DEVELOPMENT OF ALGORITHMS FOR PLANNING AND MANAGEMENT OF WATER RESOURCES IN IRRIGATION SYSTEMS IN THE CONDITIONS OF CLIMATE CHANGING

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ABSTRACT:

The challenge of managing water resources in watershed irrigation systems involves addressing issues related to data collection and processing, as well as decision-making for large, dispersed areas (sometimes separated by tens of kilometers). Additionally, these water resources are utilized across various sectors of the national economy, such as energy, agriculture, industry, fisheries, and municipal use. Effective management of these water resources necessitates the handling and analysis of vast amounts of diverse data. Therefore, the development of planning algorithms for water resource management in irrigation systems in conditions of climate changing is an urgent task in the national economy of the Republic of Uzbekistan. This article is dedicated to solving the problems. This scientific endeavor focuses on establishing the principles for the formation, management, and efficient utilization of surface and groundwater in Uzbekistan, addressing the challenges posed by modern climate change and the increasing demand for water resources across the country's economic sectors. This effort aims to ensure food, social,

complex hydrographic scheme.	*water, and environmental security. Notably, addressing this issue is critical for ensuring the country's water security, which is integral to national security amidst the rising water needs of the population and economic sectors, especially in the face of recent climate change and human impacts on water resources.*

INTRODUCTION. A key strategy to enhance the effectiveness of water resource management in the irrigation system's watershed management is utilizing advanced computer technology, including databases and software modules, to address water resource management issues.

The irrigated lands of the Republic of Karakalpakstan today amount to about 500 thousand hectares, of which 420 thousand hectares are arable land, 9.2 thousand hectares are perennial plantings, 36.8 thousand hectares are hayfields and pastures, 34 thousand hectares are private plots.

Figure 1 depicts a simplified map of the Lower Amudarya Watershed Department of Irrigation Systems, showing the complete irrigation network of the Republic of Karakalpakstan and the Khorezm region, with the boundaries of the Department of Irrigation Systems marked. In the Republic of Karakalpakstan, there are six Irrigation Systems Departments and the Aral Delta Department.

Irrigation System Management “Paxtaarna–Nayman”; Irrigation System Management “Mangit-Nazarxan”; Irrigation System Management “Suenli”;Irrigation System Management “Kuvanishdjarma”; Irrigation System Management “Kattagar-Bozatau”; Irrigation System Management “Qizilketken-Kegeyli”.

Aral delta management

To supply irrigation water to the agricultural sectors, the republic has 908.5 km of main canals, 2651.5 km of inter-farm canals, and 19,162 km of on-farm canals, along with 262 hydraulic engineering and water intake structures and 716 hydrometric devices. Out of the total irrigated area, 364 thousand hectares, or 73%, have drainage systems. The collector-drainage network extends 19,649.9 km, comprising 1179.8 km of main, 2219.9 km of inter-farm, and 16249.0 km of on-farm canals, with the on-farm collector-drainage networks covering a specific length of 32.8 hectares.

Currently, developing planning algorithms for water resource management in irrigation systems under changing climate conditions is a crucial task for the republic. Decision-making in water resource management for watershed irrigation systems requires the storage, processing, and dissemination of vast amounts of diverse data. To address the challenge of managing large-scale data, a comprehensive system is necessary.

1. METHODS AND RESULTS

Any complex hydrographic scheme of a water management facility can be divided into several simple structures, which represent a tree graph. The tree graph structure is segmented into hierarchies. Two parameters are used to determine the hierarchy within the graph[1]:

$$\Omega_I = \left\{ \left[i, \quad K_i^{GR} \right], \ \forall i \in I \right\} \tag{1}$$

where i – the number of hierarchy; K_I^{GR} – number of groups in this hierarchy.

Groups are a collection of areas connected to their origins. There may be one or more sections in a group (Fig. 1).

Each group is defined by the following numbers

$$\Omega_\Gamma = \left\{ \left[j_{iG}, \ n_{ijG}, \ \mathrm{k}_{ijG} \right], \ \mathrm{k}_{ijG} \in N_{ijG}, \ \forall j_{iG} \in I_{iG}, \quad \forall i \in I \right\}, \tag{2}$$

where j_{iG} – group number in hierarchy; n_{ijG} – number of the section connected to this group with its end; k_{ijG} – number of groups in a given hierarchy; N_{ijG} – many numbers included in this group of river sections; I_{iG} – set of group numbers included in this hierarchy.

