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COMPARATIVE ECONOMIC ASSESSMENT OF DRIP, SPRINKLER, AND FURROW IRRIGATION SYSTEMS IN UZBEKISTAN: EVIDENCE FROM 2021–2025

Javlonbek Asrakulov
International Agricultural University, Tashkent, Uzbekistan
Email: javlonbekasrakulov@gmail.com
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Abstract

This article compares the economic and operational characteristics of drip, sprinkler, and furrow irrigation systems in Uzbekistan using recent administrative evidence for 2021–2025, international irrigation literature, and an indicative investment-threshold model. The analysis deliberately separates national technology-adoption statistics from farm-level causal performance because Uzbekistan does not yet publish a harmonized annual panel that reports yield, water use, energy consumption, and profitability for the three systems on directly comparable farms. Reported coverage of water-saving interventions increased from approximately 308 thousand hectares in 2021 to 2.6 million hectares in 2025. Over the same period, reported drip-irrigation coverage rose from 121 thousand to 664 thousand hectares, while sprinkler-irrigation coverage reached 121 thousand hectares by 2025. The rapid expansion confirms strong policy and investment momentum, but adoption area alone does not prove economic efficiency. Drip irrigation provides the highest degree of application control and can be financially attractive for high-value crops, yet its capital, filtration, maintenance, and financing requirements are substantial. Sprinkler irrigation offers operational flexibility but introduces pressure and energy costs. Improved furrow irrigation remains economically rational where capital is scarce, fields can be levelled, and water delivery is sufficiently reliable. The article proposes a comparative framework based on net present value, benefit-cost ratio, annualized investment cost, water productivity, energy intensity, labour requirements, and institutional readiness. It concludes that Uzbekistan should evaluate irrigation technologies through verified farm budgets and system-level water accounting rather than through installation targets alone.

Keywords: drip irrigation; sprinkler irrigation; furrow irrigation; economic assessment; water-saving technologies; Uzbekistan; water productivity; 2021–2025

1. Introduction

Uzbekistan's agriculture is structurally dependent on irrigation. The country has approximately 4.3 million hectares of irrigated land, and agriculture accounts for the dominant share of national water use. In this setting, the choice of irrigation technology affects not only farm production but also electricity demand, public expenditure on pumping, canal operation, drought resilience, and the reliability of water delivery.

Between 2021 and 2025, Uzbekistan accelerated support for water-saving technologies through subsidies, concessional credit, domestic equipment production, laser land levelling, canal rehabilitation, and digital water management. Recent government reporting indicates that the scale of reported intervention coverage increased from about 308 thousand hectares in 2021 to 2.6 million hectares in 2025. This represents a major structural change in the irrigation sector.

Rapid adoption creates a new research problem. Policy success is frequently described through hectares equipped, yet installation area is an input indicator rather than an economic outcome. A technology is economically successful only when the discounted value of yield improvement, quality gains, reduced water or energy use, lower labour requirements, and avoided production risk exceeds investment, financing, maintenance, and management costs.

The objective of this article is to compare drip, sprinkler, and furrow irrigation systems from an economic perspective while using 2021–2025 evidence for the national adoption context. The study does not invent annual yield or water-use figures for the three systems. Instead, it combines transparent recent administrative data with a scenario-based investment framework and clearly identifies where farm-level evidence is still required.

2. Literature Review

Irrigation efficiency is often expressed as the proportion of withdrawn or delivered water that is beneficially used by crops. Economic water productivity adds a value dimension by relating output, revenue, or gross margin to water use. This distinction is important because a field-level reduction in application losses does not automatically generate basin-level water savings when return flows are reused downstream.

Drip irrigation applies water close to the root zone and permits frequent, controlled applications. Its potential advantages include improved uniformity, fertigation, reduced evaporation from non-cropped soil, lower labour demand, and reduced moisture stress. These advantages are most valuable in orchards, vineyards, vegetables, and other high-value production. The principal economic constraints are initial investment, financing cost, filtration, emitter clogging, pressure management, replacement of components, and the need for skilled operation.

Sprinkler irrigation can serve field crops, fodder crops, vegetables, and irregularly shaped plots. Compared with uncontrolled furrow irrigation, it can improve application uniformity and scheduling. Its main economic weakness is the energy needed to create and maintain pressure. Wind and high evaporation can reduce performance, while the cost of pumps and maintenance can make profitability highly sensitive to energy prices.

