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THE ROLE OF AGRICULTURAL EDUCATION AND WATERSHED MANAGEMENT IN PROMOTING ECO-FRIENDLY KNOWLEDGE AND TECHNOLOGIES FOR AGRICULTURAL PRODUCTION IN UZBEKISTAN*

Bahadir Bekimbetov [1], Akmal Ubaydullayev[2], Shokhida Mukhtorova[3], Nargiza Berdikulova[4], Nasiba Saparboyeva[5], Sabirova Rayxon[6], O'ktam Esanov[7]**

[1]Department of Humanities and Languages, Institute of Agrotechnologies of Karakalpakstan, Nukus, Republic of Uzbekistan
[2]Department of Finance, University of Business and Science, Namangan, Republic of Uzbekistan
[3]Department of Infectious Diseases and Infectious Diseases of Children, Bukhara State Medical Institute named after Abu Ali ibn Sino, Bukhara, Uzbekistan
[4]Jizzakh State Pedagogical University, Uzbekistan
[5]Department of Food Science, Urgench State University named after Abu Rayhon Beruniy, Uzbekistan
[6]Department of Food Science, Urgench State University named after Abu Rayhon Beruniy Uzbekistan
[7]Oriental University, Uzbekistan

Abstract

Uzbek agriculture is faced with the paramount issues of degradation of natural resources and water shortages. The aim of the current research was to study the role of agricultural education and integrated watershed management in adopting eco-friendly technologies. The present research was conducted using a mixed method and based on the survey of 250 farmers and experts. The findings revealed that 65% of the farmers did not have a minimum amount of information about watershed management and 79.2% claimed financial limitations as the major constraint to technology adoption. Practical training, on the other hand, greatly improved, with the adoption rate of the trained farmers being twice that figure and this category using 30% less water. The overall conclusion suggests that the combination of practice-based training with finance is an inevitable necessity for making the shift to sustainable agriculture in Uzbekistan.

Keywords: agricultural training, eco-friendly technologies, sustainable agriculture, Uzbekistan, watershed management

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** Corresponding author: bahadyrbekimbetov35@gmail.com

1. Introduction

Agriculture is the backbone of the economy and food supply of Uzbekistan. It not only provides livelihoods to the majority of the people in the country, but also makes an invaluable contribution to exports and national self-sufficiency (Tayirov et al., 2024). However, the legacy of the traditional agricultural system and the increased pressure to increase production created far-reaching environmental issues. They endangered the long-term sustainability of this key sector. At the forefront of these problems lies the problem of the water crisis (Toreniazova, 2024). Being in a semi-arid and arid region, Uzbekistan experiences severe water resource constraints. Inefficient irrigation systems, which are still employed in the majority of agricultural farms, have resulted in huge loss of this valuable liquid and increased pressure on groundwater resources. It has resulted in the inevitability that an overall change in water management practices is inevitable (Narzullaev and Bekov, 2024).

At the same time, the loss of soil quality is another deadly signal for the development prospects for the agricultural industry in the nation. Salinization, erosion, and decline in soil fertility brought about by the improper cultivation techniques decrease the efficiency in production and increase the need for chemical inputs (Allaberdiyev et al., 2024). This vicioius circle, in addition, creates more pollution to the environment and destruction of natural ecosystems (Torayeva, 2021). Given such complex issues, making a transition towards adopting and applying eco-friendly knowledge and technologies seems to be the only feasible alternative. Mechanisms such as drip irrigation, conservation agriculture, application of biofertilizers, and integrated pest management are not only efficient in making optimum use of resources, but they also ensure the integrity of the soil and ecosystem for future generations (Tadjiev et al., 2025; Ostonokulov et al., 2024).

However, success of such transformation is dependent on the existence of a proper platform for development and marketing of these technologies (Azizi, 2023). Here, the role of agricultural education as a driver of change becomes obvious. Without the specific and proper education, farmers will wait to embrace new ways. Education is not a simple transmission of information, but a mechanism to empower them, change attitudes and build confidence to embrace new methods (Ibironke et al., 2024). Farm education must move beyond simple concepts to embrace an integrated and holistic view of the farm as part of a larger system. This is where the idea of watershed management as an integrated concept comes into play. Rather than focusing on the farm alone, this management addresses how land, water, plant and people in a geographical area interact with each other (Xolmurotov and Xolmurotov, 2025). Combining farm education with watershed management is an integrative and effective method of addressing issues. It teaches farmers how farm operations affect water quality and quantity farther downstream and how they can help maintain soil and keep water in the ground through practices such as contour line farming or building a watershed crescent (Lubell and Fulton, 2007; Anuchin et al., 2025; Violet et al., 2025).

