Analysis of the role of long-term and short-term periods of inflow in reservoirs water resources planning

Analyse du rôle des périodes d'afflux à court et à long terme dans la planification des ressources en eau des réservoirs

Reza Kanani[1*]

[1]PhD. of Water Resources Engineering, East Azerbaijan Regional Water Corp., Iran

Abstract. Predicting of inflow discharge to reservoir dams is very important in achieving the purposes of reservoirs water planning. Due to climate change and human activities in the upstream of basins in recent years, the time series of discharge data has generally had downward trend. Therefore, estimating of the discharge in different statistical periods (long-term, medium-term and short-term) and analyzing it in the selection of project purposes has undeniable importance. In this study, the estimate of inflow discharge in 4 dams located in East Azerbaijan province (northwest of Iran) in different statistical periods was performed, and the effect of selecting each statistical period in the dams water resources planning was analyzed. The results showed that depending on the conditions of each basin, the selection of the appropriate discharge period will be different. But in general, choosing a short period of 15-20 years is appropriate and effective in achieving the goals of the project. Keywords: Inflow, Reservoir, Long-term, Short-term, East Azerbaijan

Résumé. La prévision du débit entrant dans les barrages-réservoirs est très importante pour atteindre les objectifs de la planification de l'eau des réservoirs. En raison du changement climatique et des activités humaines en amont des bassins ces dernières années, la série chronologique des données de débit a généralement eu une tendance à la baisse. Par conséquent, l'estimation du débit dans différentes périodes statistiques (long terme, moyen terme et court terme) et son analyse dans le choix des finalités du projet a une importance indéniable. Dans cette étude, l'estimation du débit entrant dans 4 barrages situés dans la province de l'Azerbaïdjan oriental (nord-ouest de l'Iran) à différentes périodes statistiques a été réalisée, et l'effet de la sélection de chaque période statistique dans la planification des

* Corresponding author: rezakanani@gmail.com

ressources en eau des barrages a été analysé. Les résultats ont montré qu'en fonction des conditions de chaque bassin, le choix de la période de rejet appropriée sera différent. Mais en général, choisir une courte période de 15 à 20 ans est approprié et efficace pour atteindre les objectifs du projet.

1 Introduction

Changes in water resources of catchments due to climate change and human activities in recent years lead to changes in the inflow of reservoir dams. These changes affected on water resources programming of dams and, of course, its quantitative objectives. Estimation of average inflow discharge of dams is generally done using the long term of discharge time series. While, due to hydrological changes in recent years, especially in arid and semi-arid regions, these estimates is not realized. Therefore, in this research, it has been tried to use different short-term periods for estimating the input flow, and its results to be determined and compared in quantitative purposes of the project such as regulatory water volume and consumption levels.

Few studies have been done on the main purpose of this article, but several similar ones can be mentioned. One apparent implication is that water resources planning methods should be modified. Few of studies, however, have attempted to account for either the chain of uncertainty in projecting water resources system vulnerability to climate change, or the adaptability of system operation resulting from existing planning strategies. Major uncertainties in water resources climate change assessments lie in a) climate modeling skill; b) errors in regional downscaling of climate model predictions; and c) uncertainties in future water demands [1]. The potential effects of climate change on the hydrology and water resources of the Colorado River basin are assessed by Christensen et al (2004) by comparing simulated hydrologic and water resources scenarios driven by observed historical (1950–1999) climate. Releases from Glen Canyon Dam to the Lower Basin (mandated by the Colorado River Compact) were met in 80% of years for the control climate simulation (versus 92% in the historical climate simulation), and only in 59–75% of years for the future climate runs [2]. A rapid increase in demand and severe droughts in recent years has increased the pressure on water supplies throughout most parts of Australia. This has resulted in the need for tools to allocate limited water across users in different regions, and explore scenarios so as to achieve economic, social and environmental benefits. A major challenge in water resource allocation is dealing with the uncertainty in the system, particularly with respect to reservoir inflow [3]. In a study by Ahmadi et al (2014), by applying a meta-heuristic, multi-objective optimization approach, real-time optimal operation rules of Karoon4 dam are extracted as two-objectives by considering performance criteria of the reservoir as objective functions. Although the dependence of reservoir release in each period to inflow during the previous period improves the values of objective functions compared with the dependent on forecast state, the difference is insignificant. Also, a comparison of results of long-term operation with real-time operation shows that bcomputed real-time operation rules are flexible and accurate [4]. Other similar studies have been performed by Ma et al (2010), Hu at al (2012) and Zhang et al (2018).

