NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 10, Oct. -2020

CRITERIA FOR EVALUATING THE STATE AND WATER RESOURCES MANAGEMENT OF WATER SYSTEMS OBJECTS OF THE REPUBLIC OF UZBEKISTAN

SHAVKAT KHUDARGENOVICH RAKHIMOV
Doctor of Technical Science, Professor, Scientific Research Institute of Irrigation and Water Problems.
Junior Researcher, Scientific Research Institute of Irrigation and Water Problems, 100007, Tashkent, Uzbekistan, e-mail:

ABDURAHMON ERMUMINOVICH CHUPONOV
Senior Lecturer of the Karshi branch of the Tashkent University of Information Technologies named after Muhammad al-Kharizmi, 180100, Karshi, Uzbekistan,
e-mail: abdurahmon19@mail.ru

FAYZULLA JALILOVICH DUSIYOROV
Junior Researcher, Scientific Research Institute of Irrigation and Water Problems, 100007, Tashkent, Uzbekistan, e-mail: fayzulla.dusiyorov@mail.ru

ABSTRACT:

The objects of research are the objects of water management systems of the Republic of Uzbekistan. The criteria for assessing the status and management of water resources of objects of water management systems make it possible to assess their condition and manage the water resources of objects. Methods are used to determine the criteria for assessing the status and management of water resources.

Criteria have been developed for assessing the status and management of water resources of objects of water management systems: basin departments of irrigation systems, departments of district irrigation, departments of pumping stations and energy, departments of main canal operation, departments of reservoir operation, reclamation expeditions, departments of irrigation systems, which will make it possible to determine various methods and water management models in the Republic of Uzbekistan.

KEYWORDS: criterion, state assessment, management, water resources, facilities, water management system, minimization, square deviation, flow rate, level of water resources.

INTRODUCTION:

The Ministry of Water Resources of the Republic of Uzbekistan includes a large number of water management systems and facilities, for which it is constantly necessary to assess their status and manage their water resources.For these systems and facilities, it is necessary to develop and use appropriate criteria for assessing the status and management of their water resources.

The water management systems include basin departments of irrigation systems, departments of district irrigation, pump stations and energy departments, main canal management (gravity and with machine lifting systems), reservoir management, reclamation expeditions and irrigation system management.

MATERIALS AND RESEARCH METHODS:

The criteria for assessing the status and management of water resources of water management systems are as follows:

1. Basin management of irrigation systems (BMIS).

The criterion for the management of water resources of the BMIS is to minimize the use of actual water resources of the basin management [1,2]

$$I_{BMIS} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left(F_{ij} - F_{ij}^{*}\right) \rightarrow \min, \quad (1)$$

where F_{ij} – is the volume of water intake; F_{ij}^{*} – actual used water resources in the sectors of the national economy of the republic related to this BMIS.

2. Departments of irrigation of districts (DIR).

The criterion for water resources management of the DIR is to minimize the use of actual water resources of the district irrigation department [1,2].

$$I_{DIR} = \sum_{i=1}^{N}\sum_{j=1}^{N}\left(D_{ij} - D_{ij}^{*}\right) \rightarrow \min, \quad (2)$$

where D_{ij} – is the water withdrawal limit, D_{ij}^{*} – actual water resources used in the area.

3. Management of pumping stations and energy (MPSE).

The criterion for the management of water resources by MPSE is to minimize the use of actual volumes of pumped water resources and consumed electricity [2,3]

$$I_{MPSE} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left(V_{ij} - V_{ij}^{*}\right)\int_{0}^{T}\left(N_{ij} - N_{ij}^{*}\right)dt \rightarrow \min, \quad (3)$$

where V_{ij} – is the total amount of water resources; V_{ij}^{*} – actual used water resources; N_{ij} – consumed electricity, actually used electricity.

4. Management of the operation of main canals (gravity and with systems of machine water) (MOMC).

The criterion for managing water resources of gravity canals is to minimize the use of actual water consumption and the quadratic deviation of the difference between the set and actual water levels in hydraulic structures [1,4]

$$I_{MOMC(gravity)} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left\{\left(Q_{ij}^{c} - Q_{ij}^{c*}\right) + \left(z_i(l,t) - z_i^{*}\right)\right\}^2 \rightarrow \min, \quad (4)$$

where Q_{ij}^{c} – is the total consumption of water resources; Q_{ij}^{c*} – Actual consumption of water resources z_i - $z_i(l,t)$ given and actual values of water levels at hydraulic structures.

