Hydro-modular zoning of irrigated lands in South Karakalpakstan and optimal irrigation regime for cotton

Cite as: AIP Conference Proceedings **2612**, 030023 (2023); https://doi.org/10.1063/5.0113264

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Hydro-Modular Zoning of Irrigated Lands in South Karakalpakstan and Optimal Irrigation Regime for Cotton

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Abstract. The article presents the results of research on hydromodular zoning of irrigated lands based on GIS technologies and cotton irrigation regimes in the conditions of South Karakalpakstan, which ensure an increase in the productivity of scarce irrigation water. Irrigated lands of the southern districts of the Republic of Karakalpakstan belong to one soil-climatic zone - desert zone, within three soil-ameliorative areas within this zone. Irrigated lands of the southern districts of the Republic of Karakalpakstan are divided into 25.78% - VII, 34.37% - VIII and 21.86% - IX hydromodule zones in the aeration layer according to soil thickness, mechanical composition, location and groundwater level. Based on field experiments, pre-irrigation of cotton in all hydromodule areas should be carried out at a soil moisture content of 70-80-60% relative to the limited field moisture capacity: Seasonal irrigation norms 3756-3856 m^3/ha in the 1-4-1 system for growth phases in VII hydromodule region with, seasonal irrigation norms of 2789-2867 m^3/ha in 1-2-1 system in hydromodule region VIII and seasonal irrigation norms of 2203-2250 m^3/ha in 0-3-0 system in hydromodule region IX.

INTRODUCTION

Water resources management requires a deep understanding of the special value of water for humans, the principles of human interaction with nature and the importance of water resources for the development of society. Only with knowledge of the numerous interrelationships that are formed in water management in ensuring the vital activity of society and natural balance, food production and economic development, and the role of water in the evolutionary processes on earth, can we take on water resources management [1]. In the context of climate change and increasing water scarcity, a decrease in water consumption of agricultural crops is of great importance in solving the problem of water conservation in the arid zone [2, 3].

As a result of global climate change, glaciers in Central Asia have shrunk by about 30 percent over the last 50-60 years. It is estimated that the volume of glaciers decreases by 50 percent when the temperature rises to 20C and by 78 percent when heated to 40C. Climate change will lead to 10-15% water evaporation from water surfaces and 10-20% more water consumption due to increased plant transpiration and irrigation standards. This leads to an average 18% increase in non-renewable water consumption. This will undoubtedly complicate the further growth of agricultural production [4, 5].

Hydromodular zoning of irrigated lands in Uzbekistan, irrigation procedures for major agricultural crops were developed in the 80s of the 21st century, and this information is still used to determine the water consumption of crops and water use plans [6]. Today, due to global climate change, changes in reclamation regimes of irrigated lands, diversification of agricultural crops, changes in water management principles and water use systems, the need for the widespread introduction of water-saving irrigation technologies to mitigate the negative effects of water scarcity. - Research work aimed at making changes in the hydromodule zoning of irrigated lands that do not fully cover the climatic and economic conditions, the distribution of irrigated lands by hydromodule regions using modern Geoinformation systems and determining scientifically based irrigation regimes for each hydromodule region [7-11].

The purpose of the study is to make changes in the hydromodular zoning of irrigated lands of South

The Third International Scientific Conference Construction Mechanics, Hydraulics and Water Resources Engineering (CONMECHYDRO 2021 AS)
AIP Conf. Proc. 2612, 030023-1–030023-14; https://doi.org/10.1063/5.0113264
Published by AIP Publishing. 978-0-7354-4337-2/$30.00

Karakalpakstan in the conditions of water scarcity, the distribution of irrigated lands by hydromodular regions, and to determine scientifically based irrigation regimes for cotton in the main hydromodular regions.

The objectives of the research are,

- Identification of newly irrigated lands in hydromodular areas by studying the soil and hydrogeological conditions of South Karakalpakstan;
- Development of scientifically based irrigation regimes for cotton in the main hydromodule regions of South Karakalpakstan;
- To determine the impact of scientifically based irrigation regimes on the water-physical properties of the soil and the growth, development and productivity of cotton;
- Creation of electronic maps of hydromodular zoning of irrigated lands of the southern districts of the Republic of Karakalpakstan using GAT technology and districts.

The object of research is the irrigated lands of the southern districts of the Republic of Karakalpakstan, their soil and hydrogeological conditions, the principles of hydromodule zoning, GAT technologies and science-based irrigation regimes for cotton.

The subject of research is the hydromodular zoning of irrigated lands of the southern districts of the Republic of Karakalpakstan, the impact of scientifically based irrigation regimes on the efficient use of water resources, growth, development and productivity of cotton.

METHODS

Soil analysis, observations, measurements and analysis of cotton, cotton selection, "Methods of studying agrophysical, agrochemical and microbiological properties of soil in cotton fields" adopted at the Scientific Research Institute of Seed Agrotechnology [12], "], the accuracy and reliability of the obtained data were analyzed mathematically and statistically based on the generally accepted method of VP Peregudov. Hydromodule zoning was carried out based on the method of N.F. Bespalov [6].

Irrigation norms according to S.Rijov's formula [15].

$$m = 100 \cdot h \cdot J \cdot (W_{lfmc} - W_{ah}) + \mathrm{K} \qquad m^3 / ha$$

determined according to. Hydromodule zoning was carried out on the basis of the method of NF Bespalov [6]. GAT technology and ArcGIS software for creating hydromodule zoning electronic maps, IDW analysis by interpolation method, algorithmic work Con ((("shavat_interpolation"> = 200) & ("shavat_interpolation" <= 300) & ("Soil_PolygonToRaster" == 1)), 1,0) ”formula was used.

RESULTS AND DISCUSSION

Scientific research to determine the irrigation regime of cotton was carried out on the irrigated lands of the farm "Reimbay boshliq" in Beruni district of southern Karakalpakstan in the following experimental system (Table 1).

TABLE 1. Field experiment implementation system

№	Pre-irrigation soil moisture, in% relative to the limited field moisture capacity	Irrigation rate, m^3/ha
1	Production control	Actual measurements
2	70-70-60	On the moisture deficit in the layer of 70–100–70 cm
3	70-80-60	On the moisture deficit in the layer of 70–100–70 cm
4	70-80-60	Moisture deficit in the 70-100-70 cm layer was increased by 30%.

