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Strategic Water Resource Management in Organic Farming Systems for Enhancing Agricultural Sustainability and Resource Efficiency in Uzbekistan

Ravshan Asamov

Department of Economics, International Agriculture University (Ass. Prof), Tashkent State Agrarian University (DSc), Tashkent, Uzbekistan

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Abstract: Water scarcity would pose a critical challenge for the sustainability of agriculture in some regions, in which intensive irrigation along with climate variability are able to threaten not only crop productivity but environmental resilience (He et al, 2021). Organic farming systems that usually emphasize soil health and some environmentally friendly practices and could offer several potential pathways for improvement of water usage efficiency while they are maintaining sustainability of agricultural systems (Crystal-Ornelas et al, 2021). This dissertation investigates some workable strategies, clear challenges, as well as opportunities for using efficient water resource management within the organic farming systems in Samarkand of Uzbekistan. Utilization of a mixed-methods approach, such as taking survey interviews from farmers who are in organic farming, field observations, along with some institutional interviews. This doing research evaluates water usage of patterns, several techniques for irrigation, soil–water interactions, and the last not least one is the role of policy frameworks in promotion of sustainable practices. The research findings can reveal that while organic farms help generally to exhibit improvement of soil moisture retention as well as lower water consumption when compared to conventional systems, significant barriers including limitation of technical support, lack of irrigation infrastructure, and there is knowledge gaps persist. The research will provide some evidence-based recommendations for optimization of water management in organic agricultural systems, emphasizing integration of irrigation approaches, which can lead to the combination of technological innovations, farmer education, and policy interventions. The results will bring about great contributions to the understanding sustainability of some water management practices in arid along with semi-arid regions. They can offer workable guidance for policymakers, crop growers, and agricultural stakeholders committed to promoting resilient and efficient organic agriculture in Uzbekistan.

Keywords: Water Resource Management, Organic Farming, Water Use Efficiency, Sustainable Agriculture, Uzbekistan, Irrigation Practices, Soil-Water Relationships.

Introduction: Water resource management which has become one of the most considered critical challenges facing modern agriculture, particularly in some regions where are arid along with semi-arid. Agriculture is recognized as having the largest share of global freshwater withdrawals (Khasanov et al, 2022). It could lead to an increase in pressure from consistent growth of population, variability of climate change as well as rising resource competition from both industrial and urban sectors has heightened several concerns regarding to limitation of water availability and sustainability of agriculture (Gamage et al, 2023). There are most inefficient irrigation practices, decreasing availability of water efficiently, along with degradation of environment would lead to rise numerous serious questions related to the long-term viability of water-

dependent agricultural systems.

Organic farming that has emerged globally as a potential pathway toward more sustainability of agricultural development (Gamage et al, 2023) and, by the help of emphasizing ecological balance, soil health and quality, biodiversity, along with reduction of dependence on synthetic inputs. The systems within organic farming aim improvement of environmental performance while they are trying to maintain agricultural productivity (Montemayor et al, 2022). We should take into consideration that one of the key environmental benefits frequently which are usually associated with organic agriculture has shown its potential for the enhancement of soil structure together with capacity of water retention (Muller et al, 2017), thereby leading to improvement of water usage efficiency and enhancement of tolerance to changing climatic conditions.

The central research problem which has addressed in this research is the lack of comprehensive, context-specific evidence on how water resources are managed within organic farming systems along with how these considered practices would lead to significant contribution for water efficiency as well as sustainability of agricultural systems (Mohamed et al, 2021). The aim of this research is to assess some water resource management practices in organic farming systems and to evaluate their effectiveness, several challenges, and examine some consequences for long-term viability of agricultural systems.

LITERATURE REVIEW

Water resource management is widely considered as a cornerstone for the sustainability of agricultural development, particularly in some regions where are characterized by drought-prone like arid along with semi-arid climatic conditions. Usually, agriculture would remain the largest consumption of global freshwater which accounts for approximately seventy percent of total withdrawals and consumption of large amounts of water is leading to substantial strain on increasingly limited water resources (Xue et al, 2017). Because of the global consistent growth of population, changes in dietary, and climate variability, all of them could lead to an increase in water demand, the agricultural sector within the last decades has faced growth of scrutiny regarding its efficiency, sustainability, along with some impacts (Xue et al, 2017). As a result of this, effective water resource management has become central for the improvement of food security while we are protecting natural ecosystems.

