Theoretical foundations for assessing the economic efficiency of resource-saving technologies in cotton production

B.J.Mirzaev Cand. Sc. (Econ.), Assoc. Prof. · **N.T. Djumabaeva** PhD Student

Institute of Agriculture and Agrotechnologies of Karakalpakstan

DOI 10.66073/ReFocus-Conf/1610174

For citation: B.J.Mirzaev, N.T. Djumabaeva. Theoretical foundations for assessing the economic efficiency of resource-saving technologies in cotton production. In: Development of innovative climate-resilient technologies for monitoring and controlling water use efficiency and the impact of salinization on crop productivity and livelihoods in the Aral Sea region: Proceedings of the International Scientific and Practical Conference. Nukus, 2026. P. 658–660. DOI: 10.66073/ReFocus-Conf/1610174

Abstract. This study examines, from a theoretical perspective, the economic essence of introducing resource-saving technologies in cotton production, a system of indicators for assessing them, and the economic and institutional factors that influence their adoption. Resource saving is defined as a reduction in the amount of resources used per unit of output while yield and quality are maintained. The paper proposes cost per unit, net income, profitability, payback period and net income per unit of resource as the core efficiency indicators, and it distinguishes farm-level savings from society-level savings.

Keywords: cotton production, resource-saving technologies, economic efficiency, profitability, drip irrigation, payback period, agricultural economics.

Introduction

Cotton is a strategic crop for Uzbekistan, linked to household incomes, the textile industry and export potential. At the same time, cotton growing is a sector with high demands on water, mineral fertilizers, fuel and labor. As water scarcity intensifies and input prices rise, the competitiveness of farms is determined not by yield alone but by the efficiency with which resources are used. Industry representatives likewise stress that the task today is not to expand the cotton area but to use existing capacity more effectively [5].

In practice, the adoption of resource-saving technologies (drip irrigation, improved planting schemes, optimized inter-row cultivation, calibrated fertilizer application, digital monitoring) is growing. However, the methods used to assess their economic efficiency are often inconsistent: some studies report only water savings, others only yield, still others only costs. As a result, technologies are hard to compare, and adoption decisions are hard to justify. At the state level, shortcomings have also been acknowledged: there is no effective mechanism to encourage drip irrigation and domestic producers of its components, and there are no scientifically grounded agrotechnical rules adapted to local soil and climate conditions [4]. This shows that the issue is not only technical but also economic and institutional.

The economic essence of resource saving

From an economic standpoint, resource saving means **a reduction in the amount of resource used per unit of output**, not an absolute reduction in resource use. The distinction matters: if inputs fall but yield falls by more, farm efficiency declines. A technology should therefore be assessed together with yield and product quality. This is consistent with the view that, in modern cotton production, yield alone is not a sufficient criterion [5].

The economic effect of resource saving arises in three ways: (a) direct cost savings (water, electricity, fertilizer, fuel, labor); (b) additional income from changes in yield and quality; (c) changes in land use, for example, more efficient use of the cropped area when the planting scheme changes. As

an illustration, a scientific article on the effect and efficiency of drip irrigation on cotton reports that the method has a positive effect on the growth and development of the crop, saves water and mineral fertilizer, and raises yield [6].

A system of economic efficiency indicators

A single system of indicators is proposed so that technologies can be compared. Calculations follow an incremental approach, that is, as the difference between the resource-saving technology (1) and the traditional technology (0).

Table 1. System of economic efficiency indicators

Indicator	Calculation	Economic meaning
Cost per unit (1 t of raw cotton)	C = Total costs / Total yield	Cost per unit of output
Net income	NI = Revenue − Total costs	Profit remaining with the farm
Profitability	P = NI / Total costs × 100%	Return per unit of cost
Incremental net income	$\Delta NI = NI_1 - NI_0$	Net economic effect of the technology
Payback period	PP = I / ΔNI	Years needed to recover the additional investment (I)
Net income per unit of water	NI / W	Net income from 1 m³ of water
Resource-saving coefficient	$K = (r_0 - r_1) / r_0$	Relative reduction in resource use per unit of output

Here W is water use, and r_0 and r_1 are resource use per unit of output under the traditional and the resource-saving technology. The advantage of this system is that it shows not only the technical saving but also the real economic result for the farm. Where a technology has a long service life (for example, a drip irrigation system), it is advisable to use, alongside the payback period, indicators that account for the present value of cash flows (net present value).

Economic and institutional factors affecting adoption

The same technology produces different economic results on different farms. The factors can be divided into four groups.

