of Akhuryan River	–2.9	–6.2	–9.2
Akhuryan	Upper flow of Akhuryan River	–2.9	–4.5	–6.2
Akhuryan	R. Mantash (Karkachun)	0	0.1	0
Araratyan	R. Azat	–1.81	–4.49	–7.02
Araratyan	R. Vedi	–7.36	–14.3	–20.2
Araratyan	R. Arpa	–9.34	–20.2	–29.7
Hrazdan	Lower flow of Hrazdan River	–5.6	–12.2	–17.8
Hrazdan	Middle flow of Hrazdan River	–2.4	–5.2	–7.7
Hrazdan	Upper flow of Hrazdan River	–3.8	–7.9	–11.9
Hrazdan	Upper flow of Kasakh River	–5.5	–8.7	–12
Hrazdan	Middle and lower flows of Kasakh River	–6.2	–13.5	–19.9
Hrazdan	R. Marmarik	–9.3	–19.7	–29
Northern	R. Pambak	–7.98	–18.5	–28
Northern	R. Aghstev	–2.38	–5.08	–8.35
Northern	R. Tavush, Hakhindja	–3.38	–6.58	–9.15
Northern	R. Dzoraget	–9.6	–29.6	–46.8
Northern	R. Debed	–11.8	–24.5	–35.9
Northern	R. Getik	–12.6	–31.6	–48.3
Northern	R. Hakhum	–29.1	–60.6	–87.2
Sevan	Lake Sevan	–12.3	–23.8	–33.8
Sevan	R. Dzknaget, North-Western shore of Lake Sevan	–19.7	–42.7	–62.8
Sevan	R. Gavaraget	0.38	–2.1	–4.2
Sevan	R. Masrik	–4.18	–7.21	–9.45
Sevan	Eastern shore of Lake Sevan	–13.1	–28.5	–41.7
Sevan	Western and South-Western shore of Lake Sevan	–10.5	–23.2	–34.1
Sevan	Southern shore of Lake Sevan	–10.6	–16.1	–21.7
Sevan	R. Karchaghbyur	–12.3	–27.3	–39.6
Sevan	R. Argichi	–19.5	–41.1	–59
Southern	R. Vorotan	–7.06	–16.4	–24.6
Southern	R. Voghji	–35.5	–64.2	–74.4
Southern	R. Meghriget	–4.47	–13.6	–22.1

From the values above we can conclude that Armenian water resources are highly vulnerable to the climate change. These projections are being confirmed with the negative changes we can see now, especially, in Lake Sevan basin and Ararat Valley.

Impact of Climate Change on the Water Resources Quality in Armenia. Climate is an important natural indirect factor in the formation of the chemical composition of natural waters [12]. Thus, climate change brings not only obvious hydrological changes, but also inevitably leads to change in hydrochemical content, in particular, water mineralization regime. In Armenia, the climate change impact on rivers water quality is more prominent in the relatively densely populated central and dry climate regions [3, 5, 11]. Accordingly, an evaluation of the trends in hydrochemical changes of the Hrazdan, Marmarik, Gegharot, Meghriget, Voghhi, Geghi, Vorotan and Sisian rivers was carried out. Due to the high level of anthropogenic pressure to the river, for climate change impact on rivers' water quality, the reference observation points were considered. The reference observation points were located near the source of the rivers and far from any anthropogenic impacts.

The assessment of the climate change impact on the water quality of rivers was carried out using the average multi-year values of river flow, mineralization and oxygen regimes for 2007–2018 against with the periods 1960–1990 and 1980–1990 baseline periods [18].

The evaluation was carried out based on the multi-year monitoring data of the Hydrometeorological and Monitoring Center SNCO of the Republic of Armenia [16, 18]. Differences in analytical methods used in the mentioned periods were also taken into account [15]. The obtained results are given in Tab. 2.