According to De Vito et al, (2017), scholarly research would consistently identify that inefficient irrigation practices are considered as a significant contributor for excessive usage of water in agriculture. The research of Nikolaou et al. (2020), there are some traditional surface irrigation methods, like water surface, basin, and furrow irrigation, most of which could usually continue to be widespread in many developing regions because of considered low initial costs along with simplicity. Nevertheless, these methods mentioned would have been frequently linked to losses in a high conveyance, evaporation of water, runoff, and the last one is waterlogging. Such inefficiencies lead to not only reduction of water availability but bring about significant contributions of secondary environmental problems and they might be soil salinization, nutrient leaching, and dimension of land output.

Table 1: Key Water Resource Management Statistics

Indicator	Value	Reference
Agriculture's share of global freshwater withdrawals	**72%**	UNESCO, 2024; UN, 2025
Groundwater's contribution to global irrigation water use	**Around 25%**	UNESCO, 2024
Population experiencing severe water scarcity for at least part of the year	**Around 50%**	UNESCO, 2024
Annual growth in global freshwater demand since the 1980s	**Just under 1%**	UNESCO, 2024
Global water-use efficiency, 2015	**US$17.4/m³**	UN-Water, 2024
Global water-use efficiency, 2021	**US$20.8/m³**	UN-Water, 2024
Increase in global water-use efficiency, 2015–2021	**19.3%**	UN-Water, 2024
Global water-use efficiency, 2022	**US$21.5/m³**	UN, 2025

Source: Compiled by the author based on UNESCO (2024), United Nations World Water Development Report 2024: Water for Prosperity and Peace; UN-Water (2024), Progress on Change in Water-Use Efficiency - 2024 Update; and United Nations Statistics Division (2025), The Sustainable Development Goals Report 2025, Goal 6.

Uzbekistan is considered in one of the water-scarce countries, water resource management would carry additional complexity because of the reason for heavy reliance on transboundary river systems along with legacy irrigation infrastructure which is inherited from earlier development models (Babakholov et al, 2022).

Table 2: Empirical Evidence on Water-Efficient Irrigation Practices

Research / Context	Irrigation Practice	Key Finding	Implication for Water-Use Efficiency
Ibrohimov et al. (2007), Uzbekistan	Drip vs. furrow irrigation	Drip irrigation saved **18-42%** of irrigation water	Demonstrates substantial water-saving potential
Ibrohimov et al. (2007), Uzbekistan	Drip irrigation	Irrigation water-use efficiency increased by **35-103%**	Improved efficiency can be achieved through appropriate scheduling
Ibrohimov et al. (2007), Uzbekistan	Drip irrigation	Cotton yield increased by **10-19%**	Water saving does not necessarily require lower productivity
Mirshadiev et al. (2018), Uzbekistan	Drip, deficit and furrow irrigation	Drip irrigation showed the highest potential for improving water productivity	Supports adoption of efficient irrigation technologies
FAO	Microirrigation	Drip systems can achieve approximately **75-90%** application efficiency under appropriate conditions	Highlights the potential of localized irrigation
FAO	Irrigation scheduling	Matching irrigation timing and amounts with crop requirements reduces water losses	Management practices are as important as irrigation technology

In Uzbekistan, outdated infrastructure and unreliable water delivery systems are crucially depended on the economic effectiveness of irrigation investments. At the expense of such conditions, farmers may avoid allocating some money regarding technologies that allow things to be more efficient if water supply sources become uncertain (Liang & Van Dijk, 2011). It clearly implies how important this is to make investments that work well with irrigation infrastructure as well as institutional changes which allows to guarantee the realization of financial advantages with the aid of increased water utilization efficiency (Takeshima, 2017).

