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ФАН ВА ТАЪЛИМ

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ANALYSIS OF THE POTENTIAL OF IRRIGATED LAND AND WATER RESOURCES IN THE ZARAFSHAN REGION

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Summary: *This article examines the availability and spatial distribution of irrigated land and water resources in the Zarafshan economic region, with particular emphasis on district-level differences. Analytical and dynamic data on irrigated land and water resources in Samarkand, Navoi, and Bukhara regions are presented and interpreted. The study provides a scientific assessment of territorial disparities, long-term changes, and the degree of resource provision across districts. Based on the findings, practical recommendations are proposed for improving the efficiency of irrigated land use and the rational management of water resources in the study area.*

Keywords: *Zarafshan region, Bukhara, Navoi, Samarkand, irrigated land, cropland, water resources.*

Introduction. The availability and rational use of natural resources, particularly irrigated land and water resources, have become increasingly important in recent years. This issue is especially significant in agrarian-oriented countries, including Uzbekistan, where agricultural productivity and regional development depend heavily on the effective use of these resources. In this context, the Zarafshan region was selected as the object of study, and its provision with irrigated land and water resources, as well as the territorial characteristics of their distribution and use, were scientifically analyzed. The article concludes with recommendations aimed at improving the management and utilization of land and water resources.

Study Area. The Zarafshan economic region is located in the relatively central part of Uzbekistan and includes the regions of Bukhara, Navoi, and Samarkand (Figure 1). Its total area is 168.1 thousand km², which accounts for 37.4% of the territory of the republic. In this respect, it ranks second in Uzbekistan after the Lower Amu Darya economic region.



Figure 1. Map of Zarafshan region

The historical and geographical foundation, as well as the principal region-forming factor of this economic region, is the Zarafshan River. Although this river no longer reaches Bukhara Region, the history and culture of ancient Bukhara were formed under its influence. Moreover, the present-day Bukhara–Karakul oasis also emerged on the basis of the ancient course of the Zarafshan River [1].

Materials and Methods. The Zarafshan economic region includes the middle and lower reaches of the transboundary Zarafshan River. From a physical-geographical perspective, most of its territory consists of the Kyzylkum Desert. Mountainous areas are partly located in Samarkand Region, while oases and valleys are distributed unevenly across the region. The territorial structure of the regional economy has developed in accordance with these natural conditions. Among the constituent regions, Navoi stands out in terms of area, whereas Samarkand is distinguished by its demographic potential. Bukhara occupies an intermediate position in this regard.

The study employed statistical analysis, cartographic methods, the historical approach, the principle of complexity, interregional comparison, and mathematical methods. Absolute indicators were presented in specific measurement units: irrigated land in hectares and water resources in cubic meters (m³).

Results and Discussion. The Zarafshan region is moderately endowed with land resources at the national scale, although their composition differs significantly by region and by land category. In this respect, irrigated lands are of particular importance, as in many other regions of Uzbekistan. In general, the total area of irrigated land in the region amounts to nearly 8.0 thousand km², or 4.8% of total regional land resources. In 2010, irrigated land covered 777.7 thousand hectares, and over the past 15 years this figure has remained almost unchanged, with growth amounting to 101%. However, compared with the beginning of the century (7,227 km²), the area of irrigated land in the region increased by 63,000 hectares. Since independence, the extent of irrigated land has changed noticeably, largely under the influence of water availability. In addition, several social factors have contributed to the reduction of irrigated lands and to structural changes in agriculture. These include the construction of new residential areas, the expansion of household plots, and the conversion of fertile irrigated land for non-agricultural purposes.

Samarkand Region, despite being the smallest region within the economic district, is very well provided with irrigated land, with a total of 388.7 thousand hectares. This accounts for 8.7% of Uzbekistan's irrigated land and nearly half of the irrigated land within the Zarafshan economic region (48.3%). Over the last 15 years, the area of irrigated land in the region has changed very little, increasing by only 300 hectares (Figure 2). However, at the beginning of the third millennium, this category of land had expanded by more than 6,000 hectares by 2010. Irrigated cropland amounted to 253.9 thousand hectares in 2010 and 243.7 thousand hectares in 2024, representing a decline of 4% over the period. This reduction is largely associated with changes in soil mechanical composition. The shares of these lands in the region and in the republic accounted for 45.1% and 7.5%, respectively.