The criterion for managing the water resources of the main canals with machine water-lifting systems is to minimize the use of actual water consumption and energy consumption [1,5]

$$I_{MOMC\,(MWLS)} = \left[\sum_{i=1}^{I}\sum_{j=1}^{J}\left(Q_{ij} - Q_{ij}^{*}\right)\int_{0}^{T}\left(N_{ij} - N_{ij}^{*}\right)dt\right] \rightarrow \min \quad (5)$$

where Q_{ij} – is the total consumption of water resources; Q_{ij}^{*} – actual pumped water consumption; N_{ij} – electricity needed; N_{ij}^{*} – actually used electricity.

5. Management of the operation of reservoirs (MOR).

The criterion for controlling the process of filling and operating reservoirs is to minimize the quadratic deviation from the actual water volume of the reservoir from the planned one, taking into account water losses due to evaporation and filtration

$$I_{MOR} = \left\{\left(W_B(T) - W_n\right)^2 + \int_{0}^{T} Q_b(t)dt\right\} \rightarrow \min, \quad (6)$$

where $W_B(T), W_n$ – is the actual and planned volume of reservoir water for evaporation and filtration $Q_b(t)$ – water loss from the reservoir for evaporation and filtration.

6. Land reclamation expeditions (LRE).

The criterion for managing the water resources of the collector-drainage network is to maximize the discharge of collector-waste water into the collector and various depressions [6]

$$I_{LRE} = \sum_{i=1}^{I} \left(K_{ij} - K_{ij}^{k} \right) \rightarrow \max, \quad (7)$$

where K_{ij} – is the total groundwater volume, K_{ij}^{*} – actual discharge of collector-drainage water into various depressions.

7. Management of irrigation systems (MIS).

The criterion for the management of water resources at MIS is the minimization of the use of the actual expenditures of water resources and the quadratic deviation of water levels in hydraulic structures from their given value [1.8]

$$I_{MIS} = \left\{ \sum_{i \in N_B} \int_0^T \sum_{j=1}^{N_{ij}} \left[\left(Q_{ij}(t) - Q_{ij}^{*} \right)^2 + \sum_{j=1}^{N_y} \left(z_i(l,t) - z_i^{*} \right)^2 \right] dt \right\} \rightarrow \min, \quad (8)$$

where Q_{ij}, Q_{ij}^{*} – is the actual and planned value i and j – water consumer; $z_i(l,t)$, z_i^{*} – actual and set water level values for hydraulic structures.

Based on the structure of the water management system and taking into account their local criteria, the quality control indicator of the process of water supply, water distribution and water loss can be written as a common functional [9,10]

$$I = \left\{ \alpha_1 I_1 + \alpha_2 I_2 + \alpha_3 I_3 + \alpha_4 I_4 + \alpha_5 I_5 + \alpha_6 I_6 + \alpha_7 I_7 \right\} \rightarrow \min, \quad (9)$$

Where $I_1 = \sum_{i,j \in N_Б} \left(F_{ij} - F_{ij}^{*} \right);$ $\quad I_2 = \sum_{i,j \in N_O} \left(D_y - D_y^{*} \right)$

$$I_{3(УНСЭ)} = \sum_{i,j \in N_{НС}} \left(V_{ij} - V_{ij}^{*} \right) \int_0^T \left(N_{ij} - N_{ij}^{*} \right) dt;$$

$$I_4 = \sum_{i \in N_B} \left(W_B^i - W_n^i \right)^2 + \int_0^T Q_b(t) dt;$$

$$I_5 = \sum_{i,j \in N_{МК}} \left\{ \left(Q_y - Q_y^{*} \right) + \left(z_i(l,t) - z_i^{*} \right) \right\} \int_0^T \left(N_y - N_y^{*} \right) dt;$$

$$I_6 = \sum_{i \in N_{МЭ}}^{I} \left(K_{ij} - K_{ij}^{k} \right);$$

$$I_7 = \left\{ \sum_{i \in N_{НС_в}} \int_0^T \sum_{j=1}^{N_{ij}} \left[\left(Q_{ij}(t) - Q_{ij}^{*} \right)^2 + \sum_{j=1}^{N_y} \left(z_i(l,t) - z_i^{*} \right) \right] dt \right\};$$

$$\sum_{i=1}^{7} \alpha_i = 1; \; 0 \le \alpha_i \le 1;$$

N_B – many basin-based irrigation systems; N_D – many water facilities of the district irrigation department; N_{PS} – many nodes with pumping stations in the water management system; N_{MC} – many sections of the main canal (gravity and with MWLS); N_W – many sites of reservoirs in the water management system; N_{LRE} – many reservoirs in the water management system; N_{LRE} – many reclamation expeditions; N_{IS} – a plurality of channel section numbers having lateral outlets; α – weighting factors determined by expert assessments of the significance of individual local criteria.

