Water Productivity in Agriculture: A Key to Sustainable Food Production

Article · December 2023

3 authors:

Resham Chawla
Indian Institute of Technology Kharagpur

Snehil Dubey
Indian Institute of Technology Hyderabad

Suyog Balasaheb Khose
Indian Institute of Technology Kharagpur

AGRICULTURE & FOOD: E-NEWSLETTER
WWW.AGRIFOODMAGAZINE.CO.IN
ISSN: 2581 - 8317

Water Productivity in Agriculture: A Key to Sustainable Food Production

Article ID: 44706

Resham Chawla[1], Snehil Dubey[2], Khose Suyog Balasaheb[1]
[1]Research Scholar, Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, West Bengal, India, 721302.
[2]JRF, Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, West Bengal, India, 721302.

Introduction

Water stands as the lifeblood of agriculture, and the effective utilization of this invaluable resource holds paramount importance for ensuring sustainable and productive farming methodologies. The significance of water use efficiency in agriculture, its effects on farming, and cutting-edge technologies to boost efficiency are all covered in this article. In addition, case studies of effective methods, government programs encouraging water use efficiency, and the financial and environmental advantages of implementing water-efficient measures are covered. It explores the future of water-efficient agriculture as well as the difficulties and solutions associated with putting water-efficient strategies into practice. For farming to be sustainable, water productivity—the net return per unit of water used—is essential. The goal is to produce more food, income, livelihoods, and ecosystem services while using less water (Molden and oweis, 2010). Moreover, climate change is a major threat to agriculture. It lowers crop yields, reduces water availability, damages soil health, and contributes to the emission of greenhouse gases (Khose et al., 2023a). Hence, a thorough understanding of the biophysical and socioeconomic aspects affecting crops, animals, and fisheries is necessary to increase water productivity. The main points of the relationship between water and productivity are examined, along with methods for improving agricultural water usage efficiency. Figure one shows the connection between the prevalent issues and their relationship with each other.

The Growing Imperative: Enhancing Water Use Efficiency in Agriculture

The global population is increasing, leading to a surge in food and water demand. With limited freshwater resources and the threat of climate change, improving water use efficiency in agriculture is crucial for meeting the growing population's food needs while preserving the environment. By enhancing water use efficiency, farmers can maximize crop yields, reduce water waste, and mitigate environmental impacts (Hamdy Ragab, 2003; Khose et al., 2021; Khose et al., 2022). Water productivity, a concept that includes both physical and economic dimensions, is essential for meeting food demands, responding to water scarcity, and contributing to poverty reduction and economic growth (Molden and oweis, 2007). By improving water productivity, farmers can maximize crop yields, reduce water waste, and mitigate the environmental impact of agricultural activities.

Impact of Water Use Efficiency on Agriculture

Water use efficiency in agriculture is crucial for sustainable water availability, crop productivity, and climate resilience. It minimizes water losses, improves soil health, and enhances farming sustainability. Efficient water use also contributes to the conservation of natural ecosystems and biodiversity, safeguarding the environment (Gleick, P. H.,1998) Factors influencing water productivity include crop density, which determines grain yield and water use efficiency. Increasing plant density can boost maize yields, but the response depends on water availability during the growth season, especially in arid areas (Jia and Sun, 2017). High water use efficiency is essential for sustainable agriculture. Leaf area index (LAI), which reflects crop population size and is related to grain yield and evapotranspiration, is another important indicator. Increasing LAI can enhance radiation interception and transpiration, leading to higher yields. However, excessive LAI can result in self-shading, competition for soil water and nutrients, and reduced yields (Zhang and Ming, 2021). Finding the optimal LAI is essential for balancing yield increase and water use efficiency.

Innovative Technologies for Enhancing Water Use Efficiency

New technologies have completely changed the agriculture industry by providing creative ways to increase farm water efficiency. These technologies enable farmers to make well-informed decisions and maximize water usage, from drought-resistant crop varieties and sensor-based water management to precision irrigation systems and soil moisture monitoring. Furthermore, while preserving or even raising crop yields, advances in water-efficient irrigation techniques like drip and micro-sprinkler systems have drastically decreased water use (Molle et al., 2004). It is imperative to leverage the capabilities of these technologies in order to advance water-efficient and sustainable agriculture.

Irrigation is crucial for agriculture, especially in arid regions with limited water resources. Optimizing irrigation schedules and strategies can improve water productivity. Practices like water harvesting, supplemental irrigation, deficit irrigation, precision irrigation techniques, and soil-water conservation methods enhance water use efficiency. These practices impact water management, soil fertility, pest control, crop selection, and market access. Adequate irrigation is essential for crop growth, but excessive irrigation can lead to water wastage. Finding the right balance between irrigation levels and plant density is essential for maximum water productivity. Tailoring irrigation practices to specific crop needs can optimize water use efficiency.