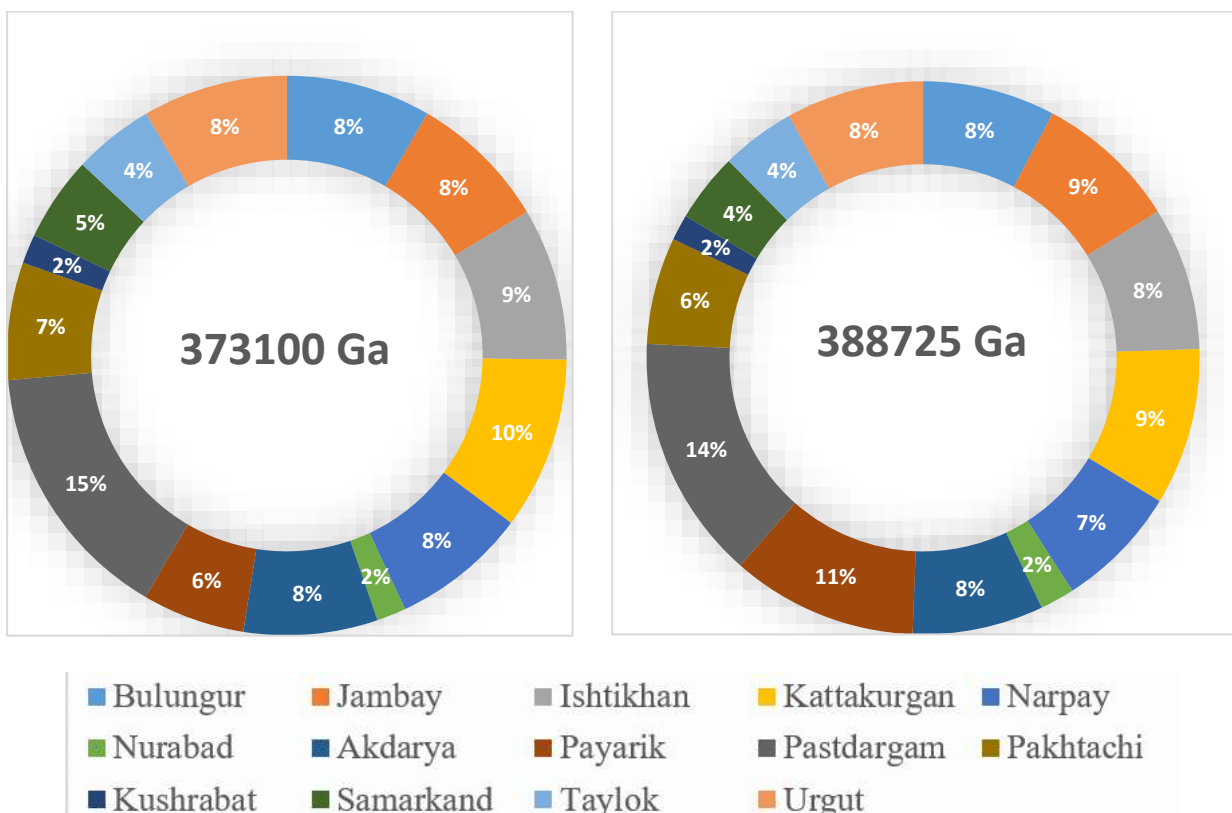


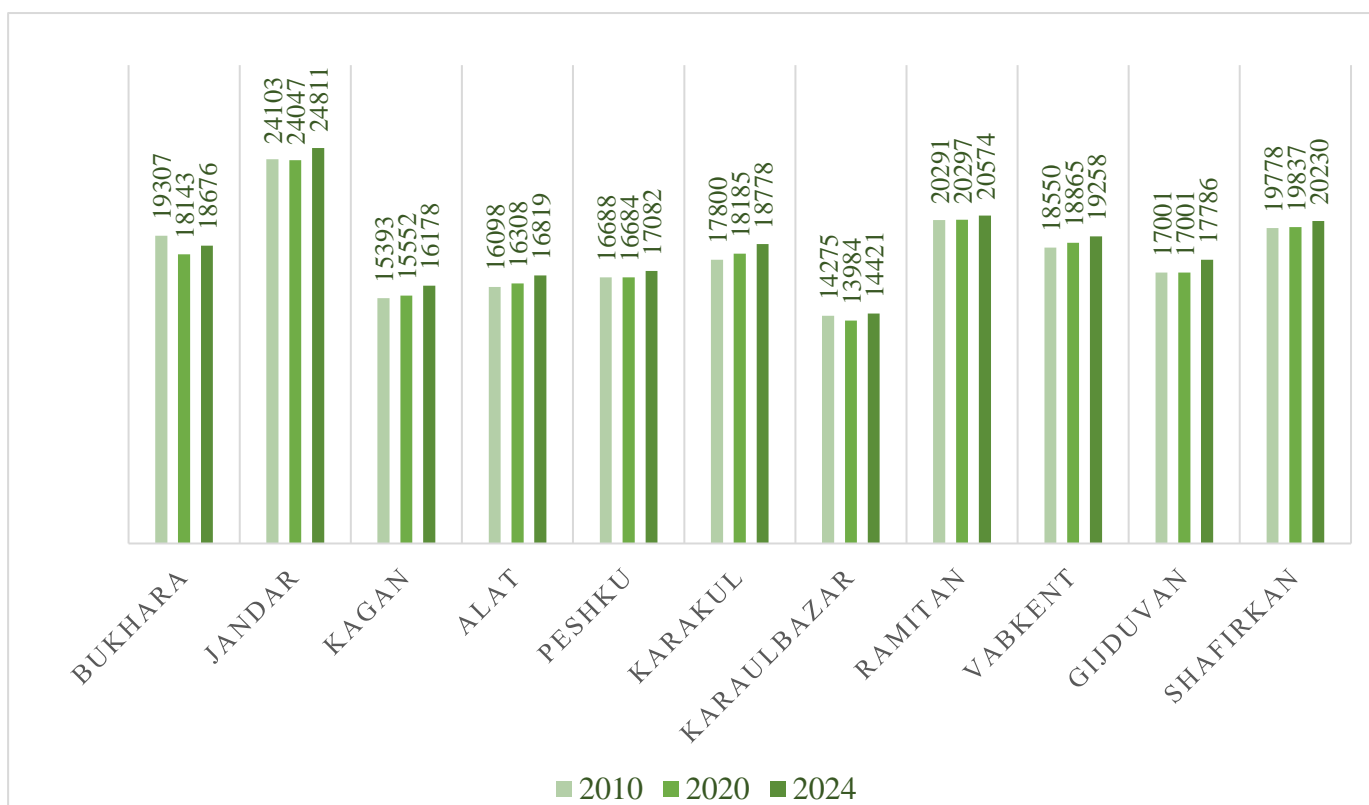
Figure 2. Share of irrigated land in districts of Samarkand region in 2000-2024