2 Material and methods

The catchments studied in this study include Kalghan, Vanyar, Ghaleh-Chai and Aydoghmush reservoir dams located in East Azerbaijan province, northwest of Iran. The specifications of the above dams are presented in Table 1. The location of these dams is also

shown in Figure 1. In order to compare the inflow of dams, the data of hydrometric stations located in upstream of the dams in the available statistical periods have been used.

Table 1. Information of the studied dams.

No.	Name of Dam	Type	Establish year	Area of catchment (km^2)	Volume (mcm)	Height (m)	Regulatory volume (mcm)
1	Vanyar	rockfill	Under construction	7723	361.2	48	300
2	Aydoghmush	rockfill	2005	1625	145.7	67	131.5
3	Kalghan	embankment	2020	190	22	54	24
4	Ghaleh-chai	embankment	2008	250	40	77	46

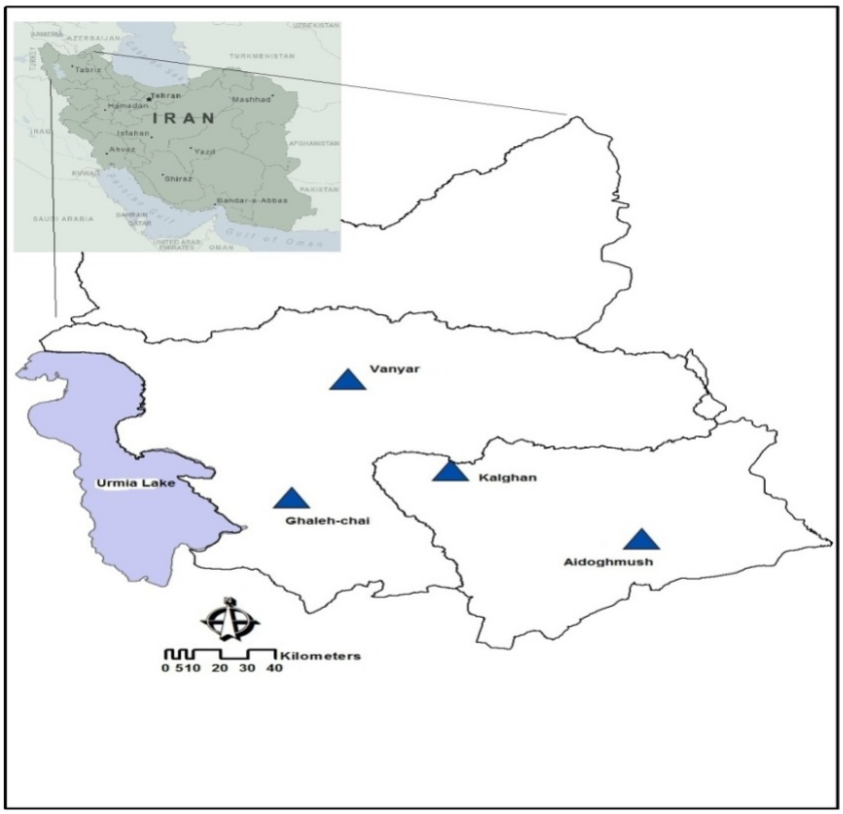


Fig. 1. Location of the studied dams in East-Azerbaijan province, northwest of Iran.

