

Human settlements in Shofirkon District, Bukhara Region: geographical features, problems and development prospects

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Abstract: This study examines the geographical features, current problems, and development prospects of human settlements in Shofirkon District of Bukhara Region, Uzbekistan, representing one of the first district-level analyses conducted within the region. Drawing on official statistics from the Bukhara Regional Statistical Department, GIS-based cartographic analysis, and comparative-geographical and statistical-analytical methods, the study characterizes a settlement network comprising one administrative city, eight towns, and 144 rural settlements across 3.72 thousand km². The city of Shofirkon grew by 31.9 % between 1995 and 2024, while the district's eight towns, all established in 2009 under the state program "Rural Development and Prosperity," grew unevenly, from 8.0 % to 25.7 %. They remain functionally close to ordinary villages, commonly termed "agro-towns," and display markedly uneven infrastructure despite their shared founding date. Rural settlements are dominated numerically by small, dispersed communities (60.0 % of the total) concentrated mainly in desert and buffer zones, while medium-sized settlements, though fewer, accommodate 61.3 % of the rural population in the fertile oasis center. This spatial pattern reflects a pronounced intra-district ecological gradient associated with water availability. The district faces mounting geoecological problems, including declining groundwater levels, increasing soil salinity, more frequent dust days, and a widening seasonal water deficit associated with population growth and constrained cross-border river management. A household-scale rainwater-harvesting measure is proposed, with an estimated annual yield of approximately 7,800 liters per household, providing a feasible, low-cost means of reducing peak summer water demand in oasis and buffer-zone settlements. The findings indicate that administrative reclassification of villages as towns has not overcome underlying ecological constraints. Further development therefore requires infrastructure investment tailored to each settlement's ecological zone and economic base rather than further status changes. The study provides a replicable district-level framework for analyzing settlement development in arid, oasis-dependent areas of Central Asia.

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1. Introduction

Population is central to the economic reforms aimed at building a stable and efficient national economy, and about 60 % of state budget expenditures are directed toward the social sphere – a fact that underscores the relevance of scientific research on population and related fields.

Globally, accelerating urbanization and international migration continue to widen the development gap between rural and urban settlements. Although urban and rural areas remain functionally interconnected, rural territories in many developing countries lag behind in infrastructure and living standards, and the majority of the world's poor still reside in rural settlements. The United Nations' 2030 Agenda for Sustainable Development and the New Urban Agenda both call for preventing the intensification of socio-ecological, economic-demographic, transport, and other problems within human settlement systems, making territorial research on settlement planning and the dynamics of settlement change particularly relevant.

In Uzbekistan, a number of reforms are underway to improve the territorial distribution of population and settlement development. The New Uzbekistan Development Strategy for 2022–2026 specifically emphasizes the development of a General Scheme for Population Distribution and prioritizes social infrastructure placement around territorial "growth points" within the framework of the "Obod Qishloq" (Prosperous Village) and "Obod Mahalla" (Prosperous Neighborhood) programs. Within this context, research addressing the socio-economic problems of population growth and territorial settlement formation in Bukhara Region – an area of considerable tourism and resource potential – takes on particular significance.

At the same time, continued population growth is increasing demand for social infrastructure and human settlements while intensifying pressure on the ecological condition of the regions, including growing strain on water, land, biological, and climatic resources. Shofirkon District of Bukhara Region, the object of the present study, exemplifies these processes: it faces a range of geographical and environmental problems that constrain its development prospects. A geographical and ecological analysis of these problems is therefore both timely and practically relevant.

Literature analysis and methodology. Geographical research on population has traditionally developed along two lines. The first is oriented toward demographic characteristics proper – population growth, age and sex structure, ethnic composition, and reproduction – while the second addresses human settlement networks, which are themselves a spatial outcome of these demographic processes (Adams, 2022; Bell, Jayne, 2009). Human settlements are commonly defined in the literature not merely as places of residence, but as territorial units combining production, consumption, and socio-economic functions; several scholars converge on this understanding while emphasizing different aspects – from the material conditions of communal life (Conrad et al., 2015) to settlements as centers of labor activity, production, and economic linkage (Di Clemente et al., 2021). Recent scholarship on the Global South has reframed peri-urban and small-settlement dynamics in ways directly relevant to Shofirkon District. Follmann (2022) argues that peri-urbanization is not a transitional or residual category between "rural" and "urban," but a distinct spatial process with its own logic of land-use change, infrastructure lag, and governance ambiguity. This framework fits Shofirkon's eight recently reclassified towns, which occupy exactly this ambiguous administrative-functional space. Roberts (2016) similarly finds that small and intermediate towns in developing regions frequently absorb rural population growth without a corresponding transformation of their economic base, consistent with this study's characterization of the district's towns as "agro-towns." Here, "agro-towns" refers to settlements that acquired formal town status through administrative reclassification while retaining a predominantly agricultural economic base and village-level infrastructure.

Several regional studies establish the comparative context for Shofirkon's settlement network. Ma and Sun (2020) trace the divergent pace of urbanization across the five Central Asian states, finding that Uzbekistan has urbanized more slowly and unevenly than Kazakhstan – consistent with Shofirkon's modest 23.2 % urbanization level. Turemuratov et al. (2024) distinguish "extensive"

agglomeration growth, driven by administrative reclassification, from "intensive" growth built on genuine economic diversification, a distinction that closely matches this study's finding that town status alone has not produced functional urban development in the district. Zhang et al. (2020) document a broader resource-urbanization tension across Central Asia, showing that settlement growth in arid basins tends to outpace sustainable water and land management, corroborating the geoecological pressures identified here. Junussova et al. (2022) show that Central Asian cities' infrastructure investment has generally lagged population growth, particularly in secondary and small urban centers, mirroring the infrastructure-population mismatch documented for Chandir and Juyrabat.

Kurbanov (2014) offers an earlier district-level assessment of urbanization problems across Uzbekistan's administrative districts but does not address Bukhara Region's desert-oasis districts individually - the gap this study fills for Shofirkon. Kurbanov and Oteuliev (2021) document persistent territorial disparities in living standards between Uzbekistan's regions, reinforcing the case for disaggregated, district-level analysis rather than regional averages. Saliev and Fedorko (2012) examine population distribution within Uzbekistan's natural-economic complexes, an approach conceptually related to this study's four-zone classification (oasis center, border, buffer, desert) of Shofirkon's rural settlements. Sergeyeva et al. (2025) analyze urbanization and spatial transformation specifically within Bukhara Region's cities, providing the closest existing comparator to this study, though at the regional rather than district scale.