Source: Prepared by the author based on data from the Cadastral Agency under the Ministry of Economy and Finance.

An analysis of the territorial distribution of irrigated land in Samarkand Region shows that more than 10% of such lands are concentrated in each of the Pastdargam and Payarik districts. The proportion of irrigated cropland is also high in these districts, reaching 17.2% in Pastdargam and 12.7% in Payarik. In contrast, desert districts such as Nurabad and Kushrabat are much less endowed, with only about 1.5–2%. Over the last 25 years, the district-level shares have remained relatively stable, changing by only 1–2%. However, increased attention to irrigated agriculture in Payarik District led to a 5% increase in its share compared with 2000 (Figure 2).

Bukhara Region demonstrates average indicators in terms of provision with irrigated land. As noted above, almost all agricultural land categories in this region are irrigated, while rainfed farming is absent. The total irrigated land area of 280 thousand hectares accounts for slightly more than one-third of the Zarafshan economic region (35.7%) and 6.5% of the national total. Over the course of a quarter century, these lands increased by nearly 7,000 hectares, while irrigated cropland expanded by about 6,000 hectares. Irrigated cropland covers approximately 205.8 thousand hectares, and its shares in the region and in the republic are similar to those of total irrigated lands, amounting to 38.1% and 6.3%, respectively.

Figure 3. Gradual changes in irrigated land in Bukhara region



Source: Prepared by the author based on data from the Cadastral Agency under the Ministry of Economy and Finance.

There are significant differences in the level of irrigated land provision among the districts of Bukhara Region, which can be explained by such factors as geographical location, water availability, and other territorial conditions. In general, irrigated lands are more extensive in Jandar, Shofirkon, and Bukhara districts, whereas Kagan and Karaulbazar have relatively limited irrigated land. Jandar also ranks first in terms of irrigated cropland area (24.8 thousand hectares), while Karaulbazar ranks last (7%) (Figure 3). Perennial plantations are most widespread in Bukhara District, where they occupy 3,831 hectares, accounting for almost one-fifth of the region’s total. In Olot and Karaulbazar districts, their area has declined due to increasing anthropogenic pressures. Compared with the total land area, the share of irrigated land in cropland, fallow land, and perennial plantations is nearly 100%. Since agro-climatic resources in the region are insufficient for rainfed farming, all cropland belongs to the irrigated land category.

Navoi Region is relatively poor in agricultural resources, including irrigated land. These lands account for only 1.8% of the region’s agricultural land and 1.1% of its total area. Their share in the Zarafshan region (16%) and in the republic (2.6%) is also comparatively low. Irrigated cropland covers 91.2 thousand hectares, which represents nearly 17% of the region’s irrigated land resources (Table 1). The analysis of changes since the beginning of the century does not reveal substantial differences: total irrigated land expanded by slightly more than 1,500 hectares, whereas irrigated cropland decreased slightly by around 200 hectares.

Table 1. Dynamics of the share of irrigated land in the districts of Navoi region relative to the region

№	Districts	Irrigated lands			
		2010	2020	2024	Difference between 2010 and 2024
1	Karmana	16,2	17,2	15,7	99,0
2	Kanimekh	4,8	4,8	4,7	100,3
3	Navbahar	19,5	19,2	19,1	99,9
4	Nurata	3,7	3,7	5,5	151,9
5	Kyzyltepa	26,1	25,5	25,6	100,2
6	Tamdi	0,2	0,2	0,2	100,0
7	Uchkuduk	0,1	0,1	0,1	100,0
8	Khatirchi	29,4	29,3	29,1	99,9
Region		100	100	100	102,1

Source: Prepared by the author based on data from the Cadastral Agency under the Ministry of Economy and Finance.