Water management systems include reservoirs and their cascades, pumping stations and their cascades, sections of canals limited by hydraulic structures, and side water intakes to provide consumers with water resources. [1]

RESERVOIRS:

The criterion for controlling the process of filling and discharging the reservoir is written in the form [11,12]

$$I_1 = \left\{ (W_B(T) - W_n)^2 + \int_0^T Q_n(t)dt, \right\} \to \min$$

(10)

where WB (T) - is the actual volume of reservoir water at the end of the control period; Qn (t) - is the intensity of water losses due to evaporation and filtration; Wn- is the planned volume of reservoir water at the end of the management period.

The physical meaning of criterion (10) is to minimize the quadratic deviation from the actual reservoir water volume from the planned at the end of the control period and the volume of water losses due to evaporation and filtration.

The restrictions on the reservoirs are as follows [13]

$$W_B^{\min} \le W_b(t) \le W_B^{\max}(t),$$

$$\frac{dz_b(t)}{dt} \le z_H,$$

(11)

where $W_B^{\min}, W_B^{\max}(t) -$ minimum and maximum allowable values of water volumes in reservoirs; $z_b -$ maximum permissible value of the rate of filling and discharge of the reservoir.

Pumping stations:

The criterion for controlling the process of water supply in pumping stations is to minimize the consumed electric power while ensuring a given water supply of pumping stations [14]

$$I_2 = \left\{ \sum_{j \in M_{HC}} \int_0^T \left(\sum_{i \in N_j^P} N_i^j \left(H_{LH}^j, H_{UH}^j \left[N_j, N_j^p, \psi_j^p \right] \right) \right) dt \right\} \to \min$$

(12)

at $\left| Q^{PS} - Q^* \right| \le \varepsilon,$

where N_i- is the consumed electric power of the pumping stations; ; Q^{HC}, Q^*– actual and required capacity of pumping stations; $H_{LH}^j, H_{UH}^j - N_j -$ levels of the lower and upper heads of pumping stations; N^p – the number of working pumping units; ψ^P – many numbers of working pumping units; many angles of rotation of the blades of axial pumps (for pumping stations with centrifugal pumps - the number of working centrifugal pumps of the pumping station); ε - - set error of water supply regulation.

THE MAIN RESTRICTIONS AT PUMPING STATIONS ARE [15]

$$\left(N_i^{\min}, N_i^{P\min}, \psi^{P\min}\right) \le \left(N_i(t), N_i^P(t), \psi_I^P(t)\right) \le \left(N_i^{\max}, N_i^{P\max}, \psi_i^{P\max}\right), \quad i = 1,\dots,6$$

, (13)

where N_i^{min} and N_i^{max}- the minimum and maximum number of running pumping units; N_i^{pmin} and N_i^{pmax}- the minimum and maximum set of numbers of working pumping units; ψ_i^{pmin} and ψ_i^{pmax}- the minimum and maximum set of angles of rotation of the blades of the axial pumps of the *i*-pump station (for pump stations with centrifugal pumps, the minimum and maximum number of working centrifugal pumps of the *i*-pump station).

CHANNEL SECTION:

The control criterion for hydraulic processes in the channel section is to minimize the quadratic deviation of the water level in the channel from their predetermined value and has the form [16]

$$I_3 = \min \left\{ \sum_{j=1}^{Ny} \int_0^T \left[z_i(\ell_i, t) - z_i^* \right]^2 dt, \right\}$$

(14)

where *z(l,t)* is the actual change in the water level in the channel section,, , $z^*$is the set value of the water level in the channel section.

Functional (14) shows that during water distribution in the channel section, the set values of the water level fluctuations in the channel section were minimal, i.e. the process on the canal has become more stable, which is necessary to ensure water use

Technological restrictions on the operation modes of the channel sections has the form [17]

$$z_i^{\min} \le z_i(x_i, t) \le z_i^{\max},$$
$$Q_i^{\min} \le Q_i(x_i, t) \le Q_i^{\max}, \tag{15}$$

where $Q_i^{\min}$, $Q_i^{\max}$- minimum and maximum allowable water flow rates on the *i*-section of the channel; ;z_i^{min} , z_i^{max} - - minimum and maximum permissible ordinates of the free surface of water on the *i*- section of the channel.

Side water consumers. In lateral water consumers, the criterion for controlling the water distribution process can be the root-mean-square integral deviation of the actual water flow from the planned (limited) values for the control period, i.e. [18]

$$I_4 = \left\{ \sum_{i \in N_s} \int_0^T \sum_{j=1}^{N_s^i} \left(Q_i^j(t) - Q_{ij}^* \right)^2 dt, \right\} \to \min, \tag{16}$$

where $Q^j_i(t)$is the actual value of the water flow rate of the *j*-side water consumer; Q_{ij}^*- is the planned value of the water flow rate of the *i*-water consumer in section *j*

The main restrictions on hydraulic structures are [19,20]

$$a^j_i{}^{min} \le a^j_i(t) \le a^j_i{}^{max}, \tag{17}$$

a jimin, zimax - minimum and maximum permissible openings of gates of hydraulic structures.