Liu et al. (2021), examining the Manas River Basin, show how urbanization in arid regions reshapes ecosystem services and human well-being through changes in water and carbon flows, offering a methodological parallel for the water-scarcity mechanisms described here. Nickayin et al. (2022) find that settlement density and agglomeration are closely tied to fertility transitions across the urban-rural divide, relevant to the elevated fertility noted in Mirzoqul, Chandir, and Iskogare. Polinesi et al. (2020) develop a local-regression approach to modeling density effects on population trends, a technique that could extend the present district-level classification to finer spatial resolution in future work. Veckalne and Tambovceva (2023) propose a composite indicator for evaluating urban sustainability in Uzbekistan, a framework that could be applied to assess whether Shofirkon's towns meet sustainability thresholds beyond the infrastructure counts used here.

This literature establishes three points of departure. First, Central Asian urbanization research has largely operated at the national or regional scale (Ma & Sun, 2020; Turemuratov et al., 2024; Zhang et al., 2020), leaving district-level dynamics in arid, oasis-dependent districts comparatively unexamined. Second, Uzbekistan-specific studies (Kurbanov, 2014; Kurbanov & Oteuliev, 2021; Sergeyeva et al., 2025) confirm persistent sub-regional disparities but stop short of the individual-district resolution provided here for Shofirkon. Third, the ecological-demographic literature (Liu et al., 2021; Nickayin et al., 2022) links settlement growth to water-resource constraints but has not previously been applied to a desert-oasis district of Bukhara Region. The present study addresses this threefold gap through a combined demographic, infrastructural, and hydrological analysis at the district level.

Despite this substantial body of work, the natural, historical, and socio-economic factors shaping settlement formation, settlement classification, and the territorial changes occurring within urban- and rural-type settlements have not been examined at the level of individual administrative districts of Bukhara Region - including Shofirkon District. This gap constitutes the immediate rationale for the present study, which combines statistical, cartographic, and comparative-geographical methods to analyze the geographical features, current problems, and development prospects of human settlements in Shofirkon District.

2. Materials and Methods

Study area and data sources

The study area is Shofirkon District, located in the northern part of Bukhara Region, Uzbekistan, bordering Vobkent District to the south, Romitan District to the southwest, Peshku

District to the west, G'ijduvon District to the east, and Konimex District of Navoi Region to the north. The district covers 3.72 thousand km² (9.2 % of the region's total area) and, as of January 1, 2024, had a population of 186.5 thousand people (43.2 thousand urban, 143.3 thousand rural), distributed across 1 city, 8 towns, and 144 rural settlements (Bukhara Regional Department of Statistics, 2024) (Figure 1).

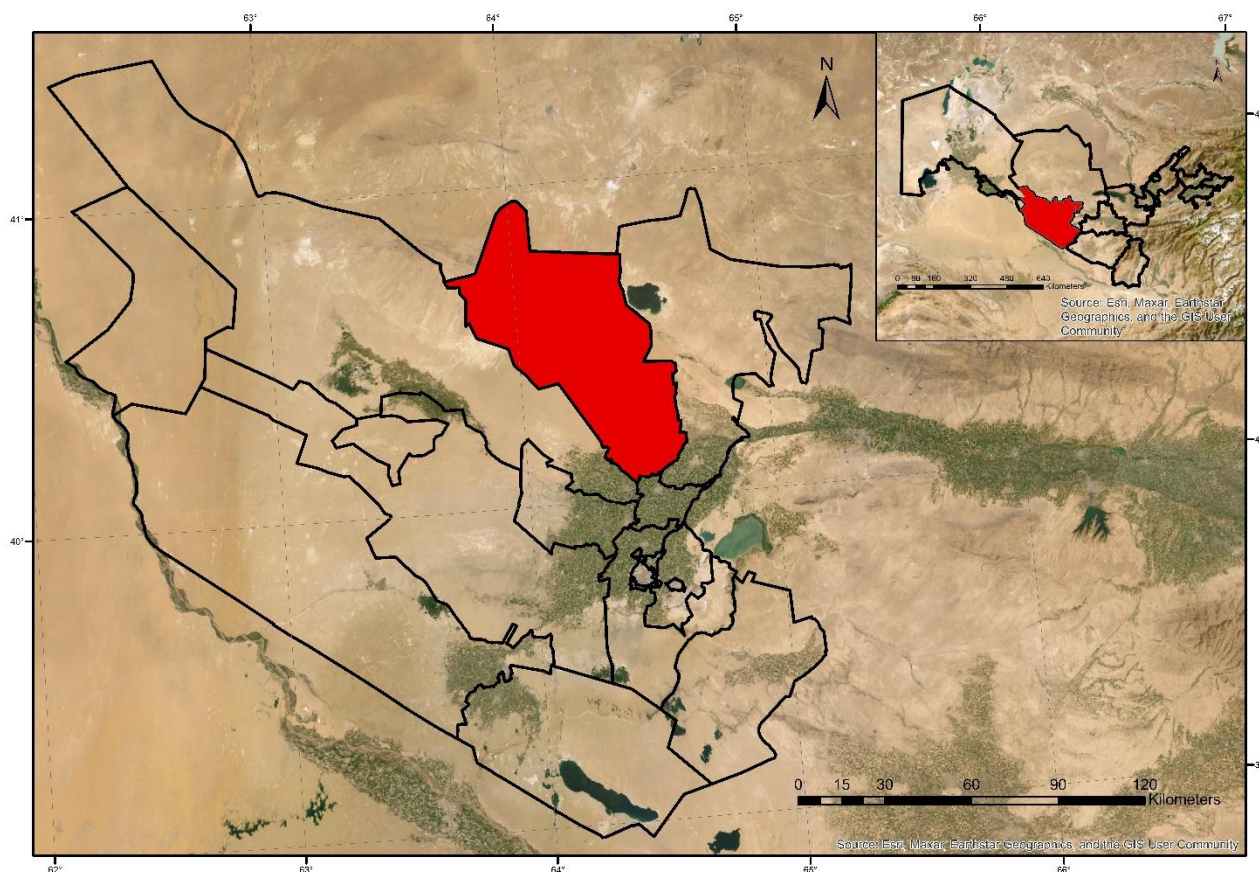


Figure 1. Location of the study area (Shofirkon District) within Bukhara Region, Uzbekistan

