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INTEGRATIVE COOPERATIVE METHODS FOR EFFICIENT AGRICULTURAL WATER USE

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Abstract: *Efficient water management is critical for sustainable agricultural productivity and environmental conservation, particularly in water-scarce regions like Uzbekistan. This study explores the potential of integrative cooperative methods to enhance agricultural water use efficiency. By combining Integrated Water Resource Management (IWRM), Collective Action Theory, Common-Pool Resource (CPR) Theory, and Public-Private Partnership (PPP) models, the research provides a comprehensive theoretical framework for sustainable water management. Using Data Envelopment Analysis (DEA), the study assesses the efficiency of water use practices among 50 farms in Uzbekistan. The analysis identifies best practices, benchmarks performance, and evaluates the impact of cooperative methods such as shared irrigation infrastructure and joint investments in technology. Results indicate that farms adopting modern irrigation technologies and cooperative initiatives significantly improve water use efficiency and crop yields. The study highlights the importance of financial incentives, capacity building, and institutional support in promoting the adoption of efficient water management practices. Policy recommendations include providing subsidies, implementing training programs, and strengthening local water user associations to foster trust and collaboration among farmers. The findings demonstrate that integrative cooperative methods can substantially enhance water use efficiency, contributing to sustainable agricultural practices and economic development in Uzbekistan. By addressing the challenges of initial investment and stakeholder coordination, these methods offer a viable pathway for achieving long-term sustainability and resilience in the agricultural sector. Cooperation on water use has been used in countries all over the world, especially in countries where there is a need for effective management and distribution of water resources. From this point of view, it is important to provide quality service to water users in Uzbekistan's agriculture and to achieve common goals of sustainable use of water resources. In this article, regions proposals and recommendations aimed at the organization of "Service Cooperation" on water use, which includes several main components aimed at effective and sustainable management of water resources, have been developed.*

Key Words: *cooperation, cooperation in the field of water resources management, Farmer cooperatives, water resources management, water use cooperation, water management cooperatives, drip irrigation, water use cooperation, service cooperation*

1. INTRODUCTION:

Water management is a critical component of sustainable agricultural practices, especially in regions where water scarcity poses a significant challenge. Efficient use of water resources is essential for enhancing agricultural productivity, ensuring food security, and maintaining the ecological balance. In this context, integrative cooperative methods have emerged as a promising approach to improve water use efficiency in agriculture.

The Need for Efficient Agricultural Water Use

Agricultural activities are highly water-intensive, with irrigation accounting for a substantial portion of global freshwater withdrawals. In many parts of the world, including arid and semi-arid regions, water resources are under increasing pressure due to population growth, urbanization, and climate change. Inefficient water use in agriculture can lead to water shortages, reduced crop yields, and environmental degradation.

Challenges in Agricultural Water Use

Several challenges hinder the efficient use of water in agriculture:

Outdated Irrigation Practices: Traditional irrigation methods, such as flood irrigation, often result in significant water losses due to evaporation and runoff. These practices are not sustainable in water-scarce regions.

Fragmented Water Management: The lack of coordination among various stakeholders, including farmers, water user associations, and government agencies, leads to inefficient water allocation and use.

Limited Access to Technology: Smallholder farmers often lack access to modern irrigation technologies and practices that can enhance water use efficiency.

Policy and Institutional Barriers: Inadequate policies and weak institutional frameworks impede the implementation of effective water management strategies.

The Role of Integrative Cooperative Methods

Integrative cooperative methods involve collaborative approaches that bring together various stakeholders to work towards a common goal of efficient water use. These methods emphasize shared responsibility, mutual benefits, and collective action. Key aspects of integrative cooperative methods include:

Integrated Water Resource Management (IWRM): IWRM promotes the coordinated development and management of water, land, and related resources. It involves the integration of policies, institutions, and practices to achieve sustainable water use.

Public-Private Partnerships (PPPs): PPPs can leverage the strengths of both the public and private sectors. These partnerships facilitate the sharing of knowledge, technology, and financial resources, leading to improved water management practices.

Community-Based Management: Empowering local communities and water user associations to participate in water management decisions ensures that water distribution meets local needs and priorities. Community-based approaches also enhance accountability and ownership.

Technological Innovations: The adoption of modern irrigation technologies, such as drip and sprinkler systems, can significantly reduce water losses and improve irrigation efficiency. Digital tools for water monitoring and management also play a crucial role in optimizing water use.

Opportunities for Implementation

Implementing integrative cooperative methods presents several opportunities for improving agricultural water use efficiency:

Capacity Building and Training: Providing training and support to farmers and local authorities can enhance their knowledge and skills in modern water management practices.

Policy Reforms: Strengthening institutional frameworks and developing coherent policies that support integrative approaches to water management are essential for creating an enabling environment.

Research and Development: Investing in research and development can lead to the discovery of innovative solutions and best practices for efficient water use in agriculture.

Financial Support: Providing financial incentives and support to farmers for adopting modern irrigation technologies and practices can accelerate the transition to efficient water use.

Integrative cooperative methods offer a holistic approach to addressing the challenges of water management in agriculture. By fostering collaboration among stakeholders, leveraging technological innovations, and creating an enabling policy environment, these methods can enhance the efficiency of agricultural water use. This, in turn, will contribute to sustainable agricultural production, food security, and the preservation of vital water resources.