Territorial differences in irrigated land within Navoi Region are highly pronounced, with the south-eastern districts being better supplied. Khatirchi and Kiziltepa districts account for 54.4% of total irrigated land and 53.2% of irrigated cropland in the region. By contrast, Tamdi and Uchkuduk, which are among the largest districts not only in the region but also in the republic, account for only 0.3% and 0.4% of these lands, respectively. Due to acute water scarcity, other categories of irrigated land are virtually absent in these territories. Navbahar and Karmana districts are also relatively well provided with irrigated land. The share of irrigated land in the total area of districts changed differently over the last 15 years. For example, irrigated land in Nurata District increased from 3.5% to 5.5%, corresponding to a growth rate of 151.9%, whereas irrigated cropland in Karmana (formerly Navoi) District declined by nearly 6% (Table). Not only agriculture, but also other sectors of the economy in Navoi Region show strong territorial disparities. Consequently, the agrarian sector of the region, particularly crop production, demonstrates clear spatial unevenness.

In arid climatic zones, and especially in the Zarafshan region, water is the principal resource for human life, production activities, economic development, and the functioning of хозяйство. Over the last 20–30 years, the population of the region has increasingly suffered from water scarcity and its socio-economic consequences. Irrational use of water resources, together with their quantitative and qualitative decline, has led to a range of serious problems. These include irrigation water shortages, land degradation, and the deterioration of lands adjacent to the Zarafshan River. As a result, unfavorable water-resource conditions have emerged in the densely populated Zarafshan Valley, where large areas of irrigated land are concentrated.

The constituent regions of the study area obtain their main water supply from the Zarafshan and Amu Darya rivers. In this respect, the Zarafshan River is the principal artery of the region, fully supplying Samarkand Region, almost fully supplying Navoi Region, and partially supplying Bukhara Region with water. In addition, the Amu Darya is also a major source of water, delivering the water required for agriculture and population needs through the Amu–Bukhara and Amu–Karakul canals. In order to ensure the rational use of water resources and regulate this process, basin administrations of irrigation systems operate throughout the region. The most important among them is the Zarafshan Basin Administration of Irrigation Systems, which includes five irrigation system departments. In the lower Zarafshan, the Lower Zarafshan Basin Administration of Irrigation Systems and its two irrigation system departments are active. For the irrigation of agricultural lands in Bukhara Region, the Amu–Bukhara Basin Administration of Irrigation Systems was established, incorporating five irrigation system departments. In addition, each district has its own irrigation divisions.