The primary data source was official statistics obtained from the Bukhara Regional Statistical Department, covering settlement-level population figures for the district's city and eight towns across five reference years (1990, 1995, 2000, 2016, and 2024 for the city; 2013, 2016, and 2024 for the towns), as well as current data on the socio-economic infrastructure of the newly formed towns, compiled from official records of the Bukhara Regional Statistical Department (no independent field survey was conducted) - the number of small businesses, sales and service outlets, schools, hospitals, pharmacies, markets, and the presence of gas and centralized water supply. These infrastructure indicators were used as a proxy set for assessing how far each town's development corresponds to formal urban-planning criteria. Infrastructure indicators are reported as absolute counts rather than per-capita values because reliable settlement-level population figures for all eight towns in the relevant reference years were not available from the Bukhara Regional Statistical Department; this constraint is discussed further under Limitations. Regulatory and programmatic documents were used as secondary sources to establish the administrative history of the settlement network, in particular the 2009 state program "Rural Development and Prosperity" and Cabinet of Ministers Decree No. 68, under which 966 rural settlements nationwide (67 in Bukhara Region, 8 in Shofirkon District) were granted town status.

Cartographic and GIS methods

Spatial data consisted of vector layers (administrative boundaries and settlement points) obtained from the open cartographic database OpenStreetMap (OSM), with satellite imagery from

Esri World Imagery (Esri, Maxar, Earthstar Geographics, and the GIS User Community) used as a background base layer (spatial resolution up to 0.3–1 m in urban areas, generally 15 m elsewhere, per Esri World Imagery specifications). Data processing, visualization, and spatial analysis were performed in ArcGIS Desktop 10.5 (ArcMap 10.5) using the WGS 1984 / UTM Zone 40N (EPSG:32640) coordinate reference system. The principal methods applied included spatial overlay of thematic layers, analysis of the relative position of objects, measurement of distances and areas, as well as thematic classification and cartographic visualization. These data and methods were used to produce the location map of the study area within Bukhara Region (Fig. 1) and the settlement-distribution map showing the spatial arrangement of the district's city and eight towns relative to the district center (Fig. 2). Straight-line distances from each of the eight towns to the district center were calculated in the GIS environment using Euclidean (straight-line) distance rather than road-network distance, since a complete and geometrically accurate road-network dataset for the district was not available (ranging from 4 km for Mirzoqul to 11.9 km for Quyi Chuqurak) and used as an indicator of geographical accessibility and locational advantage within the settlement network; straight-line distance is therefore used here as a proxy for relative locational advantage rather than actual travel distance.

Comparative-geographical method

This method was applied at two spatial scales. First, at the district scale, the settlement network of Shofirkon was compared with those of neighboring and other rural districts of Bukhara Region to characterize its degree of urbanization (23.2 %, typical of the region's rural districts) and the relative weight of small, medium, and large rural settlements. Second, within the district, the comparative-geographical method was used to differentiate the rural settlement network into four geographically conditioned zones according to their position relative to the Zarafshan oasis and the Kyzylkum desert: (1) settlements located in the oasis center (Revgar, Naqqosh, Savrak); (2) settlements bordering neighboring districts (Madaniyat, Mavri, Yuqori Chitgaron); (3) settlements in the buffer zone between oasis and desert (Jilvon, Quyi Jilvon, Tezguzar); and (4) settlements located within the desert proper (Churuk, Yangibog').

Zone assignment followed a qualitative expert classification based on each settlement's position relative to the boundary of irrigated (oasis) land and its proximity to the Zarafshan River irrigation network, rather than a fixed quantitative distance threshold.

Statistical-analytical method

Population data for all settlements were processed to classify them by demographic size using the threefold typology conventional in Uzbek settlement geography (Saliev & Nazarov, 2009): for rural settlements - small (up to 1,000 inhabitants), medium (1,000–3,000), and large (3,000–5,000 and above); towns were assessed on a comparable scale. Based on this classification, the number, share, and total population of each settlement category were calculated (e.g., 86 small rural settlements, 60 % of the total, with a combined population of 49.3 thousand; 56 medium settlements, 38.6 %, with 87.8 thousand inhabitants; and 2 large settlements, 1.4 %). The same method was applied to the eight towns to determine their combined share (64.4 %) of the district's total urban population and to track their population dynamics since receiving town status in 2009.

To assess whether population growth was associated with proximity to the district center, Spearman's rank correlation coefficient was calculated between the population growth rates of the eight towns during 2013–2024 and their GIS-derived Euclidean distances from Shofirkon. Spearman's rank correlation was selected because of the small sample size ($n = 8$) and because it does not require an assumption of normality. Statistical significance was evaluated at $p < 0.05$.

Applied hydrological estimation

To evaluate a practical mitigation measure for the district's water shortage, a simplified water-harvesting calculation was performed using the standard relationship that 1 mm of precipitation yields 1 liter of water per m^2 of collection surface. This was applied to the average hard-roof (slate-covered) catchment area of rural households in the district (approximately $60 m^2$) combined with the midpoint of average regional annual precipitation (130 mm, taken as the mean of the 120–140 mm range),

yielding an estimated potential rainwater-harvesting volume of approximately 7,800 liters per household annually (range: 7,200–8,400 liters across the full precipitation range). This figure represents gross catchment potential before accounting for runoff-coefficient losses (typically 0.8–0.9 for slate roofs) and storage/collection losses, and should therefore be treated as an upper-bound estimate rather than a net usable volume, and its practical use depends on storage capacity sufficient to carry water over into the peak-demand summer period.

Limitations

The analysis relies on district-level administrative statistics rather than primary field survey data; infrastructure indicators for the eight towns are presented as counts rather than per-capita or normalized values, and the hydrological estimate is a first-order approximation intended to illustrate feasibility rather than a full water-balance model.