The need for this research arises from the understanding that to accelerate the transition of Uzbekistan towards sustainable agriculture, it is essential to understand better the current knowledge level and the acceptance level of the farmers towards these technologies (Rasulov et al., 2024). In addition, capacities as well as knowledge gaps both in the agricultural education system and watershed management project must be explored and assessed. This research attempts to shed light on the meaningful link between these two areas and examine their role in promoting and implementing a green and resilient mode of production. The finding of this research can serve as a guiding star to policymakers, planners, and teachers to establish successful programs based on grassroots realities.

Lastly, investment in education and integrated resource management is not an option but a natural imperative if one desires to ensure food security, protect the environment, and ensure a future success of agriculture and the Uzbek nation. This research is a small step toward establishing what the proper means for this important investment should be. Literature review and previous studies reveal that agricultural education, adoption of green technology, and sustainable management of resources are intricately connected (Rasulov et al., 2024). Monumental research on a global scale has repeatedly expressed that agricultural education and extension are the cornerstones of any transformation and development in the agriculture sector. These trainings are most effective when they exceed the simple transfer of methods to empower farmers, enhance their environmental knowledge and reinforce responsible dispositions toward the environment. Here, the farmer is viewed not merely as a passive recipient, but rather as an active producer of knowledge and adjustor to local conditions (McLaughlin and Kinzelbach, 2015).

Integrated watershed management strategy has been globally accepted as a holistic strategic approach in sustainable resource management. In the literature, it is shown that the strategy, in highlighting all the components in a watershed like water resources, land, vegetation and human activities as an integrated system, offers more effective solutions to issues like soil erosion, qualitative and quantitative loss of water resources and land degradation. The success of watershed activities depends on the earnest and well-informed participation of local stakeholders, and most importantly, the farmers, which in turn demands successful education programs (Alemu, 2016). The crux of this research lies in the union of the two independent disciplines, i.e., agricultural education and watershed management. Specialists all over the world have demonstrated that education programs based on watershed management principles have succeeded tremendously in promoting eco-friendly practices. For example, if farmers are not only taught about drip irrigation but also about how it is connected to aquifer conservation and the rights of downstream users, they are more self-motivated to use that technology. This type of education makes farmers' systematic knowledge of complex environmental relationships more robust (Wang et al., 2016; Ruzieva et al., 2025).

Within the category of green technologies, researchers have demarcated and combined a wide range of solutions. These include a broad array of technologies related to water management (e.g., pressurized irrigation systems, riverbank enclosure, low-water-use crop production), soil management (e.g., conservation agriculture, the use of green manures and organic manures), and integrated pest and disease management (Xiang and Guo, 2023). Literature on the studies shows that adoption of such technologies among farmers depends on a range of factors, including farmers' perception of the technology's benefits, the complexity of the technology, adaptability of the technology to local conditions, and most importantly, access to training and technical support (Lioutas and Charatsari, 2018).

If one looks at the Central Asian region and Uzbekistan in particular, it is seen that although the water resource and soil degradation problems are well documented and studied, studies have focused mostly on technical and engineering aspects. Fewer studies have explored the role of human capacity development and education as a major driving factor for resolving the problems. Uzbekistan's agricultural reform initiatives have mainly been focusing on infrastructure modernization and changes in cropping patterns, with education and empowerment of human capital being sometimes relegated to secondary status. A review of the earlier course of Uzbekistan's agricultural education indicates that this field is a legacy of the period of centralized planning, where education was essentially prescriptive and uni-dimensional in nature (Tadjiev et al., 2025). Despite attempts made at reforming this system after independence, there is still a gap between the formal knowledge spread and the indigenous knowledge and real requirements of the farmers in the field. The prevalent system does not typically involve a participatory and ecosystem-based framework that can address the problems of watershed management holistically (Sui and Gao, 2023).