Furrow irrigation remains widespread because it is familiar, generally requires lower equipment investment, and can operate with gravity supply. Its performance varies substantially. Poor levelling, long furrows, uncontrolled inflow, and unreliable delivery can cause excessive water use and non-uniform application. Improved furrow systems that combine laser levelling, shorter runs, controlled inflow, flexible pipes, and better scheduling can offer a lower-cost modernization pathway.

Recent Uzbek research also warns about rebound effects. Hamidov et al. (2022) argue that technical efficiency gains may be partly offset when saved water supports expansion of irrigated area, shifts to water-intensive crops, or increased production. Therefore, technology assessment should consider farm, irrigation-system, and basin scales rather than interpreting reduced field application as an automatic reduction in total consumption.

3. Materials and Methods

3.1. Data sources

The empirical context is based on public information from the Ministry of Water Resources of the Republic of Uzbekistan, the Government Portal, parliamentary reporting, the World Bank, FAO AQUASTAT, IWMI, and peer-reviewed literature. The recent time series covers 2021–2025. Because the administrative sources use slightly different reporting concepts, the article refers to reported intervention coverage rather than assuming that every figure represents unique, non-overlapping hectares.

3.2. Comparability rules

The 2021 figure represents the reported baseline of water-saving irrigation technology coverage. For 2022, the documented total is calculated from the principal reported categories: drip irrigation, sprinkler irrigation, discrete irrigation, and laser land levelling. The 2023–2025 totals are headline coverage values reported by public institutions. The series is suitable for

analysing the direction and scale of adoption, but it should not be interpreted as a statistically harmonized farm panel.

The study avoids assigning national adoption figures to farm-level yield or profitability effects. Economic comparison is therefore conducted using: (i) recent adoption trends; (ii) qualitative technical characteristics; and (iii) an indicative annualized investment-cost model for drip irrigation. This distinction protects the analysis from presenting administrative coverage as causal evidence of farm performance.

3.3. Economic indicators

Net present value is defined as NPV = Σ[(Bt − Ct)/(1 + r)^t] − I0, where Bt and Ct are annual benefits and costs, r is the discount rate, t is the year, and I0 is initial investment. A technology is financially acceptable when NPV is positive.

The benefit-cost ratio is BCR = PV(Benefits)/PV(Costs). A value above one indicates that discounted benefits exceed discounted costs. Water productivity can be expressed physically as yield per cubic metre and economically as gross margin per cubic metre.

The annualized capital cost is estimated with the capital recovery factor: CRF = r(1+r)^n / [(1+r)^n − 1]. The illustrative calculation assumes a ten-year economic life, a real discount rate of 10 percent, and annual operation and maintenance equal to 3 percent of initial investment.

4. Results

4.1. Expansion of water-saving technologies, 2021–2025

Year	Reported intervention coverage, thousand ha	Drip irrigation, thousand ha	Sprinkler irrigation, thousand ha	Interpretation
2021	308.0	121.0	Not separately reported	Strategy baseline
2022	897.6*	398.4	31.0	Sum of principal reported categories
2023	1,200.0	472.0	48.0	Headline national coverage
2024	1,900.0	561.0	90.0	Headline national coverage
2025	2,600.0	664.0	121.0	Headline national coverage

Table 1. Reported expansion of water-saving intervention coverage in Uzbekistan, 2021–2025

Note: *The 2022 value is calculated from reported drip, sprinkler, discrete irrigation, and laser-levelling areas. The series combines administrative reports with slightly different definitions; values should be interpreted as intervention coverage rather than a harmonized estimate of unique hectares.

The recent series shows a rapid increase in policy-supported irrigation modernization. Reported coverage expanded more than eightfold between 2021 and 2025. The most important analytical implication is that technology adoption is no longer marginal: investment performance, maintenance, financing, and monitoring now affect a substantial share of irrigated agriculture.