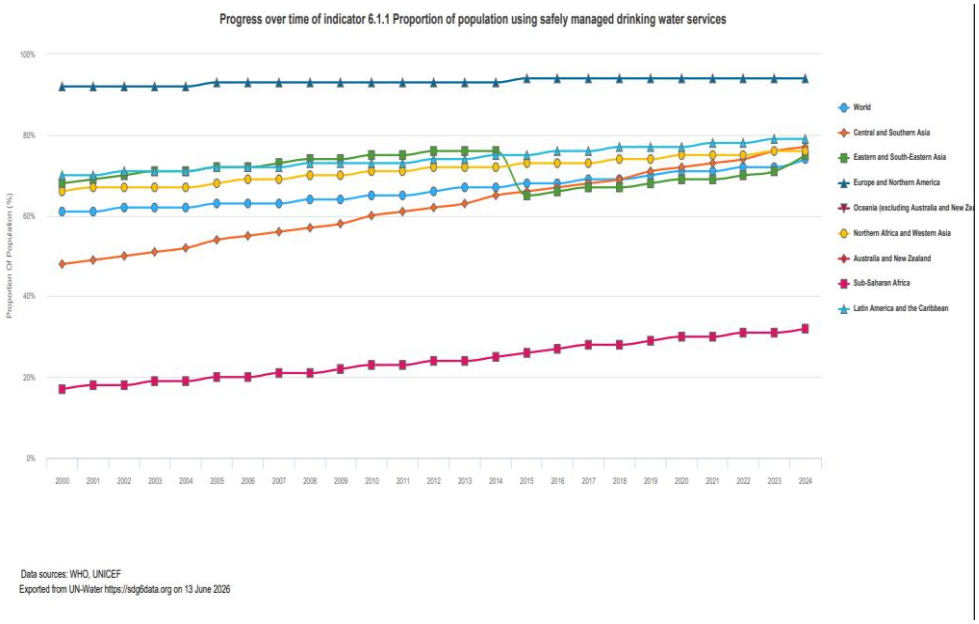


Figure 1: Status in different countries (or areas) of indicator 6.1.1 Proportion of population using safely

managed drinking water services (2024) https://sdg6data.org/en/indicator/6.1.1

Comparative analyses that are between organic along with conventional farming systems could provide mixed but increasingly nuanced insights into not only usage of water efficiency but also water productivity (Ayilara et al, 2020). A growing body of literature that usually suggests that there are organic farming systems which can achieve comparable, and in some cases superior, productivity of water over the long term.

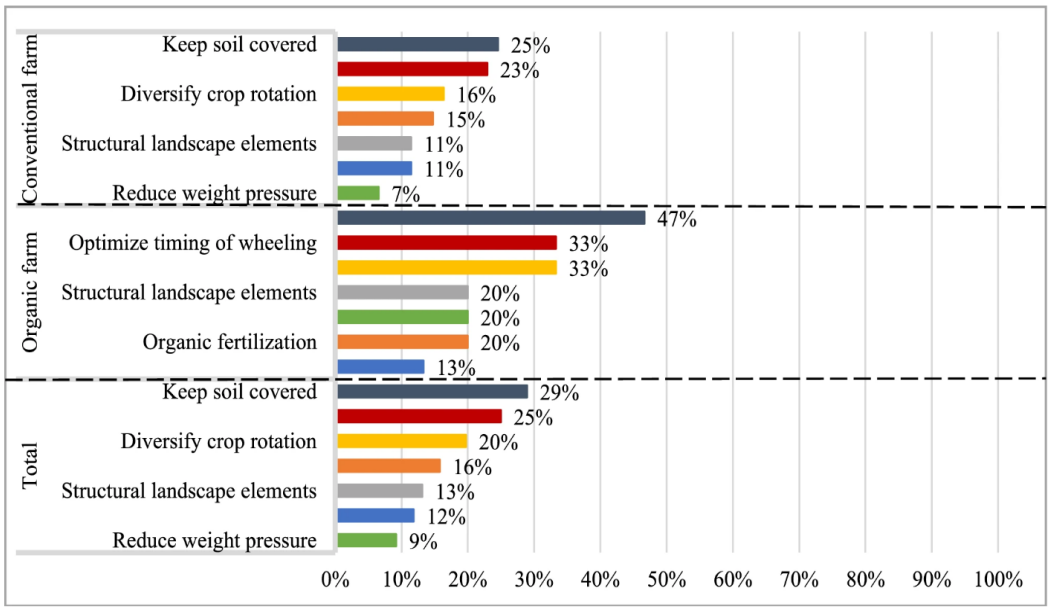


Figure 2: Barriers of adopting sustainable soil management practices for organic and conventional farming systems

