ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 5, Issue 3 , March 2018

Modeling of Water Resource Management Processes in River Basins (on the example of the basin of the Kashkadarya River)

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ABSTRACT: The equation of the water balance of the river basin is used to create a simulation model for water resources management in river basins. To implement the simulation model, the use of the regulating capacity of the reservoirs gives quite good results. Thus, solutions of equation (1) are obtained, which allows simulating the change in parameters that contributed to the management of the regime of functioning of the main reservoirs of the basin of the Kashkadarya River.

KEYWORDS: Kashkadarya river, water balance, mathematical formalization or modeling, hydrographic network, groundwater.

I.INTRODUCTION

Over the last years a rapid population growth of the Republic of Uzbekistan has shown a high local demand for food and water supply. Moreover, the population of Uzbekistan is projected to reach 34.2 million by 2025 [1], which will put extra pressure on agriculture, i.e., the need to produce more food with limited land and water resources. The agriculture sector of Uzbekistan relies heavily on the resources of the Amudarya and Syrdarya rivers as well as on small tributaries rivers which have transboundary and national characters [2].

The topography of the Kashkadarya Province is diverse: In the northeast, east and southeast the province is bordered by the Zarafshan and Gissar mountain ranges, the highest points of which rise up to 3,750-4,400 m a.s.l. The territories of Shakhrisabz, Kamashi, Dehkanabad and partially Chirakchi rural districts refer to the mountainous areas. In general, altitudes degrade in the northwest, which define the main features of the territorial division of labor, specialization of agricultural production and the main features of agrogeography of the province.

In the plain part, which occupies about half of the basin, there are three areas according to physical and geographical characteristics: Karshi Steppe; Sundukli Sands; areas of Kitab, Shakhrisabz Basin and Guzar-Karshi Oasis [1, 3]. The management of water resources in the Aral Sea Basin is a highly complex process that is further complicated by the rising demand for energy and food, environmental degradation, and increased pressure on the region’s finite water resources due to economic development, population growth, and climate change [4].

II. SIGNIFICANCE OF THE SYSTEM

Formulation of the problem. The basis of mathematical formalization or modeling of the state and methods of water resources management in river basins is water-balance methods. Water balance can be considered as a method of scientific research (from the group of balance methods), which allows deep penetration into the processes of formation of the hydrological regime and reveal their regularities. The technical means of realizing this aspect of the water balance arethe water balance equations that characterize the relationship between the arrival and the flow of water for selected sections of the territory or water bodies at certain intervals, namely for the basin of the Kashkadarya River, whose hydrographic network is depicted in Fig 1.

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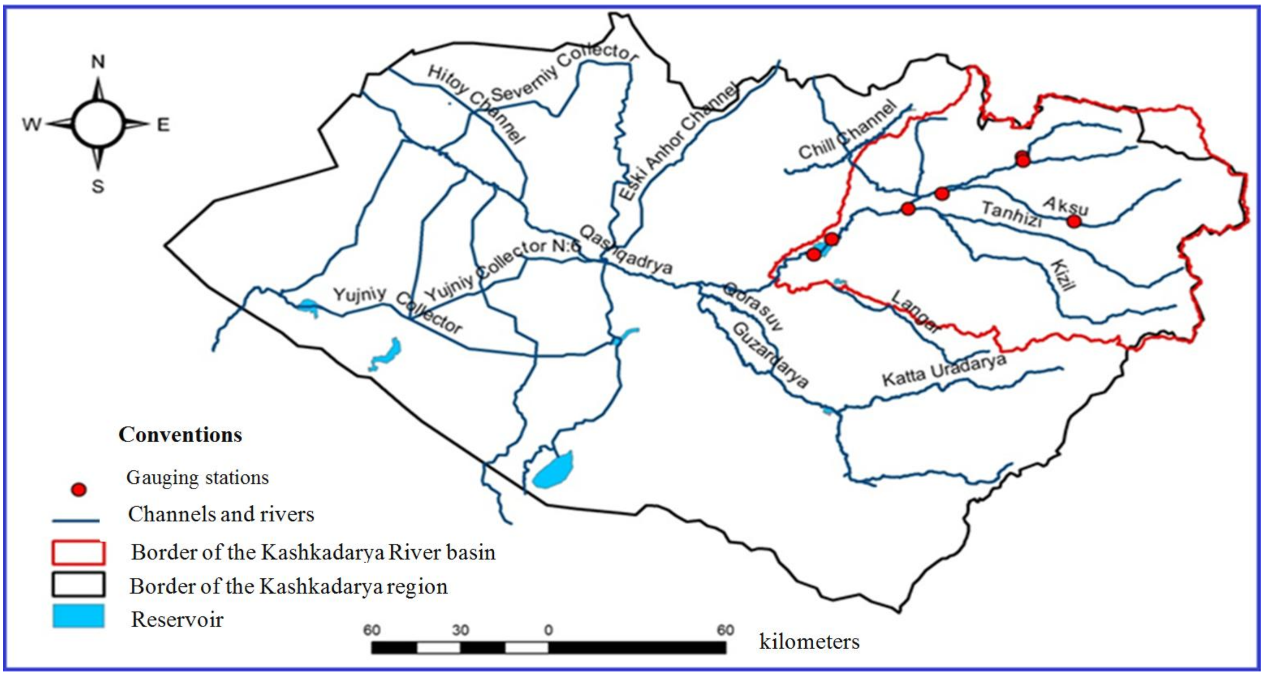