Each section of the graph is defined as follows [2]:

$$\Omega_M = \left\{ \left[m, \ k_{mV}, \ k_{mP}, m_u \right], \ \forall k_{mV} \in K_{mV}, \ \forall k_{mP} \in K_{mP}, \ \forall m \in M \right\}, \tag{3}$$

where m – plot number; k_{mV} , k_{mP} and m_u – accordingly, the number of water intakes, tributaries and sections at the end; K_{mV}, K_{mP} and m_u – set of numbers of water intakes, tributaries and numbers of sites located at the end, respectively. Each channel segment has its unique morphological and hydraulic characteristics, which, for instance, can be described for trapezoidal prismatic sections as follows[3]

$$\Omega_M^x = \left\{ \left[m, \ b_{0m}, \ m_m, \ i_m, \ n_m, \ l_m, \ \eta_m \right] \forall m \in M \right\}, \tag{4}$$

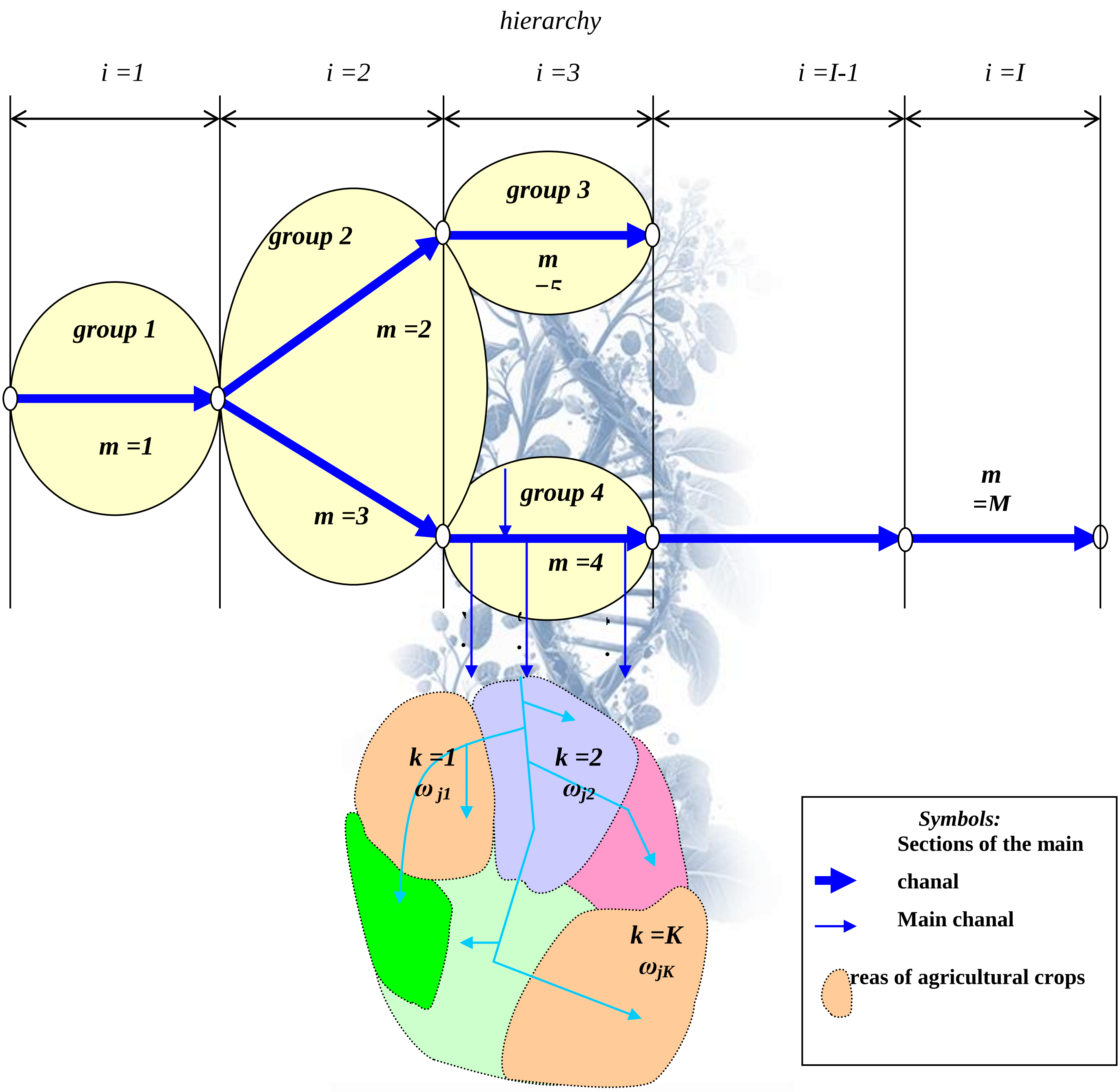

Figure 1 - Description of the elements of the main chanal

where m – plot number, b_{0m} – bottom width, m_m – slope coefficient, n_m – roughness coefficient, i_m – site bottom slope, l_m – section length, η_m – efficiency factor of the channel section.

In the case of a non-prismatic section of the channel, the characteristics are specified as follows

$$\Omega_M^x = \left\{ \left[m,\ h_{im},\ V_{im},\ Q_{im},\ l_m \right],\ \forall i \in I_m,\ \forall m \in M \right\}, \quad (5)$$

where m – plot number, h_{im} – depth, V_{im} – width at the top of the area in vertical section i, Q_{im} – water flow corresponding to this regime, i.e. flow characteristics of canal sections.

Therefore, the structure of the main canal is defined by the sets (1) – (5), which completely describe its topology and hydraulic characteristics.

$$\Omega_K = \Omega_I \cup \Omega_G \cup \Omega_M \quad (6)$$

Using the linear diagram of the main canal, hierarchies and groups are identified, and all sections, branches, and tributaries of the canal are numbered. After this, sets Ω_I, Ω_G, Ω_M are compiled in the form of a table with the corresponding fields, these tables are filled in in accordance with the accepted numbering of sections, branches, tributaries, groups and hierarchies. This depiction of the main canal structure is highly useful for creating a database and addressing water resource management issues of the main canal.