There are organic farming systems which would typically emphasize practices that improvement of the physical along with biological properties of soil, both can lead to enhancement of water infiltration as well as reduction of losses through both runoff and evaporation (Asamov, 2024). These considered soil-related benefits that are frequently cited as key mechanisms through what kind of organic systems can improve usage outcomes of water compared with several conventional systems. In contrast, farming systems related to conventional which would often rely on synthetic inputs along with intensive tillage. They can degrade soil structure over time and lead reduction of the soil's capacity for retaining water, particularly under sustained irrigation (Yang et al, 2020).

	CONVENTIONAL FARMING	ORGANIC FARMING
Farming Technique	Involve methods based on synthetic inputs to increase production.	Depends on organic ways, rejecting all things synthetic
Fertilizers Used	Chemical fertilizers like DAP, Urea, and DD	Only fertilizers obtained through organic ways, like manure & composts
Sustainability	No, sustainability. Focused more on yield	Sustainability is the main focus ecology and environment is the main principle
Disease Resistance	More adapted to disease resistance, thanks to pesticides	Vulnerable to disease and pest attacks
Health Concerns	Heavy use of chemical fertilizers and pesticides poses extensive health risks	No health risk because of the absence of harmful chemicals
Environmental Concerns	Intensive farming methods prove detrimental to land, soil, and water	Improve the overall ecology thanks to safe farming techniques

Click to expand

Table 3: Comparison of Organic and Conventional Farming https://www.collidu.com/presentation-conventional-vs-organic-farming

Despite their growing international interest in the sustainability of agriculture as well as organic farming, significant research gaps would persist regarding water management within the systems of organic farming

under managed irrigation. Existing studies which would be mainly concentrated in temperate regions, with limitation of empirical evidence from arid and semi-arid environments such as Central Asia. It can be researched that there is a lack of integrated analyses that can examine technical, institutional as well as socio-economic dimensions with the sector of water management (Asamov, 2026).

METHODOLOGY

The research design is based on a mixed-methods approach, which can combine both quantitative analyses related to water use and some farm-level practices with the help of qualitative insights which are based on experiences, perceptions of farmers, along with numerous organizational limitations. This design is highly likely to enable a deeper understanding of practices in water management by the assist of capturing both measurable outcomes as well as some contextual factors (Asamov, 2025).

The research can be conducted in Samarqand region of Uzbekistan in which some organic farming activities are present along with irrigation is considered as a significant role in agricultural production. Predominantly arid climate in Uzbekistan, heavy dependence on irrigation systems along with increasing policy interests in sustainability of agriculture heavy dependence on some irrigation systems to examine water management.

Case selection would follow a purposive sampling approach, targeting some regions that represent diversity in terms of the availability of water, irrigation infrastructures, along with practices of farming systems. Organic farms are selected based on criteria including either certification status or recognized some organic practices, reliance on irrigation, together with accessibility for data collection. This approach can ensure that the cases examined are information-rich along with relevant research objectives while it is maintaining contextual diversity.

Data collection is structured for addressing research questions through the integration of quantitative and qualitative methods. Not only primary but also secondary data sources will be utilized to strengthen the evidence base of the research.

RESULTS

The analysis is considered responsible for combining descriptive evidence in terms of a small-scale survey of 20 organic farmers with qualitative evidence. This has been obtained with the help of open-ended questions as well as farmer debates. By doing this analysis, that could aim to assess several current water-management practices, awareness among agricultural growers along with understanding of water-use efficiency, implementation of the latest water-saving technologies. There are several key constraints together with perceived opportunities for leading to significant improvement for sustainability of water management.

Table 4. General characteristics of surveyed farmers

Indicator	Result
Number of respondents	20
Average age	44.8 years
Average farming experience	17.6 years
Average farm size	3.4 ha
Farmers primarily producing fruit	12 (60.0%)
Farmers producing vegetables	5 (25.0%)
Farmers producing mixed organic crops	3 (15.0%)

Source: Primary farmer survey, Samarkand Region, 2026.