Fig 1: Hydrographic network of the basin of the Kashkadarya River and the border of its formation

III. LITERATURE SURVEY

In the basin of Kashkadarya, there are 3122 rivers, of which only 149 rivers have a length of more than 10 km, 33 have a length of 20 km or more [4]. At different times, observations of the runoff of water were conducted or conducted on 18 rivers in 51 stations, the Karasu-Nizhaya, Garauchashma and Shurabsai rivers are not rivers as such, but the so-called "Karas" in Central Asia, that is, water objects formed due to seepage irrigation waters into soil and their outlet to the surface of the earth naturally by lower irrigation zones and having all the signs of natural rivers. Out of 51 stations, 25 are located on river sites with undisturbed economic activity flow regime taking into account the Akdarya-kishlar post. Hazarnau, which before the creation of the reservoir above the post in 1984, was also on the river with undistorted drainage. Therefore, only the data of these 25 posts are used to estimate the natural water resources of the basin.

In the basin of Kashkadarya, as in many river basins of Central Asia, two areas are clearly distinguished: the area of formation of the runoff and the area of its dispersion. The boundary between them can be conditionally drawn along an isohypse of 600-700 m.

The modeling of water resources management in river basins, in particular the Kashkadarya river basin, with the help of regulation of the operating mode of the water outlet facilities of the reservoir waterworks is worthy of attention.

Together with these, the modeling of the regime for regulating water river basins must meet the demand for water for the needs of the economy, especially for irrigation. However, in this research, this aspect of the problem of managing the use of water resources in river basins has not been adequately addressed, the following sections of this work are devoted to solving this problem.

IV. METHODOLOGY

Research methods. To draw up the equation of water balance, a structural diagram of the formation and use of water resources of the KashkadaryaRiver basin (Fig 2) [5-6]