Let us examine the recording of balance relationships in the canal sections within the database, assuming the presence of steady-state regimes in the canal sections.

Water flow at the beginning of the channel section is determined as follows [7]

$$Q_m^H = \frac{Q_m^K + \sum_{j \in J_m^V} Q_{Vmj} - \sum_{j \in J_m^P} Q_{Pmj}}{\eta_m}, \quad \forall m \in M, \quad (7)$$

where Q_m^H, Q_m^K – water flow at the beginning and end, Q_{Vmj}, Q_{Pmj} – water flow of water intakes and tributaries, η_m – efficiency factor m – the th section of the canal.

In the groups of j_{iG} in the i – th hierarchy of the trunk channel structure, the balance ratios are written as [4]

$$Q_{n_{ijG}}^K = \sum_{k_{ijG} \in N_{ijG}} Q_{k_{ijG}}^H, \quad \forall n_{ijG} \in I_{iG}, \quad (8)$$

where $Q^K_{n_{ijG}}$ – water flow at the end of the section n_{ijG} – th section connected to this group at its end, $Q^H_{k_{ijG}}$ - water flow at the end of the section k_{ijG} – th section of the group channel j_{iG} .

For end sections in groups, water flow rates at the end of these sections are specified.

$$Q^K_{m_k} = Q_{m_k}, \quad \forall m_k \in M_k, \tag{9}$$

where $Q^K_{m_k}$ – water flow rates at the end of terminal sections in groups m_k – th section connected to this group at its end, Q_{m_k} – specified water flow in the end sections of the main canal, $M_k \in M$ – set of numbers of the final sections of the main channel.

By using expressions (7) – (9) with known water flow rates at the outlets of water intakes, tributaries, and the ends of the final sections of the main canal, starting from the last hierarchy of the canal structure, it is possible to calculate the required water flow rates at the beginning of all sections of the main canal. The resulting water flow rates ensure the specified flow rates at water intakes and the final sections of canals, considering the known water flow rates at tributaries and given efficiency values[18].