On the farm's lands, there are collector-drainage networks, and irrigation networks are of an engineering nature. To irrigate agricultural crops, water is delivered to the fields through horns and temporary ditches, and the crops are irrigated side by side. The soil of the farm is weak and moderately saline. The mechanical composition of the experimental field soil, according to N.Kachinsky's description, is a layer of medium sand with a depth of 0-85 cm and a layer of light sand with a depth of 85-118 cm.

While plant development and productivity are related to soil fertility, plants also affect soil composition. Depending on the farming culture, its fertility will also change after the soil begins to develop from its natural state through the cultivation of agricultural crops. Improving soil fertility depends on 4 main factors: reclamation regime, mechanical treatment, fertilization schedule, and the type of plant to be planted. The plant improves as much water-air and nutrient regimes as possible in the soil during the growing season and leaves behind it a certain amount of organic matter in the soil. However, chronic planting of one crop in a given area does not have a positive effect. On the contrary, it reduces soil fertility, so intensive farming should be used to cultivate each crop based on crop rotation, irrigation and optimal use of fertilizers [14].

The soils of the experimental field are grassy alluvial soils that have been irrigated since ancient times, and the groundwater is located close to the surface (2-3 m). Soil formation processes take place under the influence of groundwater.

The humus content of the experimental field soil was 0.699%, total nitrogen 0.098% and total phosphorus 0.150%, as well as mobile nitrogen 22.7 mg/kg, phosphorus 36.5 mg/kg and potassium 156.7 mg/kg. did (Table 2).

TABLE 2. Agrochemical parameters of experimental field soils.

Layers, cm	**Humus%**	**Total reserve,%**		**Still mg/kg**		
		Nitrogen	**Phosphorus**	**N-$N0_3$**	**$P_2 0_5$**	**$K_2 0$**
0 - 20	0.699	0.091	0.150	22.7	36.5	156.7
20 - 43	0.654	0.086	0.129	16.8	35.4	148.4
43 - 52	0.654	0.083	0.120	14.1	34.8	145.2
52 – 65	0.654	0.085	0.117	11.8	32.7	144.4
65 - 85	0.531	0.071	0.110	8.8	26.4	128.6
85 - 100	0.442	0.069	0.100	8.2	24.3	124.7
100 - 150	0.441	0.064	0.092	69	22.1	120.3

In the cultivation of agricultural crops, the order of irrigation is necessary to ensure a water regime for each plant species in specific climatic conditions. Agricultural crops react differently to water supply conditions depending on the biological properties of cotton. However, when the water demand is continuously met throughout the entire period of growth and development, all plants are provided with maximum yields.

The irrigation rate was determined according to the following formula [15].

$$m = 100 \cdot h \cdot J \cdot (W_{lfmc} - W_{ah}) + \mathrm{K} \qquad m^3 / ha$$

W_{lfmc} is limited field moisture capacity relative to soil weight, %;

Wah is actual moisture before irrigation relative to soil weight, %;

J is bulk density of soil, g / cm^3;

h is calculated layer value, m;

k is water consumption for evaporation in irrigation, m^3/ha (10% of the lack of moisture in the calculated layer).

Cotton planted in the experimental field was irrigated based on the specified humidity. During the growing season, the number of irrigations in each cotton variant, its duration, and the total amount of water supplied varied significantly (Table 3).

In option 3, where the pre-irrigation soil moisture was 70-80-60% relative to the limited field moisture capacity, the cotton was irrigated three times during the flowering-harvesting period according to the 0-3-0 scheme with 714-766 m^3/ha irrigation norms. Seasonal irrigation norms were 2203-2250 m^3/ha or 1428-1632 m^3/ha less water than the control. Depending on the pre-irrigation moisture of the soil, the period between irrigations was 18-22 days.

In variant 1 of the experiment, cotton was irrigated once during the growing season according to the 1-2-1 scheme once before the flowering-yield period, 2 times during the flowering-fruiting period and once during the ripening period, a total of 4 times, at 1112-1291 m^3/ha. The seasonal irrigation rate was 4638-4744 m^3/ha. The period between irrigations was 25-26 days.

TABLE 3. Irrigation regime of cotton

Options	**Indicators**	**Irrigation, m^3/ha**						**Irrigation scheme**	**Seasonal Irrigation norm, m^3/ha**
		1	**2**	**3**	**4**	**5**	**6**		
				2018					
	Irrigation period	18.06	13.07	08.08	3.09				
1	Irrigation interval, days		25	26	26			1-2-1	4678
	Irrigation rate, m^3/ha	1247	1126	1164	1141				
	Irrigation period	20.06	14.07	06.08	03.09				
2	Irrigation interval, days		24	23	27			1-2-1	3335
	Irrigation rate, m^3/ha	650	891	921	873				
	Irrigation period	19.06	07.07	24.07	17.08				
3	Irrigation interval, days		18	17	24			1-2-1	2854
	Irrigation rate, m^3/ha	643	663	693	855				
	Irrigation period	18.06	08.07	30.07	25.08				
4	Irrigation interval, days		20	22	26			1-2-1	3731
	Irrigation rate, m^3/ha	823	883	901	1124				
				2019					
1	Irrigation period	19.06	14.07	09.08	4.09				
	Irrigation interval, days		25	26	26			1-2-1	4744
	Irrigation rate, m^3/ha	1276	1159	1142	1167				
2	Irrigation period	22.06	15.07	05.08	02.09				
	Irrigation interval, days		23	23	26			1-2-1	3422
	Irrigation rate, m^3/ha	664	926	956	876				
3	Irrigation period	21.06	09.07	26.07	18.08				
	Irrigation interval, days		18	17	23			1-2-1	2789
	Irrigation rate, m^3/ha	633	623	668	865				
4	Irrigation period	20.06	11.07	02.08	29.08				
	Irrigation interval, days		21	22	27			1-2-1	3711
	Irrigation rate, m^3/ha	836	848	888	1139				
				2020					
1	Irrigation period	19.06	14.07	09.08	4.09				
	Irrigation interval, days		25	26	26			1-2-1	4738
	Irrigation rate, m^3/ha	1291	1214	1112	1121				
2	Irrigation period	06.07	29.07	21.08					
	Irrigation interval, days		23	23				1-2-1	3432
	Irrigation rate, m^3/ha	680	933	948	871				
3	Irrigation period	20.06	08.07	25.07	18.08				
	Irrigation interval, days		18	17	24			1-2-1	2867
	Irrigation rate, m^3/ha	638	658	689	882				
4	Irrigation period	19.06	11.07	03.08	30.08				
	Irrigation interval, days		20	23	27			1-2-1	3772
	Irrigation rate, m^3/ha	871	855	914	1132				

Also, in hydromorphic soils, the regime of groundwater level has a significant impact on crop irrigation times, numbers and irrigation standards, and land reclamation. Therefore, it is of great practical importance to study groundwater distribution order in meadow alluvial soils, which are part of hydromorphic soils.