3. Results

The district covers 3.72 thousand km² (9.2 % of the region's total area) and, as of January 1, 2024, had a population of 186.5 thousand people, of which 43.2 thousand (23.2 %) were urban and 143.3 thousand rural - a level of urbanization typical of the province's predominantly agrarian districts. In Shofirkon District, where the majority of the population is rural, the settlement network is correspondingly dominated by rural forms of habitation. As of 2024, the district comprises 1 city, 8 towns, and 144 rural settlements, most of which are of considerable antiquity and differ markedly from one another in size, architectural landscape, ethnic composition, ecological condition, and tourism potential – a diversity that nonetheless follows the general character of a desert-zone settlement pattern.

As Figure 2 shows, the city of Shofirkon - the district's only city and administrative center - has grown steadily since receiving city status in 1995, its population increasing from 11.6 thousand to 15.3 thousand, or by 31.9 %, over the following three decades. Growth was most rapid in the earliest period (6.9 % between 1995 and 2000) and has since proceeded at a more moderate pace (12.9 % between 2000 and 2016; 9.3 % between 2016 and 2024), suggesting a gradual maturation of the city's demographic base rather than continued rapid expansion.

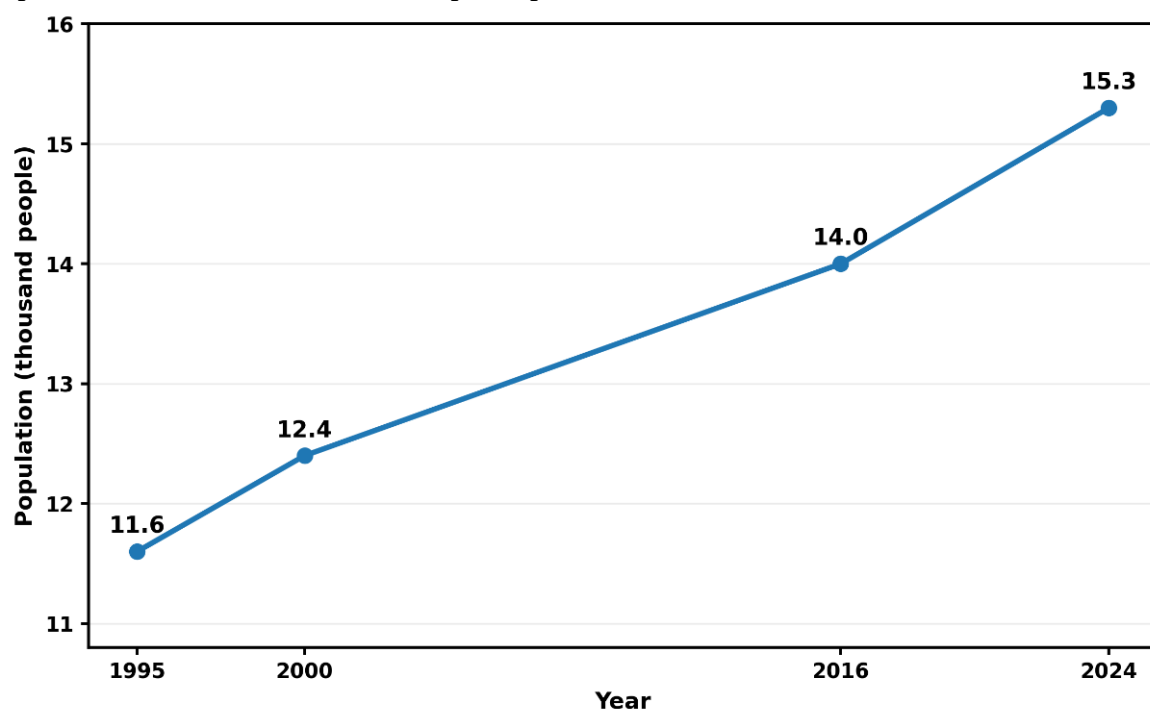


Figure 2. City population dynamics, Shofirkon District, 1995–2024 (thousand people)

To quantitatively assess whether population growth is associated with proximity to the district center, the population dynamics of the eight urban settlements were compared with their distances from Shofirkon (Table 1)

Table 1. Distance from Shofirkon and population growth in urban settlements, 2013–2024

Urban settlement	Distance from Shofirkon, km	Population, 2013, thousand	Population, 2024, thousand	Population growth, 2013–2024, %
Juyrabat	7.0	3.5	4.4	25.7
Iskogare	11.1	4.3	4.9	14.0
Quyi Chuqurak	11.9	2.5	2.7	8.0
Mirzoqul	4.0	2.4	2.6	8.3
Talisafed	9.0	3.8	4.4	15.8
Undare	5.1	2.5	2.8	12.0
Chandir	9.4	2.8	3.4	21.4
Gulomte	8.7	2.2	2.6	18.2

Note: compiled by the authors based on data from the Bukhara Regional statistical department and GIS-based distance calculations

Spearman’s rank correlation analysis was used to assess the relationship between distance from the district center and population growth across the eight urban settlements during 2013–2024. The analysis indicated no statistically significant association between the two variables (Spearman’s $\rho = -0.071$, $p = 0.867$, $n = 8$). Thus, within this small sample, population growth does not appear to vary systematically with distance from the district center.

All eight settlements were granted town status in 2009 under the state program “Rural Development and Prosperity”, when 966 rural settlements nationwide, including 67 in Bukhara Region and 8 in Shofirkon District, were reclassified as towns. As Figure 3 indicates, these towns have grown unevenly over the following fifteen years: their combined population rose from 24.0 thousand in 2013 to 27.8 thousand in 2024, an aggregate increase of 15.8 %, but individual growth rates ranged from 8.0 % (Quyi Chuqurak) to 25.7 % (Juyrabat).

