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Article

Managing Resource Conservation in Karakalpakstan Agriculture Through Statistical Diagnosis and Shared Services

Berdakh Askarbay uli Tajibaev*¹

1. Lecturer, Department of Management and Fundamentals of Economics
Karakalpak State University named after Berdakh, Nukus, Uzbekistan
E-mail: berdax_97@bk.ru

Abstract: This study examines how regional agricultural statistics can inform the targeting of resource conservation measures in Karakalpakstan. It combines descriptive analysis of preliminary official data for 2025 with the design of an organisational and economic management framework. Output shares, published growth indices and the combined share of the four largest producing districts are compared after checking the sectoral coverage of the source data. Agricultural production increased by 4.9%, while vegetable production fell by 7.2%. Dehkan and household farms accounted for 59.6% of agricultural output value but recorded a 3.7% decline in production. The four leading districts generated 52.3% of agricultural output value. These contrasts identify priorities for field investigation and service planning; they do not establish the causes of change or measure resource productivity. The proposed framework connects regional diagnosis, field verification, shared services and outcome evaluation. It specifies indicators for land and irrigation water productivity, gross margin and investment appraisal. The contribution is a procedure for translating aggregate statistical signals into testable management decisions. Its effects on resource use and farm performance require subsequent empirical evaluation.

Keywords: Karakalpakstan; agriculture; resource conservation; agricultural management; statistical diagnosis; shared services; irrigation water productivity; digital field records

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1. Introduction

Agricultural resource management requires production objectives to be reconciled with water availability, land conditions and the financial capacity of producers. For Karakalpakstan, this coordination must account for differences across crops, farm categories and districts. A uniform technology package may therefore overlook the conditions that determine whether an intervention is economically viable and operationally feasible.

Aggregate output growth provides an incomplete basis for selecting resource conservation measures. An increase in regional production can coexist with contraction in a particular crop or producer category. Conversely, a decline in output does not reveal whether the underlying constraint concerns cultivated area, irrigation, soil quality, labour availability or market conditions. The management problem is to use regional evidence to select investigations without treating statistical associations as established technological effects.

The distinction between farm-level performance and wider resource outcomes is central to evaluating irrigation interventions. Higher crop water productivity does not automatically deliver real water savings once the water balance and effects beyond the immediate production unit are considered [1], and improvements in irrigation efficiency cannot be equated with greater water availability at basin scale [2]. Part of this difficulty is terminological: inconsistent definitions of “irrigation efficiency” have supported recommendations that do not hold once consumptive and non-consumptive uses are distinguished [3], which is why comprehensive assessments of agricultural water management call for evaluating interventions across the field, scheme and basin scales rather than at the farm level alone [4]. For Karakalpakstan specifically, monitoring of salt-affected croplands using remote sensing in the Nukus district provides a relevant methodological reference for selecting locations for closer investigation, although remotely observed vegetation changes identify potential anomalies that still require laboratory measurement and agronomic assessment to interpret [5]; this local evidence sits within the wider regional record of environmental decline in the Aral Sea basin, which underlines why aggregate signals in Karakalpakstan cannot be read in isolation from basin-scale water and land conditions [6].

The organisational dimension of resource conservation is similarly under-examined for the region. Research on land consolidation and farm restructuring in Uzbekistan shows that reforms directed at farm structure alone can trigger unfavourable side effects without corresponding institutional support [7], while studies of water user cooperation in Central Asia show that collective arrangements for shared infrastructure can improve coordination among small producers, though their effectiveness depends on local demand and governance conditions [8]. Farm-level case studies further document that access to land and water in the Uzbek rural economy is negotiated through overlapping social and administrative relationships rather than determined by production statistics alone [9]. Together, these sources establish the need for measurement and careful interpretation, but they do not specify the organisational step between a regional production signal and a farm-level action: who verifies the constraint, how producers access the required service, and how the outcome is assessed. The present study addresses this gap; its engagement with prior literature is targeted rather than systematic, and its contribution is the integration of diagnostic levels and responsibilities, not a new irrigation technology or a claim of universally optimal institutional design.

The objective of this study is to develop a differentiated organisational and economic framework for resource conservation based on statistical diagnosis of Karakalpakstan agriculture. The research question is how observable production contrasts can guide field verification and service provision. The study combines descriptive empirical analysis with a methodological proposal. It does not estimate the causal impact of a technology or claim that the proposed framework has already improved farm performance.