To determine changes in the depth and mineralization of groundwater levels in the experimental fields, observation wells were installed in all options, where groundwater levels were measured every 10 days, and chemical samples were chemically analyzed (Figure 1).

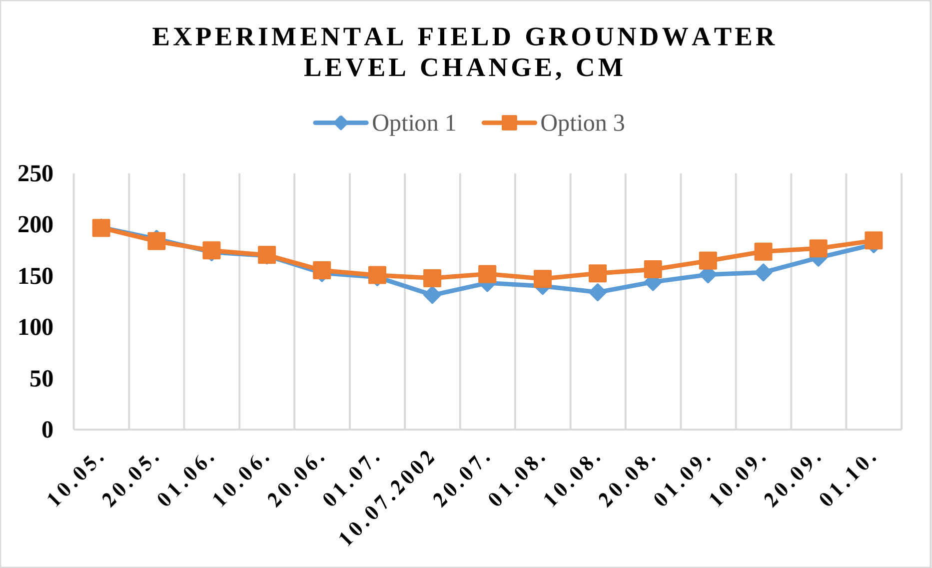


FIGURE 1. Changes in the average groundwater level for 2018-2020, cm

In the experimental fields, groundwater mineralisation is 2.16-2.41 g/l at the beginning of the growing season and is classified as weak (1-3 g/l) mineralized by classification (Fig. 2).

At the end of the growing season, the mineralization of groundwater changed relatively little in the variant irrigated with irrigation norms designed to cover the moisture deficit of the active layer of soil. In control option 1, groundwater mineralisation increased to 2.24–3.89 g/l after irrigation because the cotton was irrigated at high irrigation rates, i.e., water-soluble salts in the soil were added to the groundwater along with the irrigation water.

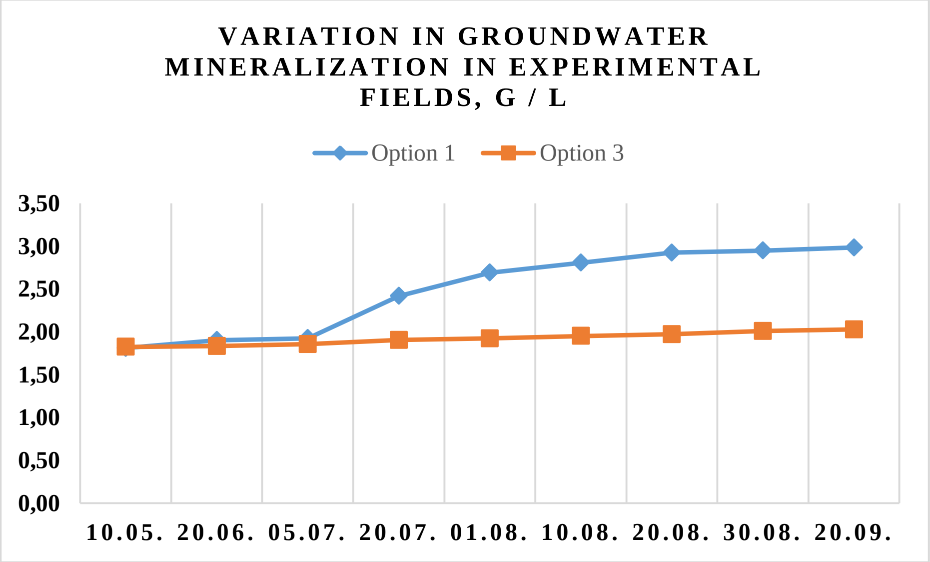


FIGURE 2. Change in average groundwater mineralization for 2018-2020, g/l

In the experimental field, the groundwater level averaged 192-198 cm at the beginning of the growing season, 126-159 cm during the growing season, and 180-188 cm at the end of the growing season.

In general, the results of the study of the dynamics of groundwater level changes in the experimental fields can be summarized as follows, in the experimental fields and the adjacent area, irrigation works were carried out at a time when irrigation systems were operating at high loads, and leakage losses were high.

The study of the salt regime of the soil showed that the amount of chlorine ions relative to the weight of the soil at the beginning of the growing season in the topsoil (0-30 cm) is 0.010-0.012%, in the active layer of the soil (0-100 cm) 0.009-0.011%. At the end of the growing season in the tillage layer (0-30 cm), the amount of chloride ion relative to the weight of the soil was 0.023-0.024%, in the active layer of the soil (0-100 cm) 0.017-0.020%. The dry residue at the beginning of the vegetation in the plowing layer was 0.192-1.96%, and in the active layer of the soil was 0.167-1.72%. The dry residue at the end of the growing season in the tillage layer was 0.401-0.412%, and in the active layer of the soil was 0.352-0.362%. The coefficient of seasonal salt accumulation in the driving layer was 2.0-2.40 on the chloride ion and 2.01-2.15 on the dry residue. The active 0–100 cm layer of soil was 1.82–1.90 and 2.05–2.18, respectively.