Table 2

Deviations (%) of several hydrochemical parameters annual average concentrations in period of 2007–2018 against with 1980–1990 at the reference observation points of the rivers

Hydrochemical parameter	Hrazdan–Hrazdan	Marmarik–Hankhavan	Voghji–Kajaran	Geghi–Geghi	Vorotan–Gorhaykh	Sisian–Arevis	Meghriget–Lichkh	Gegharot–Aragats
Oxygen regime								
Dissolved oxygen, *mg*/*L*	2.5	No	2.7	no	2.7	no	no	no
BOD5, *mg* O/*L*	2.6	7.1	no	no	4.5	no	9.6	4.3
Mineralization regime								
Hardness, *mg* equ/*L*	–3.4	No	no	no	–20.4	no	11.0	no
Salinity, *mg*/*L*	1.2	–7.8	–9.0	–5.1	–19.8	no	7.4	no
Sulfate ion, *mg*/*L*	–8.4	–9.8	–8.7	–11.3	–23.3	no	2.9	5.1
Hydrocarbon ion, *mg*/*L*	no	–6.6	–10.1	–3.1	–17.6	–1.5	9.5	–6.5
Chloride ion, *mg*/*L*	no	–8.2	–13.6	–14.0	–21.8	–9.8	–6.1	no
Calcium ion, *mg*/*L*	no	4.1	no	9.2	–19.8	1.7	12.5	no
Magnesium ion, *mg*/*L*	5.6	–13.9	–4.7	–12.8	–21.2	–1.5	7.3	–4.8
Sum of sodium and potassium ions, *mg*/*L*	–10.3	–15.7	–13.5	–16.7	–21.5	–5.6	–8.5	–2.5

Assessment of the climate change impact on the rivers water quality showed the clear correlation between the reduction in the natural flow and changes in the hydrochemical content at the reference observation points. Over time, calcium became dominant among the cations in the rivers' water, as well as the hyrochemical charachterization of waters changed from hydrocarbonate-sulfate-sodium-potassium to pronounced hydrocarbonate-sulfate-calcium.

Uncertainties in Hydrometeorological Monitoring Data and Modelling Issues. Although there are different studies on climate change and its impacts in Armenia, there are still data gaps in the meteorological and hydrological monitoring system that do not allow to accurately assess the:

- trends in precipitation throughout the Republic;
- changes in the natural river flow, as well as the influence of water abstraction on the change in the river flow;
- water and water and water–economic balance of river basins; and
- trends in the intensity of extreme hydrometeorological events (floods, mudflows, drought, frostbite, etc.).

These gaps also lead to unreliable projections of the changes in climatic elements.

Various hydrologic models are utilized to analyze the effects of climate change on water resources. The primary challenge in running intricate hydrologic models like WEAP or SWAT lies in their extensive data prerequisites. Notably, these models demand not just hydro-meteorological parameters, but also encompass hydrogeological aspects (such as infiltration coefficient, porosity, and deep flow), soil composition, vegetation, and accurate water use data to yield dependable modeling outcomes. Hence, it becomes imperative to conduct investigations focused on pinpointing accessible data origins suitable for hydrological modeling. Through these investigations' outcomes, the priorities for enhancing the hydro-meteorological and hydrogeological monitoring networks, as well as for conducting research on hydrogeology, soil, vegetation, and related data acquisition, will be delineated to support effective hydrological modeling. In the last two decades, satellite remote sensing data has become important data source in filling the ground monitoring gaps. Combined with the artificial intelligence and machine learning, they have a huge potential for modelling the complex physical processes such as global temperature changes due to the greenhouse gas emissions and changes in hydrological cycle due to the climate change. Even though the spatial and temporal resolution of remotely sensed data often impede in achieving the appropriate modelling results small territories, the quality satellite images is continuously increasing.

Research elements play a pivotal role in strategizing and executing adaptive measures. The integration of eco-friendly techniques for wastewater treatment, the utilization of multispectral drone imagery for precise agriculture, the substitution of chemical pesticides with organic fertilizers, adoption of drip irrigation systems, early warning setups for floods, and the implementation of circular irrigation concepts collectively bolster the effectiveness of water sector adaptation endeavors. Education stands as a critical enabler for enhancing the nation's research capabilities. While Armenian universities presently offer education in environmental sciences, a significant step forward would involve incorporating coursework focused on climate change into their academic programs in the coming years.