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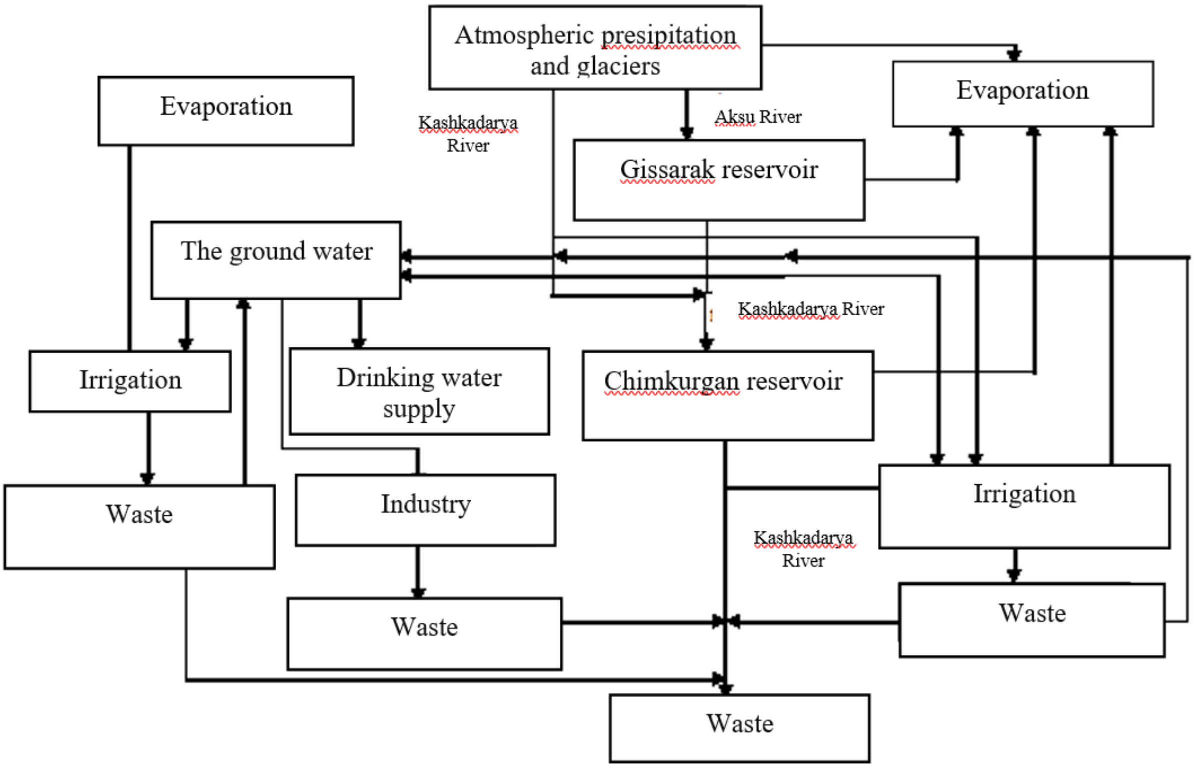

Fig2: Structural diagram of the formation and use of water resources of the Kashkadarya River basin.

Dataset Description

Investigation of the process. Surface water resources of the river. Kashkadarya is completely regulated (a mechanism for water resources management has been established) by reservoirs and other hydraulic structures. The largest reservoirs in the basin of the KashkadaryaRiver are the Gissarak and Chimkurgan.

V. EXPERIMENTAL RESULTS

The capacity of the thickets of the Gissarak and Chimkurgan reservoirs is capable of ensuring sustainable water management throughout the basin of the Kashkadarya River. Reservoirs are capable of regulating the water resources of the basin for many years, these reservoir features ensure that they become the main"Water Bank" in the basin of the Kashkadarya River. Using these features of the reservoir we compiled a model in the form of a balance differential equation. To compile a balance differential equation, we use the following scheme (Fig 2).
Then the water balance equation of the KashkadaryaRiver basin is written as:

$$W_{Kash}(t) = W_{Chim}(t) + W_{Gis.}(t) + W_{in}(t) - W_{loss}(t) \quad (1)$$

The following notations are used in equation (1):

$W_{Kash}(t)$ - change in the flow of water in the basin of the KashkadaryaRiver during–*t;*

$W_{Gis}(t)$ and $W_{Chim}(t)$ -volumes of water in the water bank-in the Gissarak and Chimkurgan reservoirs during –*t*;

$W_{in}(t) -$ the volume of all incoming water in the basin of the Kashkadarya River;

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$W_{consump}(t)$ - Volume of loss and used for variouswater needs in the basin of the Kashkadarya River.

Whence the constituent items of thewater balance of the basin of the Kashkadarya River are characterized as follows:

$$W_{in}(t) = W_{river}(t) + W_{draft}(t) + W^{+}_{in.gw} + W^{+}_{reset} \quad (2)$$

In equation (2): $W_{river}(t) -$ the river runoff formed by the catchment area of the rivers of the Kashkadarya basin and the flow of the river- Q_{river} in m^3/s entering the Gissarak and Chimkurgan reservoirs is determined from Table 1 (data from 2012)

Table 1

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
64,2	61,8	82,7	218	417	550	414	232	135	98,1	86	72,4

$$W_{river}(t) = \int_{t_0}^{t} Q_{river} dt = Q^{0}_{river}(t - t_0)$$

At $Q_{river}(t_0) = 0$, then

$$W_{river}(t) = Q^{0}_{river}(t)$$

$$W_{river}(t) = Q^{0}{}_{river}(t) * 0,26 * 10^{6} mil.m^{3} / month.$$

$W_{draft}(t)$ - the amount of atmospheric precipitation, determined dependingon the season in the basin of the Kashkadarya River, without taking into account the catchment area, in which directly the river runoff is formed, is taken from the data in Fig. 3, while the area is 14240 – 1424= 12816km^2.

