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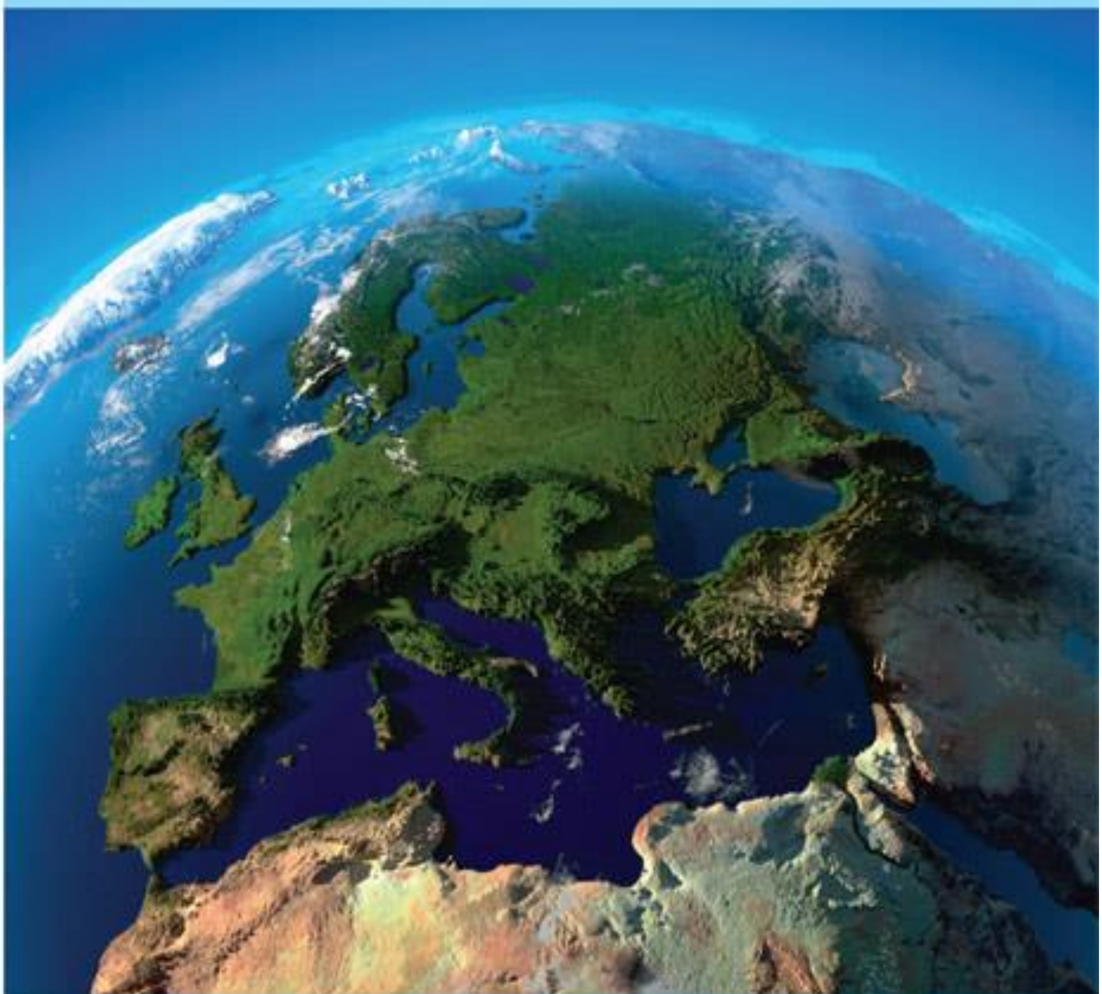

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Several approaches to the estimation of the components of the consuming part of water balance on irrigation territories

Abstract: In the abstract a series of the up-to-date approaches to the estimation of the components of the consuming part of water balance on irrigation territories are considered on the example of Karshi irrigation region (KarIR) of Uzbekistan.

Keywords: irrigation, irrigated territory, water balance equation, incoming part of the equation, elements of consuming part of the equation, quantitative assessment of the consuming part.

As it is known, during the recent years in Uzbekistan the attention is given to the studies of the irrigated lands hydrology [1–7 and others]. The results of these studies give possibility to make systematization of the existing methods of the quantitative estimation of the component of the water balance of irrigated territories. Taking this in mind, it is concluded that this work considers the issues of assessment of the components of the present water balances of irrigated territories of Kashkadarja oasis.

Regarding the water balance equation of the newly irrigated territory of the studied territory, i. e. Karshi irrigation area (KIrAr), we propose the following:

$$X + У_п + У_{КМК} + V_п = У_о + V_о + E_с + P + \Delta U + \Delta W + \Delta W_в \pm \Delta У. \quad (1)$$

According to the above mentioned water balance equation KIrAr (1), its left part, i. e. atmospheric precipitation (X), surface inflow ($У_п$), water inflow along the Karshi main canal ($У_{КМК}$), underground inflow ($V_п$) characterizes the incoming part of the water balance. The surface outflow ($V_о$), total evaporation ($E_с$), water consumed for the industrial and municipal-and-domestic needs (P) are related to the elements of the consuming part of equation (1).