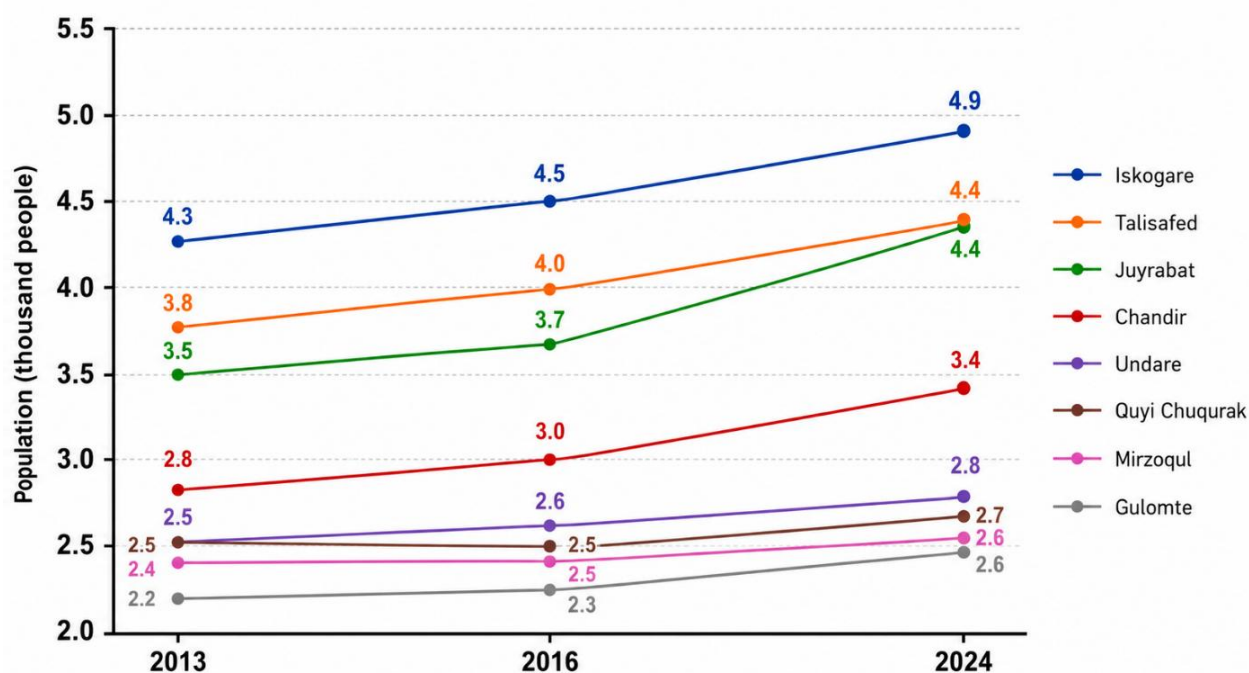


Figure 3. Population Dynamics of Urban Settlements in Shofirkon District, 2013–2024

Juyrabat, Chandir, and Gulomte grew fastest (25.7 %, 21.4 %, and 18.2 %, respectively), while Quyi Chuqurak and Mirzoqul grew slowest (8.0 % and 8.3 %, respectively). Consistent with the Spearman rank correlation analysis presented in Table 1, these differences in population growth show no statistically significant association with distance from the district center (Spearman's $\rho = -0.071$, $p = 0.867$, $n = 8$). This suggests that other factors, including differences in economic specialization and natural-resource conditions, may contribute to the observed variation. Combined, the town population of 27.8 thousand accounts for 64.4 % of the district's total urban population of 43.2 thousand, with the remaining share concentrated in Shofirkon city itself.

Because comparable population data for all eight towns were unavailable, the infrastructure indicators are interpreted descriptively and are not used to rank the towns by per-capita infrastructure provision.

As Figure 4 illustrates, Shofirkon city occupies a geographically favorable central position relative to the surrounding settlements, being comparatively close to all eight towns.

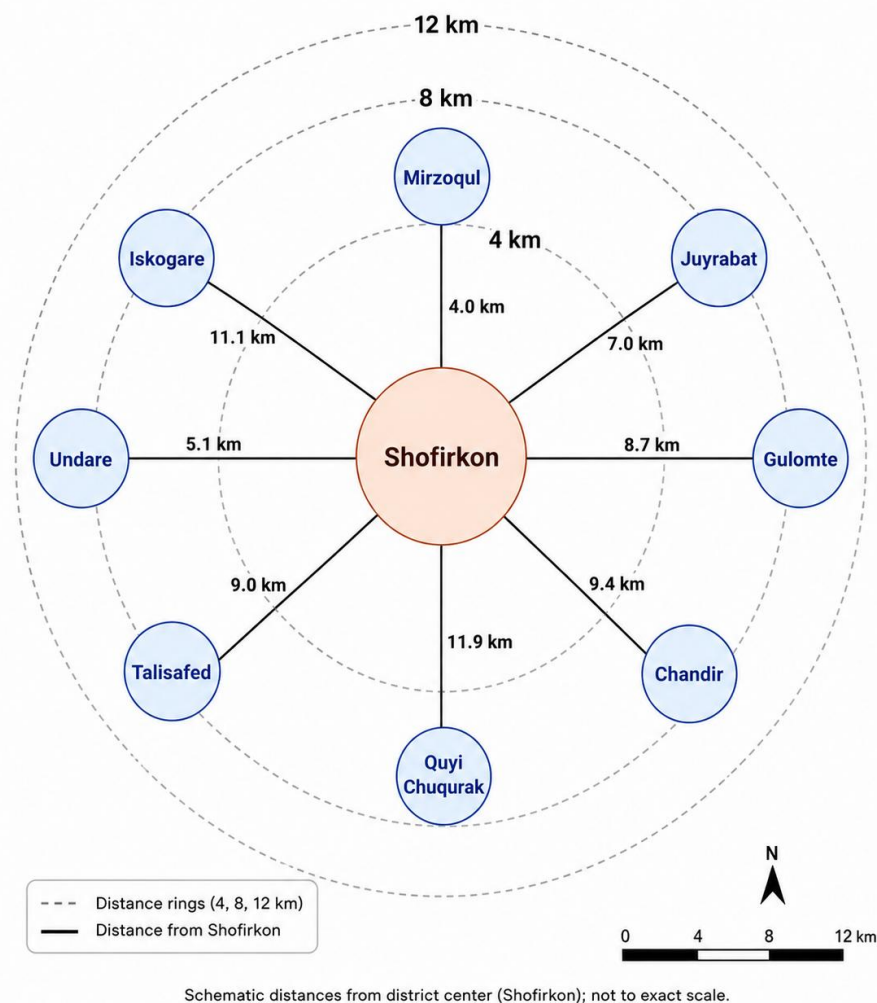


Figure 4. Distance of Urban Settlements from Shofirkon District Center

Mirzoqul is the nearest town to the center, at 4.0 km, followed by Undare (5.1 km) and Juyrabat (7.0 km); Quyi Chuqurak (11.9 km) and Iskogare (11.1 km) are the most peripheral, located roughly three times farther from the center than Mirzoqul. This favorable central position of the district capital, combined with the relatively short average distances to the surrounding towns, is one of the structural advantages of Shofirkon's settlement network compared with more dispersed districts of the region.