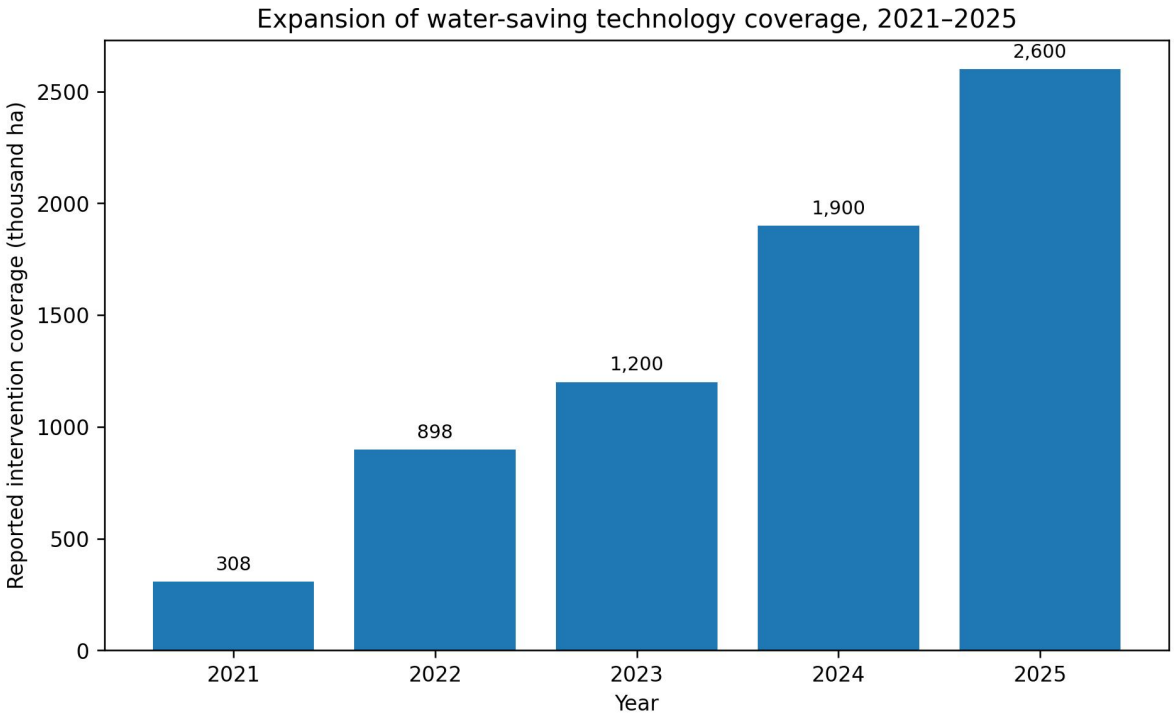


Figure 1. Expansion of reported water-saving intervention coverage in Uzbekistan, 2021–2025.

4.2. Growth of drip and sprinkler irrigation

Drip irrigation expanded from 121 thousand hectares in 2021 to 664 thousand hectares in 2025. Sprinkler irrigation, reported separately from 2022 onward in the reviewed sources, increased from 31 thousand hectares to 121 thousand hectares. Drip has therefore remained the dominant pressurized application technology, while sprinkler irrigation has grown from a much smaller base.