In the task of determining water needs during annual planning of water distribution for the growing season, crop irrigation regimes are used i, in which for each hydromodular region k in every watering j irrigation norms are given W_{ikjP}, irrigation timing, i.e. started t_{ikjH}, end t_{ikjK} and duration of watering $T_{ikj} = t_{ikjH} - t_{ikjK}$ [8]. Irrigation rate W_{ikO} for the growing season is determined as the sum of irrigation norms, i.e. $W_{ikO} = \sum_{j=1}^{N_i} W_{ikjP}$. Table 1, shows the irrigation regimes for the main crops depending on the hydromodular zoning. To plan water resources, ten-day hydro and irrigation modules are calculated for each crop. The ten-day hydromodule represents the necessary specific water flow (l/s/ha) supplied evenly over a ten-day period during the growing season. The ten-day irrigation module indicates the specific area (ha/irrigation) that needs to be irrigated during a given ten-day period of the growing season.

Table 1 – In the Republic of Karakalpakstan, the main cultivated areas are cotton, grain, rice and water

Names and indications of crops		Years										
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Cotton	thousand. hectares	95,5	76,1	74,0	91,4	102,9	104,0	106,6	112,6	93,2	94,7	
	harvest (centner/ hectares)	13,1	14,7	11,1	11,2	19,5	20,6	19,1	20,2	12,2	18,6	
Wheat	thousand. hectares	28,8	15,6	17,8	60,8	58,4	60,9	63,9	65,2	59,8	53,0	
	harvest (centner/ hectares)	21,2	18,7	34,1	22,5	26,4	26,6	33,6	34,1	21,5	22,3	
Rice	thousand. hectares	7,7	0,9	18,8	59,1	22,3	21,9	22,7	23,1	15,9	80,2	
	harvest (centner/ hectares)	17,4	17,5	17,5	19,3	19,7	21,5	24,4	25,2	18,5	21,3	
Get water	million.m^3	4828	2714	6280	8526	8156	8504	8965	8678	7250	8119	
Reset	million. m^3	1544,1	296,2	3878	10039	4476	14218	13425	12543	5383	12534	

The procedure (algorithm) for calculating the ten-day hydro and irrigation module based on crop irrigation schedules for the growing season, essential for integration into the water resources management database, is as follows:

1. Irrigation schedules for agricultural crops are chosen according to the hydromodular zone of the region in question.

2. For a specified hydromodular area of the region, the irrigation schedule for the chosen crop is evaluated from the first ten-day interval of the growing season. The start and end dates of each ten-day interval are compared with the initial irrigation date of the crops. The following scenarios may arise [5]:

a. the starting date for watering crops is outside the ten-day limit, in this case, for a given ten-day period, ten-day hydro – q_{ikjnD} and irrigation modules s_{ikjnD} equal to zero i.e.

$$q_{ikjnD} = 0, \tag{10}$$

$$s_{ikjnD} = 0, \tag{11}$$

where q_{ikjnD} – ten-day hydromodule (l/s/ha), s_{ikjnD} – irrigation module (ha/irrigation), i – agricultural crop, k - hydromodular area, j – irrigation number, n – number of the current decade.

b. if the initial date for watering crops falls between the start and end dates of the ten-day interval, then the ten-day hydromodule q_{ikjnD} and irrigation s_{ikjnD} modules for this interval are determined by the following relationships:

$$q_{ikjnD} = \frac{W_{ikjnD}(T_{ikj} - t_{ijkH} - 1)}{86,4T_{ikj}}, \tag{12}$$

$$s_{ikjnD} = \frac{(T_{ikj} - t_{ijkH} - 1)}{T_{ikj}}, \tag{13}$$

where t_{nH} – start date of decade, n – current decade number,

c. if the start and end dates of a ten-day period fall within the start and end dates of crop irrigation, then the hydromodule q_{ikjnD} and irrigation s_{ikjnD} modules for this period are determined as follows:

$$q_{ikjnD} = \frac{W_{ikjnD}}{86,4T_{ikj}}, \tag{14}$$

$$s_{ikjnD} = \frac{T_{nD}}{T_{ikj}}, \tag{15}$$

where T_{nD} – number of days in a given decade.

d. if the final date of crop irrigation falls between the start and end dates of the ten-day period, then the ten-day hydromodule for this period is determined as follows:

$$q_{ikjnD} = \frac{W_{ikjnD}(t_{ijkH} - t_{nK})}{86,4T_{ikj}}, \tag{16}$$

$$s_{ikjnD} = \frac{(t_{ijkH} - t_{nK})}{T_{ikj}}, \tag{17}$$

where t_{nK} – start date of decade, n – number of the current decade.