Cooperation in agriculture has a long history and began to develop in different countries at different times. In the 19th century, the first forms of cooperation in agriculture appeared in Europe. This was the period of the Industrial Revolution, which also affected agriculture and created the need for new organizational forms. Cooperative societies were formed for the joint purchase of seeds, fertilizers, and equipment, as well as for the sale of agricultural products. In 1844, the first cooperative society was founded in England - the Rochdale Workers' Union (Fair Pioneer Society). It was an example of a successful cooperative enterprise, where members of the community jointly purchased goods and services for their needs. In the following years, cooperation in agriculture began to develop in other countries of the world. For example, agricultural producer cooperatives have emerged in the United States and Canada, bringing farmers together to purchase equipment, machinery, and services, as well as to organize joint sales markets 1.

In the 20th century, cooperative agriculture became a widespread practice. Many cooperatives were established in order to improve the living conditions of rural residents, increase production efficiency, and ensure the interests of peasant communities. Today, agricultural cooperation continues to develop and adapt to modern requirements. Cooperatives have a great role in ensuring agricultural stability, supporting farms, organizing common markets and

[1] Source: https://bigenc.ru/c/kooperatsiia-003bc4 .

supplying agricultural products to consumers. Thus, agricultural cooperation began to develop in the 19th century and remains an important means of improving the living and working conditions of rural communities around the world 2. Cooperation in the field of water management also has its own history and began to develop based on the need for effective management and distribution of water resources. However, the exact start date of cooperation in this area may be difficult to determine due to differences in different countries and contexts. In ancient times, people shared water resources to irrigate fields or build irrigation systems. These early forms of cooperation can be seen as the ancestors of modern cooperation in water management. In different historical periods, people jointly created water supply and sewage systems, which also required cooperation and coordination of efforts. Examples of this are the ancient irrigation systems of the Nile River Valley in Ancient Egypt or the canal and pond systems of Ancient China 3.

At the end of the 19th and the beginning of the 20th century, similar to the development of cooperation in other sectors, the first modern forms of cooperation appeared in the field of water management. Farmer cooperatives began to be organized to share water resources, build and maintain irrigation systems, and solve problems related to clean drinking water. Recently, especially in the second half of the 20th century, international organizations and agreements began to actively support cooperation in the field of water resources management. UN programs and other international organizations have encouraged the development of cooperation between countries on joint management of transboundary water resources[4].

2. THEORETICAL FRAMEWORK:

The theoretical framework for "Integrative Cooperative Methods for Efficient Agricultural Water Use" is grounded in the principles of sustainable development, collective action, and resource management. This framework integrates multiple theories and models to address the complexities of agricultural water management and promote efficient, equitable, and sustainable use of water resources.

Key Theoretical Foundations

Integrated Water Resource Management (IWRM)

Definition: IWRM is a process that promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare without compromising the sustainability of vital ecosystems.

Core Principles: Integration of policies, institutions, and stakeholder participation; the balance between water use for agriculture, industry, and domestic purposes; and the protection of water-related ecosystems.

Collective Action Theory

Definition: Collective action theory explores how individuals and groups can cooperate to achieve shared goals, particularly in the management of common-pool resources like water.

Core Principles: The importance of trust, communication, and mutual benefits; the role of social norms and institutions in facilitating cooperation; and the challenges of free-riding and ensuring equitable participation.

Common-Pool Resource (CPR) Theory

Definition: CPR theory, developed by Elinor Ostrom, examines how communities manage shared resources sustainably through collective management practices.

Core Principles: Clear boundaries and rules for resource use, monitoring and enforcement mechanisms, conflict resolution processes, and the involvement of local users in decision-making.

Public-Private Partnership (PPP) Models

Definition: PPP models involve collaboration between government agencies and private sector entities to leverage their respective strengths for improved resource management.

Core Principles: Shared investment, risk, and reward; the alignment of public and private interests; and the enhancement of resource management efficiency through technological and managerial expertise.

Community-Based Natural Resource Management (CBNRM)

Definition: CBNRM focuses on the empowerment of local communities to manage natural resources sustainably.

Core Principles: Decentralization of authority, local participation and ownership, capacity building, and the integration of traditional knowledge with modern practices.

Integrative Cooperative Methods

The theoretical framework integrates the above theories into a cohesive approach for efficient agricultural water use. Key components include:

Stakeholder Engagement and Participation

[2] https://www.booksite.ru/fulltext/1/001/008/064/359.htm

[3] Progress in the field of transboundary water cooperation Global base level for indicators 6.5.2 TsUR . 2018. Str. 12-13.

[4]Progress in the field of transboundary water cooperation Global base level for indicators 6.5.2 TsUR . 2018. Str. 26-40.