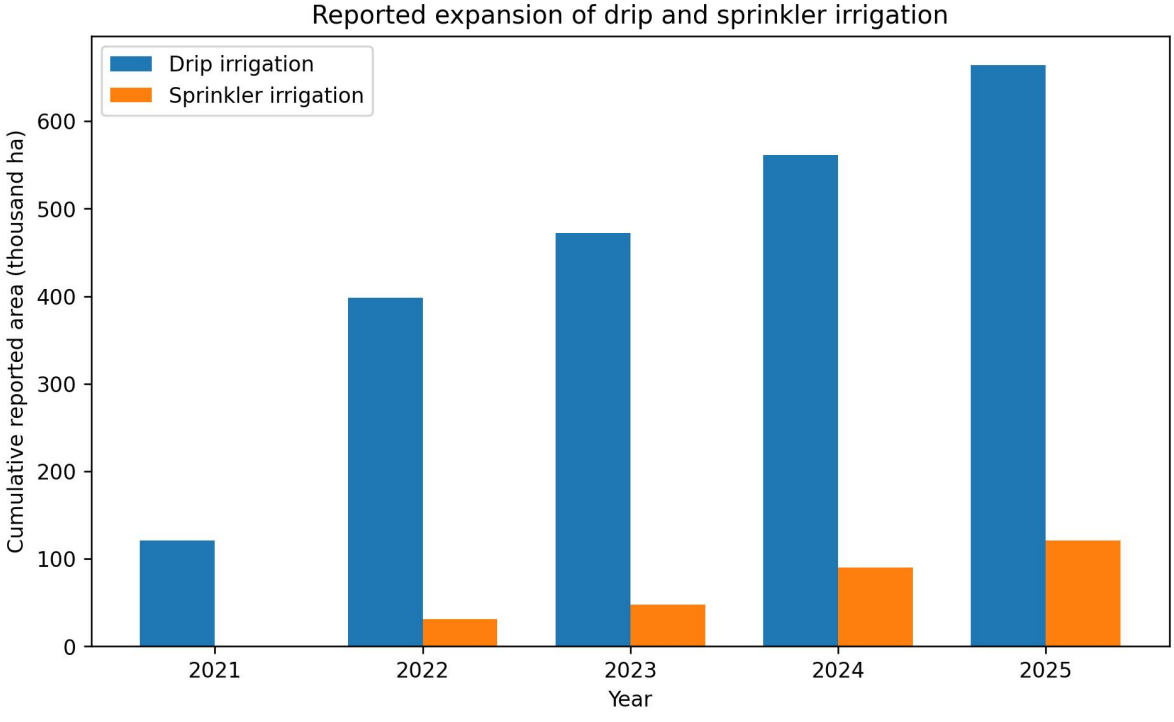


Figure 2. Reported cumulative area under drip and sprinkler irrigation, 2021–2025. The 2021 sprinkler value was not separately reported in the reviewed source.

The different adoption trajectories are economically plausible. Drip irrigation has strong policy appeal for cotton, orchards, vineyards, and horticulture because it can combine water delivery with fertigation and precise scheduling. Sprinkler irrigation is relevant to a wider set of field situations, but its energy requirement can reduce the financial return where pressure must be created through pumping.

4.3. Technology composition in 2025

Technology category	Reported area, thousand ha	Share of listed total, %	Primary economic function
Drip irrigation	664	25.7	High application control and potential yield/quality gains
Sprinkler irrigation	121	4.7	Uniform application and operational flexibility
Discrete irrigation	73	2.8	Controlled surface-irrigation delivery
Other irrigation technologies	123	4.8	Flexible pipes and related methods
Laser land levelling	1,600	62.0	Improved uniformity and lower-cost field modernization
Total listed categories	2,581	100.0	Approximately equal to the reported 2.6 million ha headline

Table 2. Composition of reported water-saving intervention coverage in 2025

Source: Ministry of Water Resources of the Republic of Uzbekistan (2025). Percentages are author calculations.