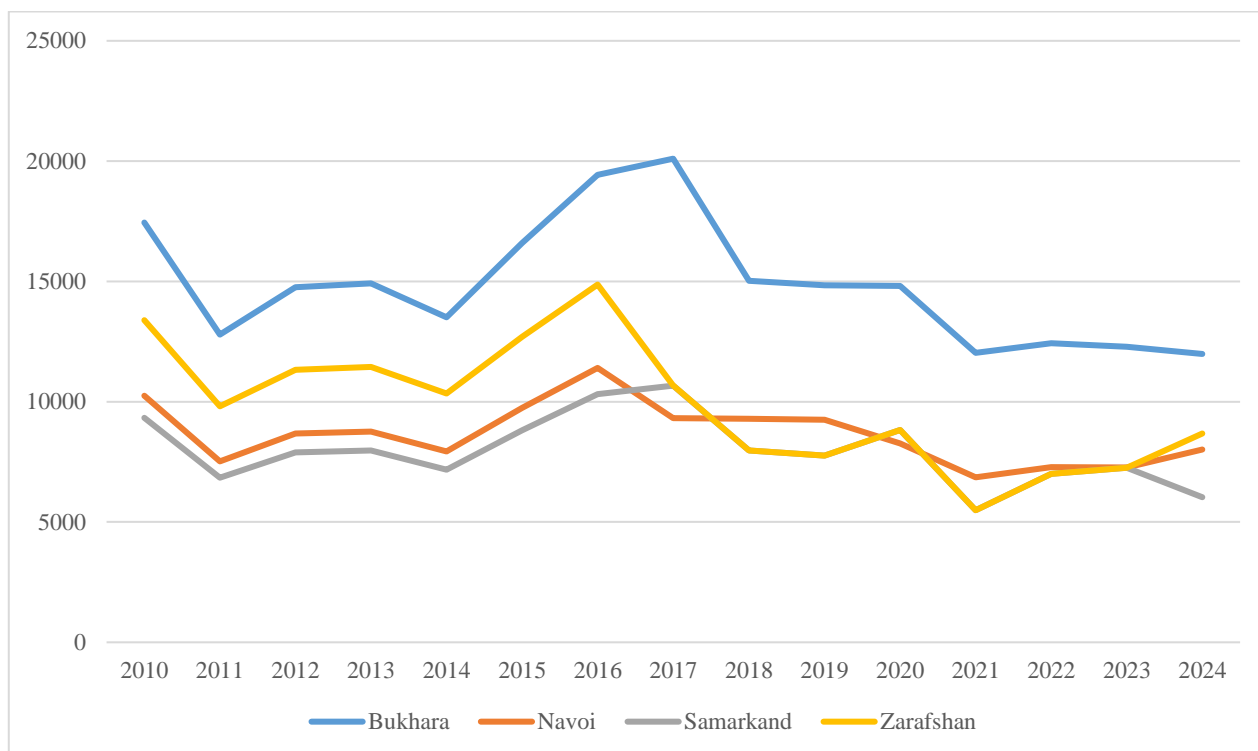


Figure 4. Dynamics of the amount of water available for irrigated land (m³ per 1 ha)

In 2024, a total of 8,559 million m³ of water was used in the region for irrigation purposes. This figure corresponds to 18.5% of the national total. Compared with 2010, water resources declined by 524 million m³, indicating the ongoing fluctuation and reduction of available reserves. This trend is clearly reflected in the dynamics of water resources per unit of irrigated land (Figure 3). The largest share of water resources is consumed by the agricultural lands of Samarkand Region (44%). Bukhara Region accounts for 16.7% of total water reserves (3,958.6 million m³) (Figure 4). Territorial differences are also observed within each region. In terms of water-resource provision, Samarkand Region stands out distinctly.

On average, Samarkand Region receives 3,050.9 million m³ of water annually for its irrigated lands, and the main source is the Zarafshan River, which provides 85–87% of total supply. Additional sources include local streams and springs, groundwater, and drainage collectors. The volume of water obtained from drainage collectors averages 330.9 million m³, accounting for 9.5% of total water consumption. Water from local streams and springs is particularly important for irrigated agriculture in mountainous and foothill districts such as Urgut, Bulung‘ur, and Tayloq. Although the amount of groundwater is relatively small at 42.3 million m³, its good quality makes it important for drinking water and livestock needs. In some territories where water supply conditions are particularly difficult, groundwater is also used for farming. The practice of irrigating crops with such water has existed since ancient times and has been passed down from generation to generation.

Approximately 75% of total water resources are consumed within the region itself through agricultural and economic use, evaporation, infiltration, and related processes, while the remainder returns to the river and is subsequently used in neighboring regions (Figure 5).

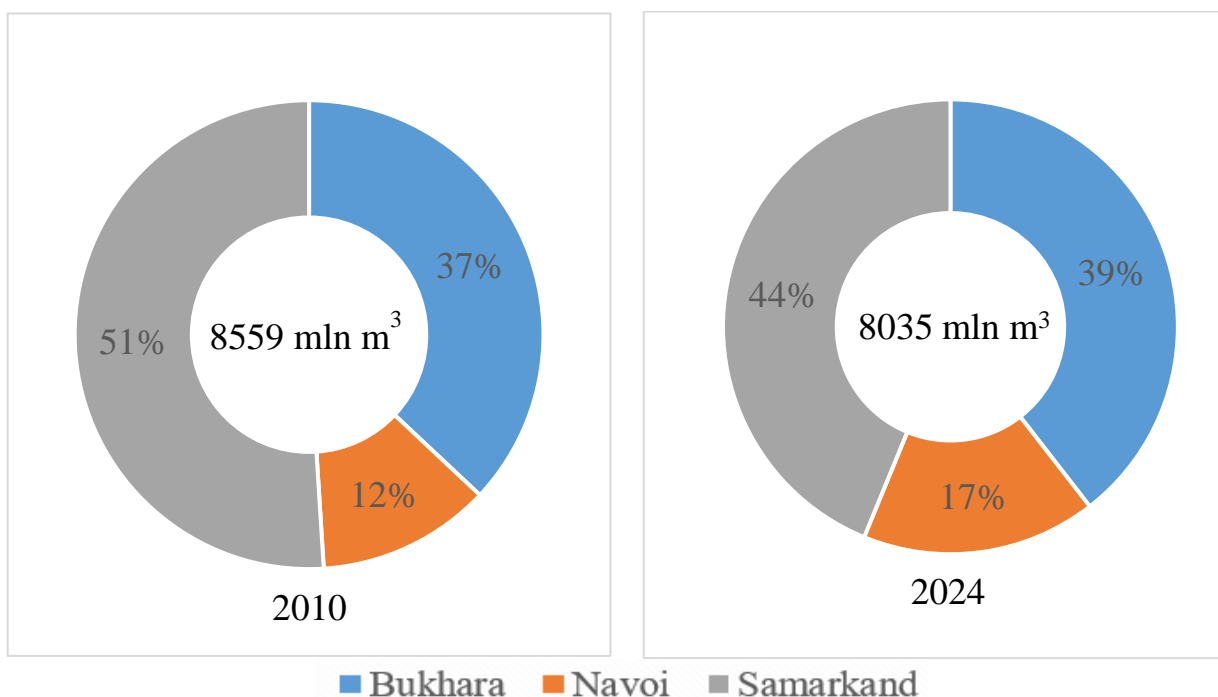


Figure 5. Dynamics of the share of regions in water resources used for irrigation in the region
Source: Prepared by the author based on data from the Ministry of Water Resources.