3 Results and Discussion

Due to the hydrological changes in the catchment areas of reservoir dams located in the study area due to climate change and human activities in recent years, the study of water resources of the four dams was considered. For this purpose, different periods of discharge time series (long-term, medium-term and short-term) were used to estimate the volume of inflow to the dams. A summary of the results of estimating the volume of inflow of each dam in different

periods is presented in Table 2. It is observed that generally the volume of inflow decreases significantly with the shortening of the statistical period.

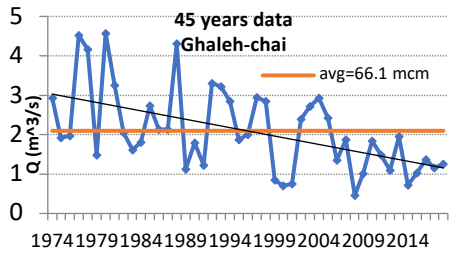
Discharge changes in different time series along with their trend line were plotted and examined. Figure 2 shows the changes in discharge values during statistical periods for Ghaleh-Chai and Kalghan dams as an example. As can be seen, the study of the trend line of the data shows that in Kalghan and Ghaleh-Chai dams, the 20-year period has the lowest trend slope and the discharge time series is relatively static. This result is also relatively consistent with the evidence in the basins and the streamflow observational data in recent years.

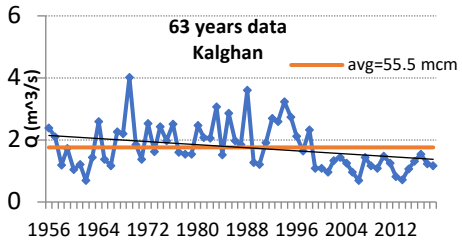
Table 2. Calculated inflow volume in various discharge periods in studied dams (mcm).

No.	Name of Dam	Total data	35 years	30 years	25 years	20 years	15 years
1	Vanyar	327	303	288.7	287	263	249
2	Aydoghmush	200.5	190.3	190.4	188.1	172.6	144.3
3	Kalghan	55.5	51.1	47.2	44.4	36.5	36.2
4	Ghaleh-chai	66.1	59.2	55.1	52.6	46.4	46.2

It should be noted that flow changes are due to climatic and human factors. The purpose of this article is not to analyze the causes of flow reduction. But to show climate change in the region, the results of trend analysis of temperature variables in Liqhvan station located in the basin by Mann-Kendall test showed that the temperature has an increasing trend in all seasons. Especially in winter and spring, the increasing trend of T_{mean} and T_{max} is very significant (Z=2.33). Also, the analysis of the trend of precipitation variables showed that the amount of precipitation in the spring has a decreasing trend [8].

In relation to Vanyar and Aydoghmush dams, the results showed that the average of the 15-year period gives a more appropriate estimate of the potential of inflow. Due to the fact that the catchment area of these two dams is larger and upstream have been more affected by hydrological changes and human activities, as a result, the average inflow water is more reduced. While the basins of Kalghan and Ghaleh-Chai dams are smaller and the dams are located in upstream, so less than the other two dams are subject to discharge changes.





