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The Use Of Innovative Technologies In Water Use In Conditions Of A Shortage Of Water Resources.

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Abstract. Research in the 80s of the XX century aimed at changing the hydromodular zoning of irrigated lands of the Khorezm oasis in Uzbekistan, the distribution of irrigated lands by hydromodular regions and the definition of scientifically based irrigation regimes for cotton in each hydromodule region. This article presents the results of scientific research on the implementation of hydromodular zoning of irrigated lands of Khorezm region, the distribution of irrigated lands by hydromodular regions and the definition of scientifically based irrigation regimes for cotton in the main hydromodular regions of Khorezm region. Moreover, it provides information on the study of hydrogeological conditions, the definition of irrigated lands in the new hydromodular areas of the oasis.

Irrigated lands of Khorezm region belong to one soil-climatic zone - desert zone, three soil-ameliorative areas within this zone. For the first time electronic distribution of irrigated lands of Shovot and Gurlan districts of Khorezm region on the basis of geographic information system (GIS) technology, using the data of soil-lithological sections and observational wells maps were created.

When irrigating cotton in the most common hydromodule regions VII, VIII and IX in the region cotton, while maintaining the pre-irrigation the soil moistureat the level of 70-80-60% LSMC (lowest soil moisture capacity), and cotton is grown at 3856 m^3 / ha (VII), 2789 (VIII) and 2203 m^3 / ha (IX) irrigated according to seasonal irrigation norms; 35.0, 38.9 and 39.8 C/ha of cotton, with a minimum of one quintal for growing cotton: 55.4; 71.7 and 110.2 m^3 of river water is consumed.

Keywords: Hydromodule zoning, irrigated lands, soil, groundwater, cotton, irrigation schedule, irrigation rate, phenology, yield, water shortage.

Introduction

Due to global climate change, population growth and sectors of the economy, their demand for water is increasing year by year, the shortage of water resources is increasing year by year. Central Asian countries are among the states that are vulnerable to climate change. Mean annual air temperature increases have already been observed across Central Asia due mainly to natural causes [2].As a result of climate change, the area of glaciers in Central Asia has shrunk by about 30 percent over the past 50-60 years. It is estimated that when the temperature rises to 2^{0}C, the volume of glaciers decreases by 50 percent, and when heated to 4^{0}C, by 78 percent. According to estimates, by 2050, water resources in the Syrdarya basin are expected to decrease by 5%, and in the Amudarya basin - by 15%. The total water shortage in Uzbekistan in the period up to 2015 amounted to more than 3 billion cubic meters, by 2030 it may reach 7 billion cubic meters, and by 2050 - 15 billion cubic meters [1]. Climate change will lead to 10-15% evaporation of water 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 [3,4,5].

During the years of independence, the water use system in Uzbekistan has changed radically. Previously, in the Khorezm oasis, water intake from rivers was stopped in September, and canals and ditches were inspected and repaired before the start of saline washing. Currently, as a result of the use of cotton-winter wheat rotation system, irrigation networks are working continuously throughout the year. The load on the collector-drainage networks has greatly increased. These, in turn, affect the process of soil formation in the Khorezm oasis, where there is an increase in the area of hydromorphic soils. Therefore, changes in the hydromodule zoning of irrigated lands of Khorezm oasis, developed in the 80s, the distribution of irrigated lands by hydromodule regions and the definition of scientifically based irrigation regimes for each hydromodule region and the transition to "smart agriculture" The research work aimed at solving this problem is relevant in the context of climate change and the growing water shortage in the country.

Hydromodule zoning,water-saving regimes of cotton irrigationand GIS technology.

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, as well as high crop yields. The main principles of hydromodule zoning: developed for Central Asia in 1932-1951 by VM Legostaev, BS Konkov and GP Geltser, based on the mechanical composition of the soil and the location of groundwater [6]. In 1948-1957, SN Ryjov, BV Fedorov and VE Eremenko improved the basic principles of zoning and divided the lands of Central Asia into 10 hydromodular regions [7]. Further improvements were made in 1968 by the former Sredazgiprovodkhlopok (UzGIP LLC) Institute (Schreder et al.). In addition to the above, they have identified hydrogeological and reclamation areas. These are:

- deep groundwater has a good flow and they do not participate in the process of soil formation (the area of groundwater infiltration);
- groundwater close to the surface, an area that is good to flow from the outside, but difficult to drain, they are involved in the process of soil formation (the area of groundwater rising to the surface);

- areas that do not have a constant level of groundwater, but change depending on the natural conditions of a particular place, and are difficult to flow and drain from the outside (the area of distribution of groundwater).