2. Materials and Methods

The main empirical source is the Karakalpakstan statistical bulletin for January–December 2025 [10, pp. 19–30]. The analysis uses the preliminary annual data retrieved on 8 September 2026. Growth indices by farm category are cross-checked against a separate official table [11]. Partial-year observations for 2026 are excluded to preserve period comparability. The unit of descriptive analysis is a regional production category or district, not an individually observed farm.

Source validation identified a difference in sectoral coverage. The main-indicators table [12] reports UZS 21,623.8 billion for 2025 under an agricultural production heading. In the detailed bulletin, that amount covers agriculture, forestry and fishing. Crop and livestock production together equal UZS 19,932.0 billion, which is the agriculture-only total. The latter denominator is used

throughout the analysis. This choice reconciles the scope of the components and the aggregate rather than averaging two differently defined figures.

The output share of group i is calculated as $d_i = 100 \times V_i / V$, where V_i is the value of the group's production and V is total regional agricultural production. The combined share of the four largest districts is $CR_4 = 100 \times \sum V_i / V$, with the sum covering those four districts, adapting a concentration-ratio measure originally developed for industrial-organisation analysis [13]. CR_4 describes the geographical distribution of output value. It is not a measure of firm-level market power.

Changes in production are obtained by subtracting 100 from the published growth index expressed with the previous year equal to 100. For example, an index of 104.9 corresponds to growth of 4.9%. Author calculations are rounded to one decimal place. Current-price value shares and published growth indices are interpreted separately: the shares are not used as exact weights for decomposing the aggregate growth index.

The method has three stages. First, the sources are checked for period, unit and sectoral consistency. Second, contrasts are identified across farm categories, crops and districts. Third, each contrast is linked to a proposed investigation and a measurable management outcome. Missing observations on irrigation water, costs and cultivated area are not replaced with assumed coefficients. Accordingly, the empirical results support diagnostic targeting but do not establish land, water or labour productivity.

The organisational framework is assessed for internal consistency: each statistical signal must lead to a verification task before an intervention is chosen. Service arrangements and evaluation indicators are then specified as proposals for testing. No survey sample, experimental treatment, regression estimate or statistical significance test is reported because the source data do not support those forms of inference.

3. Result and Discussion

Agricultural output and differences across farm categories

Agricultural production in 2025 totalled UZS 19,932.0 billion, with a published growth index of 104.9. Crop production contributed UZS 8,970.1 billion and livestock production UZS 10,961.9 billion. Their calculated shares were 45.0% and 55.0%, respectively. Crop production grew by 10.1%, compared with 0.5% for livestock. Thus, the larger value share of livestock coexisted with faster growth in crop production.

Table 1. Agricultural output by farm category in Karakalpakstan, 2025

Farm category	Output value share, %	Growth index, 2024 = 100
Dehkan and household farms	59.6	96.3
Farmer enterprises	31.1	119.9
Organisations engaged in agriculture	9.3	119.6
All categories	100.0	104.9

Sources: shares from official statistics; growth indices from official statistics. Preliminary data. "Farmer enterprises" denotes the official farmer xo'jaliklari category. Value shares are measured at current prices.

Dehkan and household farms generated the largest share of output value, but their production fell by 3.7%. Farmer enterprises and agricultural organisations recorded increases of 19.9% and 19.6%, respectively. These differences justify separate diagnosis. They do not prove that one category is technologically inferior: specialisation, resource access and changes in the composition of producers may all affect the observed pattern.

The practical implication is that a resource conservation programme should

examine its coverage of small producers. A programme centred on equipment purchases by larger enterprises may have limited reach among the producers responsible for 59.6% of output value. Shared access to water measurement, soil testing, agronomic advice and equipment maintenance is therefore a candidate for economic assessment.

Under the proposed arrangement, farms retain operational independence while a service provider distributes fixed costs across users. Its feasibility depends on actual demand, travel distances, seasonal workload and quality requirements. Cooperation alone does not ensure lower costs. A service agreement must define the task, fee, response time, measurement method and procedure for correcting unsatisfactory work. Whether these arrangements improve resource performance remains an empirical question.

Crop production and priorities for field investigation

The region produced 393.3 thousand tonnes of cereals, 113.0 thousand tonnes of potatoes, 419.0 thousand tonnes of vegetables, 236.8 thousand tonnes of melons, 80.0 thousand tonnes of fruit and berries, and 16.2 thousand tonnes of grapes in 2025. Their production trajectories differed substantially. Overall crop growth coexisted with a decline in vegetable production (Figure 1).