For managing the watersheds, there have been several projects done in Uzbekistan with the support of international organizations. These project reports will mostly emphasize technical and physical achievements such as the construction of protective structures and enhanced irrigation efficiency (Roʻziyev, 2025). Estimating social sustainability and institutionalization of such interventions in the long term requires more emphasis on the education component and engagement by local communities. That is, the lack of an up-to-date and enduring education program can cause success of these projects to wane gradually with the withdrawal of international sponsors. Therefore, there is a stark research gap in the subject literature with respect to Uzbekistan (Turdiev, 2024). Research that has scrutinized the impact of agro-education programs on eco-technology adoption and put such scrutiny in the perspective of watershed management is extremely rare. In addition, fewer studies have evaluated current educational content against capturing the lessons of integrated management and climate change adaptability (Esthi et al., 2023; Suhansa, et al., 2025).

This study aims to close this gap by presenting a more vivid picture of the interdependent and supportive interplay of agricultural education and watershed management for developing sustainable agriculture in Uzbekistan. This literature review provides the justification for a systematic and interdisciplinary approach to treating the issue.

2. Methods

2.1. Research design

Mixed method was utilized in designing this study with the aim to collect comprehensive and elaborate data. The current study design is descriptive-analytical in which variables' correlation is assessed. This one will not only help us deal with the size and scale of the problem, but also with its qualitative underlayers and causes underlying it. The statistical population for this research includes all the actors involved in agriculture in a particular watershed of Uzbekistan.

2.2. Spatial and temporal scope of the study

The study will be conducted in a selected watershed in one of the regions of Uzbekistan suffering from acute issues of water shortage and land degradation. This region was picked with the understanding that it is representative of climatic and farming conditions prevailing across most such regions of the country. Sampling is planned over two successive cropping seasons in order to allow the inclusion of season factors and finish crop growth phases in the analysis.

2.3. Statistical population and sampling method

The statistical population of this study consists of three broad types of stakeholders: small and medium farmers, agricultural specialists/promoters, and local managers in the context of the soil and water sector. From each of these types, a representative sample shall be selected by employing a stratified sampling technique in proportion to the size of the community. This method ensures that views of all concerned levels of the problem are captured in our study.

2.4. Instruments and data collection methods

The data for the current study will be collected with the help of three main instruments. The first one is a structured questionnaire, which will serve as an instrument for the measurement of the level of the farmers' knowledge, attitude, and practice regarding environmentally conscious technologies and best watershed management practices. The validity of the questionnaire will be confirmed through an expert panel and reliability by Cronbach's alpha coefficient. The second tool involves in-depth semi-structured interviews with experts and managers to generate qualitative insights into policy concerns and implementation. Finally, field observation is used to empirically record practices used on farms.

2.5. Data analysis techniques

SPSS statistical package shall be used to analyze quantitative data gathered in questionnaires. Descriptive statistics (mean, standard deviation) are utilized to summarize the data at this level while inferential statistics (correlation, regression, t-test) are utilized to test variables' relationships and test research hypotheses. Thematic Analysis is utilized to code qualitative interview data to classify and identify key themes and patterns within participants' responses. Finally, qualitative and quantitative findings will be integrated using triangulation to present a better representation of the research issue.

3. Results

Here are the empirical findings of the study presented, structured to address the major research objectives in connection with levels of knowledge, rates of adoption, perceived difficulty, and correlations between variables. The sample was composed of 250 farmers, providing a diverse cross-section of the agricultural community in the selected watershed. As shown in Table 1, the majority of respondents (40.8%) belonged to the 36-50 age group, indicating a relatively experienced farming population. A significant finding is that over half of the farmers (50.8%) operated on small plots of land less than 5 hectares, which a critical factor is influencing their capacity to invest in new technologies. Furthermore, while a high proportion (92%) had received some level of formal education, only 34% had attained higher education, suggesting potential variations in the receptiveness to complex technical information.

Table 1. Demographic and professional profile of surveyed farmers (N=250)

Characteristic	*Category*	*Frequency*	*Percentage (%)*
Age group	18-35 years	45	18.0
	36-50 years	102	40.8
	51-65 years	88	35.2
	Over 65 years	15	6.0
Farm size	< 5 hectares	127	50.8
	5-20 hectares	93	37.2
	> 20 hectares	30	12.0
Education level	No formal education	20	8.0
	Secondary School	145	58.0
	College/University	85	34.0

The assessment of farmers' self-reported knowledge revealed substantial gaps, particularly in advanced concepts. Table 2 shows that while a combined 40% claimed at least "good knowledge" of water conservation techniques, this figure dropped drastically to 28% for soil health and 20% for integrated pest management. Most strikingly, 65% of farmers reported having no knowledge whatsoever of watershed management principles, underscoring a critical area where agricultural education has failed to penetrate. This deficiency highlights a significant barrier to the adoption of a systemic, watershed-based approach to farming.