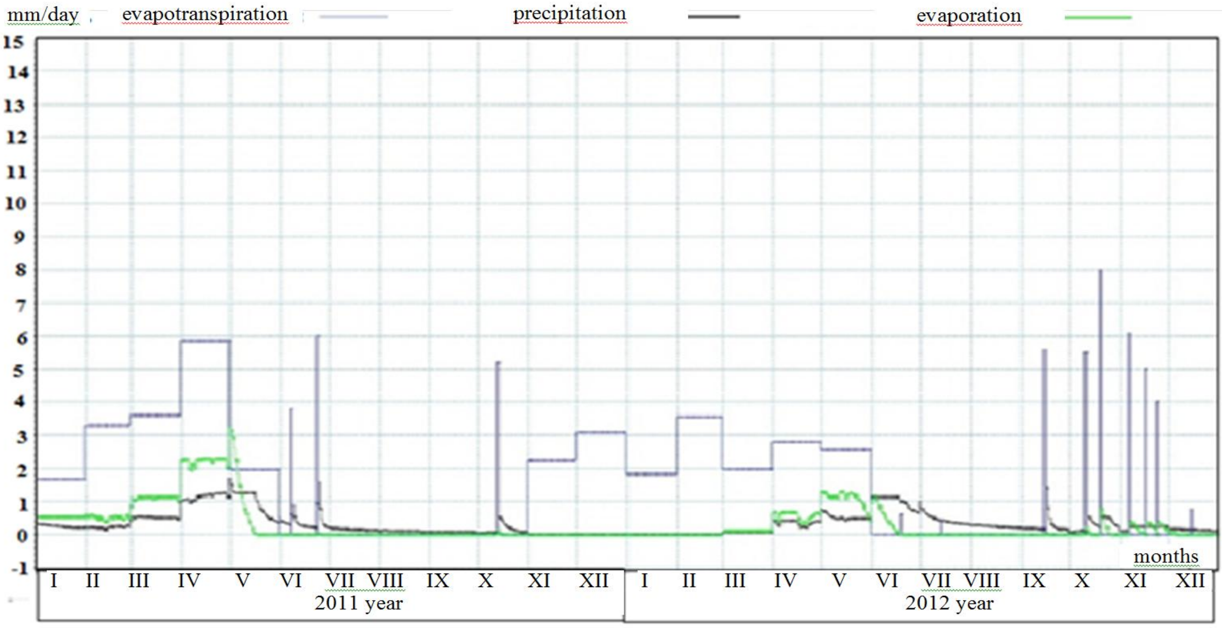

Fig3: Calculation data for the numerical solution of the simulationmodel of river basin management

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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$$W_{draft}(t) = \int_{t_0}^{t} Q_{dr} \ dt = Q_{dr}^{0}(t) \ \ Q_{dr}^{0}(t_0) = 0$$

$$W_{draft}(t) = Q^{0}{}_{dr}(t) * 12816 * 10^{3} dt(m^{3} / month) \quad (3)$$

$W_{in.gw}^{+}$ – the influx of groundwater, determined by the dependence

$$W_{in.gw}^{+} = \int_{t_0}^{t} Q_{in.gw} dt = Q_{in.gw}^{0} \int_{t_o}^{t} dt = Q_{in.gw}^{0}(t)$$

$$Q_{in.gw}^{0}(t_0) = 0$$

$$W_{in.gw}^{+} = Q^{0}{}_{in.gw}(t) = (0{,}0317 \mu \Delta h_{consump} F)(t) \quad (4)$$

where the following designations have been adopted:

$Q^{0}{}_{in.gw}$ - the flow of water coming from underground sources into the river basin;

0,0317- conversion factor;

μ- water loss factor (in fractions of a unit), 0.25 is assumed;

F – The area of the deposit (in our case, 1949 km^2). $\Delta h_{consump}$ -Amplitude of oscillation of GWL (when spending groundwater) is determined from Table 3.

Average monthly values of fluctuations in the level of groundwater in the wells of the basin of the Kashkadarya River with the use of groundwater.- $\Delta h_{consump}$.