The data presented in Table 2 show that, despite formally holding town status since 2009, the infrastructure profile of these settlements remains close to that of ordinary villages, which is why they continue to be referred to locally as “agro-towns.”

Basic social infrastructure (one school and one hospital per town) is uniformly present, reflecting the standardized planning norms applied when the settlements were reclassified, but commercial and utility infrastructure is markedly uneven: Mirzoqul stands out with the highest number of small businesses (3) and service outlets (7), consistent with its central location, while Juyrabat and Undare have no functioning markets. Gas supply is available in five of the eight towns but absent in Chandir, Juyrabat, and Gulomte, indicating an unresolved gap in utility coverage. A comparison of population growth rates and infrastructure indicators shows that Chandir and Juyrabat, despite lacking gas supply, recorded the highest population growth rates (21.4 % and 25.7 %, respectively). This suggests that population growth in these towns has so far outpaced infrastructure development. Overall, only Chandir, Talisafed, and Mirzoqul show the beginnings of genuine urban-forming (non-agricultural) economic networks; the remaining five towns require targeted

development of industry, transport, and public services before they can be considered to meet formal urban-planning criteria.

Table 2. Infrastructure indicators of the eight towns of Shofirkon District (2024)

Indicator	Isko gare	Talis afed	Ju yra bat	Cha ndir	Und are	Quyi Chuqur ak	Mir zoqu l	Gulo mte
Distance from district center, km	11.1	9.0	7.0	9.4	5.1	11.9	4.0	8.7
Small businesses	1	2	1	2	1	1	3	1
Sales/service outlets	5	6	4	6	5	4	7	4
Schools	1	1	1	1	1	1	1	1
Hospitals	1	1	1	1	1	1	1	1
Pharmacies	2	2	1	2	1	1	1	1
Markets	1	1	0	1	0	1	0	0
Transport link to district/regional center	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-
Gas supply	+	+	—	—	+	+	+	—
Water supply	+	+	+	+	+	+	+	+

Note: "+" - available; "—" - not available; "+/-" - partial or seasonal availability. All eight towns share the same intermediate (partial/seasonal) transport-link status to the district and regional centers. Compiled by the authors based on data from the Bukhara Regional Statistical Department

As shown in Table 3, small rural settlements dominate numerically (86 settlements, 60.0 % of the total).

This pattern is associated with the district's geographical position: much of its territory lies within the Kyzylkum Desert, where natural conditions and water resources are limited, and the population is thinly and unevenly distributed. Settlements of this category are mainly specialized in livestock husbandry.

Medium-sized settlements, although fewer in number (56, or 38.6 % of the total), account for the largest share of the rural population - 87.8 thousand people, or 61.3 % of the district's rural population. They are typically located in the fertile, well-irrigated center of the oasis, where population density is considerably higher than in the peripheral desert zones.

Only two rural settlements - Mahalakozi and Savrak - exceed 3,000 inhabitants. Across Bukhara Region, only five rural settlements reach this size, of which two are located in Olot District and one in Qorako'l District. This indicates that large rural settlements are relatively uncommon both at the regional scale and within Shofirkon District.

Table 3. Classification of rural settlements in Shofirkon District by population size (2024)

Category	Number of settlements	Share, %	Total population, thousand people
Small (up to 1,000 people)	86	60.0	49.3
Medium (1,000–3,000 people)	56	38.6	87.8
Large (3,000 people and above)	2	1.4	6.2
Total	144	100.0	143.3

Note: compiled by the authors based on data from the Bukhara Regional statistical department. The total population of the “Large” settlement category was calculated as the combined 2024 population of Mahallaqozi (3,157) and Savrak (3,079), totaling 6,236 people (6.2 thousand).

Roughly 90 % of the district's human settlements are concentrated in its southern part, while the extremely arid, typically desert landscape of the central and northern parts leaves settlements there sparse and widely scattered. Accordingly, the rural settlement network can be divided into four geographically conditioned zones: (1) settlements in the center of the oasis (Revgar, Naqqosh, Savrak), corresponding to the district's medium and large settlements; (2) settlements bordering neighboring districts (Madaniyat, Mavri, Yuqori Chitgaron); (3) settlements in the buffer zone between oasis and desert (Jilvon, Quyi Jilvon, Tezguzar); and (4) settlements located within the desert proper (Churuk, Yangibog'), corresponding largely to the small, livestock-oriented settlements that make up 60 % of the district's rural settlement stock.

The district currently faces a number of interlinked geoecological problems, most notably a growing shortage of running water, an increase in dust days, declining groundwater levels, and rising salinity of agricultural land. These pressures appear to be associated with rapid population growth and constraints in the management and use of transboundary water resources. Because the district lies in the sharply continental part of the temperate zone, water demand peaks during the summer “chilla” period, when channel water availability is at its lowest, placing particular pressure on medium-sized, agriculturally dependent oasis settlements that accommodate a large share of the district’s rural population. Under these conditions, household-scale “small reservoirs” for collecting precipitation from hard (slate) roof surfaces may provide a practical, low-cost supplementary measure for reducing seasonal water shortages. Given an average roof catchment area of 60 m² and average regional annual precipitation of 120–140 mm, the gross rainwater-harvesting potential is estimated at approximately 7,800 liters per household annually, before accounting for runoff and storage losses.

4. Discussion

The settlement pattern identified in Shofirkon District is consistent with, yet also refines, the broader regional picture established in earlier studies of Bukhara Region. Tojiyeva et al. (2021) found that Bukhara Region as a whole is characterized by a large number of predominantly small and medium-sized rural settlements, with roughly 70 % of villages in the region having fewer than 500 inhabitants. The present study confirms this pattern at the district level and adds a spatial explanation that a region-wide statistical analysis cannot provide: the predominance of small settlements in Shofirkon is not randomly distributed but concentrated specifically in the desert and buffer zones, while medium-sized settlements cluster in the oasis center. This suggests that the settlement-size distributions reported at the regional scale are, at least in Shofirkon's case, the aggregate outcome of a sharp intra-district ecological gradient rather than a uniform regional tendency - a distinction that

is only visible when the analysis is disaggregated below the regional level, which is precisely the gap identified in the Literature Analysis.