Thus, according to the analysis of the effect of irrigation regimes on the soil salt regime, salt accumulation was observed in the 0-100 cm layer of soil where the cotton root is located at the end of the growing season in all variants. Salt drive accumulated more in the 0–30 cm layer than in other layers. The intensity of salt accumulation was less than in the control options in the irrigated variants with irrigation standards designed to cover the moisture deficit in the one-meter layer of soil (Fig. 3).

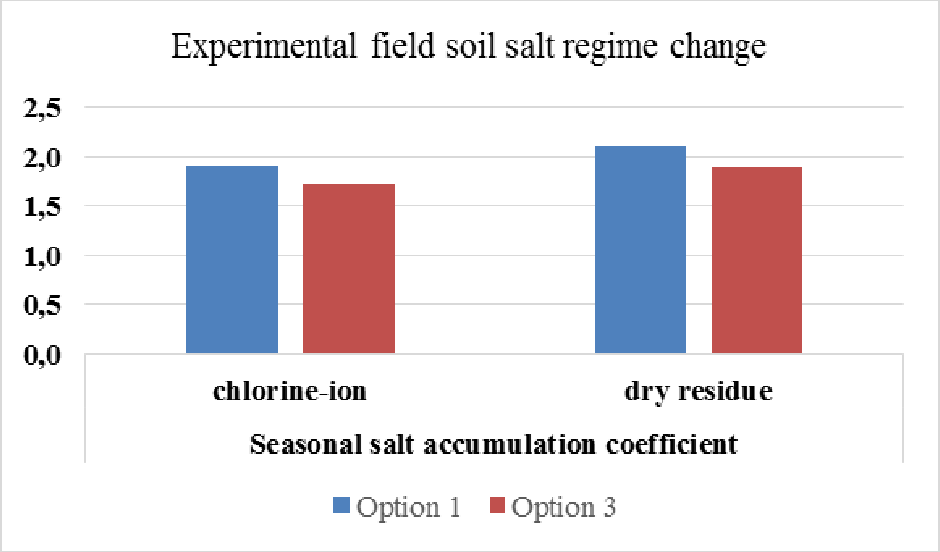


FIGURE 3. Changes in seasonal salt accumulation in the soil for 2018-2020.

Phenological observations on the growth and development of cotton show that maintaining an optimal water regime in the root spreading layers of the plant in saline or saline soils depends on the composition and amount of water-soluble salts in the soil, which determines the direction of physiological processes in plant bodies. In such areas, the main period of cotton cultivation is the flowering and fruiting phase of cotton.

In experiments, the effect of irrigation regimes on the growth and development of cotton was studied through phenological observations (Table 4).

TABLE 4. The effect of irrigation regimes on the growth and development of cotton

Options	Seedling thickness, thousand pieces	Real sheet, cm	Cotton height, cm				Number of harvested branches, pieces		Number of pieces, pcs			Seedling thickness, thousand pieces
	1.06	1.06	1.06	1.07	1.08	1.09	1.07	1.08	1.08	1.09	1.09 opening	1.09
2018												
1	100.6	3.5	10.1	34.6	80.9	95.3	6.6	10.4	6.1	10.2	2.1	98.5
2	100.8	3.6	11.0	30.7	72.8	81.8	7.2	10.9	6.3	10.7	2.2	99.1
3	100.8	3.7	11.0	32.7	78.8	87.8	7.2	11.3	6.8	11.2	2.8	99.7
4	100.3	3.4	10.6	33.3	79.9	91.1	7.2	10.7	6.6	10.4	2.3	99.3
2019												
1	97.4	3.2	9.1	36.5	82.6	98.7	6.3	10.1	5.7	9.7	2.0	95.2
2	98.6	3.4	9.0	36.4	70.2	82.5	6.2	10.4	5.6	10.0	2.1	96.4
3	98.4	3.5	9.1	36.4	76.4	88.9	6.4	10.9	6.3	10.5	2.6	96.9
4	97.9	3.3	9.2	37.1	78.3	92.5	6.3	10.5	6.1	10.3	2.2	95.5
2020												
1	100.0	3.7	10.3	38.2	92.4	98.9	6.1	10.3	5.4	9.8	2.1	96.5
2	100.5	3.8	11.1	40.5	71.6	82.8	6.2	10.6	5.7	10.1	2.2	97.2
3	100.6	3.6	11.2	42.4	77.2	90.4	6.5	10.8	6.0	10.4	2.5	98.7
4	100.4	3.5	10.6	40.6	77.4	93.7	6.4	10.7	5.9	10.2	2.3	97.8

According to Table 4, in the 3rd variant of the experiment, as of September 1, the length of the cotton was 87.8-90.4 cm, the number of branches was 10.8-11.3, the number of pods was 10.4-11.2, and the number of open buds. The number of branches was 0.5-0.9, the number of pods was 0.5-0.8, and the number of pods opened on September 1 was 0.4-0. There were 7 more.

Table 5 provides data on the impact of irrigation regimes on cotton yields. According to the table, 34.2-34.8 t / ha of cotton was obtained from the control variety "Sultan" in the experimental field, and more than -136.0-138.5 m3 of river water was used to grow 1 quintal of cotton compared to other options.

TABLE 5. Influence of irrigation regimes on cotton yield.