Identified Issues in Climate Change Adaptation in Water Sector. Despite the implementation of various adaptation measures within the country, there are instances where these measures prove ineffective in addressing the challenges posed by climate change. A notable example pertains to the water sector, where the treatment of household and industrial wastewater remains a significant unresolved issue within the existing measures.

Our analysis indicates that multiple projects funded by international donors, aimed at enhancing climate change adaptation within Armenia's water sector (such as reducing water losses, managing river flows, enhancing water quality, bolstering water availability, and refining national and river basin water management), exist. However, there is a notable deficiency in the extent to which climate change adaptation is integrated into Armenia's development planning process, especially concerning the strategies related to the use of water resources. While a limited number of pertinent documents (strategies and concepts for water use sector development) touch upon the potential impact of climate change on water resources, they fail to adequately consider the projected rise in water demand and the heightened vulnerability of water resources attributable to anticipated climate changes. In particular, the following gaps and shortcomings have been identified:

Agriculture:

- The measures listed in the sector development strategy and various concepts are dedicated to mitigating the water stress in the country, rather than adaptation measures. Thus, they do not consider the water availability changes and expected water demand increase due to the forecasted climate change impact in the long-term period.
- The national strategy and concepts for the development of the sector implies improving water supply systems and reducing the volume of water losses, however, in the measures and planning activities the potential changes in the irrigation lands and irrigation water norms do not consider in order to be able to reliably estimate the irrigation water demand and its possible change in the nearby future.
- In the Development Strategies for Marzes, it is briefly mentioned that the reduction of precipitation and river flow and increase in natural disasters due to climate change will lead to huge impact on the agricultural sector. However, in-assessments on potential changes in hydrometeorological phenomena, water balance, water supply and demand due to climate change impacts should be conducted and considered during the development of adaptation programs on Marz level.
- A strategic plan and concept on fish breeding sector development in the Armenia have not been developed yet. Although Lake Sevan and the Ararat Valley are most concerned with this issue, the only project is the "Lake Sevan Trout Reserve Development and Fish breeding Development Program". However, the program does not address the vulnerability of Lake Sevan to climate change and no adaptation measures are foreseen.
- The vulnerability of groundwater resources to climate change has not been assessed in the Republic. Based on this gap, it is not possible to predict trends in the volumes of water use from groundwater sources in fish farming and irrigation due to climate change.
- During the permitting of the long-term use of surface water resources for fish farming and irrigation, the potential vulnerability of river flow due to climate change does not consider which will create risks for the effective development of the agricultural sector. At the same time, it should be noted that the vulnerability of river

flow to climate change in the short term is not immediately apparent (hydrological cycles can be expressed over a couple of years, that is, the hydrological state of the river with respect to the long-term average value and, possibly, the maximum or minimum annual flow). As it is difficult to consider the impact of climate change when granting short-term water use permits for irrigation and fish farming, mid-term mechanisms for planning abstraction of volumes should be envisaged based on thorough models and indicators.

Drinking Water Supply:

• The "Water Supply and Sanitation Strategy and Financing Plan for 2018–2030" of Armenia is based on the studies carried out in 2014 and does not include the further assessments of water resources changes provided in the National Communications and river basin management plans. In addition, this main strategy document does not consider the expected changes in the RA water balance by 2030 due to climate change, the water supply and demand by regions dependent on that, the change in the water balance of the Republic, as well as the decreasing trend of water yield of water sources due to climate changes.

• While in all regional programs and Marzes development strategies mentioned that the improvement of the water supply and sanitation sector is a priority, nevertheless there are a few if any, measures conducted or developed to treat the household wastewater and re-use the treated one in other sectors. The sector development strategies and concepts do not set the privileges and mechanisms for the self-supply communities to promote the establishment of a local wastewater treatment plant and secondary use of treated urban wastewater.