3. The ten-day hydromodule for agricultural plants is determined by summing the irrigation ten-day hydromodules[6]

$$q_{iknD} = \sum_{n=1}^{N_{ik}} q_{ikjnD} . \tag{18}$$

$$s_{iknD} = \sum_{n=1}^{N_{ik}} s_{ikjnD} . \tag{19}$$

In (10) – (19) ten-day hydraulic modules q_{ikjnD} has a dimension (l/s/ha*)*, ten-day irrigation modules s_{ikjnD} *– (for/watering),* duration of watering T_{ikj} and date differences, for example $t_{ikjH} - t_{nK}$ *(day).*

The ten-day hydro and irrigation modules for agricultural plant, calculated according to algorithm (10) – (19), form the basis for determining the water requirements of agricultural plants for the growing season, depending on the sown areas of the respective plants. In Fig. the irrigation schedules, and the calculation results of hydromodules and irrigation modules for cotton in various hydromodule regions are shown [9].

Next, we consider the sequence of calculating the needs of water resources of the main canal consisting of $m \in M$ sections, in each section of the canal there are branches $j \in J_m$, and every tap j irrigates areas ω_{jmik}

where $j \in J_m$ – numbers of taps on m- area, J_m – set of branch numbers on m- area;

- $m \in M$ – numbers of sections of the main canal, M – multiple numbers of sections of the main canal; $i \in I_{mj}$ – types of crops sown on suspended lands j – th branch on the canal section c number m, I_{mj} – many types of agricultural crops suspended in the lands j – th branch on the canal section with number m*;*

- $k \in K_{mjk}$ - types of hydromodular areas of suspended lands j – th branch on the canal section with number m, K_{mjk} - many types
- hydromodular areas of suspended lands j – th branch on the canal section with number m.

Thus, ω_{mjik} represents the structure of the sown areas of the entire main canal, then for each diversion, taking into account crop irrigation regimes, the need for water resources is determined as follows[10]

$$Q_{Omjn}^{P} = \sum_{i \in I_{mj}} \sum_{k \in K_{mji}} \frac{q_{iknD}\omega_{mjik}}{\eta_{vxmj}}, \quad (20)$$

$$Q_{mjn}^{P} = Q_{Omjn}^{P} + q_{DPmjn}, \quad (21)$$

where q_{iknD} – ten-day hydraulic modules i – th crops k – th hydromodular area for n – th decade; $Q^{P}{}_{Omjn}$ – required flow rate for irrigation water, q_{DPmjn} – required expenditures of non-agricultural consumers – total required water consumption j – th branch m – th section of the main canal for n – th decade; η_{vxjm} – efficiency of on-farm channels j – th branch m – th section of the main canal.

Irrigated areas by consumers are determined in the form

$$S_{mjn}^{P} = \sum_{i \in I_{mj}} \sum_{k \in K_{mji}} s_{iknD}\omega_{mjik} \quad (22)$$

where S_{mjn}^{P} – irrigated areas j – th branch m – th section of the main canal for n – th ten days of the growing season; s_{iknD} – ten-day irrigation modules i – th crops k – th hydromodular area for n – th decade .

Similarly, using formula (20), the required water flows at the final outlets of the main canal are determined.

Required expenses and irrigation areas suspended in the m –th plot on the n –th decade of the growing season in the plots are determined as follows [11]

$$Q_{mn}^{P} = \sum_{j \in J_m} Q_{mjn}^{P}, \quad (23)$$

$$S_{mn}^{P} = \sum_{j \in J_m} S_{mjn}^{P}, \quad (24)$$

where J_{mj} – multiple tap numbers m – th section of the main canal.

Using expressions (20) – (21), the needs of canal sections for water resources are determined for the n –th decade of the growing season.