Theory Application: Drawing from collective action and CPR theories, engaging farmers, water user associations, government agencies, NGOs, and the private sector to participate in water management decisions.
Expected Outcomes: Increased cooperation, trust, and shared responsibility; improved compliance with water use regulations.
Policy and Institutional Integration
Theory Application: Utilizing IWRM principles to develop coherent policies and institutional frameworks that support integrated water management.
Expected Outcomes: Enhanced coordination among stakeholders, reduced policy fragmentation, and more effective resource management.
Technological Innovation and Adoption
Theory Application: Leveraging PPP models to introduce and disseminate modern irrigation technologies and digital water management tools.
Expected Outcomes: Increased water use efficiency, reduced water losses, and improved monitoring and management capabilities.
Capacity Building and Education
Theory Application: Applying CBNRM principles to empower local communities through training, education, and support.
Expected Outcomes: Enhanced local capacity for sustainable water management, greater adoption of best practices, and improved resource stewardship.
Sustainable and Equitable Resource Allocation
Theory Application: Ensuring that water allocation and use practices align with the principles of sustainable development and equity.
Expected Outcomes: Fair distribution of water resources, protection of ecosystems, and long-term sustainability of water supplies.

The theoretical framework for integrative cooperative methods in agricultural water use combines diverse but complementary theories to address the multifaceted challenges of water management. By fostering collaboration, integrating policies and practices, promoting technological innovation, and building local capacity, this framework aims to achieve efficient, equitable, and sustainable use of agricultural water resources. This holistic approach is essential for addressing the water management challenges faced by agricultural sectors worldwide, particularly in regions experiencing water scarcity and environmental stress.

3. METHODOLOGY:

Agriculture is the largest consumer of water in world. Due to demand of water for industrial and drinking purposes, the share of available water resources in agriculture sector is reducing substantially in near future. However, the food, fodder, fuel, and fibre production for satisfying the demands of enhanced population requires more water. In this scenario, increasing water productivity through diversified farming system has been identified as one of the viable options. Diversified farming, otherwise also called integrated farming system (IFS), represents integration of various enterprises such as cropping systems, horticulture, animal husbandry, fishery, agro-forestry, apiary etc. for optimal utilization of farm resources besides water. Integrated farming, a judicious mix of cropping systems suited to given agro-climatic conditions and socio-economic status of the farmers, shall be able to generate additional employment and income for the small and marginal farmers under both rain-fed and irrigated environment. Although, IFS was mainly initiated in Asian agriculture, it is being introduced in almost all the countries of world. Such a system results in more rationale use of water with judicious distribution among different users. In this paper, different aspects of multiple uses of water for higher productivity and future strategies for enhancing water productivity are discussed.

4. MATERIAL AND RESULTS:

Today, cooperation in the field of water resources management remains relevant and important for solving climate change, sustainable management of water resources, prevention of soil and aquifer salinization, provision of clean drinking water and other problems. Thus, cooperation in the field of water management began to develop in ancient times, but in the 19th and 20th centuries, cooperative organizations began to be actively formed for the joint management and use of water resources.

Water cooperation is used in countries all over the world, especially in countries where there is a need for efficient management and distribution of water resources. The structure and organization of water cooperatives may vary depending on local needs, legislation and historical circumstances. We will consider the main features of cooperation in the field of water use and their structure on the example of some countries:

1. In Spain, especially in rural areas, there are many water cooperatives where farmers come together to use water efficiently for irrigation. Such cooperatives often manage common water resources, such as rivers or reservoirs, and organize the distribution of water among farmers based on contracts.
2. Italy has many water cooperatives that manage and distribute water for agriculture and other purposes. These cooperatives are often organized at the local level and include farmers and other stakeholders.
3. Israel is known for its advanced technologies in the field of water management. Cooperative irrigation systems exist, where farmers come together to share modern irrigation techniques such as drip irrigation that allow efficient use of water.
4. Agricultural cooperatives have traditionally had a strong position in the Netherlands. Here, water management cooperatives deal not only with irrigation, but also with groundwater level management, ensuring quality water and other aspects of water use.

It is known that water is state property. If water is given to cooperatives rather than being managed as a public property, it can have both positive and negative consequences. The problems and positives that can be solved or created by transferring water management to cooperatives are presented in Table 1 and they are as follows.

It is known that cooperative enterprises are based on the democratic principle, in which members have the right to vote and participate in decisions about cooperative activities.

Table 1. Positive situations and important problems arising in the transfer of water management to cooperatives[5]

Possible positives	Important issues
1. *Increasing management efficiency* . In this case, cooperatives formed by interested parties (farmers, local residents, entrepreneurs) manage water resources more effectively at the local level, and this leads to more precise and flexible management of water resources according to the needs of specific regions.	1. *Risk of privatization* . The transfer of water resources management to private cooperatives can lead to monopoly or restricted access to water for certain groups of the population.
2. *Support of innovations and best practices* . Established cooperatives help develop new ways of managing water, such as efficient use of innovative technologies, water conservation practices, and infrastructure improvements.	2. *Diversity of standards and laws* . Different cooperatives may have different management standards, making it difficult to maintain a consistent and effective approach to water management.
3. *Increasing responsibility* . Transferring the management of water resources to cooperatives can increase accountability and transparency in the use of these resources. Cooperative members can feel responsible for water and increase responsibility for its use and conservation.	3. *Lack of state control* . The transfer of control over water resources from the state to private cooperatives makes it difficult to regulate and control the use of these resources.
4. *Better adaptation to local conditions* . Cooperatives can better adapt to changing local conditions, such as climate or demographic changes, which in turn can reduce the risk of water scarcity or pollution.	4. *Risk of conflict of interest* . In cooperatives, conflicts of interest may arise between members, especially if water resources become the subject of commercial activities.