The finding that the district's eight towns remain functionally and morphologically close to villages fifteen years after acquiring town status corroborates the broader critique advanced by Saliev and Nazarov (2009) that most of Uzbekistan's post-2009 "new towns" do not meet formal urban-planning criteria and are better understood as agro-towns. What the present study contributes beyond this general observation is evidence that infrastructure deficits are unevenly distributed even within a single, small district: gas supply, market access, and business density vary considerably among the eight towns despite their shared founding date and shared administrative status, and this variation does not track distance from the district center in any simple way. This indicates that proximity to the administrative center alone is an insufficient predictor of a town's development trajectory, and that other factors - most plausibly each settlement's original economic specialization and its access to irrigation water - play a comparatively larger role.

The coexistence of comparatively rapid population growth in towns that lack gas supply (Chandir, Juyrabat) is a pattern that merits particular attention. Read alongside Khamroev's (2024) finding that Bukhara Region's urbanization level (36.7 %) remains below the national average, this suggests that population is accumulating in these settlements faster than the formal infrastructure needed to support genuinely urban living conditions, reproducing at a micro-scale the same lag between numerical urbanization and functional urbanization that Khamroev documents for the region's cities generally. If this pattern continues, the risk is not merely that these towns remain agro-towns in name, but that population pressure without matching infrastructure investment could intensify the very geoeological problems - groundwater depletion, salinization, water scarcity - that the district is already experiencing.

The geoeological problems identified here should be read as a district-scale manifestation of pressures that are already documented at the national and regional level. Mavlonov's (2010) earlier study of settlement formation in desert conditions across Bukhara Region as a whole identified natural constraints (water availability, soil salinity, desert encroachment) as fundamental determinants of settlement viability; the present findings suggest that, more than a decade later, these same constraints continue to shape not only where settlements can form but which settlements are able to develop beyond agro-town status. This continuity indicates that administrative reclassification (granting town status) has not, by itself, been sufficient to overcome the underlying ecological constraints on development - a conclusion with direct relevance for how future settlement-status decisions in similarly arid districts of Uzbekistan should be evaluated.

The proposed household rainwater-harvesting measure should be understood as a targeted, small-scale response rather than a substitute for addressing the district's structural water problems, which stem primarily from the shared, cross-border management of the Zarafshan River's flow (Abdullaev & Rakhmatullaev, 2004) rather than from a lack of local storage capacity. Its practical value lies in bridging the seasonal gap between peak "chilla"-period demand and minimum channel flow, and it is most directly applicable to the oasis-center and buffer-zone settlements identified in this study, rather than to the desert-zone settlements, where roof catchment area and household density are both lower.

Several limitations of the present analysis should be acknowledged. The reliance on district-level administrative statistics means that infrastructure indicators are reported as simple counts rather than population-normalized measures, which limits direct comparability between towns of different sizes. The rainwater-harvesting estimate is a first-order approximation based on average roof area and average precipitation, and does not account for inter-annual precipitation variability or actual household storage capacity. Finally, because this is, to the authors' knowledge, one of the first studies to examine settlement formation and development at the level of an individual administrative district of Bukhara Region, the findings cannot yet be directly compared with equivalent district-level data from neighboring territories. Establishing whether the patterns identified here are specific to

Shofirkon or characteristic of desert-oasis districts more broadly will require comparable studies of other districts, such as Peshku, Qorako'l, and Olot.

5. Conclusion

This study has examined the geographical features, current problems, and development prospects of human settlements in Shofirkon District of Bukhara Region - one of the first analyses, to the authors' knowledge, conducted at the level of an individual administrative district of the region. The findings show that the district's settlement network is overwhelmingly rural, structured around a single administrative city (Shofirkon) and eight recently formed towns that, despite fifteen years under town status, continue to function largely as agro-towns rather than as settlements meeting formal urban-planning criteria. This gap between administrative classification and functional urban development is not uniform: it varies across the eight towns in ways only partly explained by their distance from the district center, suggesting that differences in economic specialization and access to irrigation water may also contribute to the observed variation.

The district's rural settlement pattern is directly shaped by its physical geography. The predominance of small, dispersed settlements in the desert and buffer zones, contrasted with denser, larger settlements in the fertile oasis center, suggests that natural conditions, particularly water availability, play an important role in shaping where and how settlements form and grow in this part of Bukhara Region. The geoecological problems identified - declining groundwater levels, rising soil salinity, increasing dust days, and a widening seasonal water deficit - are consequences of this same natural constraint interacting with sustained population growth, and they place the greatest pressure precisely on the medium-sized oasis settlements that house the majority of the district's rural population.

On this basis, the following conclusions and recommendations are proposed for improving the development prospects of human settlements in Shofirkon District and mitigating its existing geoecological problems:

- Household-scale "small reservoirs" for collecting seasonal precipitation from roof surfaces should be introduced as a priority measure in oasis-center and buffer-zone settlements, where they can meaningfully offset the summer "chilla"-period water deficit at low cost;
- The feasibility of regulating residential density and developing multi-storey housing in the district center and selected agro-towns should be further assessed as potential land- and water-saving planning measures;
- Settlements adjacent to the desert zone should be protected through natural windbreaks and afforestation measures to slow desertification and reduce dust generation;
- Because the district's town network was formed rapidly and simultaneously in 2009, its urban composition remains fragmented and includes a number of economically vulnerable municipalities; continued monitoring of their functional development is warranted, particularly in Mirzoqul, Chandir, and Iskogare;
- Since the urban network of Shofirkon District remains underdeveloped relative to formal urban-planning norms, priority should be given to strengthening the functional composition of its towns — expanding small industrial enterprises, improving public services, and closing the remaining gaps in gas-supply coverage identified in this study.

Taken together, these findings indicate that further improvement of settlement conditions in Shofirkon District depends less on additional reclassification of villages as towns than on targeted infrastructure investment calibrated to each settlement's ecological zone and economic base. Future research should extend this district-level approach to neighboring desert-oasis districts of Bukhara Region - such as Peshku, Qorako'l, and Olot — to establish whether the patterns identified here are specific to Shofirkon or characteristic of the region's arid districts more broadly.

6. Supplementary Materials: No supplementary material.

7. Author Contributions

Conceptualization - A.U.; methodology - A.U.; software - S.S.; validation - S.S.; formal analysis - A.U.; investigation - A.U.; resources - S.S.; data curation - S.S.; writing - original draft preparation - A.U.; A.A.; writing - review and editing - A.U.; visualization - S.S.; supervision - A.U.; project administration - A.U. All authors have read and agreed to the published version of the manuscript.