The sequence (algorithm) for calculating water flow rates for sections of the main canal is as follows [12]:

1. In accordance with (9) and (20), the required water flows are calculated for the n –th decade at the end of the final sections of the main canal

$$Q^{PK}_{nm_k} = Q^{P}_{nm_k}, \quad \forall m_k \in M_k, \quad \forall n \in N_V, \tag{25}$$

2. Next, starting from the last hierarchy by hierarchy groups in the sections, the required water flows for the n-th decade at the beginning of the sections of the main canal are calculated as follows

$$Q^{PH}_{mn} = \frac{Q^{PK}_{mn} + Q^{P}_{Vmn} - Q^{P}_{Pmn}}{\eta_m}, \quad \forall m \in I_{iG}, \quad \forall n \in N_V, \tag{26}$$

$$Q^{P}_{Vmn} = \sum_{j \in J^V_m} \left(Q^{P}_{OVmjn} + q_{DPmjn} \right) = Q^{P}_{OVmn} + q_{DPmn}, \quad \forall m \in I_{iG}, \quad \forall n \in N, \tag{27}$$

$$Q^{P}_{Pmn} = \sum_{j \in J^P_m} Q^{P}_{Pmjn}, \quad \forall m \in I_{iG}, \quad \forall n \in N_V, \tag{28}$$

$$Q^{P}_{OVmn} = \sum_{j \in J^V_m} Q^{P}_{OVmjn}, \quad \forall m \in I_{iG}, \quad \forall n \in N_V, \tag{29}$$

$$q_{DPmn} = \sum_{j \in J^V_m} q_{DPmjn}, \quad \forall m \in I_{iG}, \quad \forall n \in N, \tag{30}$$

where Q^{PH}_{mn} , Q^{PK}_{mn} – water flow at the beginning and end of the section, Q^{P}_{Vmn}, Q^{P}_{Pmn} – total water consumption of required water intakes and forecast inflows, Q^{P}_{OVmn}, q_{DPmn} – total water consumption of required water intakes for irrigation and other consumers, J^V_m - many numbers of water intakes on the site, J^P_m - many numbers of tributaries in the area, I_{iV} - set of site numbers in the group under consideration, η_m – efficiency m – th section of the canal, N_V – numbers of the ten-day period of the growing season.

3. In groups j_{iG} in i – in the hierarchy of the main canal structure, the balance relationships are written in the form

$$Q^{PK}_{n_{ijG}n} = \sum_{k_{ijG} \in N_{ijG}} Q^{PH}_{k_{ijG}n}, \quad \forall n_{ijG} \in I_{iG}, \ \forall n \in N_V, \tag{31}$$

where $Q^{K}_{n_{ijG}}$ – end water consumption n_{ijG} – th plot.

4. Next, the calculation is repeated in steps 2 – 3 for the next hierarchy in the structure[17].

Thus, the planned operating modes of the main chanal sections are calculated to meet the needs of all consumers, which are characterized by the following set

$$\Omega^{VP}_{M} = \left\{ \left[m, \ Q^{PH}_{mn}, \ Q^{PK}_{mn}, \ Q^{P}_{Vmn}, \ Q^{P}_{Pmn}, \ Q^{P}_{OVmn}, q^{P}_{DPmn}, \ S^{P}_{mn} \right], \ \forall m \in M, \ \forall n \in N_V \right\}. \tag{32}$$

Here Q^{PH}_{mn}, Q^{PK}_{mn} – water flow at the beginning and end of the section, Q^{P}_{Vmn}, Q^{P}_{Pmn} – total water flows of water intakes and tributaries, Q^{P}_{OVmn}, q^{P}_{DPmn} – total water consumption for irrigation and other consumers, S^{P}_{mn} – irrigated areas of agricultural crops suspended on the site m for a decade n growing season.

Main required (planned) water consumption $Q^{HP}_{m_g n}$, corresponding to the initial section of the main canal over ten days of the growing season is the required consumption for all canal consumers. Here m_g – number of the initial section of the main canal [13].

Calculating the water resource requirements for consumers of the main canal during the non-growing season follows the same procedure as during the growing season. The distinction lies in utilizing leaching norms for irrigation of saline lands based on salinity type, irrigation norms for grains and other crops during the non-growing season, and norms for moisture-recharging irrigation, instead of irrigation schedules for agricultural crops.