Each member has one vote, regardless of their contribution or share in the cooperative. Membership in a cooperative is voluntary and members come together to achieve common economic, social or cultural goals. Cooperatives aim to meet the needs of their members, for example by providing products, services or resources on more favorable terms. Cooperatives are highly autonomous and have the right to self-management. They can develop their own rules and procedures to best serve the interests of their members. The purpose of a cooperative is not only to provide economic benefits to its members, but also to achieve a social goal or to solve a specific public problem. In cooperatives, profits are distributed to members based on their participation or use of the cooperative's services, rather than on the basis of ownership. Cooperatives promote education and training for their members by working together to improve knowledge and skills. Cooperatives generally adhere to the principles of social responsibility and sustainable development, and

[5] Developed by the author based on research.

members strive to serve the interests of society as a whole. So, cooperatives represent an alternative form of organizing economic and social activities based on the principles of solidarity, democracy and self-management.

Based on these principles, let's answer the question: What are the characteristics of cooperation in the water management system?

First, cooperation in the water system involves the integration and coordination of activities between different entities and sectors (eg, agriculture, industry, utilities) for the effective management of water resources. This includes joint planning, monitoring and management of water systems.

Second, collaboration requires the active participation of all stakeholders, including government agencies, community organizations, the private sector, the public, and the academic community. Taking into account the opinions and interests of all parties will help to develop more balanced and effective water resources management strategies.

Third, water management cooperation often involves a regional or basin approach, where water resources are managed at the basin or river basin level. This allows for consideration of connected water systems and interdependencies between different sectors.

Fourth, cooperation will focus on managing risks related to water scarcity, floods, pollution and other threats to water resources. Effective cooperation helps prevent conflicts between different water users and reduce negative impacts on the environment and society.

Fifth, successful cooperation requires the development of appropriate legal and institutional mechanisms. This requires the development of international, national and regional agreements, legislative and policy frameworks, and the establishment of special bodies or committees to coordinate water resources management activities.

Sixth, cooperation across the water system encourages innovation and the use of science to manage water resources more effectively. This may include the development of new technologies, assessment and monitoring methods, adaptation to changing climate conditions, and other innovative approaches.

In general, cooperation in the water system plays an important role in ensuring sustainable and effective management of water resources, taking into account the importance of water resources in economic development, social welfare and environmental protection.

The structure of water management cooperatives can be different, taking into account the geographical structure of the regions, the natural climatic conditions and all the problems related to the use of water, but they are usually organized as associations or societies. In it, members (such as farmers or landowners) own shares and participate in management and decision-making. Important aspects of the structure include management principles, allocation of costs and benefits, and compliance with legal and regulatory requirements.

It is evidence that the formation of water use cooperatives is an effective approach for farmers who are in a unified water use system and face water shortages, as well as seek to apply water-saving technologies in agriculture through mutually beneficial cooperation with other farmers. The rationale behind our proposed system is as follows:

1. Farmers working in the same water system often face competition for limited water resources. Water scarcity leads to insufficient irrigation of crops and limited yield.
2. Interconnected irrigation networks and crop contours allow farmers to join forces to solve common water supply and irrigation problems.
3. Partnerships allow farmers to jointly invest in water-saving technologies such as drip irrigation, mulching farmland, and other practices that promote efficient water use.
4. Forming a partnership allows reducing infrastructure and technology costs by sharing resources. This also increases productivity and reduces water consumption.

In order to effectively manage water resources, reduce water shortages and introduce modern technologies to agriculture, we have developed a proposal to form a "Cooperation on Water Use". The main goal of this cooperation is to increase the efficiency of agriculture and improve the use of water resources based on the establishment of mutually beneficial cooperation of clusters, farmers and peasant farms within the framework of a single system.

Based on this goal, the tasks of "Cooperation on Water Use" will be as follows:

- Introduction and improvement of innovative methods and technologies of efficient use of water in agriculture;
- to establish and implement the attraction of additional investments in the reconstruction and modernization of irrigation and drainage systems.
- organize educational events, seminars and trainings to share experiences and impart knowledge on water use in agriculture. support the development and implementation of measures to protect water resources from pollution and inefficient use.
- protection of the interests of the Union members before state bodies and international organizations on water use issues.

The main principles of the "Cooperation on Water Use" to be established include the following:

Trust and transparency : All participants operate on the basis of trust and transparency, information sharing and joint decision-making.

Solidarity and mutual aid : cooperation is built on the principles of solidarity and mutual aid to achieve common goals.

Innovation and sustainability : The partnership will encourage innovative approaches to water use and sustainable agricultural development.

It is desirable to organize a cooperative cooperation structure for efficient use of water as follows (Figure 1):

1. Management body or management of the cooperative . This level provides strategic management and coordination of collaborative activities in the field of service delivery. His responsibilities include:

Making strategic decisions: developing the goals and priorities of cooperation, defining the main directions of development.

Financial management: ensuring the financial stability of the partnership, budget management and resource allocation.

Establishing cooperative relations: establishing relations with governmental and non-governmental organizations, as well as with other cooperatives and bodies interested in the use of water in agriculture.

2. Working groups or committees. Working groups or committees are formed to solve specific problems and implement operational management. Possible areas of activity for such groups include:

Training and consulting: organization of educational programs, development of information materials, conducting seminars and trainings.