Options	Cotton yield by returns, centner/ha			Average yield, centner/ha	± Centner/ha relative to control	Seasonal irrigation rate, m^3/ha	1 centner of river water for cotton, m^3
	I	II	III				
2018							
1	33.7	35.1	34.3	34.4	0.0	4678	136.0
2	35.5	34.6	36.4	35.5	+ 1.1	3205	90.3
3	39.6	38.3	36.7	38.2	+ 3.8	2854	74.7
4	35.4	36.4	37.5	36.4	+ 2.0	3731	102.5
2019							
1	33.6	35.8	34.9	34.8	0.0	4744	136.3
2	35.7	36.2	37.8	36.6	+1.8	3422	93.5
3	39.2	40.4	37.2	38.9	+4.1	2789	71.7
4	36.9	37.2	38.7	37.6	+2.8	3711	98.7
2020							
1	35.4	34.1	33.2	34.2	0.0	4738	138.5
2	36.0	35.1	37.2	36.1	+1.9	3432	95.1
3	38.4	39.6	37.2	38.4	+4.2	2867	74.7
4	36.1	38.2	37.3	37.2	+3.0	3772	101.4

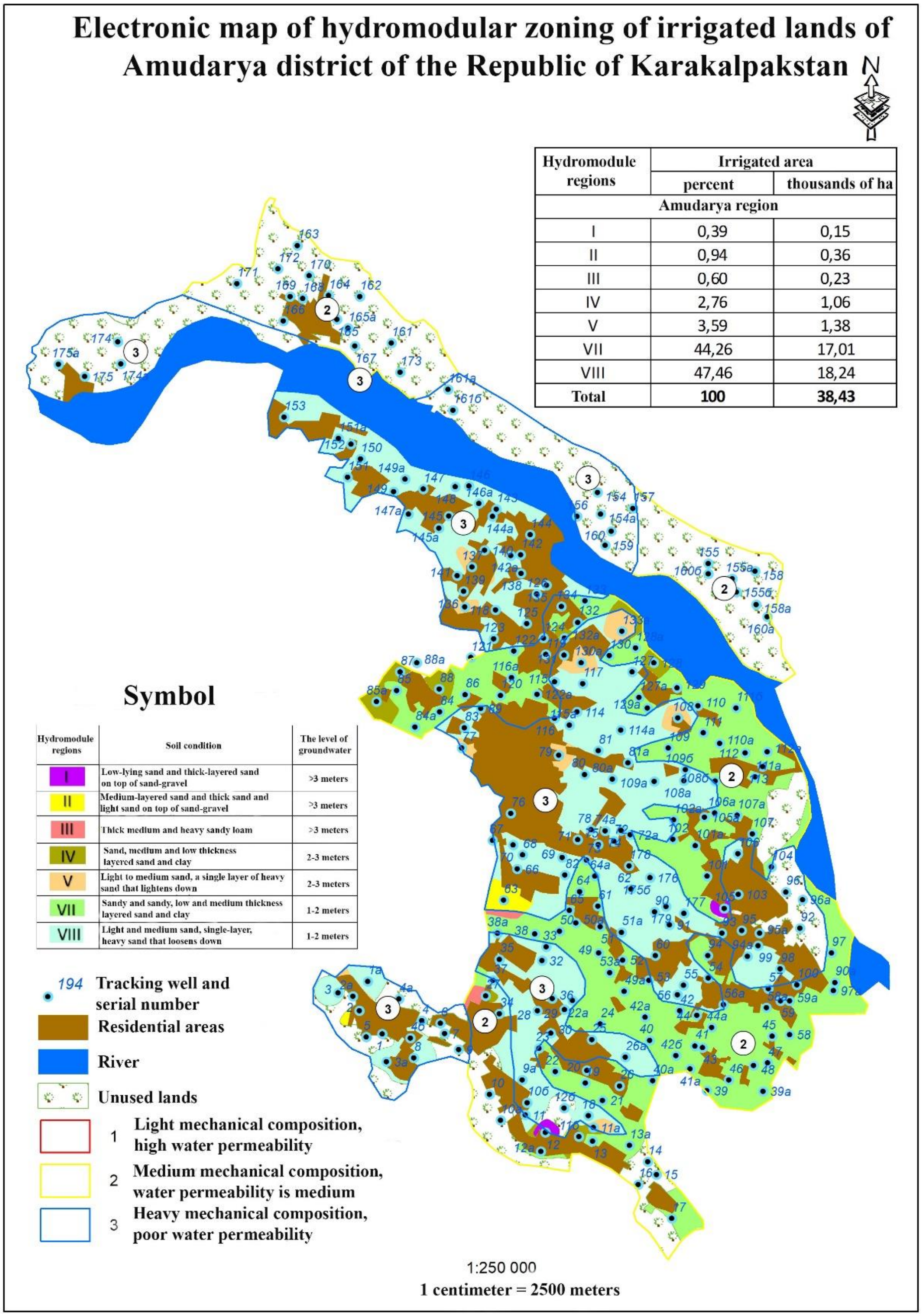
Hydromodular zoning of irrigated lands is the division of the territory into taxonomic unit areas, the purpose of which is the efficient use of land and water resources and the application of science-based irrigation regimes on them and high crop yields. The basic principles of hydromodule zoning for Central Asia were developed by V.M. Legostaev, B.S. Konkov and G.P. Geltser in 1932-1951, based on the mechanical composition of the soil and the location of groundwater [16,17, 18].

The thickness, mechanical composition and current state of the groundwater table in the aeration layer of irrigated lands of South Karakalpakstan were analyzed according to the data of the Amelioration Expedition under the Lower Amudarya Irrigation Basin Department. The map of the administrative territories of Amudarya, Ellikkala, Turtkul and Beruni districts of South Karakalpakstan (scale 1: 50000) and observation wells of the expedition included in it were used. According to the data of soil-lithological sections from the "passport" of observation wells and the average perennial indicators of groundwater level in the vegetation period for each observation well of the reclamation expedition, irrigated lands of Amudarya, Ellikkala, Turtkul and Beruni districts are mainly 6: IV, V, VI, Hydromodule VII, VIII and IX belong to the regions (Table 6).

TABLE 6. Distribution of irrigated lands of South Karakalpakstan districts by hydromodular regions, ha.