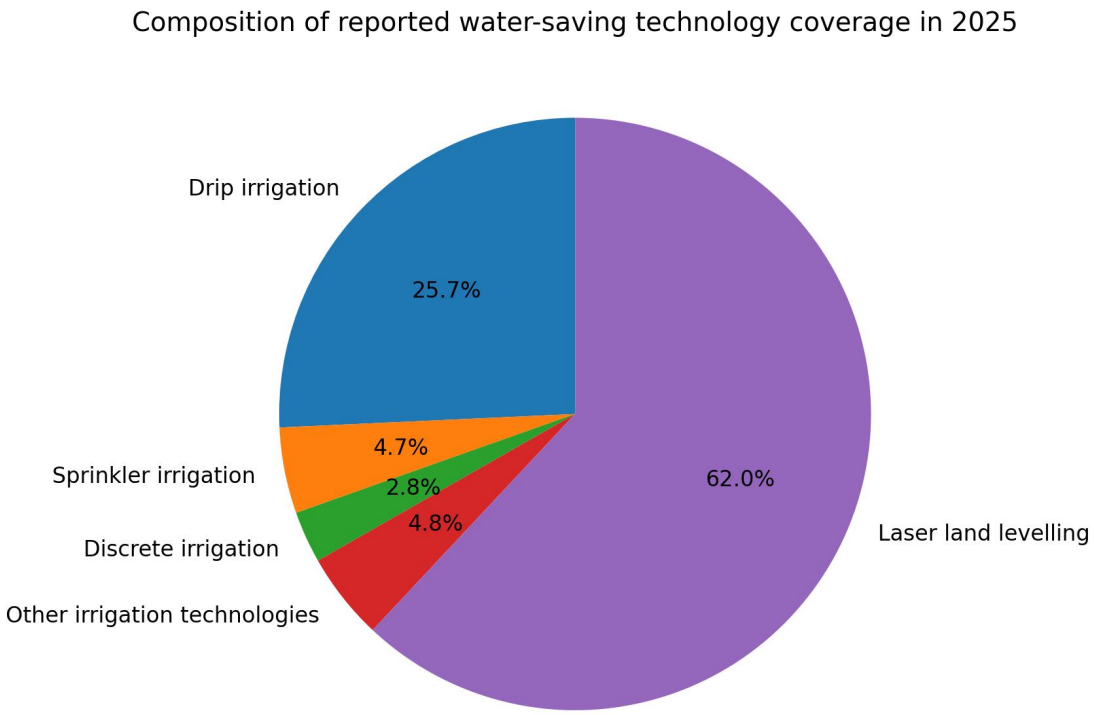


Figure 3. Composition of reported water-saving intervention coverage in 2025.

Laser land levelling represents the largest reported category. This is economically important because it demonstrates that modernization does not consist only of expensive pressurized systems. A relatively lower-cost intervention can improve water distribution, shorten irrigation time, and raise the performance of surface irrigation. The composition supports a portfolio approach rather than a single-technology policy.

4.4. Annual implementation in 2024 and 2025

Technology	2024, thousand ha	2025, thousand ha	Change, thousand ha
Drip irrigation	84.9	103.2	+18.3
Sprinkler irrigation	37.2	30.7	−6.5
Discrete irrigation	30.6	13.7	−16.9
Other irrigation methods	173.9	123.0	−50.9
Laser land levelling	522.8	546.0	+23.2
Total	849.4	817.2	−32.2

Table 3. Annual implementation of water-saving interventions, 2024–2025

Sources: Ministry of Water Resources of the Republic of Uzbekistan (2025a, 2025b). Change values are author calculations.

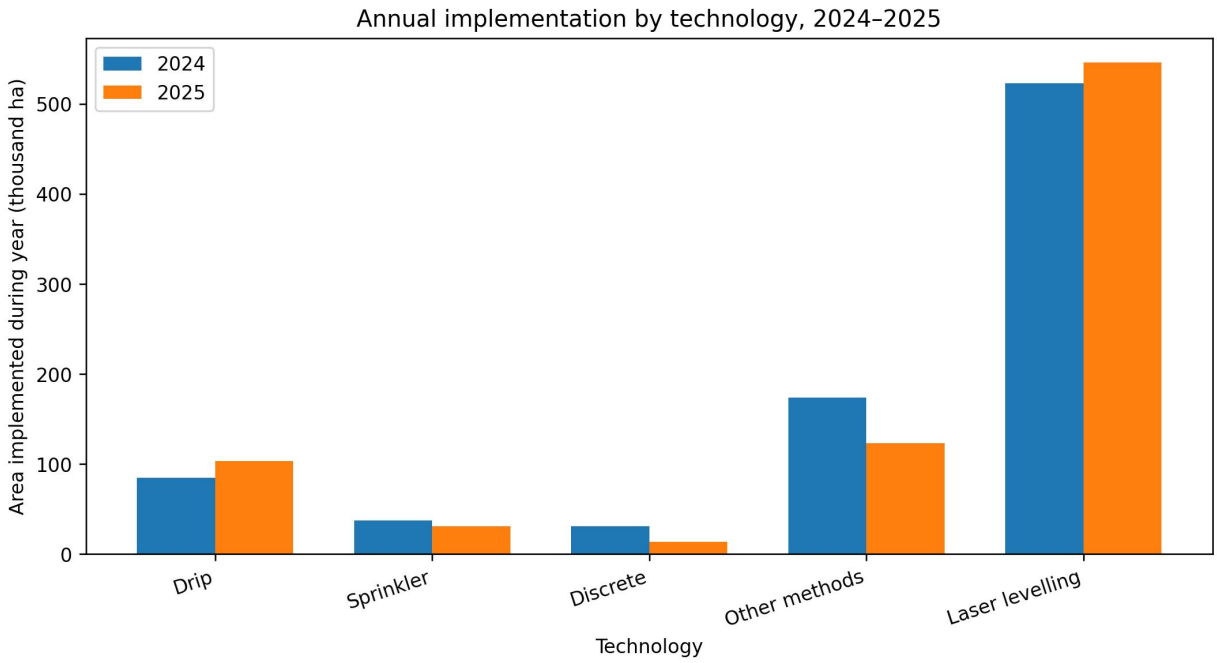


Figure 4. Comparison of annual implementation by technology in 2024 and 2025.