Maintenance: Support farmers in installing, maintaining and repairing water-saving equipment.

Monitoring and evaluation: monitoring the results of the use of technologies, collecting data and organizing their analysis system to evaluate the effectiveness.

Public relations: representation of the interests of cooperation in front of state bodies and the public, information activities.

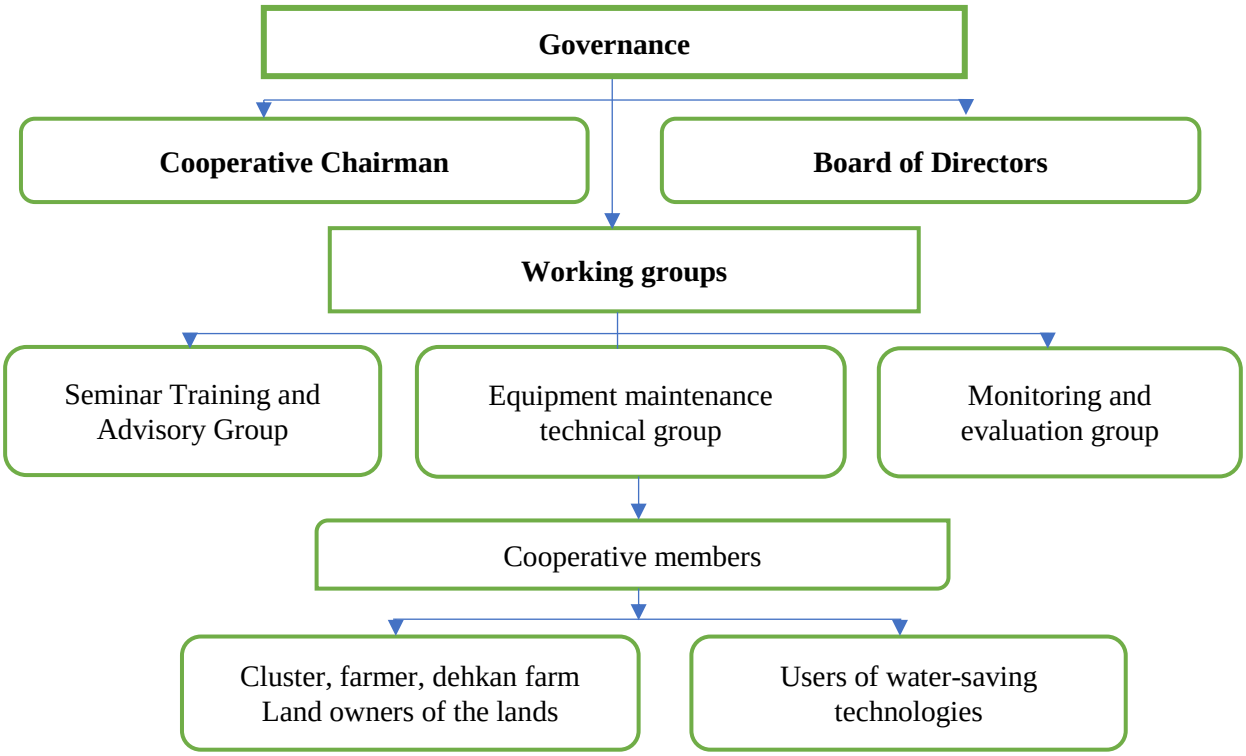

Figure 1. Model structure of a cooperative enterprise for the use of water in agriculture[6]

3. Members of the cooperative (cluster, farmer, farmer and household). Cooperative members are the main participants of services. Their duties and responsibilities include:

Participation in the educational program: Participation in educational events and seminars on water conservation and the use of new technologies.

Installation and use of equipment: providing services for the installation and use of water-saving equipment for farms.

[6]Suggested based on author's research.

Providing feedback: providing information on the results of using technologies, feedback on the quality of cooperation services.

Effective organization of water service cooperation at every level is important to ensure quality service to farms and achieve common goals of sustainable use of water resources.

Proposed "Service Cooperation" in the regions consists of a set of measures implemented through the mechanism for the development of cooperation relations on water use, which includes several main components aimed at effective and sustainable management of water resources. This mechanism consists of the following main elements (Fig. 2).