CONCLUSIONS:

Criteria have been developed for assessing the status and management of water resources of objects of water management systems: basin departments of irrigation systems, departments of energy stations, departments of operation of main canals with self-draining and sisters of machine lifting, drainage management departments of reservoirs, reclamation expeditions and departments of irrigation systems that will make it possible to determine various methods and mathematical models of water use management in the Republic of Uzbekistan.

A general functional has been developed that defines a quality indicator for managing the processes of water supply, water distribution and water loss of objects of water management systems. The main restrictions on the management of reservoirs, pumping stations, sections of canals and hydraulic structures are identified, which will make it possible to determine the areas of management of objects.

REFERENCES:

1) Rakhimov Sh. Kh., Seytov A. Zh., Research report "Development of the scientific foundations for the formation, management and efficient use of surface and groundwaters of the Republic of Uzbekistan under conditions of climate change" Tashkent, NIIIVP at TIAME, 2017, -53s.
2) Rakhimov Sh. Kh., Begimov I., Gaffarov H. Sh., SeitovA. Zh. The theory of optimal control of water distribution in the channels of irrigation systems in conditions of discreteness of water supply to consumers. Monograph. Publishing house of Belgim LLC, Tashkent, 2017 p. 169.
3) Rakhimov Sh. Kh., Gaffarov Kh. Sh., SeitovA.Zh . Algorithms for optimal control of water distribution in the channels of irrigation systems in conditions of discreteness of water supply to consumers, // Land Reclamation and Water Resources of the Russian Federation, 2016, No. 6, C. 6-10. (05.00.00; No.51)
4) Rakhimov Sh. Kh., Gaffarov H. Sh., Seitov A. Zh. Prerequisites for optimal distribution of water in irrigation canal systems // Austrian Journal of Technical and Natural Sciences, No. 9–10, Vienna. 2017 C.50-58

5) Equations Ridolfi L., Porporato A., Revelli R. Green's Function of Linearized de Saint-Venant //Journal of engineering mechanics, ASCE (132)2, p.125-131.2006
6) Tsai C. W-C. Applicability of kinematic, noninertia, and quasisteady dynamics wave models to unsteady flow routing.// Journal of engineering mechanics. 129(8), p.613-627. 2003
7) Tsai C. W-C., and Yen B.C. Linear analysis of shallow water wave propagation in open channels. Journal of engineering mechanics. 127(5), p.459-472.2001
8) Jain S.C. Open channel flow, Wiley, New York, 1-345pp. 2001
9) Wang1 G.-T., Chen S. Asemianalytical solution of the Saint-Venant equations for channel flood routing. WATER RESOURCES RESEARCH, VOL. 39, NO. 4, USA, 2003
10) Ponce V. M., and A. Lugo. Modeling looped rating in Muskingum-Cunge routing, J. Hydrol. Eng., 6(2), 119–124, 2001.
11) Sturm T. W. Open Channel Hydraulics, McGraw-Hill, New York, 560 pages 2001.
12) Venutelli M. Stability and accuracy of weighted four-point implicit finite difference schemes for open channel flow. J HydraulEng 128(3):281–288. 2002.
13) Strub I, Bayen A Weak formulation of the boundary condition for scalar conservation laws: an application to highway traffic odeling. Int J Robust NonlinContr 16(16):733–748. (2006)
14) Mohapatra P.K., Chaudhry M.H., Numerical solution of Boussinesq equations to simulate dam-break flows. J HydraulEng 130(2):156–159 (2004)
15) Krstic M., Smyshlyaev A. Boundary control of PDEs: A course on backstepping designs. SIAM (2008)
16) Alleux J, Prieur C, Coron J.M., d'Andr´ea Novel B., Bastin G. Boundary feedback control in networks of open-channels. Automatica39:1365–1376. (2003)
17) Valérie Dos Santos, Mickael Rodrigues, MamadouDiagne.A multi-models approach of Saint-Venant's equations: a stability study by LMI. International Journal of Applied Mathematics and Computer Science, De Gruyter, 22 (3), pp.539-550. 2012, https://hal.archives-ouvertes.fr/hal-00701005
18) Rakhimov Sh. Kh., Begimov I., Research report "Development of criteria for interstate water management in Central Asia (final)".
19) Jalalov A.A. Water resources management in Uzbekistan - legal basis and areas for improvement, Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, Tashkent, 1997.-8c.
20) Daniel P. Loucks and Eelco van Beek,. Water Resources Systems Planning and Management An Introduction to Methods, Models and Applications – ISBN 92-3-103998-9 – © UNESCO 2005-680p