Although the groundwater level and the mechanical composition of the soil are the same, the hydrogeological-reclamation area is different, the irrigation regime is also different [7].

A. Rachinsky [8] recommends irrigation of cotton with a norm of 900-1200 m^3/ha, which exceeds the deficit of the root layer by 20-30%, in saline soils and ground water depth of 1-2 m in southern Khorezm.

Many scientists around the world have been studying the reduction of drainage water mineralization with the help of water plants and their use for irrigation [9]. In the meadow-alluvial soils of the Bukhara region, to obtain a cotton crop of 42.4 C/ha, irrigation was carried out with maintaining pre-irrigation soil moisture at the level of 70-75-65% LSMC and irrigation with biologically restored drainage water [10,11]. The best regime of pre-irrigation soil moisture for the growth, development and yield of cotton on irrigated lands of the Khorezm region is 70-80-60 % LSMC. In this mode, cotton is watered: on light mechanical soils according to the scheme 1-4-1, irrigation norms 437 - 825m^3/ha, irrigation norms 3641-3676 m^3/ha; on medium loamy soils according to the scheme 1-4-0, irrigation norms 494-664 m^3/ha and irrigation norms 3090-3133 m^3/ha and on heavy mechanical soils according to the 1-3-0 scheme, with irrigation standards of 541-753 m^3/ha and irrigation standards of 2766-2786 m^3/ha [12].

In agriculture and water management, the use of geoinformation systems technology (GIS) allows to solve many problems quickly. The main course of GIS technology is the ArcGIS computer program, which creates a user-friendly and user-friendly interface and is not hidden, no matter how much cartographic modification is given. The operations are clear and simple, with the ability to work with basic data. The most important geoinformation system is to enter data into computer memory and perform all the analytical work that needs to be done to achieve the goal [13,14].

Using GIS technology, it is possible to study the hydraulic processes in the river and river basins, to accurately, reliably and quickly identify the deformation processes in the river, and to control this process [15,16]. The technical condition of irrigation systems in the Syrdarya region was studied using QuickBird satellite images, which were analyzed in the ArcMap program for their various properties and the technical condition of water bodies was studied. ArcMap software from ArcGIS software was used to prepare images for analysis, pre-process them, and create a database. At the initial stage of the analysis, water bodies were separated using the NDWI index. As a result of the research, the technical condition of the district's irrigation networks was determined and it was possible to take operational measures to ensure their working condition [17].

As a result of the research, it was found that ArcGIS software provides a wide range of opportunities for researchers to analyze the results of soil surveys of Spatial Analyst and Geostatistical Analyst modules and create custom thematic maps. In addition, the ArcGIS software used in soil surveys can perfectly analyze the data using a number of methods at the same time, monitor soil condition based on data collected over the years, print the data in any size and copy at the customer's request, save the analysis results electronically and many other similar options have been demonstrated. It should be noted that the application of these modern geographic information technology technologies in the field of soil science can obtain accurate and fast data, increase their processing and storage capabilities, as well as create a database and create a perfect analysis of land resources [18,19].

In order to address the existing shortcomings in the analysis and imaging of groundwater data, the ZEF / UNESCO project staff has developed a new electronic program based on GIS [20]. The advantages of this program are: timely updating and processing of data on groundwater; comparison of created maps with previous data; linking groundwater maps with other important information such as field boundaries, vectors of canals and drainage networks, soil properties. This allows the use of modern techniques such as Kriging to interpolate data from observation wells in order to create regional maps of groundwater levels and their salinity [21,22].

Methods

When conducting research studies were used "Methods of studying agrophysical, agrochemical and microbiological properties of cotton in cotton fields" [23], "Methods of studying field experiments in cotton fields"[24]. Hydromodule zoning was based on the method of N.F.Bespalov [25].