The survey surveyed respondents who could be characterized with considerable experience within farming households. With an average of approximately 17.6 years of farming experience, reflecting local production along with irrigation conditions, both were recorded many respondents by considerable practical knowledge. The average farm size was counted as around 3.4 hectares. Both small and medium-sized organic farms are targeted in this research.

Table 5. Main sources of irrigation water

Main water source	Farmers (n)	Percentage (%)
Irrigation canals	13	65.0
Groundwater/wells	4	20.0
Reservoir/storage systems	3	15.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

According to the results, irrigation canal networks have emerged as the main source of agricultural water, with 65% of respondents relying on them. Agricultural producers who found groundwater sources and wells, both were practical and useful, using 20%. But 15% was mainly used on either reservoirs or storage systems.

Table 6. Main irrigation methods used by farmers

Irrigation method	Farmers (n)	Percentage (%)
Traditional surface irrigation	12	60.0
Drip irrigation	4	20.0
Combination of traditional and drip irrigation	3	15.0
Sprinkler irrigation	1	5.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

Conventional surface irrigation was used as the most common method by agricultural producers, and they would represent 60% of respondents. Only 20% of respondents have primarily used drip irrigation methods/ both combining traditional and drip irrigation, that accounted for 15%.

Table 7. Farmers' knowledge of annual irrigation water use

Response	Farmers (n)	Percentage (%)
Know approximately their water consumption	7	35.0
Do not know	13	65.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

The important descriptive findings reveal a substantial gap about lack of awareness among farmers in terms of water usage, with 65% of respondents being unable to quantify their annual irrigation water consumption.

Only seven farmer respondents indicated that they could provide an approximate estimate of their irrigation water, which was utilized on their farms. Owing to this research finding, they have recorded a few potential weaknesses in water accounting at the farm level.

Table 8. Use of irrigation scheduling

Frequency	Farmers (n)	Percentage (%)
Always	6	30.0
Often	8	40.0
Sometimes	6	30.0
Never	0	0.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

According to the findings, agricultural producers practice irrigation scheduling, although crop and soil conditions are not always considered. Even though all respondents used irrigation scheduling at least occasionally, only 30% regularly considered these factors when it is determined by irrigation timing. The largest share of respondents, a further 40%, are reported doing so often, as the remaining 30% considered these factors only sometimes. This indicates that irrigation scheduling is practiced within the farming community yet does not always rely on systematic monitoring of crop and soil conditions.

Table 9. Water-saving practices used by surveyed farmers

Water-saving practice	Farmers (n)	Percentage (%)
Irrigation scheduling	20	100.0
Regular irrigation-system maintenance	14	70.0
Mulching	10	50.0
Drip irrigation	7	35.0
Drought-tolerant varieties	6	30.0
Soil-moisture monitoring	5	25.0
Water storage	4	20.0

Source: Primary farmer survey, Samarkand Region, 2026. Multiple responses permitted.

The research findings suggest that agricultural producers mainly rely on basic irrigation-management practices, while advanced monitoring technologies are used and remain limited. All respondents report using at least one form of irrigation scheduling practices, with irrigation systems regularly maintained by 70% of respondents. Half of the farmers who have reported using mulch.

Nevertheless, soil-moisture control accounted for only 25%, with water storage being used by 20%. With the help of research findings, it is pointed out to the continued reliance on conventional, experience-based irrigation practices means that measurement would play a more limited role in water management.

Table 10. Frequency of experienced water shortages

Frequency	Farmers (n)	Percentage (%)
Frequently	9	45.0
Sometimes	8	40.0
Rarely	3	15.0
Never	0	0.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

Lack of water resources was considered a common and vital issue. The figure for respondents who have experienced water shortages was forty-five percent, while the remaining 40% reported experiencing them from time to time.

If taken together, the results show that 85% of the surveyed farmers are more likely to experience either frequently or occasionally water shortages. This finding could align with the previous studies that are concerning irrigation-water scarcity, several challenges regarding agricultural production in Uzbekistan. When it comes to the research which was conducted in Samarkand, it played a central role in identifying irrigation availability in terms of climate conditions as well as farm productivity.