The coefficient of territorial differentiation in water use within Samarkand Region approaches fortyfold, which is especially evident in the contrast between Pastdargam and Kushrabat districts. This situation is shaped by several factors, including hydrographic location, differences in territorial size, and the diversity of relief conditions.

The districts of the region differ significantly in terms of provision with irrigated land and water resources, as well as in the efficiency of their use. The largest areas of irrigated land and the highest water limits are concentrated in Pastdargam and Payarik districts. In Nurabad and Kushrabat districts, both resources are considerably limited; therefore, extensive agriculture, including pastoralism and rainfed farming, predominates there. In Kushrabat, none of the above-mentioned categories of irrigated land, such as cotton-growing, cereal-producing, or leached agricultural lands, are present. In general, the main problem in this area is insufficient water availability.

In 2024, 1,012.9 million m³ of water was used to irrigate land in Navoi Region. It should be noted that, compared with other regions, more water is also used there for industrial and municipal purposes. Specifically, 34% of total water reserves, amounting to 1,534.9 million m³, was consumed for these purposes. In order to regulate the use of water resources in the regional economy, the Lower Zarafshan Irrigation Systems Administration was established in 2017, and the Karmana–Konimex and Toshrobot–O‘rtacho‘l irrigation system administrations were subordinated to it. All districts of the region, except Tomdi and Uchquduq, receive water from this basin administration.

Although Navoi Region is the largest in area within the study region, it lags considerably behind in terms of water use. On average, it accounts for 1,025.9 million m³ of water annually (Table 2). Changes in water-supply indicators are not particularly pronounced. In this regard, Qiziltepa and Xatirchi districts stand out, as they contain a large share of the region’s irrigated lands and therefore constitute the principal water consumers. Karmana and Navbahor districts also account for relatively high levels of water use. However, very small volumes of water are allocated to irrigated lands in Konimex, due to the limited extent of agricultural land, and especially in Nurota, which is the main mountainous district of the region.

The water resources of Bukhara Region are supplied mainly by the Amu Darya and Zarafshan rivers (Figure 6). The Zarafshan is used for irrigation throughout the territory, although its natural discharge is relatively small. For example, in Karakul the average annual flow is about 14.3 m³/s,

whereas in the mountainous section it reaches around 155 m³/s. To bring water from the Amu Darya, canals such as the Amu–Bukhara and Amu–Karakul were constructed. The flow capacity of the Amu–Bukhara Canal is approximately 235 m³/s.