Field experiments to determine scientifically based irrigation regimes for cotton in different hydraulic modules in ErgashRuzimov farm (heavy sandy soils, IX GMR) in Shovot district of Khorezm region, Tulkin, Mirzabek, Asilbek farm in Gurlan district (light sandy soils VII GR) At the farm “Reimbayboshliq” in Beruni district of the Republic of Karakalpakstan (medium sandy soils, VIII GMR).Field tests on the cotton growing regime were carried out according to the scheme: 1-option - production control, 2-option - pre-irrigation soil humidity 70-80-60% LSMC, 3-option - pre - irrigation soil humidity 80-80-60% LSMC and 4-option-pre-irrigation soil humidity 80-80-60% LSMC (irrigation norms exceed the moisture deficit in the layer 0-100 cm by 30%).

Results and Discussion

Hydromodular region is a part of the soil-ameliorative area, the proximity of soil thickness, mechanical composition, their location in the aeration zone, water-physical properties, location of the groundwater table, the order, norms and hydromodule ordinate of irrigation of agricultural crops in general, characterized by proximity. Therefore, the hydromodule zoning of irrigated lands, the creation of its electronic maps - allows you to make operational decisions to ensure the efficient use of water resources and their rational management.

According to the above principles of hydromodule zoning, irrigated lands of Khorezm region belong to one soil-climatic zone - desert zone, and three soil-ameliorative areas within this zone. These are:

- automorphic soils with groundwater depth of more than 3 m;
- semi-hydromorphic soils with groundwater 2-3 meters;
- hydromorphic soils with groundwater 1-2 meters.

Currently, the thickness, mechanical composition and current state of the groundwater table in the aeration layer of irrigated lands of Khorezm region were analyzed according to the data of the Regional Land Reclamation Expedition under the «ChapkyrgakAmudarya» Irrigation Basin Department. A map of the administrative territories of the region and districts (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 during the growing season for each observation well of the Regional Land Reclamation Expedition, 6 irrigated lands of Khiva, Gurlan, Shovot and Koshkopir districts of Khorezm region: IV, V, Hydromodule VI, VII, VIII and IX can be divided into regions (Table 1).

Table 1: Distribution of irrigated lands in some districts of Khorezm region by hydromodular regions,%

#	Districts	Irrigated area, thousand ha	Observation wells, pcs	Observed area, thousand ha	Hydromodule regions					
					IV	V	VI	VII	VIII	IX
1	Khiva	19.81	191	18.36	1.5	0.5	3.2	15.5	47.8	31.5
2	Gurlan	30.36	227	30.36	1.8	4.5	0.1	31.2	41.5	19.9
3	Kushkupir	31.11	225	31.11	3.0	4.0	4.1	10.0	53.9	25.0
4	Shovot	28.95	205	28.95	1.0	1.0	-	10.0	30.0	58.0

In recent years, the transition from paper to electronic digital mapping, i.e. the transition to computer technology of mapping using a geographic information system, is developing rapidly. The fact that many types of data change frequently over time makes it much more difficult to use a paper card that is structured in a simple way. Today, only an automated system can guarantee the receipt of fast information, showing their relevance.

Here, the modern GIS is considered to be an automated system that combines spatial data into a cartographic form, draws various conclusions and monitors, combined with a large number of graphical and thematic databases, model-based modeling and computational functions.

This technology of card creation today is, firstly - a significantly universalized, and secondly - a very rapidly evolving process, covering all areas of human activity. Today, industrial enterprises and organizations are working hard to convert cards and plans from paper to electronic digital form.

Electronic map of hydromodular zoning of irrigated lands of Khorezm region, digital map showing the distribution of 3 types of soils (light, medium and heavy sand) with mechanical composition, passports of observation wells installed to monitor the dynamics of groundwater in each district, Land resources, geodesy, cartography and the State Cadastre was created using the ArcGIS program, based on the materials of the State Committee and the results of field research.To do this, in order to monitor the level and mineralization of permanent groundwater in the regions, the geographical location of observation wells (in Shape format) and monthly attributive data were collected, based on the attributive data representing the groundwater level in the observation wells, ArcGIS IDW distances) using an interpolation algorithm to create a groundwater location map, a digital map describing the level of interpolated groundwater and the mechanical composition of the soil to raster view taken. In this order, an electronic map of two districts of the region: Shovot and Gurlan districts was created (Figures 1 and 2).