Practices for Optimizing Water Use in Agriculture

In addition to innovative technologies, implementing best practices in agriculture, such as conservation tillage, cover cropping, and mulching, can optimize water use. These techniques retain soil moisture (Khose et al., 2023b) and reduce water evaporation, enhancing efficiency. Integrated water management approaches like rainwater harvesting and water recycling can mitigate water scarcity and improve farm productivity, contributing to sustainable water resource management. Enhanced water use efficiency in agriculture offers compelling economic benefits for farmers and the broader agricultural sector. By optimizing water use, farmers can reduce their production costs, improve resource utilization, and enhance the profitability of their operations. Moreover, increased water productivity leads to higher crop yields, which can bolster food security, generate economic growth, and create employment opportunities in rural communities (Hanjra and Ferede, 2009). The adoption of water-efficient practices also reduces the financial risks associated with water scarcity and climate-related uncertainties, contributing to the long-term viability of agricultural enterprises.

Economic Benefits of Improved Water Use Efficiency in Farming

Water use efficiency in agriculture provides economic benefits for farmers and the sector. It reduces production costs, improves resource utilization, and enhances profitability. Increased water productivity leads to higher crop yields, food security, economic growth, and employment opportunities. Adopting water-efficient practices reduces financial risks from water scarcity and climate uncertainties, ensuring the long-term viability of agricultural enterprises (Tiwari and Mishra, 2023).

Environmental Benefits of Water-Efficient Agricultural Practices

Water-efficient agricultural practices not only provide economic benefits but also offer significant environmental benefits. They minimize freshwater resource depletion, reduce environmental footprint, and help farmers mitigate water pollution, erosion, and habitat degradation. Sustainable water management also contributes to climate change adaptation, promoting agricultural ecosystem resilience and overall planet health.

Government Initiatives and Policies Promoting Water Use Efficiency in Agriculture

Governments play a crucial role in encouraging water efficiency in agriculture by enacting laws, providing incentives, and establishing supportive policies. Governments can enable farmers to implement sustainable water management practices by funding research and development, offering financial support for water-saving technologies, and setting up water governance frameworks. Furthermore, policy interventions that support land-use planning, water pricing mechanisms, and irrigation that uses less water might encourage agricultural stakeholders to place a greater emphasis on water efficiency and conservation (Imburgia et al., 2019) The collaborative efforts of the public and private sectors can create a conducive environment that is favourable to water-efficient agriculture.

Challenges and Solutions in Implementing Water-Efficient Practice

Water-efficient methods have many advantages, but there are a number of challenges preventing their widespread implementation. Improving water use efficiency in agriculture is hampered by restricted access to technologies, insufficient infrastructure, and water scarcity (Hsiao and Steduto, 2007). Furthermore, adopting water-saving techniques may need upfront financial investments and specialized knowledge, which could be difficult for farmers with little resources. However, these challenges can be overcome by the adoption of water-efficient techniques and technology-assisted strategies including information transfer, capacity building, and customized financing arrangements (Jackson and Stewart, 2019). Stakeholders can expedite the shift toward sustainable and water-efficient agriculture by tackling these issues jointly. Although significant increases in water productivity are possible, there are obstacles that must be overcome. Crop water productivity is fairly high in highly productive areas and increases in yield per unit of land area may not always translate into increases in water productivity. Furthermore, in terms of water quantity, reusing water inside irrigated areas or basins could compensate for perceived losses at the field scale; however, water quality may be compromised (Ramirez and Almulla, 2021).

In the past, biotechnology and crop breeding have been key factors in increasing water productivity, (Varshney and Bansal, 2011) especially when it comes to gains in the harvest index. Future harvest index advances, though, might be constrained, so alternative approaches need to be investigated. Improving water productivity requires creating favourable conditions for farmers and water managers, such as market accessibility and policies that support them (Molden and oweis, 2010). When creating solutions to increase water use efficiency, socioeconomic considerations and the intricate relationships between various scales—from the field to the basin—must be taken into consideration.