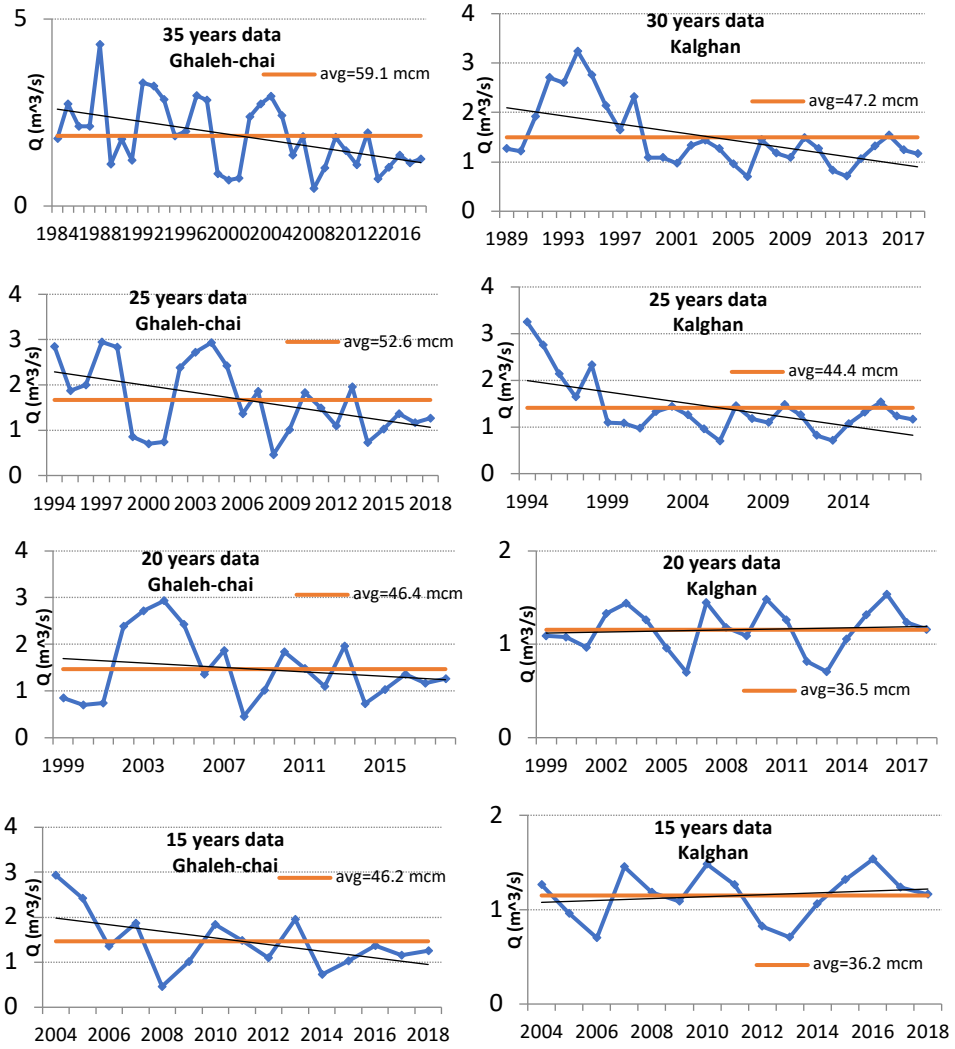


Fig 2. Changes of inflow discharge in Ghaleh-chai and Kalghan dams in various time series.

A review of the estimation of water resources of dams has significant implications for the quantitative objectives of the project. For example, by selecting a short 15-year period in Vanyar Dam, the volume of regulated water of the dam will be reduced from initial 272.8 mcm to 180.3 mcm and the land area of the irrigation network will be reduced from 27,000 ha to 11,000 ha.

In the case of Aydoghmush dam, by selecting a 15-year discharge period, the volume of regulated water has been changed from 131.5 mcm to 82.1 mcm and the area of its irrigation network will be reduced from 9472 ha to 7450 ha.

4 Conclusion

Due to hydrological changes in catchments and reduction of discharge of rivers in arid and semi-arid regions such as Iran in recent years, in this study the estimate of inflow to four dams Vanyar, Aydoghmush, Kalghan and Ghaleh-Chai located in northwest of Iran is

reviewed. For this purpose, the average discharge in different periods was estimated and studied. The results showed that in dams whose catchment area is relatively small and are located upstream and before entering the plain, the average 20-year discharge period is a suitable amount for planning. In dams that have a large catchment area and are located almost in the plain, due to the impact of more activities in upstream, the average 15-year discharge period is more appropriate. According to the above revisions, it is necessary to review the planning of water resources of dam and project design in different dimensions.

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