Table 11. Major challenges affecting efficient water management

Challenge	Farmers (n)	Percentage (%)
Water scarcity	17	85.0
High irrigation costs	13	65.0
Old irrigation infrastructure	12	60.0
High cost of modern irrigation technologies	12	60.0
Lack of technical knowledge	10	50.0
Limited access to training	9	45.0
Unreliable water supply	9	45.0
Limited financial support	8	40.0

Source: Primary farmer survey, Samarkand Region, 2026. Multiple responses permitted.

Water shortages have emerged as the most common challenge, which was reported by 85% of respondents. The figure for respondents that has reported high irrigation expenses and it was 65%, while 60% cited ageing infrastructure together with the cost of modern technologies as challenges.

Table 12. Adoption of modern irrigation technologies

Adoption status	Farmers (n)	Percentage (%)
Adopted at least one modern technology	8	40.0
Have not adopted modern technology	12	60.0
Total	**20**	**100.0**

Source: Primary farmer survey, Samarkand Region, 2026.

Modern water-saving technology had been adopted by 40% of the respondents, who use at least using one technology, compared with three-fifths who had not. Limited adoption does not necessarily reflect negative attitudes in terms of modern irrigation technologies. Responses of agricultural producers inform that the potential benefits are relatively high, but financial and technical and infrastructural barriers, all are continuing to limit implementation.

Table 13. Perceived benefits of water-saving technologies

Statement	Agree	Neutral	Disagree
Water-saving technologies are likely to reduce water consumption	17 (85%)	2 (10%)	1 (5%)
They are likely to reduce irrigation costs	14 (70%)	3 (15%)	3 (15%)
They can reflect improvement in crop productivity	14 (70%)	4 (20%)	2 (10%)
They can reduce water-shortage risks	16 (80%)	3 (15%)	1 (5%)
They can enhance long-term sustainability	17 (85%)	2 (10%)	1 (5%)
Modern technologies are affordable	8 (40%)	3 (15%)	9 (45%)

Source: Primary farmer survey, Samarkand Region, 2026.

The research results reveal that recognizing the benefits of these technologies does not essentially mean that farmers consider them affordable. Many farmers were able to comprehend the potential environmental as well as productive advantages of water-saving technologies. For example, 85% agreed these technologies were more likely to cause reduction in water consumption, whereas a further 85% are seen as beneficial in terms of long-time sustainability.

Table 14. Integration of descriptive and qualitative findings

Descriptive finding	Qualitative interpretation
85% experienced water shortages	Agricultural producers who have reported unreliable as well as insufficient irrigation supply
Over 60% mainly utilize traditional irrigation	Familiarity and lower initial investment both bring about encouragement of continued use
Around 65% do not know annual water consumption	Water management is likely to be often based on experience rather than measurement
60% identify high technology costs	Initial investment is likely to limit adoption
50% identify lack of technical knowledge	Farmers could require practical training
85% recognize water-saving benefits	Most crop growers generally have positive attitudes
Only 40% consider modern technology affordable	Economic constraints can create an awareness of adoption gap

Taken together, quantitative and qualitative evidence suggests that there is a key challenge facing organic crop producers and it is not merely limited awareness of water conservation. Instead, the effectiveness of water management would depend on several factors in terms of water scarcity, several limitations in infrastructure, and finance-related constraints, alongside farmers' technical knowledge and institutional capacity.

Table 15. Irrigation Water Withdrawal in Uzbekistan, 2013-2025

Year	Irrigation Water Withdrawal (Million m^3)	Change from Previous Period (%)
2013	48,912.3	_
2015	49,969.9	+2.2
2017	53,745.0	+7.6
2019	48,562.9	-9.6
2021	38,452.1	-20.8
2022	38,838.5	+1.0
2023	40,022.5	+3.0
2024	39,934.5	-0.2

Year	Irrigation Water Withdrawal (Million m³)	Change from Previous Period (%)
2025	40,681.0	+1.9

Source: This table is compiled by the author based on the Statistics Agency of the Republic of Uzbekistan, SIAT database.

