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Original Article**Sustainable Water Resource Management in Agriculture: A Crucial Imperative for a Greener Future****Narayan Dutt Mishra^{1*} and Anamika Patel¹**¹Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229 U.P,**Corresponding Author: narayanjai2448@gmail.com*

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ABSTRACT

Water is a resource that is becoming more, scarce. Managing water in a way is crucial for keeping food supplies safe protecting nature helping farmers earn a living and making farming stronger against climate change. This article looks at the problems in managing water for farming. Those problems are water scarcity, water pollution, bad irrigation practices and unfair sharing of water. It also gives ideas for solutions. These ideas include precision agriculture, efficient irrigation, soil and water conservation collecting rainwater recharging groundwater, growing kinds of crops reusing wastewater and using nature based methods. Smart irrigation tools and precision irrigation can make water use more efficient by applying the amount of water to match the needs of crops and the environment. Growing a mix of crops that need water can ease the pressure on water. Reusing wastewater gives farmers water for irrigation. The article also stresses the importance of crops that can resist drought tools, farmer involvement, helpful rules and restoring ecosystems to boost climate resilience. In a water plan that mixes technology, good farming habits, support, from institutions and farmer input is needed to cut water waste boost water productivity protect natural resources and reach long term sustainable farming.

Keywords: Water resource management; Water scarcity; Precision agriculture; Water-use efficiency; Crop diversification; Wastewater reuse; Climate change; Soil and water conservation.

INTRODUCTION

Water is one of the natural resources for keeping life going supporting ecosystems helping with farming taking care of animals helping people do things and supporting the economy. Farming needs water not for plants to grow but also for taking care of animals processing food and keeping the environment on farms. More people, cities growing changes in the weather and different groups fighting over water are making it harder to get enough fresh water. Because of this taking care of water in a way that lasts has become very important for farming today.

Agricultural water management tries to give crops the amount of water at the time while keeping losses from evaporation water running off water going too deep into the ground and not using water properly. Making the use of water is very important when there is not water and the weather is

changing a lot. Water-use efficiency helps to see how farming and using water are connected and can be checked in places and at times. **Hoover et al. (2023)** Said that the right ways to measure water-use efficiency are important for understanding how water and farming are linked and for helping farmers deal with changes in the weather.

Taking care of water in a way that lasts needs a way of doing things that includes irrigation protecting the soil collecting rainwater refilling groundwater growing different crops using used water again using high-tech tools good rules and helping farmers get involved. These ways can cut down on losing water make farming better help keep nature healthy and make farming stronger when the weather changes.

Challenges of Water Resource Management in Agriculture

Several challenges affect water resource management; some of them are discussed below:

1. Water scarcity. Due to a growing population natural water resources are insufficient to meet demand and needs. Water scarcity is a stressor for ecosystems and can have negative consequences for agricultural production and natural communities. Water scarcity not occurs due to the fact that the population is large but also due to the fact that people use water resources more than necessary. The lack of water can lead to deterioration in the functioning of ecosystems and affect the survival of species. A significant factor causing scarcity is climate change and associated droughts. 4 Billion People experience severe water scarcity for at least one month every year while agriculture remains the sector most vulnerable to declining freshwater availability. Climate models predict a 20–30% increase in crop water demand by 2050 due to rising temperatures.

2. Water pollution. Industrial enterprises, industrial facilities, farms and cities are sources of water pollution with substances. Industrial waste, pesticides, fertilizers and untreated sewage are dangerous for ecosystems, humans and other living organisms. To solve this problem it is necessary to develop and implement regulatory and legal strategies, as well as to develop and apply new technologies to regulate and control water pollution. 80% of global wastewater is discharged untreated contaminating rivers and groundwater with nutrients, pesticides and pathogens.

3. Inefficient irrigation methods: Conventional irrigation methods such as flood irrigation are associated with high water waste through evaporation or other processes. It is necessary to introduce efficient methods of irrigation and water management to regulate the use of water resources in agriculture. Traditional flood irrigation has an efficiency of 35–45% whereas drip irrigation can achieve 90–95% water-use efficiency significantly reducing water losses.

4. Water resource management and equity: Unequal water resources lead to inequality between groups as well as to conflicts associated with the distribution of these resources. To prevent these problems it is necessary to create fair water resource management systems and involve all interested stakeholders in solving this issue. The World Bank estimates that water-related conflicts are increasing in water-stressed regions because of allocation and weak institutional governance.

Planning for Sustainable Water Management in Sustainable Agriculture

1. Precision agriculture: Precision agriculture is the application of technologies that monitor and control the temporal variations in the field. In relation to water management Precision agriculture

can integrate the data coming from soil-moisture sensors, weather stations, remote sensing, GPS, IoT devices and crop-monitoring systems. You may notice how all these tools converge. The original article highlights Precision irrigation as a means to monitor the soil conditions, water regimes and weather conditions so that irrigation can be adjusted to the plant requirements. You will see how Precision irrigation is tailored to what plants want.

