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WATER RESOURCES MANAGEMENT OF DISTRIBUTED IRRIGATION SYSTEMS

Aydarova Aysulu Bakitovna
system analyst in “BRI GROUP” LLC.
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ABSTRACT

The development of a management system and the determination of trends in the parameters of water use in the context of climate change is important. The climate of Uzbekistan is sharply continental, arid, due to the southern location of the republic and a great distance from the oceans. The average amount of precipitation in the desert zone of the country is less than 200 mm/year, and in the foothills and mountains - varies from 400 to 800 mm / year, with a maximum in the highlands up to 2000 mm/year [1].

In the Republic of Uzbekistan, only 11.5 km3 of surface runoff of internal rivers is formed, 9.5 km3 of return and groundwater, as well as 60-67 km3 of water resources come from the transboundary rivers of the Amu Darya and Syr Darya, depending on the water content of the year.

Data on the use of the republic's water resources by the branches of the country's economy for the period 1991-2015 are given in Table 1.1. The table shows that the largest consumer of the republic's water resources is irrigation, which provides water to the irrigated agriculture of the country [2].

Use of water resources of the republic by industry for the period 1991-2015. Table 1.1

Year	Used water	In this						
		Irrigation	Housing and communal services	Factory	Energy		Fish producing	Others
					Total	Irrevocable		
1991	61681	55395	2334	1982	-	-	713	1257
1992	61510	55658	2133	1784	-	-	536	1399
1993	62131	55773	2052	2273	-	-	543	1490
1994	58445	53381	2392	1002	-	-	530	1140
1995	52960	47614	2298	1021	-	-	536	1143
1996	53525	49485	2263	801	4317	203	501	272
1997	56158	52091	2317	790	4184	198	417	345
1998	56697	52871	2082	779	4364	246	402	318
1999	60705	56661	2317	874	4213	128	409	316
2000	48070	44406	2182	735	3947	76	372	299
2001	44012	40366	2160	757	3956	78	361	291
2002	50259	46296	2336	688	3953	91	430	418
2003	56501	52443	2164	823	4265	195	508	367
2004	58457	52219	2150	851	4068	203	524	548
2005	59476	53265	2158	776	4387	209	721	473
2006	58616	52509	2283	814	4446	217	520	523
2007	53006	47528	2304	798	4737	251	484	528
2008	43870	38589	2325	804	4735	273	463	435
2009	50225	44719	2357	834	4557	255	765	561
2010	57169	51645	2385	839	4870	246	694	548
2011	48751	43389	2387	838	4916	256	569	576
2012	56096	50906	2362	744	4729	255	662	554
2013	53977	48912	2357	675	4554	250	621	582
2014	51794	46857	2335	691	4561	256	562	582
2015	55138	49970	2407	667	4487	252	803	593

Currently, an average of about 50 km3 of water is taken for irrigation of 4.3 million hectares of irrigated lands of the republic [3]. Specific water consumption in recent years in the Syrdarya River basin is 10.4 thousand m3/ha, in the Amudarya basin 12.5 thousand m3/ha. m3.

Irrational use of water and its low efficiency are the main limiting factor limiting the development of irrigated agriculture. The main reasons for low efficiency are significant filtration losses from main channels, on-farm network and, directly, during irrigation production. Only half of the water taken from the source is used in the fields of farmers and dehkan farms, as well as other water users [4].

Let there theoretically be some linear dependence between the variables x and y. However, in reality, there is not such a rigid connection between x and y. Individual observations of y will deviate from the linear dependence due to the influence of various reasons. Usually the dependent variable is influenced by a number of factors, including unknown to the researcher, as well as random causes (disturbances and interference). Measurement errors are a significant source of deviations in some cases. Deviations from the assumed form of the relationship, of course, can also occur due to incorrect specification of the equation, i.e. incorrect choice of the type of the equation itself describing this dependence [1]. In the future, we will assume that the specification is executed correctly. Taking into account possible deviations, the linear equation of the relationship of two variables (pair regression) is represented as

$y = \alpha+\beta x+\varepsilon$, (1.1)

where α and β - unknown regression parameters (coefficients); ε - a random variable that characterizes the deviation from the theoretically assumed regression - perturbation.