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Бұхара облысы Шофиркон ауданындағы елді мекендер: географиялық ерекшеліктері, мәселелері және даму келешегі

Ахрорбек Усмонов, Сабина Сувонова

Аңдатпа: Зерттеуде Өзбекстанның Бұхара облысы Шофиркон ауданындағы елді мекендердің географиялық ерекшеліктері, қазіргі проблемалары мен даму келешегі қарастырылады. Жұмыс – жеке әкімшілік аудан деңгейінде жүргізілген алғашқы зерттеулердің бірі. Бұхара облыстық статистика басқармасының ресми статистикалық деректеріне, ГАЖ негізіндегі картографиялық талдауға, салыстырмалы-географиялық және статистикалық-талдамалық әдістерге сүйене отырып, зерттеуде аумағы 3,72 мың км² болатын аудандағы бір әкімшілік қала, 8 кент және 144 ауылдық елді мекеннен тұратын қоныстану жүйесіне сипаттама берілді. Шофиркон қаласының халқы 1995–2024 жылдар аралығында 31,9 %-ға өсті, ал 2009 жылы «Ауылды дамыту және көркейту» мемлекеттік бағдарламасы аясында құрылған ауданның 8 кентінде халық саны әрқелкі, яғни 8,0 %-дан 25,7 %-ға дейін өскен. Құрылған уақыты бірдей болғанына қарамастан, олардың инфрақұрылымдық қамтамасыз етілу деңгейі айтарлықтай әрқелкі және функционалдық тұрғыдан олар «агроқалашықтар» деп аталатын қарапайым ауылдарға жақын болып калуда. Ауылдық елді мекендер саны бойынша негізінен шөл және буферлік аймақтарда шоғырланған шағын әрі шашыраңқы қоныстар басым (жалпы санының 60,0 %-ы), ал саны аз болғанымен, орташа көлемдегі елді мекендер құнарлы оазистік орталықтағы ауыл халқының 61,3 %-ын қамтиды. Бұл кеңістіктік заңдылық сумен қамтамасыз етілуге байланысты ауданішілік айқын экологиялық градиентті көрсетеді. Ауданда жер асты сулары деңгейінің төмендеуі, топырақтың тұздануының күшеюі, шаңды күндер санының артуы және халық санының өсуі мен трансшекаралық өзен суларын басқарудағы шектеулерге байланысты маусымдық су тапшылығының ұлғаюы сияқты геоэкологиялық проблемалар күшейіп келеді. Үй шаруашылығы деңгейінде жаңбыр суын жинау шарасы ұсынылып, оның жылдық әлеуеті бір үй шаруашылығына шамамен 7 800 литр деп бағаланды. Бұл оазистік және буферлік аймақтардағы елді мекендерде жазғы кезеңдегі суға ең жоғары сұранысты төмендетудің іске асыруға болатын әрі шығыны аз тәсіл. Зерттеу нәтижелері ауылдарды кенттер санатына әкімшілік тұрғыдан қайта жіктеу дамудың негізгі экологиялық шектеулерін жоя алмағанын көрсетті. Сондықтан одан әрі даму елді мекендердің мәртебесін қайта өзгертуден гөрі, әрбір елді мекеннің экологиялық аймағы мен экономикалық базасына бейімделген инфрақұрылымдық инвестицияларды қажет етеді. Зерттеу Орталық Азияның қуаң, оазистерге тәуелді аумақтарындағы елді мекендердің дамуын аудан деңгейінде талдауға арналған басқа аумақтарда да қолдануға болатын әдістемелік негіз ұсынады.

Түйін сөздер: елді мекендер; Шофиркон ауданы; Бұхара облысы; ауылдық елді мекендер; геоэкологиялық мәселелер; су тапшылығы; агроқалашықтар; Өзбекстан.

Населённые пункты Шофирконского района Бухарской области: географические особенности, проблемы и перспективы развития

Ахрорбек Усмонов, Сабина Сувонова

Аннотация: В исследовании рассматриваются географические особенности, современные проблемы и перспективы развития населённых пунктов Шофирконского района Бухарской области Узбекистана. Работа представляет собой одно из первых исследований, проведённых на уровне отдельного административного района. На основе официальных статистических данных Бухарского областного управления статистики, картографического анализа с использованием ГИС, сравнительно-географического и статистико-аналитического методов охарактеризована система расселения района площадью 3,72 тыс. км², включающая один административный город, 8 посёлков и 144 сельских населённых пункта. Численность населения города Шофиркон в период с 1995 по 2024 г. увеличилась на 31,9 %, тогда как в 8 посёлках района, образованных в 2009 г. в рамках государственной программы «Развитие и благоустройство села», рост населения был неравномерным и составил от 8,0 до 25,7 %. Несмотря на одинаковое время их образования, уровень инфраструктурной обеспеченности существенно различается, а в функциональном отношении они остаются близкими к обычным сельским населённым пунктам, которые часто характеризуются как «агрогородки». В структуре сельского расселения по числу населённых пунктов преобладают небольшие и рассредоточенные поселения (60,0 % от общего количества), сосредоточенные преимущественно в пустынной и буферной зонах. В то же время средние по размеру населённые пункты, несмотря на их меньшее количество, концентрируют 61,3 % сельского населения в плодородной оазисной зоне. В районе усиливаются геоэкологические проблемы, включая снижение уровня грунтовых вод, увеличение засоления почв, рост числа пыльных дней и усиление сезонного дефицита воды, обусловленные ростом населения и ограничениями трансграничного управления речными водами. Предложена мера по сбору дождевой воды на уровне домохозяйств, годовой потенциал которой оценивается примерно в 7 800 литров на одно домохозяйство. Результаты исследования показывают, что административная переклассификация сельских населённых пунктов в посёлки сама по себе не устранила основные экологические ограничения их развития. Исследование предлагает методическую основу, которая может быть использована для анализа развития населённых пунктов на районном уровне в других аридных, зависимых от оазисов территориях Центральной Азии.

Ключевые слова: населённые пункты; Шофирконский район; Бухарская область; сельские населённые пункты; геоэкологические проблемы; дефицит воды; агрогородки; Узбекистан.