The actual adoption rates of key eco-friendly technologies, presented in Table 3, were generally low. Drip irrigation, a highly efficient water-saving technology, had only been adopted by 18% of the farmers, with a significant 65% not using it at all. The use of organic fertilizers was more common (35% adoption), likely due to lower upfront costs and cultural familiarity. Practices like cover cropping (12% adoption) remained niche, indicating that more knowledge-intensive and long-term strategies are less likely to be implemented without targeted support and demonstration of their tangible benefits.

Understanding how farmers access information is crucial for designing effective outreach. As Fig. 1 shows, informal networks are paramount; nearly half of the farmers (45%) cited other farmers and neighbors as their most trusted and used source of information. Government extension services played a significant but secondary role, often being the second most important source. Notably, NGOs and media were peripheral sources, suggesting that their campaigns, while existing, may not be effectively reaching or resonating with the majority of the farming community.

Table 2. Farmers' knowledge level of eco-friendly practices (self-assessed)

Knowledge area	*No knowledge*	*Basic knowledge*	*Good knowledge*	*Expert knowledge*
Water conservation techniques	15	45	32	8
Soil health management	22	50	25	3
Integrated pest management	38	42	17	3
Watershed management principles	65	28	6	1

Table 3. Adoption rate of eco-friendly technologies

Technology/practice	*Adopted*	*Not adopted*	*Aware, but not adopted*
Drip Irrigation Systems	18	65	17
Organic Fertilizers	35	45	20
Cover Cropping	12	75	13
Conservation Tillage	28	60	12

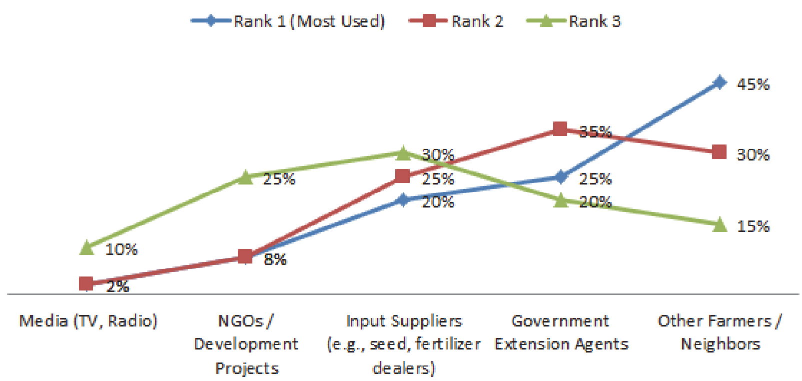

Fig. 1. Primary sources of agricultural information for farmers

Table 4. Perceived major constraints to adoption (multiple responses possible)

Constraint	*Number of responses*	*Percentage of farmers*
High initial investment cost	198	79.2
Lack of access to credit	175	70.0
Lack of technical knowledge and skills	160	64.0
Uncertainty about benefits/yield	142	56.8
Lack of available equipment/materials	110	44.0

The barriers to adoption are multifaceted but overwhelmingly economic. Table 4 shows that financial constraints are the predominant hurdle, with 79.2% of farmers citing high initial investment costs and 70% pointing to a lack of access to credit as critical barriers. However, a knowledge barrier is also highly significant, with 64% explicitly stating that a lack of technical knowledge and skills prevents them from adopting new practices. This reinforces the notion that financial support mechanisms must be coupled with comprehensive training programs to be effective.

A statistical analysis was conducted to explore the relationship between knowledge and action. The results in Table 5 show statistically significant positive correlations between knowledge levels in all areas and the likelihood of adopting related technologies. The strongest correlation was found in water conservation ($r=0.452$, $p<0.01$), meaning that farmers with higher knowledge in this area were significantly more likely to use technologies like drip irrigation. Although weaker, the correlation for watershed principles was still significant ($p<0.05$), suggesting that even basic understanding of systemic concepts can positively influence farming practices.