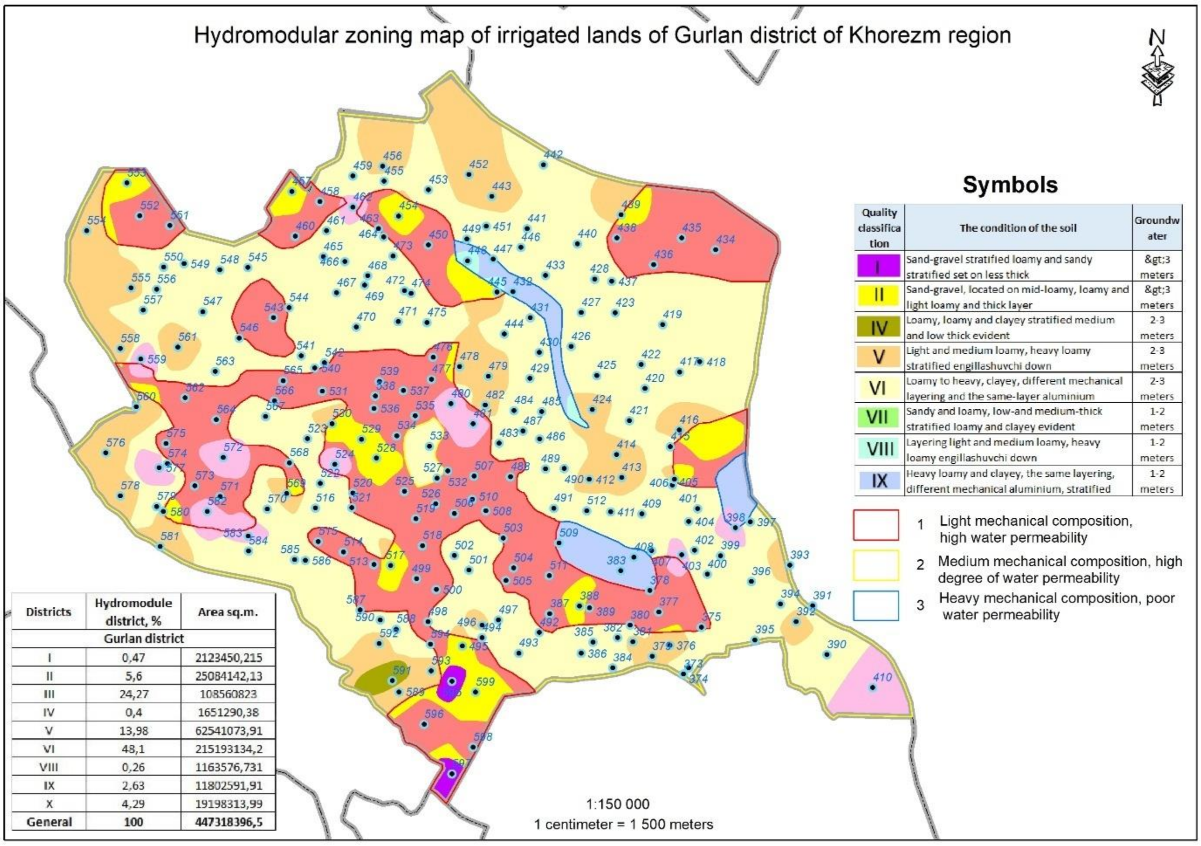

Figure 1. Electronic map of irrigated lands of Gurlan district of Khorezm region by hydromodular regions