Machine learning and data-driven approaches are increasingly being employed in irrigation. **Gao et al. (2023)** reviewed the application of machine learning for irrigation. Highlighted how precise and smart irrigation technologies can enhance production while alleviating the strain on the scarce water resources. You can see how Machine learning can facilitate farmers in utilizing the water. Similarly **Togneri et al. (2023)** Reviewed data-driven estimation of crop water needs for IoT-based irrigation systems. Identified water-need estimation as a critical component of modern Precision irrigation. You notice that water-need estimation is essential for Precision irrigation.

2. Using water-saving technologies: Water saving technologies should be used both in cities and in the sector. Water-saving technologies include a drip irrigation system, water-saving devices and much more. It is essential to use soil management technologies to maintain and preserve water resources in the agricultural sector.

3. Crop diversification and rotation: Crop rotation is also a way to sustainably manage water. Different crops have water requirements so it is useful to use less water-intensive crops. In addition some crops for example legumes help enrich the soil with nutrients they also reduce the likelihood of disease and the need for fertilizers. Thus crop rotation will help regulate and conserve water resources. Research indicates that replacing rice with millets or pulses can reduce irrigation water requirements by 30–60% depending on -climatic conditions.

4. Water reuse/recycling:

Treated wastewater represents an alternative water source for agricultural irrigation particularly in regions facing freshwater shortages. Reusing wastewater can reduce competition between domestic and industrial water demands and contribute to a circular water economy. The original article recommends wastewater recycling as a strategy for conserving freshwater and providing irrigation water. However wastewater reuse must be carefully managed because untreated or inadequately treated wastewater can contain pathogens, salts, heavy metals, pharmaceutical residues and other contaminants. **Christou et al. (2024)** Reported that treated wastewater can provide an irrigation-water source when supported by appropriate treatment, monitoring and regulations but contaminants of emerging concern remain an important challenge.

Similarly **Ghanbari et al. (2024)** emphasized the importance of management, water recycling and appropriate institutional arrangements for agricultural wastewater use.

Therefore wastewater reuse should include:

- Wastewater treatment
- Regular monitoring of water quality
- Soil and crop monitoring

- Pathogen-risk management
- Appropriate irrigation methods
- Regulation and quality standards
- Farmer awareness and training

Safe wastewater reuse can contribute to both water security and nutrient recycling but public health and environmental safety must remain priorities

5. Nature-based solutions: Another way of conserving and protecting water resources is to use nature to help in this process. Naturally many ecosystems have self-regulating abilities; they naturally. Clean water. Natural wetlands for example act as filters for water. Restoring the forest and protecting ecosystems can significantly help in regulating water use and water resource management.

Innovation and the Way Forward

1. Irrigation technologies: Smart irrigation systems are designed to regulate the amount of water delivered to crops based on specific indicators. Thus smart irrigation systems help optimize irrigation and water use. Moreover they are a way to save water and water resources. They also allow you to save time, effort and money since the systems are automated and do not require monitoring and adjustment. Smart irrigation systems can reduce water use by 20–50% while improving crop productivity.

2. Crop varieties resistant to drought: Scientists are working on developing resistant crop varieties that can resist drought periods and reduce the amount of water needed for their proper growth and development. Such technologies can help solve the problem of water scarcity and provide agricultural production.

3. Aquaponics: Closed-loop aquaculture systems that use water from fish farming to grow plants in a soilless substrate are a way to optimize water use. Such systems are very good because they allow you to recycle water while growing plants and fish. Therefore they help solve two problems at once.

4. Integrated Approach, for Agricultural Water Management

No technology can solve every problem related to water in farming. It is important to think about different ways that can help use water in a sustainable way. The best way is to bring efforts from the community like better ways to water crops and using smart farming techniques keeping the soil covered and collecting rainwater. These should be combined with recharging groundwater using crops that can handle weather growing different types of crops reusing water and using natural methods to manage water in farming. These ideas can help use water and also deal with problems like bad soil, climate change and the need for food and growth in rural areas. However it is also important to check how well water is used in places instead of just using one way to measure it. According to the research by **Hoover et al. (2023)** that is why it is important to pick the signs to measure what is needed.

CONCLUSION

The paper talked about how important it's to manage water resources in farming that is good for the environment. The paper showed ways and tools that can help solve the problems with managing water resources. To sum up managing water resources in farming that's good for the environment is very important and necessary to make sure farming can keep going and to protect natural resources. The paper also shows that it is important to create and use good ways to manage water as well as to use the tools and ideas that are already there. Managing water in a way is needed to reach **Sustainable Development Goal 6 (Clean Water and Sanitation) and SDG 2 (Zero Hunger)**. New information shows that using farming small-scale watering using treated water again growing different crops and farming that takes climate into account can help use water well and make sure farming can last a long time.

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