A cohort of farmers who had participated in a formal agricultural training program within the last two years was compared to those who had not. The differences, shown in Table 6, are stark and statistically significant. Training participants had an average adoption score more than double that of non-participants. Furthermore, they perceived the practices as more profitable and reported significantly higher confidence in their ability to apply them correctly. This provides strong evidence for the pivotal role of structured education in driving both the practical and perceptual changes necessary for sustainable agricultural transformation.

Table 5. Correlation between knowledge level and adoption rate

Knowledge area	*Correlation coefficient (R) with adoption*	*P-value*
Water conservation	0.452	0.001
Soil health management	0.387	0.005
Integrated pest management	0.321	0.010
Watershed principles	0.285	0.020

Table 6. Impact of training participation on adoption and perception

Indicator	*Participants (n=60)*	*Non-participants (n=190)*	*p-value*
Average adoption score (0-10 scale)	6.8	3.2	0.001
Perceived profitability (1-5 scale)	4.1	3.0	0.005
Confidence in applying techniques (1-5 scale)	4.3	2.8	0.001

Finally, observations from the field provided tangible proof of the impact of adopted practices. As shown in Table 7, those crops in which ecotechnology was adopted had substantially better environmental performance.

Table 7. Observed environmental outcomes at the field level

Outcome measure	*Fields with adopted practices (n=85)*	*Fields with conventional practices (n=165)*
Estimated water use (m^3/hectare/season)	5200	7500
Soil organic matter content (%)	2.1	1.5
Visual soil erosion index (1-5, 5=severe)	1.8	3.5

They consumed approximately 30% less water per hectare per season. Furthermore, these crops had improved soil organic matter content, one of the best markers of soil health, and a considerably lower visual erosion index. These findings validate that implementation of the encouraged technologies leads to real gains in resource usage efficiency and environmental conservation of the watershed.

4. Conclusion

The findings of this study clearly point towards the pivotal role being played by agricultural education and integrated watershed management to encourage environmentally sustainable technologies in Uzbekistan. The feedbacks received reflect that although the overall level of awareness of farmers for certain minimum practices is satisfactory, very poor knowledge about systematic and interlinked concepts of watershed management exists. The knowledge gap is clearly manifested in the lack of adoption of enhanced technologies such as drip irrigation and cover crops. This is supported by the results of previous research conducted elsewhere in the world that is semi-arid and arid and has highlighted the inadequacy of theoretical knowledge alone to bring about sustainable change.

The most relevant barrier to access from the stakeholder's perspective is the economic and financial barrier. High upfront investment and lack of credit and financial facilities are the biggest handicaps in translating knowledge into action. This suggests that even with a good design of training programs, desired change cannot be achieved unless they are backed up by financial support packages and economic incentives. Therefore, compatibility of training policies and financial and credit policies is aundeniable necessity. Conversely, the research found that the main source of information among most farmers is their peers, and not professional extension agencies. This is both a threat and an opportunity. The threat is that the information being passed on may be biased or inaccurate, while the opportunity is that such pre-existing social networks can be utilized to speed up collaborative learning and enable new ideas to spread more easily. Formation and institutionalization of "model farms" run by star farmers can maximize the performance of such networks.

This study's most stimulating finding was the existence of a positive and strong correlation between the level of knowledge and rate of adoption. This result strongly confirms that investment in education can be an excellent source of long-term behavior change driver. Particularly, the excellent proof of the success of the "learning by doing" approach is provided by the excellent impact of practical training course participation on a greater rate of adoption, farmers' self-image, and their perception of new methods as lucrative.

Summing up, it is possible to affirm that development of sustainable agriculture in Uzbekistan must change from an exclusively technical and detail-specific mode of doing business to an integrated, organized, and people-centered style. This transformation can happen only if an integrated model is formed where applied and practical education, promotion of watershed management ideals, provision of financial assistance, and social network strengthening of farmers are done simultaneously and in coordination. It is recommended that the policymakers and planners make watershed-based education central to their extension programs and, through the development of educational and credit infrastructures, create a platform upon which knowledge gets converted into practice and practice into sustainable behavior. Suggestions for further research are longitudinal studies to measure the sustainability of the training effects, as well as to examine other models of public-private partnership in provision of educational and financial services.

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