Thus, in equation (1.1), the value of y is represented as the sum of two parts - systematic (x) and random (ε). In turn, the systematic part can be represented as an equation

$\acute{y}= \alpha+\beta x$, (1.2)

where ý characterizes some average value of y for a given value of X.

With respect to the perturbation ε , we make the following assumptions:

1) the perturbation ε is a normally distributed random variable;

2) mathematical expectation ε equal to: $M(\varepsilon) = 0$;

3) the variance of perturbations is constant: = const:

4) the successive values of ε are independent of each other.

So, when constructing a regression (in this case, linear pair regression), we accept the hypothesis that the following dependence is valid for each observation i

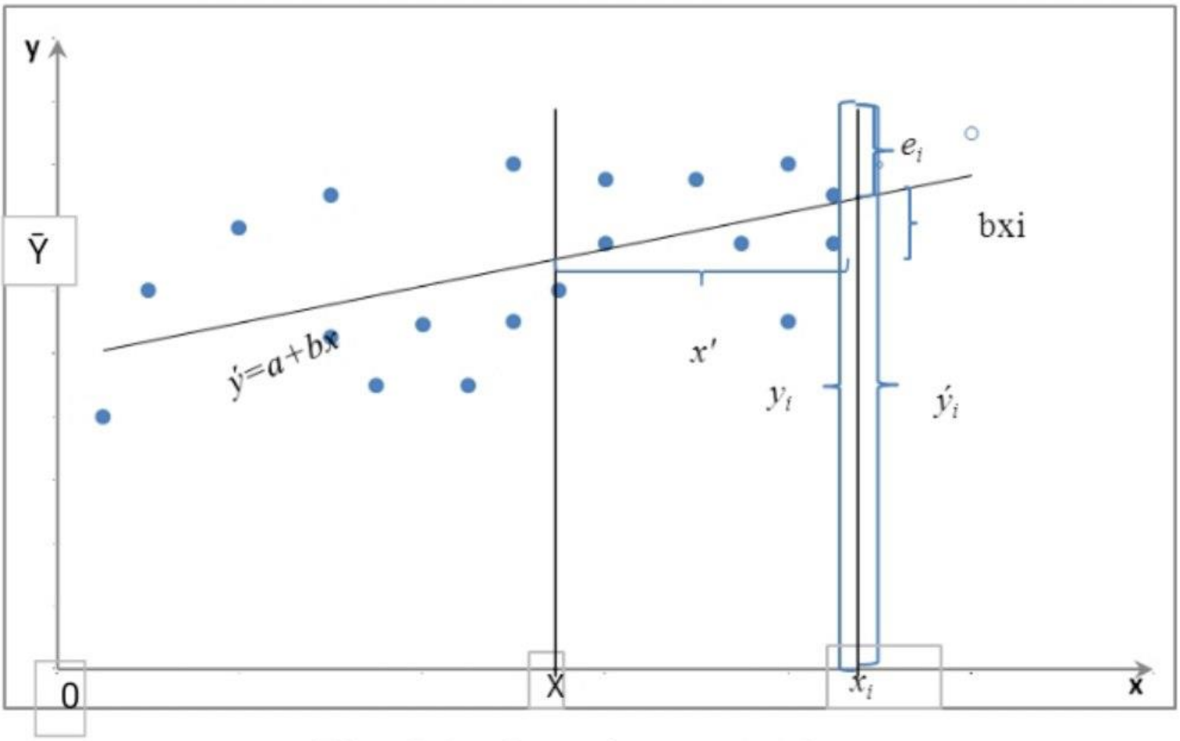
$y_i=\alpha+\beta x_i+\varepsilon_i$. (1.3)

As a result of statistical observation, we have a number of characteristics of the independent variable x and the corresponding values of the dependent variable y. The task is to determine the parameters α and β. However, the true values of these parameters cannot be obtained, since we rely on a limited sample, so the found parameter values are statistical estimates of the true parameters.Denote the corresponding estimates as a and b. Thus, the equation of paired regression has the form