The annual composition changed even though total implementation remained high. Drip irrigation and laser levelling increased in 2025, while sprinkler, discrete, and other methods declined relative to 2024. This suggests that annual targets and farmer demand can shift among technologies. Economic evaluation should therefore examine why specific systems are selected, whether equipment remains operational, and whether the expected benefits persist beyond the installation year.

4.5. Indicative investment threshold for drip irrigation

Initial cost per ha	Annualized capital cost	Annual O&M (3%)	Minimum annual net benefit
US$1,600	US$260	US$48	US$308
US$2,200	US$358	US$66	US$424
US$2,500	US$407	US$75	US$482

Table 4. Indicative break-even annual benefit for drip irrigation

Assumptions: ten-year economic life, 10 percent real discount rate, and annual operation and maintenance equal to 3 percent of initial investment. Values are illustrative rather than observed national averages.

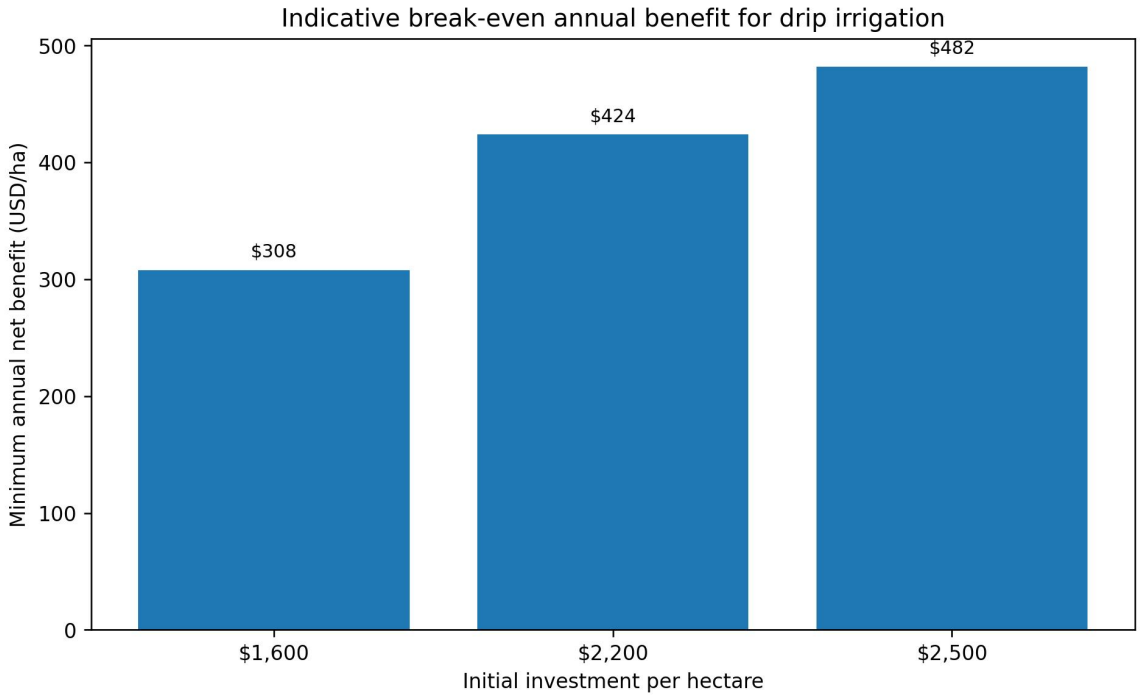


Figure 5. Minimum annual net benefit required for drip irrigation to cover indicative investment and maintenance costs.