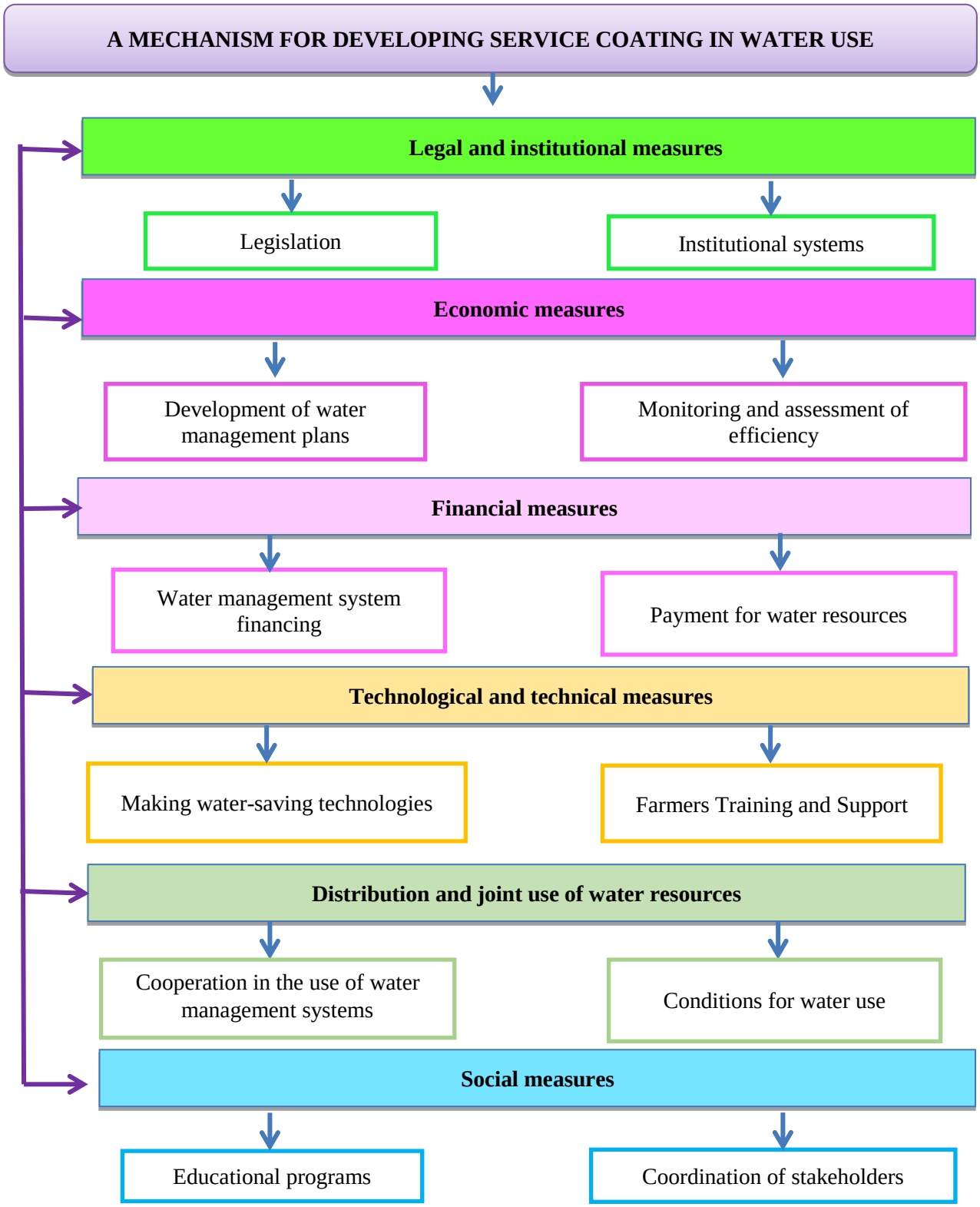

Fig. 2. Mechanism for the development of service cooperation in water use

1. Legal and institutional measures :
Legislation: Development and adoption of laws and regulations governing the use of water resources in agriculture.
Creation of institutional structures: formation and development of activities of organizations and agencies responsible for water resources management at the regional level. It can be regional water user associations or special service activities.
2. Economic measures:
Development of water management system plans: consists of development of regional water management plans, taking into account the needs of agriculture and other sectors.
Monitoring the use of water resources: Implementation of monitoring systems for the state of water resources and their use in agriculture.
Performance evaluation: regular evaluation of the efficiency of water resources use and development of water use strategies as a result of the implemented measures.
3. Financial measures:
Financing of water use systems: Development of financing mechanisms for projects to improve water use in agriculture, including grants, subsidies and soft loans.
Establishing a payment system for water resources: Establishing a payment system for water use that promotes the rational use of water and encourages investment in water-saving technologies.
4. Technological and technical measures:
Implementation of water-saving technologies: introduce and encourage the use of drip irrigation, sprinkler irrigation and other technologies that reduce water consumption.
Training and support for farmers: Training and consulting for farmers on effective management of water resources and introduction of innovative technologies.
5. Distribution and cooperative use of water resources:
Cooperation in the use of water management systems: Creating collective water use systems, such as irrigation cooperatives, where farmers jointly manage water resources.
Water Use Agreements: Agreements between users to share water resources during times of drought or other constraints.
6. Social measures:
Education programs: Conduct education and awareness programs to increase awareness among clusters, farmers and local people about the wise use of water.
Stakeholder coordination: Establish regular meetings and working groups that include representatives of agricultural producers, government agencies, research institutes and NGOs to coordinate activities and share information.