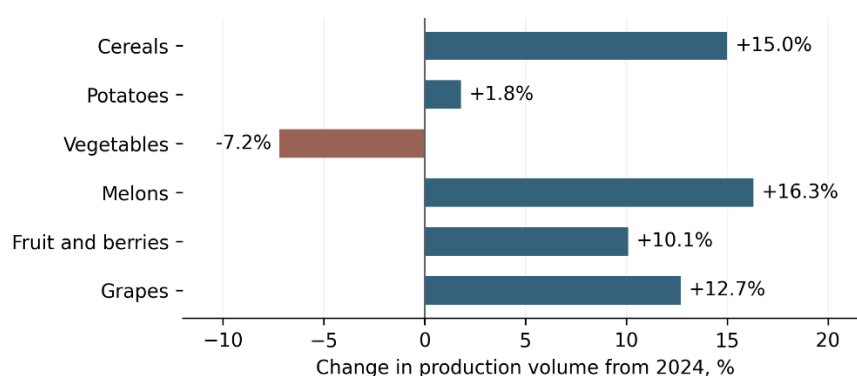


Figure 1. Change in selected crop production volumes in 2025. Source: author calculations from official statistics, using the published growth index minus 100. Preliminary data.

Vegetable production declined by 7.2%, whereas melon and cereal production increased by 16.3% and 15.0%. These are changes in gross production, not in yield per hectare. Without the corresponding crop areas, an increase cannot be separated into area expansion and yield improvement. The figures also do not identify an effect of digital technology adoption.

Vegetable production reveals a further contrast across farm categories. Farmer enterprises produced 166.6 thousand tonnes with a growth index of 117.4, while dehkan and household farms produced 236.3 thousand tonnes with an index of 78.8. The latter category accounted for 56.4% of regional vegetable output. Its declining output therefore provides a specific priority for investigation rather than a general presumption about all small farms.

Field verification should examine crop area, irrigation timing and volume, soil conditions, labour availability, input expenditure and marketing conditions. The purpose is to distinguish constraints that require different responses. Delayed water delivery may call for operational coordination or infrastructure repair; an agronomic constraint may require advice and soil treatment. A statistical decline alone does not justify subsidising a particular technology.

District differences and the targeting of services

The four largest agricultural producers by output value were Amudarya, Beruniy, Ellikkala and Turtkul districts. Their production amounted to UZS 3,656.9 billion, UZS 2,339.3 billion, UZS 2,249.8 billion and UZS 2,168.7 billion, respectively. Together they generated UZS 10,414.7 billion. Dividing this sum by the agriculture-only regional total gives $CR_4 = 52.3\%$.

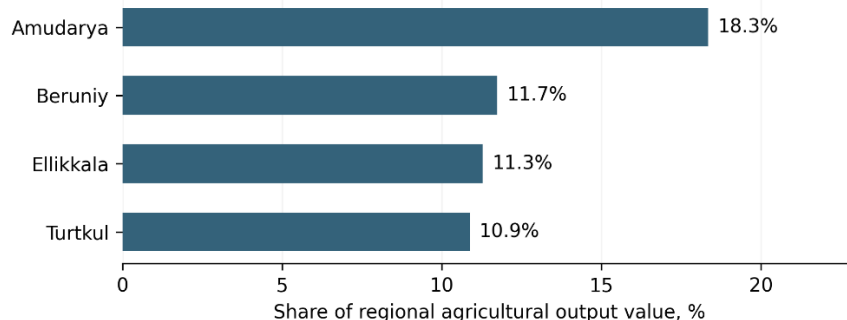


Figure 2. Shares of the four leading districts in regional agricultural output value, 2025. Source: author calculations from official statistics. Current prices; preliminary data. Combined share: 52.3%, calculated before rounding individual shares.

The concentration of production provides information about potential service coverage. It may help identify areas in which a monitoring service could reach a substantial production base. However, output value alone is insufficient for locating a service centre. The number of prospective users, travel distances, the timing of demand and existing infrastructure must also be assessed. A large production share does not demonstrate efficient water use.

Adverse production dynamics provide a different basis for targeting. In Muynak district, the agricultural growth index was 90.4 and the crop production index was 81.9. These observations support an investigation into the contraction, but they do not identify its causes or establish the extent of salinity. Such conclusions require information on fields, soils and production conditions.