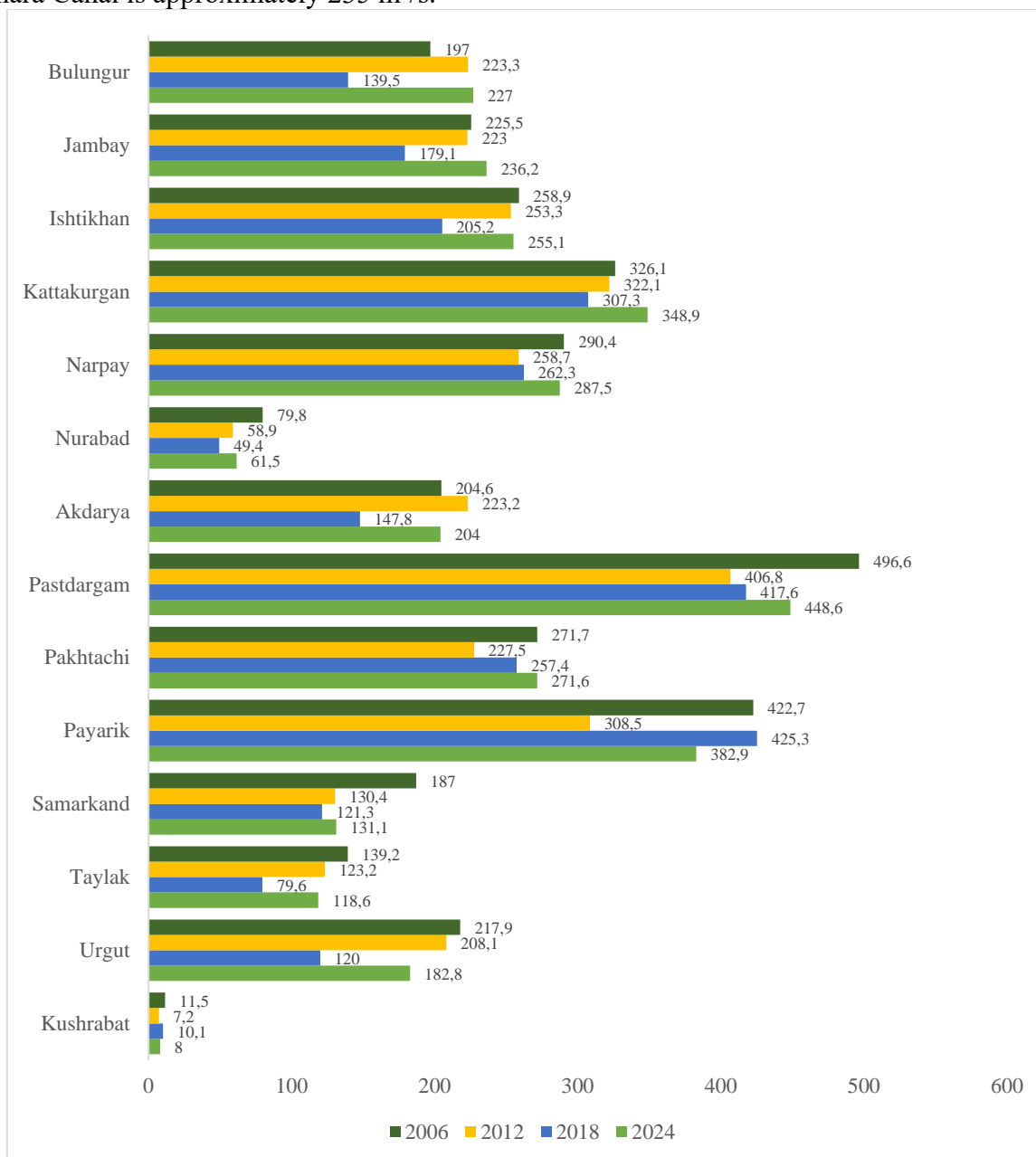


Figure 6. Dynamics of the amount of water used in agriculture in the region (in million m³)

Source: Prepared by the author based on data from the Ministry of Water Resources

Among the reservoirs located near the region, the Quyimozor Reservoir is of particular importance. Its area is about 17.2 km², its total volume is 310 million m³, and its useful storage capacity is approximately 263 million m³. It is used mainly for irrigation and drinking-water supply, while also serving to store Zarafshan waters and redistribute water from the Amu Darya.

Table 2. Dynamics of the amount of water used for irrigation of Navoi region (million cubic meters)

Districts	2020	2021	2022	2023	2024	Average
Karmana	185,9	154,8	170,9	171,9	174,8	184,5
Kanimekh	33,2	27,9	29,4	29,3	28,3	32,1
Kyzyltepa	338,8	278,7	292,6	291,4	351,8	335,3
Navbahar	173,5	142,8	159,6	160,3	188,8	176,8
Nurata	31,0	21,4	18,8	18,9	17,6	25,5
Khatirchi	282,7	241,3	249,4	247,6	251,4	271,5
Total	1045,0	866,8	920,5	919,3	1012,9	1025,9

Source: Table prepared by the author based on data from the Lower Zarafshan Irrigation Systems Basin Administration.

There are two main groundwater aquifers in the region: the Zarafshan–Hissar aquifer, extending toward the Amu Darya in the southern part of the region, and the Central Kyzylkum aquifer, located in the northern and north-western territories. Groundwater is often saline or highly mineralized, and only certain local seepage-water layers are suitable for drinking and irrigation.

Due to the dry climate, low precipitation, and high evaporation rates, groundwater occurs at considerable depth, creating additional challenges for the agrarian sector. Excess irrigation water infiltrates into the subsurface, increases groundwater mineralization, and intensifies salinization processes.

Irrigation systems play a decisive role in water use in Bukhara Region. Water is delivered from the Amu Darya through the Amu–Bukhara Canal and its branches. The natural flow of the Zarafshan River within the region is also distributed through a number of major canals, including Kanimekh, Shafirkan, Vabkentdarya, Ramitan, and others.

Agriculture in the region, especially cotton growing, horticulture, and vegetable production, consumes substantial amounts of water. The scarcity of water resources highlights the need for technological solutions such as drip irrigation and automated monitoring. Existing projects and infrastructure measures are aimed at reducing water losses and promoting more efficient water use.