This equation, unlike the equation for the before irrigated zone, also accounts for such additional discharge elements as the moisture resources changes in aeration zone (ΔU), ground water (ΔW) and water reserves in water storages ($\Delta W_в$). ± ΔУ characterizes the discrepancy of the water balance equation.

The values of the regeneration flow from the given territory can be taken as the value of the surface outflow ($У_о$) out of the KIrAr contours. The ground outflow ($V_о$) from the territory is taken into account in the calculation of the underground inflow — as the difference between the inflow and underground water outflow ($V_п – V_о$) by the data of S. Sh. Mirzaev [3].

The value of the total evaporation ($E_с$) from the surface of the studied territory can be estimated as the sum of evaporation values from the irrigated areas ($E_о$), from the surfaces of the inner systems of the inner not ploughed areas ($E_п$) and from the water surfaces of canals and water storages ($E_в$):

$$E_с = E_о + E_п + E_в. \quad (2)$$

For the estimation of the evaporation quantity from irrigated areas ($E_о$) KaIrAr we analyzed the materials and results of the previous researches of evaporation from the studied region calculated by different authors [1; 2; 4; 5; 9]. Regarding the results of these investigations, the evaporation value of 1090 mm. was taken as the layer of evaporation from the complex irrigated hectare for 1981–2015.

The value of evaporation from the water surface of Talimarjan water storage located on that territory was taken as 1663 mm. In the calculation of the value of evaporation layer the designed indices and regime of this water storage operation were taken for the account.

The change of the ground water resources (ΔU) in KarIR is calculated as follows:

$$\Delta U = m \cdot \Delta H \cdot F, \quad (3)$$

where: m — factor of water compatibility of different grounds taken to be 0.34 for the territory of KarIR; ΔH — change of the ground water level taken to be:

$$\Delta H = H_i - H_{i+1}, \quad (4)$$

where: H_i — average value of the area-averaged ground water level in the beginning of the designed period; H_{i+1} — the same in the beginning of the next period; F — total area of the 1st turn of KarIR development which equals 266 thous. he. Average area-weighted ground water level is determined by the maps of the depth of ground water level. For this the maps of the depth of ground water level for 1965, 1974 and 1979, i. e. — for different stages of Karshi steppe development, mapped by the specialists of the Central Asian Planning Institute for Water and Cotton [3; 7] were used.

Average area-weighted ground water level for KarIR during the next years (1990, 2000, 2005, 2010, 2015) were determined using the materials of the Kashkadarja province administration for the water and agriculture economy. It should be noted that during the recent years the number of wells and frequency of observations of ground water level there was decreased substantially which affected the accuracy of the expected results.

The above mentioned results made it possible to draw the chronological graph for the variation of depth of the ground water level in KarIR (Fig. 1). In the drawing of this graph it was assumed that the rise of ground water level is smooth. This graph, i. e., $H_{cp} = f(T)$ curve was used for calculation of the average weighted ground water level (H_i) of the investigated territory.

Analysis of the initial materials has shown that maximum values of the moisture resources changes in aeration zone (ΔU) accorded to the initial period of development of KarIR, i. e., in relation to the intensive rise of the ground water level in the result of the irrigation of this territory.