Table 3

Year of observation	Months ($\Delta h_{pacx.}$ in meters)											
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
2007	3,12	3,15	2,91	2,65	2,33	1,96	1,48	1,29	1,96	2,31	2,72	2,92

W_{waste}^{+} - the part of the used water in industry, in drinking water supply and in irrigation through waste channels, back gets back into the river. This value is determined from Table 4.

Table 4

Months	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Overall**

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Returned stream in the river, million m^3/month	143,2	149,4	151,5	168,4	172,1	183,2	188,6	177,5	159,6	142,3	144,2	146,5	1926,5

The volume of the runoff of the water formed due to dumping from irrigation, from treatment facilities and industry, which then returns to the Kashkadarya River

Thus, the income part of the equation of the water balance takes the following form:

$$W_{in.}(t) = W_{river}(t) + W_{draft}(t) + 15,446\Delta h_{consump.}(t) + W^{+}_{waste} \quad (4)$$

Expenditures for the water balance of the basin of the KashkadaryaRiver are characterized as follows

$$W_{consump.}(t) = W_{evap} + W^{-}_{gw.} + W_{drin.w} + W_{evapotr} + W_{indstr.} + W_{fish.f.} + W_{irig.} \quad (5)$$

$W_{evap.}$ -evaporation from the territory of the basin of the KashkadaryaRiver, the area of the basin is 14240 km^2 (Fig. 3), for this area, the weather station data located at the Guzar weather station are characteristic.

Then: $$W_{evap}(t) = Эevap * 14240 \frac{10^6}{10^3} dt = Эevap(vmm) * 14240 * 10^3 dt(m^3 / month) \quad (6)$$

$W^{-}_{in.ungw}$ -the inflow to the groundwater is determined, in this case only the amplitude of the fluctuation of groundwater's changes- $\Delta h_{pr.}$, due to the inflow of surface water to groundwater sources (for surface water losses, and for groundwater arrival).

Thus, solutions of equation (1) are obtained, which allows simulating the change in parameters that contributed to the management of the regime of functioning of the main reservoirs of the basin of the Kashkadarya River (Fig. 4).

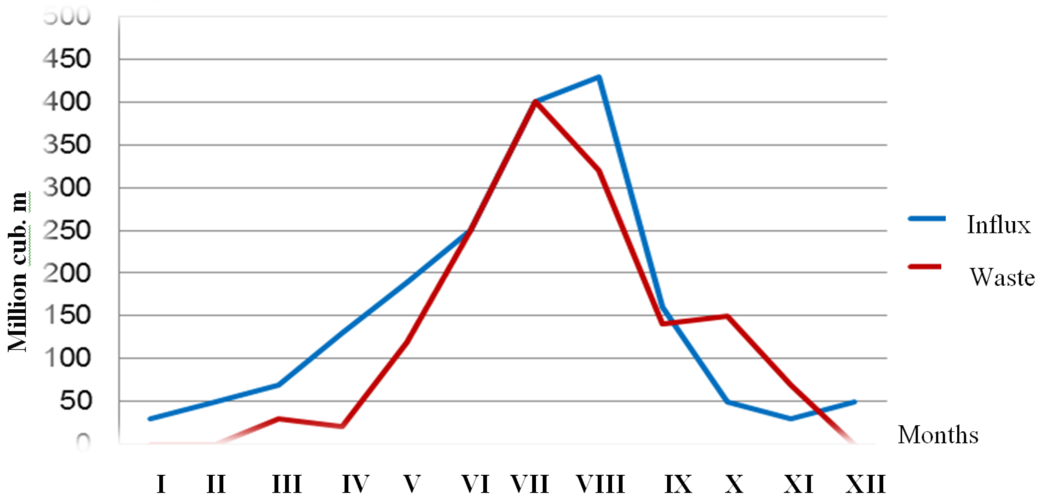

Fig4: Simulation of control over the operation mode of the Chimkurgan reservoir of the KashkadaryaRiver basin.

VI.CONCLUSION AND FUTURE WORK

The equation of the water balance of the river basin is used to create a simulation model for water resources management in river basins. To implement the simulation model, the use of the regulating capacity ofthe reservoirs gives quite good results.

Confirmation of the possibility of using a simulation model to regulate the operation of reservoirs is illustrated in Figures 3 and 4.

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