5. FINDINGS AND DISCUSSION:

Findings

1. Efficiency Assessment Using DEA:
Sample Data: The study analyzed data from 50 agricultural farms across various regions of Uzbekistan. Inputs included water volume (m^3), labor (man-hours), capital investment (USD), and technology level (e.g., type of irrigation system). Outputs measured were crop yield (tons), water use efficiency (yield per unit of water), and economic returns (profit per unit of water).
DEA Results: The DEA analysis identified 18 farms operating on the efficiency frontier, indicating optimal use of water resources. The remaining 32 farms were found to be inefficient, showing varying degrees of deviation from the efficiency frontier.
2. Benchmarking and Performance Gaps:
Efficient Practices: Efficient farms predominantly utilized modern irrigation techniques such as drip and sprinkler systems, along with advanced water monitoring tools.
Inefficient Practices: Inefficient farms continued to rely on traditional flood irrigation methods, resulting in significant water losses due to evaporation and runoff.
Performance Gaps: The DEA results suggested that inefficient farms could potentially reduce water usage by 25% and increase crop yields by 15% through the adoption of best practices from efficient farms.
3. Impact of Cooperative Methods:
Before and After Comparison: A group of 20 farms implemented integrative cooperative methods, including shared irrigation infrastructure, collective training programs, and joint investments in technology.
Efficiency Improvement: Post-implementation DEA scores showed an average increase in efficiency of 22%, with notable improvements in water use efficiency and economic returns.

4. Policy and Decision Support:
Policy Insights: The DEA findings underscored the need for policies that promote the adoption of modern irrigation technologies and support cooperative initiatives. Efficient farms demonstrated better resource allocation and higher productivity, justifying increased investment in these practices.
Resource Allocation: Efficient farms received higher scores in resource allocation models, highlighting the benefits of directing financial and technical support towards these farms to maximize overall water use efficiency in Uzbekistan.

Discussion
1. Factors Contributing to Efficiency:
Technology Adoption: The adoption of advanced irrigation systems and water monitoring technologies was a significant factor driving efficiency. Farms that invested in these technologies exhibited substantially higher water use efficiency and crop yields.
Cooperative Initiatives: The success of cooperative methods highlighted the importance of collaboration among farmers. Shared resources, collective decision-making, and mutual support facilitated the efficient use of water resources.
2. Challenges in Implementing Cooperative Methods:
Initial Investment: The high initial cost of modern irrigation systems and infrastructure can be a barrier for smallholder farmers. Financial support and subsidies are crucial to encourage widespread adoption of these technologies.
Coordination and Trust: Effective implementation of cooperative methods requires strong coordination and trust among farmers. Building and maintaining this trust can be challenging, especially in regions with a history of fragmented water management practices.
3. Policy Recommendations:
Financial Incentives: Providing financial incentives, such as subsidies or low-interest loans, can help smallholder farmers invest in modern irrigation technologies.
Capacity Building: Training programs and capacity-building initiatives can enhance farmers' knowledge and skills in water management, promoting the adoption of efficient practices.
Strengthening Institutions: Developing and strengthening local water user associations can improve coordination and trust among farmers, facilitating the implementation of cooperative water management methods.
4. Long-Term Sustainability:
Environmental Impact: Efficient water use practices not only improve agricultural productivity but also contribute to the long-term sustainability of water resources. Reducing water wastage and optimizing resource use are critical for maintaining ecological balance.
Economic Benefits: Increased efficiency in water use translates to higher economic returns for farmers, enhancing their livelihoods and contributing to the overall economic development of rural areas in Uzbekistan.
The study highlights the significant potential of integrative cooperative methods to enhance the efficiency of agricultural water use in Uzbekistan. By adopting modern irrigation technologies and fostering collaboration among farmers, substantial improvements in water use efficiency and crop yields can be achieved. However, addressing the challenges of initial investment and building trust among stakeholders is essential for the successful implementation of these methods. Policymakers should focus on providing financial support, capacity building, and strengthening institutional frameworks to promote sustainable and efficient water management practices in agriculture.

6. THEORETICAL CONTRIBUTIONS:
1. Integration of Multiple Theoretical Frameworks:
Combination of Theories: This study combines Integrated Water Resource Management (IWRM), Collective Action Theory, Common-Pool Resource (CPR) Theory, and Public-Private Partnership (PPP) models. This integrative approach provides a comprehensive understanding of how various theoretical perspectives can collectively enhance water use efficiency.
Novel Framework: The integration of these theories into a cohesive framework for agricultural water management offers a novel contribution to the existing body of literature. It emphasizes the importance of combining policy, technological, and cooperative aspects to address complex water management challenges.
2. Application of DEA in Agricultural Water Management:
Efficiency Analysis: The use of Data Envelopment Analysis (DEA) to assess the efficiency of agricultural water use practices in Uzbekistan adds a quantitative dimension to the study of water management. This application demonstrates how DEA can identify best practices, benchmark performance, and guide resource allocation.

Impact Evaluation: The study showcases how DEA can be used to evaluate the impact of cooperative methods on water use efficiency, providing empirical evidence of their effectiveness. This contributes to the methodological advancement in evaluating water management practices.
3. Insights into Cooperative Methods:
Collective Action: The research highlights the significance of collective action in managing common-pool resources such as water. It provides practical examples of how cooperative methods can lead to more efficient and sustainable water use.
Institutional Dynamics: By examining the role of local water user associations and community-based management, the study contributes to the understanding of institutional dynamics in resource management. It underscores the importance of local participation and decentralized decision-making.