Districts	**Irrigated area, thousand ha,**	**Observation wells, pcs**	**Observation area, thousand ha**	**Hydromodule regions**								
				I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Beruniy	33.32	318	33.10	0.51	0.99	0.00	2.13	2.28	1.29	34.18	27.79	30.82
Turtkul	30.38	307	30.21	0.86	2.21	0.43	8.56	3.62	2.27	17.87	30.15	34..04
Amudaryo	38.43	263	38.40	0.39	0.94	0.60	2.76	3.59	0.00	44.26	47.46	0.00
Ellikqal'a	34.10	329	34.03	0.29	1.44	0.06	7.10	28.45	2.20	3.78	29.79	26.89

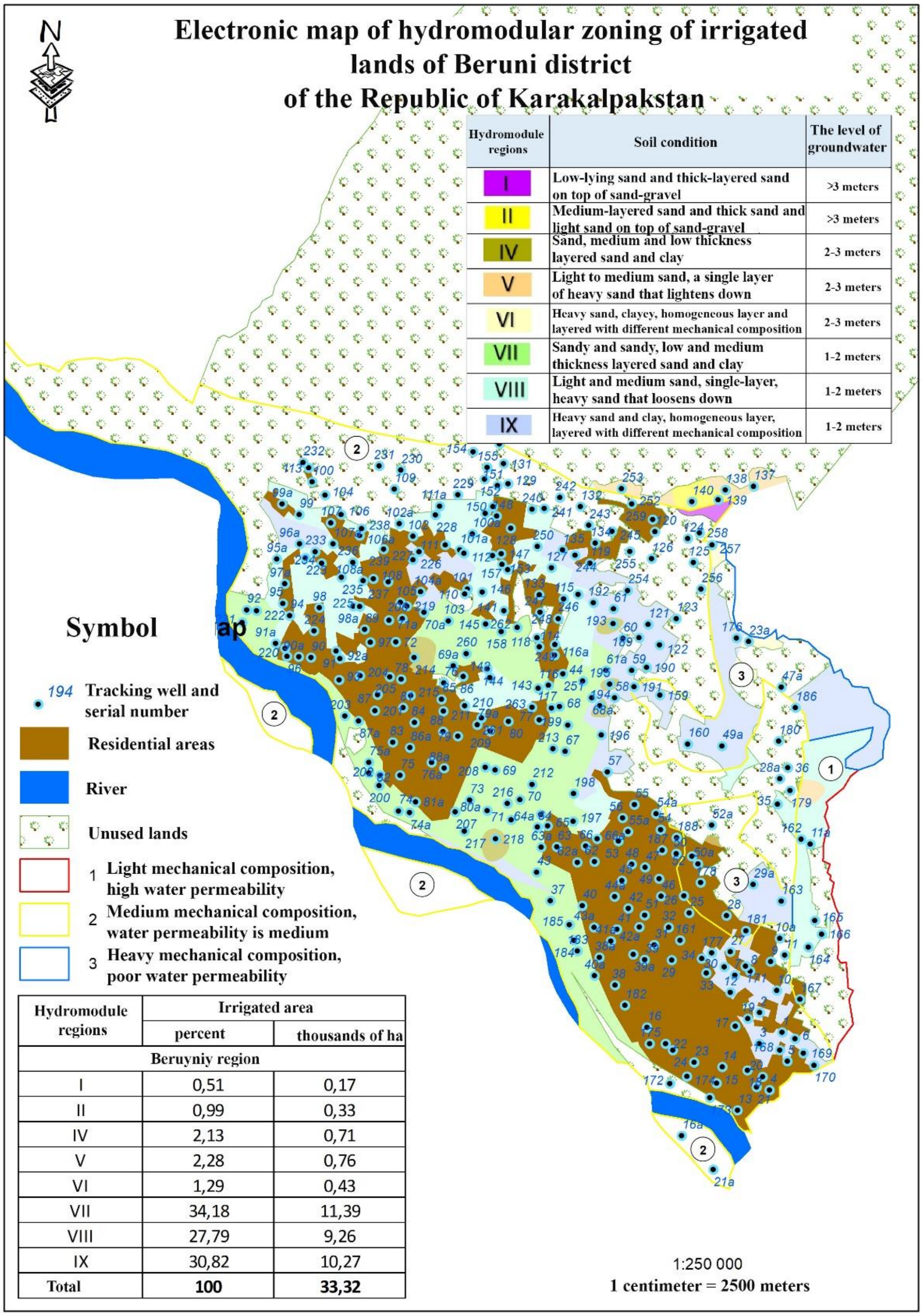
Digital map of the distribution of 3 types of soils (light, medium and heavy sand) with a mechanical composition in the Amudarya basin, based on passports of observation wells installed to monitor the dynamics of groundwater in each district and the results of field research, ArcGIS program [19,20] Electronic maps of hydromodule zoning of irrigated lands of Amudarya, Ellikkala, Turtkul and Beruni districts of South Karakalpakstan were created (Figures 4, 5, 6, 7).



Hydromodule regions	Irrigated area	
	percent	thousands of ha
Amudarya region		
I	0,39	0,15
II	0,94	0,36
III	0,60	0,23
IV	2,76	1,06
V	3,59	1,38
VII	44,26	17,01
VIII	47,46	18,24
Total	**100**	**38,43**

Hydromodule regions	Soil condition	The level of groundwater
I	Low-lying sand and thick-layered sand on top of sand-gravel	>3 meters
II	Medium-layered sand and thick sand and light sand on top of sand-gravel	>3 meters
III	Thick medium and heavy sandy loam	>3 meters
IV	Sand, medium and low thickness layered sand and clay	2-3 meters
V	Light to medium sand, a single layer of heavy sand that lightens down	2-3 meters
VII	Sandy and sandy, low and medium thickness layered sand and clay	1-2 meters
VIII	Light and medium sand, single-layer, heavy sand that loosens down	1-2 meters