For the non-growing season, washing regimes for saline areas are determined by type of salinity i, in which in each flushing irrigation j leaching norms, grain irrigation norms and moisture-recharging irrigation norms are established W_{ikjP}, irrigation timing, i.e. started t_{ikjH}, end t_{ikjK} and duration of watering $T_{ikj} = t_{ikjH} - t_{ikjK}$. Leaching norm, irrigation norm for grains during the non-growing season and norm of moisture-recharging irrigation W_{ikP} are determined as the sum of leaching and irrigation norms, i.e. $W_{ikP} = \sum_{j=1}^{N_i} W_{ikjP}$. Table A1.2, shows the regimes for leaching saline lands during the non-growing season. To plan water resources, ten-day leaching hydro and irrigation modules are calculated for each type of saline land. The ten-day leaching hydromodule is the required specific water flow (l/s/ha), supplied evenly to flush saline lands in a given ten-day period of the non-growing season. A ten-day irrigation module is the required specific area (ha/irrigation) irrigated in a given ten-day period of the non-growing season. Ten-day hydro and irrigation modules for the non-growing season are calculated using algorithm (10) – (19) using data from Table A1.2.[14]

Table 1.2 - Technical characteristics of main canals in the lower reaches of the Amudarya River

I №	Canel name	Total length, km	Parameters of the channel cross-section, the canel passes through the floor of the excavation, half of the embankment, km							Soils
			Q, m^3/c	w, m	h, m	m	W, m	Notch, km	Embankments, km	
1	Kizketken	25,2	400	63	4,5	2,0	83,0	25,2	-	loams
2	Kegeyli	56,6	140	40	4,0	1,5	52,0	7,0	29,6	sandy loam
3	Kuvanish-jarma	81,0	185	48	4,3	1,5	60,8	12,0	23,0	loams
4	Suenli	85,2	130	30	4,5	1,2	45	42,6		loams - sandy loams
5	Parallelniy	37,4	140	35	4,8	1,2	47,5	18,7		loams - sandy loams

The algorithm for calculating the planned water supply regimes for sections of the main canal during the non-growing season, aimed at ensuring leaching irrigation of saline lands, irrigation of grain, and water-recharging irrigation for all downstream consumers, is characterized by the following set [15]

$$\Omega_M^{HVP} = \left\{ \left[m,\ Q_{mn}^{HP},\ Q_{mn}^{KP},\ Q_{Vmn}^{P},\ Q_{Pmn}^{P},\ Q_{OVmn}^{P}, q_{DPmn}^{P},\ S_{mn}^{P} \right],\ \forall m \in M,\ \forall n \in N_{HV} \right\} \quad (33)$$

Here $Q^{PH}{}_{mn}$, $Q^{PK}{}_{mn}$ – water flow at the beginning and end of the canal section, $Q^{P}{}_{Vmn}$, $Q^{P}{}_{Pmn}$ – total water flows of water intakes and tributaries, $Q^{P}{}_{OVmn}$, $q^{P}{}_{DPmn}$ – total water consumption for irrigation and other consumers, $S^{P}{}_{mn}$ – irrigated areas of agricultural crops suspended on the site m for a decade n outside the growing season, N_{HV} – numbers of the ten-day period of the growing season.

The components of set (33) are computed based on the leaching regimes of saline lands and irrigation of crops during the non-growing season, taking into account the distribution of saline land areas and the cultivation of grain and other crops during the non-growing season [16].

By calculating all elements of sets (32) – (33) using the aforementioned algorithm, the issue of determining the planned requirements for annual irrigation planning of cultivated lands is resolved.

2. DISCUSSION

The foundation for conducting scientific research in this article was the State Scientific and Technical Program (SSTP)-124, titled "Development of scientifically grounded methods, systems, and management forms, as well as reliable, safe, and efficient utilization of water management facilities and hydraulic structures in the republic." This program was implemented under contract MB-KX-A-KX-2018-279 with the Ministry of Foreign Affairs, focusing on "Improving the operational modes of cascades of large pumping stations, using modern methods and new equipment, and reducing losses of water and energy resources," in collaboration with the Ministry of Innovative Development during the period of 2018-2020.

3. CONCLUSION

The issue of water resource management in basin irrigation systems is defined by the need to address challenges in collecting and processing information, as well as making decisions about the management object across vast territories and managing its components, which are situated at considerable distances from one another (in some cases, over tens of kilometers). Conversely, water resources from basin irrigation systems are utilized across diverse sectors of the national economy, including energy, agriculture, industry, fisheries, municipal use, and more. Effective management of water resources in basin irrigation systems requires handling and utilizing extensive and varied information. Therefore, the development of planning algorithms for water resource management in irrigation systems in conditions of climate change is an urgent task in the national economy of the Republic of Uzbekistan. This article is dedicated to solving these problems.

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