The proposed targeting procedure therefore keeps two objectives explicit. Production scale informs the assessment of service demand and equipment utilisation; adverse trends inform the selection of diagnostic investigations. Combining them mechanically into a single score would obscure the distinction between commercial service viability and the need to investigate production losses. A pilot programme should document which objective each selected location serves.

An organisational and economic framework for resource conservation

The proposed framework links regional identification of deviations, field-level resource records and contractual responsibility for service delivery. Digital field records and shared services connect these levels in a repeatable management cycle (Figure 3). The framework is an author proposal; its effectiveness has not been measured experimentally.

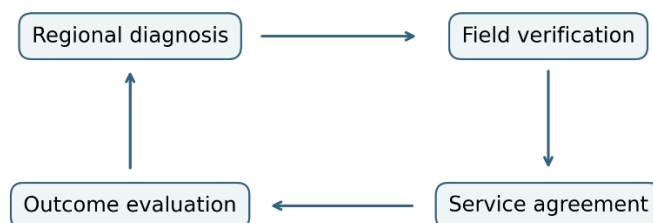


Figure 3. Proposed management cycle for agricultural resource conservation. Source: author design. Arrows represent the sequence of decisions and feedback, not a demonstrated causal relationship.

Table 2. Linking diagnostic evidence to a verifiable management action

Diagnostic basis	Proposed action	Outcome to verify
Vegetable decline among small producers	Field investigation and shared agronomic services	Constraint identified; yield and margin per hectare
Substantial district output	Assess service demand and equipment utilisation	Cost per serviced unit; access and service quality

Unrecorded irrigation deliveries	Define measurement boundary and irrigation log	Coverage of records; crop mass per m ³ delivered
Risk of soil deterioration	Laboratory testing and remediation plan	Salinity changes at comparable sampling points

Source: author proposal. Actions require confirmation of farm conditions; aggregate signals do not replace field investigation.

A digital field record should connect the field identifier, crop, area, operations, irrigation deliveries, costs and soil observations. Remote sensing can help select locations for investigation, but vegetation indices cannot replace laboratory salinity measurement or agronomic interpretation. The record becomes useful when it supports a specific decision and links the evidence to the person responsible for checking it.

Economic evaluation and empirical testing

At farm level, land and water indicators must use compatible boundaries. The proposed measures are crop yield $Y = Q/A$, irrigation water productivity $WP = Q/W$, and gross margin per hectare $GM = (R - C_v)/A$, following standard farm-management accounting practice [14]. Here Q is harvested mass, A is the corresponding area, W is irrigation water delivered to the field, R is revenue and C_v is variable cost. With Q in kilograms, A in hectares and W in cubic metres, the physical units are kg/ha and kg/m³. Gross margin is not net profit and does not automatically include all capital costs.

Investment appraisal should additionally use net present value, following standard project-appraisal practice [15]: $NPV = -I_0 + \sum_{t=1}^T \Delta CF_t / (1 + r)^t$. Initial investment is I_0 , ΔCF_t is the change in net cash flow relative to the baseline, r is the discount rate and T is the appraisal horizon. Maintenance, training, replacement and revenue changes must be included consistently. No numerical rate, investment cost or payback period is assigned here because the required project data are unavailable.

A reduction in water delivered to a field must be distinguished from real water savings at basin scale, as noted above. Economic results should therefore be considered alongside the water balance and soil condition. A higher farm margin cannot by itself establish an environmentally acceptable outcome. These indicators provide complementary checks rather than components of an automatically weighted performance score.

Empirical testing should use comparable fields and retain a comparison group. Crop, initial soil condition and water availability should inform the design. The principal outcome, implementation costs and rules for excluding observations should be specified in advance. A causal assessment requires an adequate sample and a defensible comparison strategy; a simple comparison of two seasons cannot isolate the intervention from other changes.

5. Conclusion

The 2025 evidence shows that agricultural growth of 4.9% coexisted with declining vegetable production and a contraction among dehkan and household farms. The four leading districts accounted for 52.3% of agricultural output value. Together, these findings support differentiated diagnostic and service priorities rather than a uniform package of resource conservation measures.

The study proposes a sequence of regional diagnosis, field verification, service agreement and outcome evaluation. Small-producer vegetable systems warrant investigation, while service location decisions require a separate assessment of demand and accessibility. Technology selection should follow verification of the constraint and an appraisal of its costs. The next research stage is to populate the field records and test the framework in Karakalpakstan. The absence of farm-level water, land and cost observations limits the present conclusions to targeting and methodological design.

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