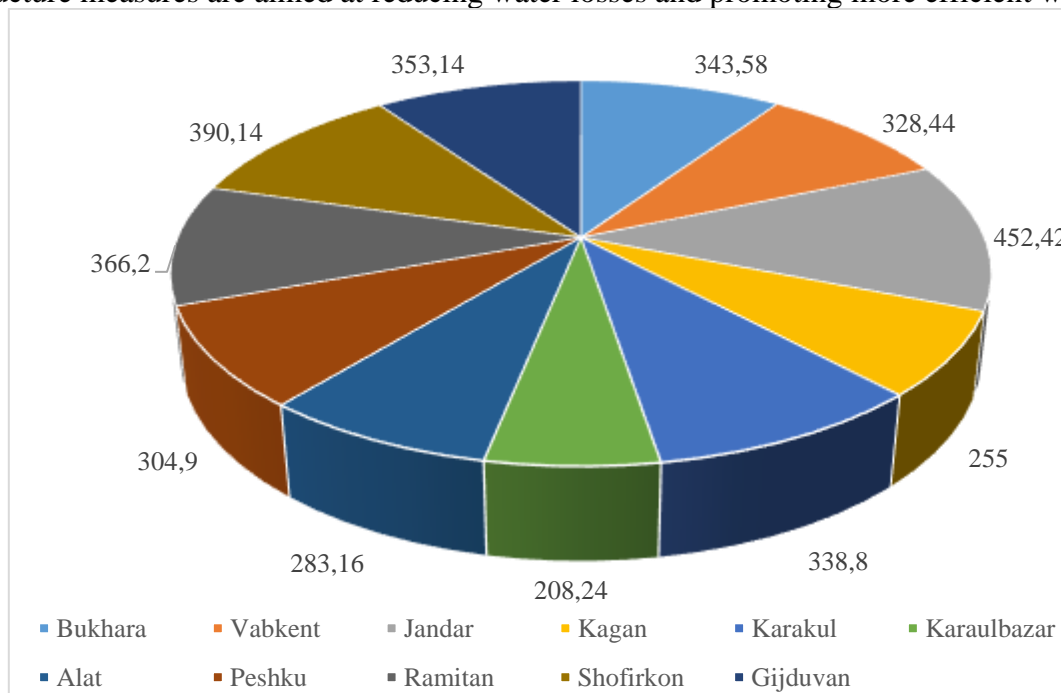


Figure 7. Water resources accounted for by the districts of Bukhara region

Source: Prepared by the author based on data from the Ministry of Water Resources

Salinization and land reclamation remain major challenges. Improper drainage and irrigation systems have caused the salinization of many lands and reduced their productivity. Water scarcity and high evaporation intensify pressure on available water resources under arid climatic conditions, where surface water evaporates rapidly and precipitation remains low.

Uzbekistan's national programs and initiatives in water-resource management include the modernization of Bukhara's water infrastructure, including the concrete lining of canals, the installation of modern control devices, and improvements in flow-regulation efficiency.

Thus, the water resources of Bukhara Region are supplied mainly through the Amu Darya and Zarafshan rivers, groundwater aquifers, and additional reservoirs. At present, the most urgent priorities include rational water use, modernization of irrigation infrastructure, strengthened groundwater monitoring, reduction of salinization, and the introduction of water-saving technologies.

Conclusion. One of the most serious problems in the Zarafshan region is the scarcity and pollution of water resources. Rivers, canals, reservoirs, and even groundwater are increasingly exposed to anthropogenic impacts. Since the 1960s, the large-scale expansion of agricultural lands, the extensive development of industry, the construction of collector-drainage systems, and the growing use of river water for irrigation have sharply intensified water scarcity in the valley, especially in the lower reaches of the river. This, in turn, has led to declining water quality in the basin, the intensification of land degradation, and the deterioration of environmental as well as sanitary-epidemiological conditions.

In recent years, a partial reduction in irrigated land and a significant decline in water resources have been observed. If this process continues, by 2030 the efficiency of irrigated land use may decrease by 20%, while the efficiency of water-resource use may decline by 30%. These figures suggest that, well before 2050, the region may face a shortage of irrigated land and, in particular, water resources. Given that these resources are distributed unevenly across the territory, it is evident that shortages of irrigated land and water resources have already begun in some environmentally and geographically disadvantaged areas.

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Rezyume: Maqolada Zarafshon iqtisodiy rayonining sug'oriladigan yer va suv resurslari bilan ta'minlanganligi, tumanlar doirasidagi holati haqida ma'lumot berilgan. Dastlab viloyatlar sug'oriladigan yerlari hamda suv resurslari bo'yicha tahliliy va dinamik ma'lumot keltirilgan. Tumanlarning mazkur yerlar bilan ta'minlanganlik holati, tadrijiy o'zgarishlari ilmiy tahlil qilingan. Tadqiqot obyekti hududi hamda umumiy holda sug'oriladigan yerlardan foydalanish bo'yicha taklif va tavsiyalar berilgan.

Резюме: В статье представлена информация об обеспечении орошаемых земель и водных ресурсов Зарафшанского экономического региона, его состоянии в районах. Первоначально представлена аналитическая и динамическая информация об орошаемых землях и водных ресурсах регионов. Научно проанализировано состояние обеспечения этих земель в районах, их постепенные изменения. Даны предложения и рекомендации по использованию орошаемых земель на территории объекта исследования и в целом.

Kalit so'zlar: Zarafshon mintaqasi, Buxoro, Navoiy, Samarqand, sug'oriladigan yerlar, ekin yerlar, suv resurslari.

Ключевые слова: Зарафшанская область, Бухара, Навои, Самарканд, орошаемые земли, пахотные земли, водные ресурсы.