There is a substantial long-term reduction regarding to irrigation water withdrawal in the secondary data that indicated within Uzbekistan. According to irrigation withdrawals, which has declined from around 48.9 billion m³ to 40.7 billion m³ among 2013 and 2025. There is the most pronounced decline, that has occurred years of 2019 and 2021, accounted for around 48.6 billion m³ to nearby 38.5 billion m³. This pattern could suggest an increasing emphasis on terms of water conservation together with managing efficient irrigation systems. Nevertheless, there is a relatively stable level of withdrawals after the year 2021 and it also indicates that the needs for further improvements in water-use efficiency.

Table 16. Trends in Irrigated Sown Area in Uzbekistan, 2010-2024

Year	Irrigated Sown Area (ha)	Change from 2010 (%)
2010	3,387,862	_
2013	3,341,497	−1.4
2015	3,375,221	−0.4
2017	3,143,387	−7.2
2019	2,984,667	−11.9
2021	3,017,473	−10.9
2022	3,031,369	−10.5
2023	2,979,121	−12.1
2024	3,008,836	−11.2

Source: Compiled by the author based on the Statistics Agency of the Republic of Uzbekistan, SIAT database, indicator “Irrigated sown area in all categories of farms.”

The irrigated sown area which would decline from 3.39 million hectares in 2010 to 3.01 million hectares in 2024 and a reduction has accounted for around 11.2%. After a notable decline among the years of 2015 and 2019, we can see that the sown area could remain relatively stable and it illustrated 3.0 million hectares. This trend, alongside lower irrigation water withdrawals, is highly likely to reflect significant improvements in terms of irrigation management, the latest water-saving technologies along with cropping arrangements. According to these findings, they would highlight the importance in examination of farm-level irrigation practices and adoption of modern irrigation technology with the help of the primary survey.

Table 17. Expansion of Water-Saving Irrigation Technologies in Uzbekistan

Indicator	Reported figure	Year / period
Land converted to drip irrigation	472,000 ha	Reported in January 2024
Land converted to sprinkler irrigation	48,000 ha	Reported in January 2024
Land using other water-saving technologies	97,000 ha	Reported in January 2024
Land treated with laser levelling	649,000 ha	Reported in January 2024
Water saved through these measures	2 billion m³	2023

Source: Compiled by the author based on the President of the Republic of Uzbekistan (2024), Measures to Improvement of Water Use Efficiency Reviewed. https://president.uz/en/lists/view/6959

According to the President of the Republic of Uzbekistan (2024), there are approximately 472,000 hectares that would have been converted to drip irrigation. In terms of sprinkler irrigation that shown 48,000 hectares, while water-saving technologies would demonstrate an additional 97,000 hectares. 649,000 hectares have also been implemented by laser land levelling, and these recognized measures can bring about contribution to approximately 2 billion m³ of water savings in 2023.

CONCLUSIONS

This research set out to assess several practices within

water resource management in organic farming systems in Samarqand region of Uzbekistan. The research would try to evaluate their effectiveness, challenges, and their numerous implications for sustainability of agriculture in the long run. The findings demonstrate that organic farming systems have a capacity to pose significant potential to contribute to improvement of water management, primarily through enhancement of soil health along with moisture retention. There are a few organic soil management practices such as the application of organic amendments, systems of mulching, as well as crop rotation, all of which were found to positively influence not only soil-water relationships but also crop resilience.

Nevertheless, the research also reveals that some improvements in soil conditions alone are recognized as insufficient to ensure optimization of water use efficiency in the long term. We can see several irrigation practices in organic farms are likely to remain conventional. Also, they are constrained by some factors, such as infrastructural limitations, limited access to different types of up-to-date irrigation technologies, along with insufficient technical guidance by masters. As a result, the potential water-saving benefits of organic farming cannot be fully realized at the system level. The research highlights the importance of institutional along with policy contexts to shape water management outcomes. Limitation of some extension services, weak coordination among the usage of water and agricultural institutions, and insufficient policy support for organic farming, all of which are highly likely to hinder the adoption of numerous efficient water management practices. To sum up, the research concludes that while organic farming which is considered as important role for sustainability of water management in Uzbekistan, its effectiveness might depend on the integration of a range of agronomic practices with supportive institutional along with governance frameworks.

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