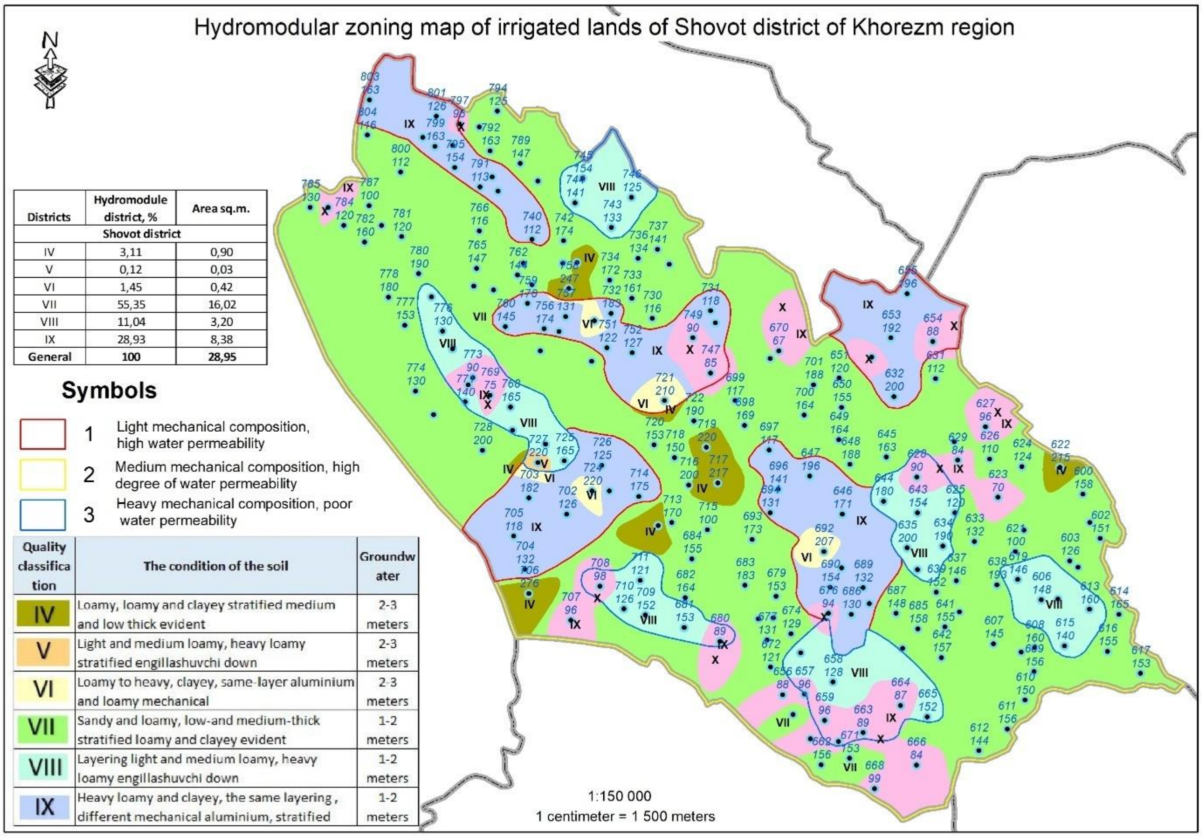

Figure 2. Electronic map of irrigated lands of Shovot district of Khorezm region by hydromodular regions

Science-based irrigation regimes for cotton. Since the irrigated lands of Khorezmregion belong mainly to 3 hydromodule regions: VII, VIII and IX, field research to determine the scientifically based irrigation regimes for cotton for these conditions was carried out on the basis of PSUEAITI methodology.

Irrigation of ErgashRuzimov farm (IX hydromodule district) in Shovot district of Khorezm region, Reimbayboshliq farm in Beruni district (VIII hydromodule district) and TolqinMirzabekAsilbek farm in Gurlan district (VII hydromodule district). was carried out. Collector-drainage networks have been built on the lands of all farms, irrigation networks are of engineering nature. To irrigate agricultural crops, water is delivered to the fields through horn and arrow ditches, and the crops are irrigated side by side. The soil of the farm is weak and moderately saline.

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

Irrigation rate was determined according to the following formula

$M=100 * h * J * (W_{LSMC} - W_{am})+K m^3/ha$ [12]

W_{LSMC} - lowest soil moisture capacity,%;

Wam - actual moisture before irrigation relative to soil weight,%;

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

h -is the calculated layer value, m;

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

Cotton planted in the experimental field was irrigated on the basis of the specified humidity. During the growing season, the number of irrigations in each variant of cotton, its duration, and the total amount of water supplied varied significantly (Table 2).