Conclusion and the Future of Water-Efficient Agriculture

The water-productivity nexus is crucial for optimizing agriculture and ensuring food security, environmental sustainability, and resilience in farming communities. By embracing innovative technologies, implementing best practices, and advocating for supportive policies, the agricultural sector can unlock the full potential of water use efficiency. The future of water-efficient agriculture lies in collaborative efforts, knowledge sharing, and a collective commitment to sustainable water management. Improving water productivity through enhanced irrigation practices, plant density optimization, and management strategies can lead to increased yields, better water use efficiency, and improved livelihoods for farmers. However, achieving gains in water productivity requires a comprehensive understanding of biophysical and socioeconomic factors influencing crop production. Prioritizing areas with low water productivity and implementing targeted strategies can significantly progress in optimizing agriculture and conserving water resources.

References

1. Gleick, P. H. (1998). Water in crisis: paths to sustainable water use. Ecological applications, 8(3), 571-579.
2. Hamdy, A., Ragab, R., & Scarascia-Mugnozza, E. (2003). Coping with water scarcity: water saving and increasing water productivity. Irrigation and Drainage: The Journal of the International Commission on Irrigation and Drainage, 52(1), 3-20.
3. Hanjra, M. A., Ferede, T., & Gutta, D. G. (2009). Reducing poverty in sub-Saharan Africa through investments in water and other priorities. Agricultural Water Management, 96(7), 1062-1070.
4. Hsiao, T. C., Steduto, P., & Fereres, E. (2007). A systematic and quantitative approach to improve water use efficiency in agriculture. Irrigation science, 25, 209-231.
5. Imburgia, L. (2019). Irrigation and equality: An integrative gender-analytical approach to water governance with examples from Ethiopia and Argentina. Water Alternatives, 12(2), 571-587.
6. Jackson, M., Stewart, R. A., & Beal, C. D. (2019). Identifying and overcoming barriers to collaborative sustainable water governance in remote Australian indigenous communities. Water, 11(11), 2410.
7. Jia, Q., Sun, L., Ali, S., Liu, D., Zhang, Y., Ren, X., ... & Jia, Z. (2017). Deficit irrigation and planting patterns strategies to improve maize yield and water productivity at different plant densities in semi-arid regions. Scientific reports, 7(1), 13881.
8. Khose, S. B., Kumar, S. B., & Mondal, K. (2023a). Understanding the Devastating Effects of Climate Change on Agriculture: How Farmers Can Take Action? AGRICULTURE & FOOD E-NEWSLETTER.
9. Khose, S. B., Mailapalli, D. R., Biswal, S., & Chatterjee, C. (2022). UAV-based multispectral image analytics for generating crop coefficient maps for rice. Arabian Journal of Geosciences, 15(22), 1681.

10. Khose, S., & Rao Mailapalli, D. (2023b). Prediction of Surface Soil Moisture Content using Multispectral Remote Sensing and Machine Learning. In EGU General Assembly Conference Abstracts (pp. EGU-7778).
11. Khose, S., Biswal, S., Mailapalli, D., & Chatterjee, C. (2021, December). Application of UAV in Estimation of Crop Coefficient (Kc) using Field and Remote Sensing Data. In AGU Fall Meeting Abstracts (Vol. 2021, pp. H35T-1269).
12. Molden, D., Oweis, T. Y., Pasquale, S., Kijne, J. W., Hanjra, M. A., Bindraban, P. S., ... & Upadhyaya, A. (2007). Pathways for increasing agricultural water productivity.
13. Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., & Kijne, J. (2010). Improving agricultural water productivity: Between optimism and caution. Agricultural water management, 97(4), 528-535.
14. Molle, F., Mamanpoush, A., & Miranzadeh, M. (2004). Robbing Yadullah's water to irrigate Saeid's garden: Hydrology and water rights in a village of central Iran (Vol. 80). IWMI.
15. Ramirez, C., Almulla, Y., & Nerini, F. F. (2021). Reusing wastewater for agricultural irrigation: a water-energy-food Nexus assessment in the North Western Sahara Aquifer System. Environmental Research Letters, 16(4), 044052.
16. Tiwari, A. K., Mishra, H., Nishad, D. C., & Pandey, A. (2023). Sustainable water management in agriculture: irrigation techniques and water conservation. Dr. Ajay B. Jadhao, 53.
17. Varshney, R. K., Bansal, K. C., Aggarwal, P. K., Datta, S. K., & Craufurd, P. Q. (2011). Agricultural biotechnology for crop improvement in a variable climate: hope or hype?. Trends in plant science, 16(7), 363-371.
18. Zhang, G., Ming, B., Shen, D., Xie, R., Hou, P., Xue, J., ... & Li, S. (2021). Optimizing grain yield and water use efficiency based on the relationship between leaf area index and evapotranspiration. Agriculture, 11(4), 313.