• Even in several Development Strategies for Marzes it is mentioned that the changes in climatic conditions made impact on drinking water sources, however, there is no assessment to understand the water capability of the water sources and the trend of changes during a short-term and long-term period. In-depth assessments on potential changes in hydrometeorological phenomena, water balance, water supply and demand due to climate change impacts should be conducted and considered during the development of adaptation programs on Marz level.

Hydropower Generation:

• Hydropower, being renewable and green source of energy, contributes to the reduction of CO_2 emissions, HPPs also have negative impacts on the river aquatic ecosystem. The main negative impact is the disturbance of environmental flow in a certain part of the river that led to the deterioration of aquatic ecosystem and biodiversity. Obviously, with the projected reduction of the river flow due to climate change, this problem becomes more complicated. However, currently, water use permits for HPP exploitation are given for up to 25 years.

• The Protocol Resolution № 8 as of 01.03.2018 "On Approval of Environmental Impact Assessment Criteria for the Construction and Operation of Small Hydro Power Plants" highlights the necessity of establishment of criteria for the construction and operation of SHPPs in order to ensure the sustainability of river ecosystems. However, the importance of the vulnerability assessment of the 69 river flow due to the climate change in short-term, mid-term, and long-term perspectives is not listed among those criteria.

• In the Small Hydropower Plants Development Scheme (2010), hydroenergy indicators for more than 100 HPPs have been analyzed, however, issues related to the projected river flow reduction also not covered. For two of those 100 HPPs – Shnogh and Meghri, there are also investment prefeasibility studies conducted. In those studies, climate change adaptation issues have also not been discussed.

• In the Development Strategies for Marzes it is briefly discussed that the reduction of river flow due to the climate change will also reduce the hydropower potential of the rivers. However, more specific assessments should be conducted and adaptation programs on Marz level should be developed. Under the CEPA, RA is encouraged to approve a list of rivers prohibited for construction and operation of small hydro power plants.

Construction of Water Reservoirs:

• As in the design of previously constructed reservoirs, nowadays, only the hydrological elements of the river flow, including the fluvial alluvium (hard flow) are calculated in the technical and economic documents to design and construction of the reservoir. The adopted sector development strategy does not take into account short and long-term trends in river flow and accumulation of the fluvial alluvium (determine the dead volume of the reservoir) due to climate change.

• The national development strategy and concepts for construction of water reservoirs in the country do not address the evaporation range at the water surface and its further trend under climate change, thus, the future economic benefits of reservoirs are not considered, as well.

• Although the regional programs and Marz development strategies mention the high importance of the construction of the reservoir to develop the agriculture sector, nevertheless, they do not assess and forecast the potential changes in microclimate and its impact on the environment and biodiversity around the area of reservoir construction.

General Recommendations for Further Studies and Overcoming the Adaptation Issues**.** To improve the hydrometeorological data and models reliability, the following steps needs to be taken:

• Extension of the hydrometeorological network through the establishment of the new up-to-date observation stations (measuring flow velocity, water level, precipitation, water and air temperature, snow depth and density) at the rivers' flow formation zones (at the altitudes of 2200–3000 *m*) in 14 major river basins in the country defined by the RA National Water Program, 2006.

• Evaluate the gaps in the minimum input data for hydrological models and analyze the options for filling those gaps.

• Select the hydrological models that will provide the most reliable results for the territory of Armenia, taking into account the physical-geographical, socio-economic conditions and availability of the input data for these models.

To strengthen the knowledge management and inter-institutional collaboration, it is recommended to establish the center of excellence for water resources and climate studies under the Ministry of Environment. The responsibilities of this center can include:

• Evaluation and recommendation of the climate and hydrologic models for future studies;

• Evaluation and approval of the National Communications of Armenia to UNFCCC;

• Determining and analyzing data gaps and define necessary data for hydrological modeling (hydrometeorological data, water use data, hydrogeology, topography, soil composition, vegetation, land use).