At an initial cost between US$1,600 and US$2,500 per hectare, the technology must generate approximately US$308–482 per hectare in additional annual net benefit under the stated assumptions. The benefit can come from additional yield, improved quality, lower labour, reduced fertilizer loss, lower water or energy costs, or avoided crop failure. If these benefits are lower than the threshold, the investment is not financially justified without a grant or other public support.

4.6. Comparative economic characteristics

Criterion	Furrow irrigation	Sprinkler irrigation	Drip irrigation
Initial investment	Low	Medium to high	High
Energy requirement	Low under gravity; variable under pumping	High because pressure is required	Medium; depends on pressure and source
Water application control	Low to medium	Medium to high	High
Labour requirement	Medium to high	Medium	Low to medium
Maintenance complexity	Low	Medium	High: filtration, flushing, emitters
Sensitivity to wind	Low	High	Low
Suitability for high-value crops	Moderate	Moderate to high	High
Main economic advantage	Low capital and familiar operation	Flexible coverage and uniformity	Precision, yield quality and water productivity
Main economic risk	Losses and unreliable application	Energy and wind losses	Capital cost, clogging and finance

Table 5. Comparative economic and operational characteristics of irrigation systems
Source: author synthesis based on FAO, World Bank, IWMI, and irrigation literature.

5. Discussion

5.1. When drip irrigation is economically preferable

Drip irrigation is most likely to be profitable where crop value, yield response, quality premiums, or production-risk reduction are high. It is particularly suitable for orchards, vineyards, vegetables, and intensive horticulture. For cotton and other field crops, profitability depends more heavily on equipment cost, subsidy design, financing terms, expected yield response, and the value placed on saved water and energy.

The 2021–2025 adoption trend confirms strong expansion but cannot by itself establish profitability. A farm may install equipment because of a subsidy while experiencing inadequate filtration, poor scheduling, or limited maintenance. Monitoring should therefore distinguish equipment installed, equipment operating, area actually irrigated, and verified economic results.

5.2. When sprinkler irrigation may be preferable

Sprinkler irrigation can be attractive for closely spaced crops, uneven or irregular plots, and farms requiring mobile or flexible systems. It may offer a lower distribution complexity than drip in some field-crop settings. However, energy use is a decisive factor. A technically effective system can have a weak financial return when electricity and pump replacement costs are high.

Project appraisal should calculate kilowatt-hours per hectare and per cubic metre, not only water application. Wind conditions, nozzle selection, operating pressure, and irrigation timing also influence the cost of effective water delivery.

5.3. Why improved furrow irrigation remains relevant

The very large share of laser land levelling in the 2025 intervention mix shows that improved surface irrigation remains central to Uzbekistan’s strategy. Where capital is limited, laser levelling, flexible pipes, gated outlets, shortened furrows, and better scheduling may produce a higher return per unit of public support than full conversion to pressurized irrigation.

Furrow irrigation is therefore not simply an outdated baseline. Its economic performance depends on field design and management. A modernized furrow system can be rational for lower-value crops and gravity-fed areas, while poorly managed furrows can impose high water and labour costs.

5.4. Rebound effects and scale

Technical water savings at field level should not automatically be counted as basin-level savings. Farmers may use improved reliability to irrigate a larger area, increase irrigation frequency, or shift to higher-value but more water-intensive crops. Return flows from surface irrigation may also support downstream users. These effects do not eliminate the value of modernization, but they change the interpretation of savings.

A credible economic assessment should report water withdrawn, water delivered, beneficial consumption, yield, gross margin, energy use, and the use of any released water. This is particularly important when public subsidies are justified by national water conservation.

6. Policy Recommendations

First, Uzbekistan should move from installation-based monitoring to performance-based monitoring. Subsidy and credit programs should record whether systems remain operational and whether they achieve measurable changes in water delivery, energy use, yield, cost, and gross margin.

Second, technology support should be differentiated by crop value, soil, field size, water source, pumping requirement, and farmer capacity. A universal technology target can lead to poor matches and underused equipment.

Third, farm-level financing should reflect seasonal cash flow and equipment life. Longer repayment periods, appropriate grace periods, insurance, and maintenance contracts can improve the financial sustainability of adoption.

Fourth, sprinkler projects should include an energy audit, while drip projects should include water-quality testing, filtration design, spare-parts access, and operator training. These costs must be part of appraisal rather than treated as later operational issues.