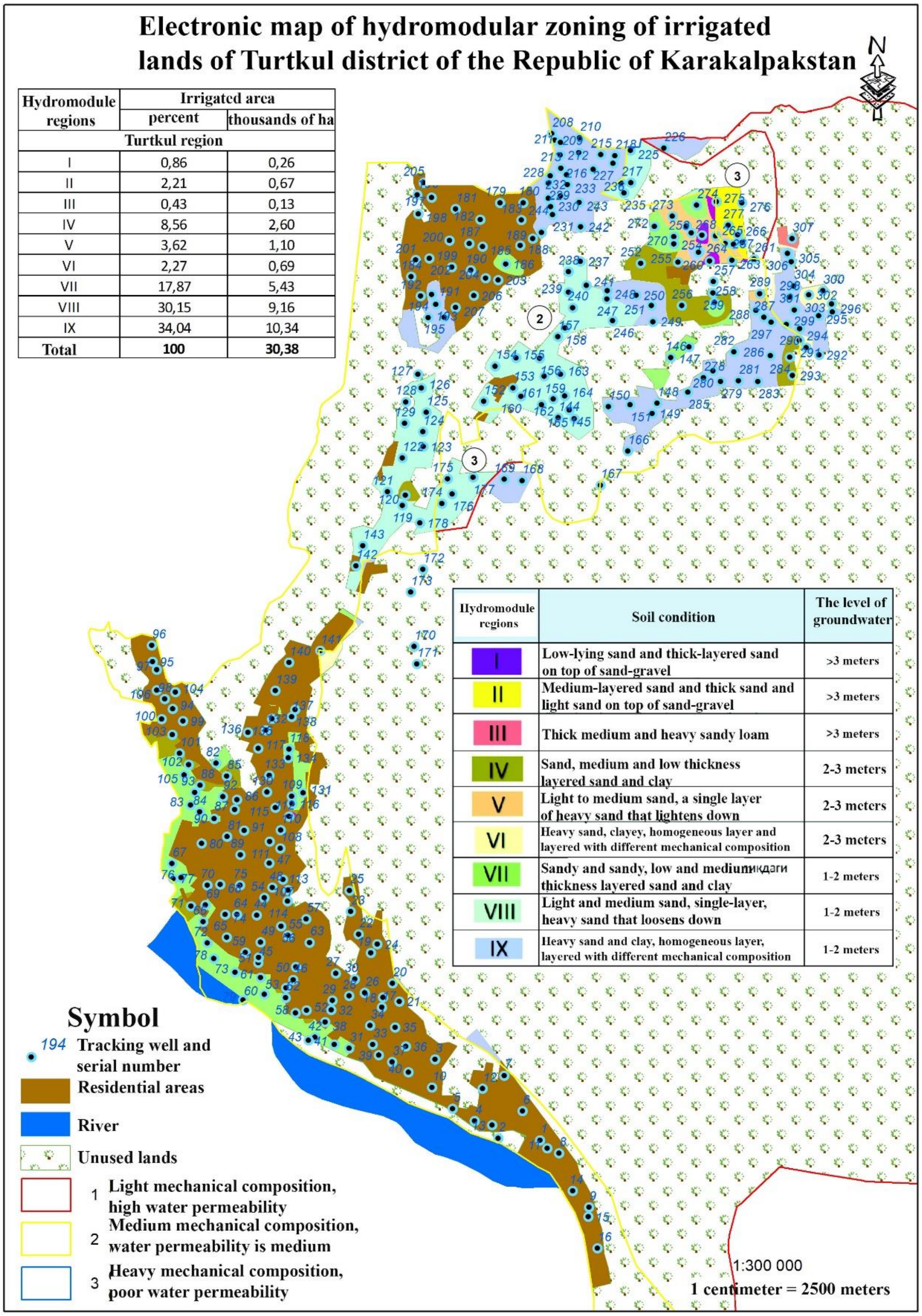
FIGURE 4. Electronic map of hydromodular zoning of irrigated lands of Amudarya district of the Republic of Karakalpakstan



Hydromodule regions	Soil condition	The level of groundwater
I	Low-lying sand and thick-layered sand on top of sand-gravel	>3 meters
II	Medium-layered sand and thick sand and light sand on top of sand-gravel	>3 meters
IV	Sand, medium and low thickness layered sand and clay	2-3 meters
V	Light to medium sand, a single layer of heavy sand that lightens down	2-3 meters
VI	Heavy sand, clayey, homogeneous layer and layered with different mechanical composition	2-3 meters
VII	Sandy and sandy, low and medium thickness layered sand and clay	1-2 meters
VIII	Light and medium sand, single-layer, heavy sand that loosens down	1-2 meters
IX	Heavy sand and clay, homogeneous layer, layered with different mechanical composition	1-2 meters

Hydromodule regions	Irrigated area	
	percent	thousands of ha
Beruyniy region		
I	0,51	0,17
II	0,99	0,33
IV	2,13	0,71
V	2,28	0,76
VI	1,29	0,43
VII	34,18	11,39
VIII	27,79	9,26
IX	30,82	10,27
Total	**100**	**33,32**

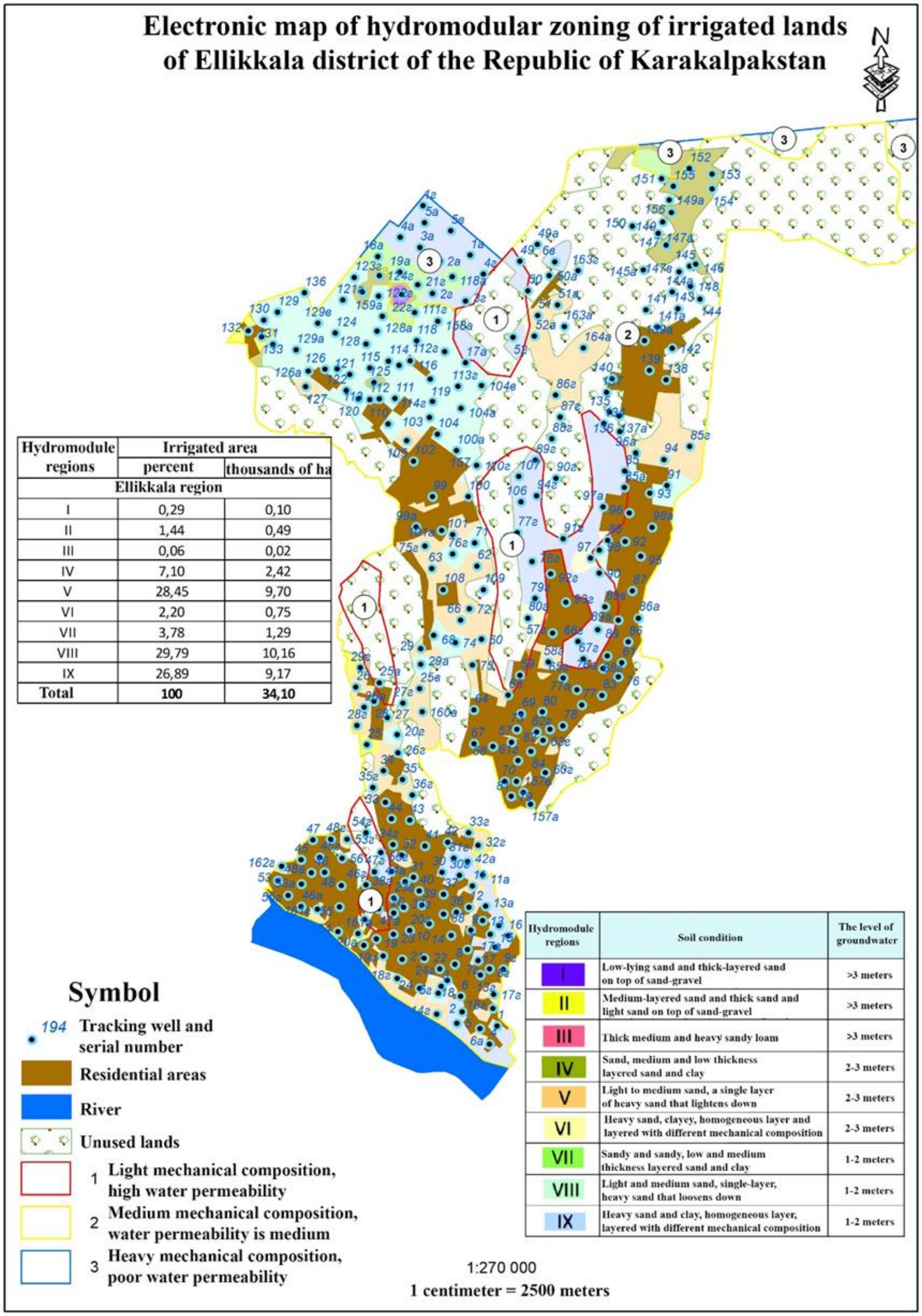
FIGURE 5. Electronic map of hydromodular zoning of irrigated lands of Beruni district of the Republic of Karakalpakstan