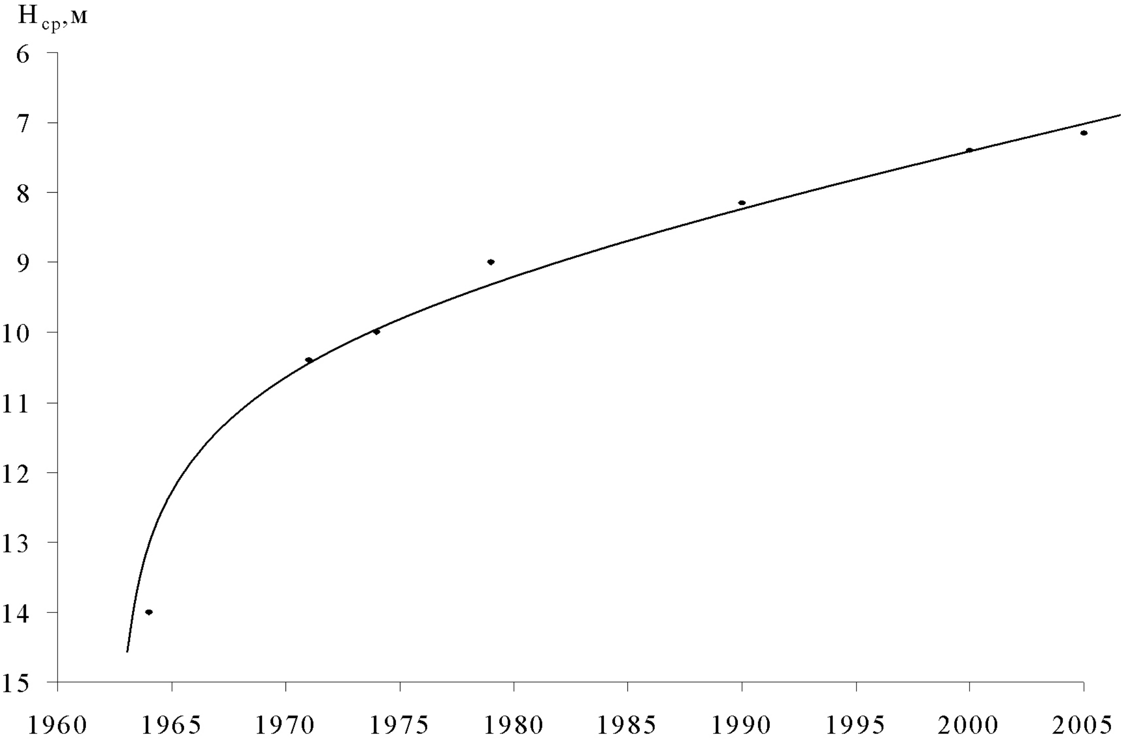

Fig. 1. Annual change of the area-averaged ground water level (Hcp) in KarIR

Estimation of the amount of water used for the moisture accumulation in the soil grounds in aeration zone (ΔW) was made as follows:

$$\Delta W = (H_i - НКП) \cdot \alpha_1 - \alpha_2) \cdot \Delta F_o, \quad (5)$$

where: H_i — is the initial average area-weighted ground water level; НКП — height of capillary rise; α_1 — initial (voluminal) humidity of the non-irrigated soils in the layer from the upper border of capillary rise to the original ground; α_2 — value of the voluminal humidity with which the down movement of moisture in the same layer starts after beginning of irrigation; ΔF_o — irrigated area increment for designed period — in our case — for the designed year.

It should be taken into account that the initial values of the average area-weighted values of ground water level (H_i) are known. Using the experience of the former researches [6] we can make the conclusion that the height of capillary rise for the studied territory is taken as 3.5 m. As it is known, the difference ($\alpha_1 - \alpha_2$) presents the increment of the humidity value in the unit of the soil volume in the beginning of irrigation. F. E. Rubinova and M. I. Getker [5] proposed that its value equals 0.06. The values of the irrigated area increment (ΔF_o) for the designed period are calculated using the initial materials of Kashkadarja province administration for the water and agriculture economy.

The values of the equation (5) components calculated in the above mentioned order, made it possible to calculate the value of the moisture reserves changes in aeration zone (ΔW) for the designed period, i. e. — for a year. The value of ΔW

characterizes the water quantity which can be absorbed by the soil grounds during the development of virgin lands with the deep initial ground water level.

It should be pointed out that the appropriateness of this approach to determination of the water quantity used for accumulation in the ground soils ($\Delta U + \Delta W$) was proved by F. E. Rubinova and M. I. Getker [5] earlier. They calculated this quantity by two independent techniques, i. e., by the water balance equation and by separate calculation of ΔU and ΔW values. As it is asserted in [6], the results of both methods of ΔU and ΔW values calculation are comparable, which testifies to the absence of significant errors of our method used for the calculation of the water balance elements.

In the result of change of the ground water reserves and water accumulation in soil grounds in aeration zone of the investigated territory during the first ten years according to the designed five-year periods (1971–1975 and 1976–1980), 184 and 198 mln. m^3/year of water was used respectively, which comprises 9.9 % of the water intake from Amudarja river via Karshi main canal. We calculated that these values were 5.7 % and 2.6 % during the designed five-year periods, i. e., 1981–1985 and 2001– 2006. These digits give the reason to prove that the flow losses for watering the soil grounds on KarIR territory are decreasing from year to year.

The results of investigation carried out by F. E. Rubinova and M. I. Getker [6] on the example of Hunger Steppe can be used for comparison. Their data show that during the development of this territory 15 % of the taken river flow was used for watering of the soil grounds. In Karshi Steppe the ground water level did not reach the depth mark of drainage system yet, that is why the process of water accumulation still continues.

Thus, during 1981–2005 in KarIR the specific losses of the river flow varied from 10.1 to 14.2 thous. m^3/he. Simultaneously, for each hectare of irrigated territory 12.9– 16.1 thous. m^3 was taken from the source. In the result of this, during this period (i. e., from the beginning of 80-s and up to 2005) the value of collector flow varied in the range of 23.9–47.6 m^3/s. In relation to the inflow of the surface water they were 18.5 and 35.4 %, respectively.

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