Financial factors. The size of the initial investment, access to credit and subsidies, and equipment prices. Experience abroad shows that leading countries use incentives such as subsidies and reduced import duties on irrigation equipment [2]. At the national level, too, the lack of an effective mechanism to encourage producers who grow cotton with drip irrigation and domestic producers of system components has been noted [3].

Price factors**.** Prices of water, electricity, fertilizer and labor. When a resource is cheap, the economic gain from saving it is small and the payback period lengthens.

Organizational and legal factors. Security of land-use rights, farm size, and relations between the cluster and the farmer. If land-use tenure is not guaranteed, a farmer is unlikely to make an investment that pays back only over many years.

Farm-level versus society-level effects

A technology that is profitable for a farm is not necessarily beneficial for society, and vice versa. If a farmer pays little for water, the incentive to save it is weak: a resource that is valuable to society is priced low in the farm's accounts. Moreover, water saved on one field may previously have reached downstream users, so field-level savings do not equal basin-level savings. The assessment should therefore distinguish a private (farm) effect from a social and environmental effect. The latter includes the impact on water scarcity and soil condition, and valuing it in monetary terms is a separate methodological problem [1].

Testable hypotheses

The theoretical analysis yields the following hypotheses: H1. The economic effect of a resource-saving technology is larger on farms where initial inefficiency is high. H2. The payback period shortens as farm size grows, because the fixed costs of the equipment are spread over a larger area. H3. Subsidies and concessional credit shorten the payback period and raise the probability of

adoption. H4. When technologies are applied in combination (for example, irrigation with calibrated fertilization), the economic effect exceeds the sum of the effects of each applied separately. H5. Where resource prices are low, the private economic effect of a technology is smaller than its social effect. Testing the hypotheses requires data on costs, yield and prices from farms of different sizes in the same region, comparing traditional and resource-saving technologies.

Conclusions and Recommendations

In cotton production, resource saving should be defined in economic terms as a reduction in resource use per unit of output while yield and quality are maintained; a decrease in the quantity of inputs alone is not a criterion of efficiency. To compare technologies, indicators such as cost per unit, net income, profitability, incremental net income, payback period and net income per unit of water should be applied in a single system, using an incremental approach relative to the traditional technology. The efficiency of adoption depends on financial, price, organizational-legal and knowledge factors. Incentive measures (subsidies, concessional credit, security of land use, advisory services) are therefore as important as the technology itself. The farm-level and society-level effects should be assessed separately; field-level water savings should not be treated as equal to basin-level savings.

References

1. Eshmurodova M.Q. *Paxta yetishtirishning tejamkor texnologiyasi* [Resource-saving technology of cotton production]: monograph (in Uzbek). Tashkent: Fan ziyosi, 2023. Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnologies.
2. Saidova D.N., Nasulloyeva M.B. Yashil iqtisodiyot sharoitida qishloq xo‘jaligida resurstejamkor texnologiyalardan foydalanishning xorij tajribasi [International experience in using resource-saving technologies in agriculture under a green economy] (in Uzbek) // Proceedings of the MMIT’26 International Conference, 6 June 2026, p. 253.
3. Shaymanov Sh.Q. Tomchilatib sug‘orish tizimini tashkil etuvchi elementlar [Elements of a drip irrigation system] (in Uzbek). Zenodo. https://zenodo.org/records/11633651
4. Suvni tejaydigan zamonaviy texnologiyalarni va agrotexnika tadbirlarini joriy qilishdagi kamchiliklar sanaldi (Prezident qarori) [Shortcomings in introducing water-saving technologies and agrotechnical measures listed (Presidential decree)] (in Uzbek) // Kun.uz, 28 December 2018. https://kun.uz/news/2018/12/28/suvni-tejaydigan-zamonaviy-texnologiyalarni-va-agrotexnika-tadbirlarini-joriy-qilishdagi-kamchiliklar-sanaldi-prezident-qarori
5. Paxtaning kelajagi dalaning o‘zida emas, ilm-fan, texnologiya va bozor o‘rtasida shakllanadi [The future of cotton is shaped not in the field alone, but between science, technology and the market] (in Uzbek) // UzA. https://uza.uz/ar/posts/paxtaning-kelajagi-dalaning-ozida-emas-ilm-fan-texnologiya-va-bozor-ortasida-shakllanadi_918365
6. Shodmonov X.M. Tomchilatib sug‘orishning g‘o‘za hosildorligiga ta’siri va samaradorligi [The effect and efficiency of drip irrigation on cotton yield] (in Uzbek) // Results of National Scientific Research International Journal, 2024, 3(4), 197–202. ISSN 2181-3639. DOI: 10.5281/zenodo.11099591. https://zenodo.org/records/11099591