$\acute{y}= \alpha+bx$ (on model $y=\alpha+\beta x+\varepsilon$). (1.4)

Having accepted some hypothesis about the shape of the curve describing the relationship of variables x and y, nevertheless, we cannot unambiguously choose the parameters of the equation unless conditions are put forward that an equation with numerically estimated parameters should meet. In fact, through the area of the correlation field in which the points corresponding to individual observations are located, many lines can be drawn (for example, connect the first and last point or the first and penultimate, etc.). It is necessary to adopt some criterion according to which the selection of parameters can be carried out. Different methods of parameter estimation rely on different selection criteria and, of course, give different values of parameter estimates for the same set of observations. At the same time, it turns out that the estimates obtained have different statistical properties.

Consider the graph (Fig. 1.1), which shows the results of observations of the values of variables x and y.



Pic. 1.1. Couple regression

A straight line a = α +βx is drawn through the area occupied by the points.The deviation (perturbation) of any point with coordinates xi, yi will be the value ei

ei= yi- ýi=yi-(α+bx), (1.5)

where yi - fact, ýi – calculated value.

As from (1.5), value ei (it is often called the residual term) is a function of the parameters a and b.

Similarly, a function of these parameters is a generalized indicator of the scattering of points around a straight line, namely Σ. Hence, it is logical to accept the criterion according to which the regression coefficients a and b should be selected so that the sum of the squares of the values ei is minimal, i.e. Σ=min.

A necessary condition for the existence of the minimum of the function is the equality of partial derivatives with respect to unknown parameters a and b to zero. So, we find for the function

$$Q = \sum e_i^2 = \sum_i (y_i - \bar{y}_i)^2 = \sum_i (y_i - a - bx_i)^2 \qquad (1.6)$$

partial derivatives of a and b and equate them to zero.

We get

$$\begin{cases} \frac{\partial Q}{\partial a} = -2\Sigma_i (y_i - a - bx_i) = 0 \\ \frac{\partial Q}{\partial b} = -2\Sigma_i (y_i - a - bx_i) x_i = 0 \end{cases} \quad (1.7)$$

Having transformed the system, we obtain the standard form of normal equations

$$\begin{cases} \Sigma y_i = na + b\Sigma x_i \\ \Sigma x_i y_i = a\Sigma x_i + b\Sigma x_i^2 \end{cases} \quad (1.8)$$

Dividing the first equation of the system (1.8) on n, we get

$$\overline{Y} = a + b\overline{X} \quad (1.9)$$

Thus, the OLS gives such estimates a and b, the found line passes through a point with coordinates

Using a standard statistical application program, the parameters of dependencies (1.8) of the relationship of various sectors of the country's economy are determined and the results of their calculations are given in Table 1.2.

Calculations of the influence of the relationship of solar radiation power on water consumption by industry of the country

Table 1.2.

№	Water users	Closeness of the relationship (correlation coefficient), R	Relationship equations	Notes
	Total using	-0,860	Q=5998566,9-4342,5 P ± 3398,1	*
		-0,905	Q=4763068,4-3446P ± 5384,4	*
	Irrigation	-0,931	Q=2381277-1851,15P ± 3202,0	*
		-0,926	Q=1072743,6-745,55 P ± 1321,9	*
	Home	0,795	Q=37,143 P-48523,5 ± 78,17	
	Factory	0,931	Q=53,77 P-72788,8 ± 55	
	Energy	0,771	Q=148 P-198064,7 ± 219	
	Fish producing	0,909	Q=110,6P-150714,2 ± 144,0	
	Others	0,99	Q=97,83P-133462,4 ± 103,23	

Note: * - in billion m3.

As can be seen from Table 1.2., R has negative and positive values. Negative values mean a decrease in water consumption and water use in the republic, and positive values mean an increase. From this it can be seen that due to the influence of solar radiation power, the total water intake in the republic and water use in irrigation are decreasing, and in other sectors of the country's economy they are increasing. To further refine these data, it is necessary to constantly organize accurate measurement of water resources consumed in all rivers, reservoirs and other water intakes that provide water resources to the country's economic sectors.

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