Fifth, improved furrow irrigation and laser levelling should remain part of the investment portfolio. Their lower capital requirement can make them suitable for broad field-crop areas where drip or sprinkler systems do not pass the financial threshold.

Finally, Tashkent Region should establish a farm panel covering drip, sprinkler, and improved furrow systems. The panel should collect harmonized data on investment, subsidy, water delivered, energy, labour, fertilizer, yield, quality, maintenance, and net income. This would allow direct NPV and productivity comparison and strengthen the empirical basis of the author's PhD research.

7. Conclusion

Uzbekistan experienced a rapid expansion of water-saving intervention coverage between 2021 and 2025. Reported coverage increased from approximately 308 thousand hectares to 2.6 million hectares, with drip irrigation reaching 664 thousand hectares and sprinkler irrigation 121 thousand hectares. The 2025 composition also shows that laser land levelling is a major modernization pathway.

The recent adoption data demonstrate scale and policy commitment, but they do not prove that one irrigation system is universally superior. Drip irrigation provides the highest control but carries high capital and maintenance requirements. Sprinkler irrigation is flexible but energy-intensive. Improved furrow irrigation remains economically relevant where investment resources are limited and land levelling and delivery management can be improved.

The central conclusion is that future policy should evaluate verified economic performance rather than hectares installed alone. A sound decision requires farm-level cash-flow analysis, water and energy measurement, maintenance assessment, and system-scale water accounting. The 2021–2025 evidence provides a current national context, while a harmonized farm dataset is the next necessary step for rigorous causal and economic comparison.

References

1. CGIAR. (2023). Irrigation innovation: Navigating challenges in Uzbekistan's water-energy-food-environment nexus. CGIAR.
2. Djumaboev, K., Hamidov, A., Anarbekov, O., Gafurov, Z., & Tussupova, K. (2017). Impact of institutional change on irrigation management: A case study from Southern Uzbekistan. Water, 9(6), 419. https://doi.org/10.3390/w9060419
3. Evans, R. G., & Sadler, E. J. (2008). Methods and technologies to improve efficiency of water use. Water Resources Research, 44(7), W00E04. https://doi.org/10.1029/2007WR006200
4. Food and Agriculture Organization of the United Nations. (2012). Irrigation in Central Asia in figures: AQUASTAT Survey 2012. FAO Water Reports No. 39.
5. Hamidov, A., Kasymov, U., Djumaboev, K., & Paul, C. (2022). Rebound effects in irrigated agriculture in Uzbekistan: A stakeholder-based assessment. Sustainability, 14(14), 8375. https://doi.org/10.3390/su14148375
6. International Water Management Institute. (2020). Water-accounting tools have become a national priority investment for 2020–2030 for Uzbekistan. IWMI/CGIAR.

7. Ministry of Water Resources of the Republic of Uzbekistan. (2025a, February 7). Suv tejovchi texnologiyalar – davr talabi [Water-saving technologies are a requirement of the time]. Government Portal of Uzbekistan.
8. Ministry of Water Resources of the Republic of Uzbekistan. (2025b, December 12). Parlamentda Suv xo‘jaligi vazirining axboroti tinglandi [Parliament heard the report of the Minister of Water Resources]. Government Portal of Uzbekistan.
9. Oliy Majlis Legislative Chamber. (2023, November 21). Suv xo‘jaligi vaziri deputatlar savollariga javob berdi [The Minister of Water Resources answered deputies’ questions].
10. Pereira, L. S., Oweis, T., & Zairi, A. (2002). Irrigation management under water scarcity. Agricultural Water Management, 57(3), 175–206. https://doi.org/10.1016/S0378-3774(02)00075-6
11. Playán, E., & Mateos, L. (2006). Modernization and optimization of irrigation systems to increase water productivity. Agricultural Water Management, 80(1–3), 100–116. https://doi.org/10.1016/j.agwat.2005.07.007
12. UzDaily. (2021, August 9). Uzbekistan takes systemic measures to adapt and mitigate the effects of climate change.
13. World Bank. (2024a). Uzbekistan: Policy perspectives for irrigation and drainage sector reform. World Bank.
14. World Bank. (2024b). Uzbekistan general water security assessment. World Bank.
15. World Bank. (2025). Uzbekistan National Irrigation and Energy Efficiency Improvement Project. World Bank.