The center should also be responsible for finding the ways to cooperate with IPCC and other international organizations such as UNESCO and WCRP for transferring the best practices in climate models downscaling and water resources vulnerability assessment for the regions with conditions similar to Armenia.

Conclusion. To address the adverse impacts of climate change in the water sector, adequate adaptation measures need to be developed and embedded into the national and regional water strategies and basin management plans. These measures include, but not limited to:

• setting up domestic and industrial wastewater discharge and treatment standards to promote water reuse;

• determining the quantitative norms of irrigation water for different crops, taking into account the climatic conditions and climate change trends;

• setting up irrigation water quality standards;

• assessment of the safety risks of the dams considering the flood intensification with the climate change, evaluation of possible microclimatic changes in the reservoir construction zones;

• calculation of the environmental flow for reservoirs with a new methodology, considering the predicted changes in the river flow under the climate change impacts;

• increasing the level of awareness and environmental education on climate change at all levels.

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ՀԱՅԱՍՏԱՆՈՒՄ ՋՐԱՅԻՆ ՌԵՍՈՒՐՍՆԵՐԻ ՀԱՄԱՊԱՐՓԱԿ ԿԱՌԱՎԱՐՄԱՆ ԽՆԴԻՐՆԵՐԸ ԳԼՈԲԱԼ ԿԼԻՄԱՅԱԿԱՆ ԵՎ ՋՐԻ ՃԳՆԱԺԱՄԻ ՀԱՄԱՏԵՔՍՏՈՒՄ

Ամփոփում

Կլիմայի փոփոխության համատեքստում բնական ջրային ռեսուրսների արդյունավետ օգտագործումն ու պաշտպանությունը ջրային ռեսուրսների կառավարման առանցքային խնդիրներից են: Հայաստանն այն երկրներից է, որտեղ կլիմայական փոփոխություններն ակնհայտ են վերջին տասնամյակների ընթացքում: ՀՀ օդի ջերմաստիճանի վերաբերյալ պատմական տվյալները վկայում են վերջին տասնամյակների ընթացքում զգալի աճի միտումի մասին: Հոդվածում ներկայացված են Հայաստանի գետերի ջրի քանակի և որակի վրա կլիմայի փոփոխության ազդեցության գնահատման արդյունքները: Գետերի բնական հոսքի վրա կլիմայի փոփոխության ազդեցության կանխատեսումները և քննարկումներն իրականացվել են տարբեր մեթոդների և մոդելների կիրառմամբ: Պարզվել է, որ հարկավոր է մշակել համապատասխան հարմարվողական միջոցառումներ և դրանք ներառել ազգային և տարածաշրջանային ջրային ռազմավարություններում և ավազանային կառավարման պլաններում՝

ուղղված Հայաստանի ջրային ռեսուրսների վրա կլիմայի փոփոխության բացասական ազդեցությունների մեղմանը:

А. А. АРАКЕЛЯН, Л. А. МАРГАРЯН

ПРОБЛЕМЫ ИНТЕГРИРОВАННОГО УПРАВЛЕНИЯ ВОДНЫМИ РЕСУРСАМИ В АРМЕНИИ В КОНТЕКСТЕ ГЛОБАЛЬНОГО КЛИМАТИЧЕСКОГО И ВОДНОГО КРИЗИСА

Резюме

В условиях изменения климата эффективное использование и охрана природных водных ресурсов являются одной из ключевых задач управления водными ресурсами. Армения является одной из стран, где климатические изменения последних десятилетий очевидны. Исторические данные о температуре воздуха в Армении указывают на значительную тенденцию к ее повышению за последние десятилетия. В статье представлены результаты оценки влияния изменения климата на количество и качество воды рек Армении. Прогнозы и обсуждение влияния изменения климата на естественный речной сток проводились с использованием различных методов и моделей. Выявлено, что необходимо разработать адекватные меры по адаптации и включить их в национальные и региональные водные стратегии и планы управления бассейнами для устранения неблагоприятного воздействия изменения климата на водные ресурсы в Армении.