Hydromodule regions	Irrigated area	
	percent	thousands of ha
Turtkul region		
I	0,86	0,26
II	2,21	0,67
III	0,43	0,13
IV	8,56	2,60
V	3,62	1,10
VI	2,27	0,69
VII	17,87	5,43
VIII	30,15	9,16
IX	34,04	10,34
Total	**100**	**30,38**

Hydromodule regions	Soil condition	The level of groundwater
I	Low-lying sand and thick-layered sand on top of sand-gravel	>3 meters
II	Medium-layered sand and thick sand and light sand on top of sand-gravel	>3 meters
III	Thick medium and heavy sandy loam	>3 meters
IV	Sand, medium and low thickness layered sand and clay	2-3 meters
V	Light to medium sand, a single layer of heavy sand that lightens down	2-3 meters
VI	Heavy sand, clayey, homogeneous layer and layered with different mechanical composition	2-3 meters
VII	Sandy and sandy, low and mediumпикдаги thickness layered sand and clay	1-2 meters
VIII	Light and medium sand, single-layer, heavy sand that loosens down	1-2 meters
IX	Heavy sand and clay, homogeneous layer, layered with different mechanical composition	1-2 meters

FIGURE 6. Electronic map of hydromodular zoning of irrigated lands of Turtkul district of the Republic of Karakalpakstan



Hydromodule regions	Irrigated area	
	percent	thousands of ha
Ellikkala region		
I	0,29	0,10
II	1,44	0,49
III	0,06	0,02
IV	7,10	2,42
V	28,45	9,70
VI	2,20	0,75
VII	3,78	1,29
VIII	29,79	10,16
IX	26,89	9,17
Total	**100**	**34,10**

Hydromodule regions	Soil condition	The level of groundwater
I	Low-lying sand and thick-layered sand on top of sand-gravel	>3 meters
II	Medium-layered sand and thick sand and light sand on top of sand-gravel	>3 meters
III	Thick medium and heavy sandy loam	>3 meters
IV	Sand, medium and low thickness layered sand and clay	2-3 meters
V	Light to medium sand, a single layer of heavy sand that lightens down	2-3 meters
VI	Heavy sand, clayey, homogeneous layer and layered with different mechanical composition	2-3 meters
VII	Sandy and sandy, low and medium thickness layered sand and clay	1-2 meters
VIII	Light and medium sand, single-layer, heavy sand that loosens down	1-2 meters
IX	Heavy sand and clay, homogeneous layer, layered with different mechanical composition	1-2 meters

FIGURE 7. Electronic map of hydromodular zoning of irrigated lands of Ellikkala district of the Republic of Karakalpakstan

CONCLUSIONS

The following conclusions can be drawn from field experiments on the development of scientifically based irrigation procedures for cotton in the alluvial soils of irrigated grasslands of the southern regions of the Republic of Karakalpakstan:

1. Hydromodular zoning of irrigated lands is one of the foundations of efficient use of water resources in times of water scarcity.

2. Irrigated lands of the southern districts of the Republic of Karakalpakstan belong to one soil-climatic zone - desert zone, three soil-ameliorative areas within this zone. Irrigated lands of the southern districts of the Republic of Karakalpakstan are divided into 25.78% - VII, 34.37% - VIII and 21.86% - IX hydromodular zones in the aeration layer according to the thickness of the soil, mechanical composition, location and groundwater level.

3. based on field experiments to determine the order of scientifically based irrigation of cotton in the most common (34.37%) VIII-hydromodule region in the irrigated lands of the southern districts of the Republic of Karakalpakstan:

- At the beginning of the experiments, the volumetric weight of the soil was 1.35-1.37 g/cm^3 in the 0-30 cm layer and 1.37-1.39 g/cm^3 in the 0-100 cm layer. At the end of the growing season, the volumetric weight of the soil increased in all experiments under the influence of cotton care and various irrigation regimes. In the variant where the minimum soil compaction was 70-80-60% relative to the boundary field moisture capacity: 0.01-0.02 g/cm^3;

- At the beginning of the experiments, the water permeability of the soil for 6 hours was 1258-1300 m^3/ha or 0.349-0.361 mm/min. By the end of the growing season, soil permeability decreased in all variants due to an increase in soil volume, but in the case of cotton irrigation, the pre-irrigation soil moisture was 70-80-60% relative to the marginal field moisture capacity (126-130 m^3/ha, 0.035-0.036 mm / min) decreased to;

- In terms of cotton yield, the best results were recorded in the variant where the soil moisture before irrigation was 70-80-60% of the limit field moisture capacity: when cotton was irrigated in the 1-2-1 system with seasonal irrigation norms of 2789-2867 m^3/ha, the yield was 38, 2-38.9 ts/ha, i.e. 3.8-4.1 ts/ha more than the control and the lowest for 1 quintal of cotton: 71.7-74.7 m^3 of river water was used.

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