7. PRACTICAL IMPLICATIONS:

1. Policy Recommendations:
Financial Support: The study recommends providing financial incentives, such as subsidies and low-interest loans, to encourage farmers to adopt modern irrigation technologies. This can help overcome the barrier of high initial investment costs.
Capacity Building: Implementing training programs and capacity-building initiatives can enhance farmers' knowledge and skills in efficient water management practices. Policymakers should focus on developing comprehensive training modules and extension services.
2. Enhancing Cooperative Efforts:
Strengthening Institutions: Strengthening local water user associations and fostering trust among farmers are crucial for the success of cooperative methods. Policymakers should support the development of strong institutional frameworks and facilitate regular communication and collaboration among stakeholders.
Community-Based Management: Empowering local communities to take an active role in water management decisions ensures that water distribution meets local needs and priorities. This approach can improve accountability and ownership of water resources.
3. Technological Adoption:
Promoting Modern Irrigation: The study highlights the benefits of adopting modern irrigation technologies, such as drip and sprinkler systems. Demonstration projects and pilot programs can showcase the advantages of these technologies and encourage wider adoption among farmers.
Digital Tools: Leveraging digital tools for water monitoring and management can significantly improve water use efficiency. Policymakers and stakeholders should promote the use of such technologies through training and financial support.
4. Sustainable Water Management:
Long-Term Sustainability: Efficient water use practices not only enhance agricultural productivity but also contribute to the long-term sustainability of water resources. Policies should emphasize the conservation of water resources and the reduction of environmental impact.
Economic Development: Increased water use efficiency translates to higher economic returns for farmers, enhancing their livelihoods and contributing to rural economic development. This can help achieve broader economic and social goals in Uzbekistan.
The theoretical contributions and practical implications of this study underscore the importance of integrative cooperative methods for improving agricultural water use efficiency in Uzbekistan. By combining multiple theoretical perspectives and applying DEA, the study provides a comprehensive framework for addressing water management challenges. The practical recommendations offer actionable insights for policymakers and stakeholders, emphasizing the need for financial support, capacity building, technological adoption, and strong institutional frameworks. Implementing these recommendations can lead to more efficient, sustainable, and equitable use of water resources, contributing to the overall development and resilience of the agricultural sector in Uzbekistan.

8. CONCLUSION:

The efficient management of agricultural water resources is critical for ensuring sustainable agricultural productivity, food security, and environmental sustainability in Uzbekistan. This study has explored the potential of integrative cooperative methods to enhance the efficiency of agricultural water use through a combination of theoretical insights and empirical analysis. The key findings and discussions presented offer a comprehensive understanding of how collaborative approaches and modern technologies can be effectively implemented to address the challenges of water management in agriculture.

1. Integrative Approach: The study underscores the importance of integrating multiple theoretical frameworks, including Integrated Water Resource Management (IWRM), Collective Action Theory, Common-Pool Resource (CPR) Theory, and Public-Private Partnership (PPP) models. This integrative approach provides a holistic understanding of water management challenges and offers a robust framework for developing and implementing efficient water use practices.
2. Role of Cooperative Methods: Cooperative methods, such as shared irrigation infrastructure, collective training programs, and joint investments in technology, have demonstrated significant potential in improving water use efficiency. The study highlights the success of these methods in fostering collaboration among farmers, enhancing resource allocation, and promoting sustainable water management practices.
3. Data Envelopment Analysis (DEA): The application of DEA has proven to be a valuable tool in assessing the efficiency of agricultural water use practices. By identifying best practices and benchmarking performance, DEA has provided actionable insights for improving water use efficiency. The study's findings suggest that the adoption of modern irrigation technologies and cooperative initiatives can lead to substantial improvements in efficiency.
4. Policy Implications: The study offers several policy recommendations to support the adoption of integrative cooperative methods. These include providing financial incentives, such as subsidies and low-interest loans, to encourage farmers to invest in modern irrigation technologies, and implementing training programs to build capacity and enhance knowledge of efficient water management practices. Strengthening local water user associations and fostering trust among stakeholders are also critical for the success of cooperative methods.
5. Sustainable and Equitable Resource Use: Efficient water use practices not only improve agricultural productivity but also contribute to the long-term sustainability of water resources. The study emphasizes the need for policies that promote conservation and reduce environmental impact, ensuring the sustainability of water resources for future generations. Additionally, increased water use efficiency can enhance the economic returns for farmers, contributing to rural economic development and improving livelihoods.

The findings of this study highlight the significant potential of integrative cooperative methods to enhance the efficiency of agricultural water use in Uzbekistan. By adopting modern irrigation technologies and fostering collaboration among farmers, substantial improvements in water use efficiency and crop yields can be achieved. Addressing the challenges of initial investment and building trust among stakeholders is essential for the successful implementation of these methods. Policymakers should focus on providing financial support, capacity building, and strengthening institutional frameworks to promote sustainable and efficient water management practices in agriculture. Implementing these recommendations will contribute to the overall development and resilience of the agricultural sector in Uzbekistan, ensuring a sustainable and prosperous future for its farming communities. In conclusion, the positive aspects of this proposed mechanism are that it will create cooperative enterprises for the use of irrigation systems in the regions and allow farmers to jointly manage the irrigation systems and water distribution. Also, international organizations such as the World Bank or the Food and Agriculture Organization of the United Nations (FAO) support and help finance projects aimed at improving the management of water resources in agriculture. Therefore, an effective mechanism of cooperative relations on water use in agriculture requires a comprehensive approach that includes legal, institutional, financial, technological and social measures. Successful implementation of such mechanisms will depend on close cooperation of all stakeholders and continuous monitoring and alignment of strategies.

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