Table 2: Irrigation regime of cotton

#	Options	Watering rate, m^3 / ha	Irrigation scheme	Seasonal irrigation rate, m^3 / ha
IX HMR	1	1109-1289	0-2-1	3644
	2	992-1024	0-3-0	3025
	3	714-760	0-3-0	2203
	4	967-1205	0-2-1	3160
VIII HMR	1	1142-1276	1-2-1	4744
	2	664-956	1-2-1	3422
	3	623-865	1-2-1	2789
	4	836-1139	1-2-1	3711
VII HMR	1	1025-1144	1-3-1	5395
	2	625-878	1-3-1	4002
	3	600-768	1-4-1	3856
	4	723-985	1-3-1	4033

According to the results of the study of the impact of irrigation regimes on cotton yield (Table 3), in the IX HMR Khorezm-127 cotton variety in the 3rd variant has the highest yield - 39.8 C / ha, the minimum for 1 quintal of cotton: 55.4 m^3 river water was consumed. In the VIII HMR, the highest yield of cotton - 38.9 C / ha before irrigation, soil moisture was maintained at 70-80-60LSMC (option 3), the minimum for the cultivation of 1 quintal of cotton was used: 2789 m^3 of river water .

VII from cotton at HMR. the highest - 35.0 C / ha of cotton was obtained in option 3, the lowest for the cultivation of 1 quintal of cotton: 110.2 m^3 of river water was used. Scientifically based irrigation regimes of Khorezm-127 cotton variety provide high yields, saving 35% of the usual amount of river water during the season.

Table 3: Influence of irrigation regimes on cotton yield

Options	Average yield, C / ha	C / ha relative to control	Seasonal irrigation rate, m^3 / ha	1 C of river water for cotton harvest, m^3
IX HMR				
1	35,6	0,0	3644	102,4
2	37,8	+2,2	3025	80,0
3	39,8	+4,2	2203	55,4
4	38,6	+3,0	3160	81,9
VIII HMR				
1	34,8	0,0	4744	136,3
2	36,6	+1,8	3422	93,5
3	38,9	+4,1	2789	71,7
4	37,6	+2,8	3711	98,7
VII HMR				
1	30,8	0,0	5395	175,2
2	33,2	+2,4	4002	120,5
3	35,0	+4,2	3856	110,2
4	33,8	+3,0	4033	119,3

Conclusions

The following conclusions can be drawn from the research on the development of scientifically based irrigation procedures for cotton in the alluvial soils of the ancient irrigated meadows of the Khorezm oasis:

1. Irrigated lands of Khorezm region belong to one soil-climatic zone - desert zone, three soil-ameliorative areas within this zone, irrigated lands in aeration layer are divided into 6 according to mechanical composition of soils, location of layers and groundwater level: IV, V, VI, Hydromodule VII, VIII and IX belong to the regions. Due to the fact that the groundwater level in the main irrigated lands during the growing season is 1-2 meters, 34.1% of the total area belongs to the VII, 30.3% to VIII and 32.6% to IX hydromodule regions.
2. Digital map describing the distribution of 3 types of soils (light, medium and heavy sand) with mechanical composition, data of soil-lithological sections and average perennial indicators of

groundwater level during the growing season for each observation well were processed in ArcGIS program and the first electronic maps of the distribution of irrigated lands in Shovot and Gurlan districts by hydromodular regions.

3. When irrigating cotton in the IX hydromodule region, which is widespread in the region, the soil moisture before irrigation is kept at 70-80-60% LSMC, cotton is irrigated according to the scheme 0-3-0, by watering norms 700-750 m^3 / ha and seasonal irrigation rates 2203 m^3 / ha. When irrigated with the norm, 39.8 C / ha of cotton was harvested, and the minimum for the cultivation of 1 quintal of cotton was: 55.4 m^3 of river water. In the VIII hydromodule region, the pre-irrigation soil moisture in cotton irrigation is 70-80-60% LSMC. 71.7 m^3 of river water was used to grow 1 quintal of cotton. When irrigating cotton in the VII hydromodule region, the soil moisture before irrigation is 70-80-60% LSMC, and when cotton is irrigated according to the scheme 1-4-1 with watering norms of 600-800 m^3 / ha and seasonal irrigation rate 3856 m^3 / ha, yield 35.0 C/ha and 110.2 m^3 of river water was used to grow 1 quintal of cotton.
4. Electronic maps of hydromodule zoning of irrigated lands created for the first time using modern GIS technology and scientifically based irrigation procedures developed for hydromodule districts.

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