Chapter 12

Water Wisdom Innovations in Irrigation Systems

Wisdom Leaf Press
Pages number, 65–70

https://journals.icapsr.com/index.php/wlp
DOI: 10.55938/wlp.v1i2.114

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Abstract

Water scarcity and climate change are discussed in this study, which promotes climate-smart water technology for more effective agricultural water management. It focuses on strengthening rural livelihoods, food production, and water use sustainably. Conservation farming, micro-irrigation, and water harvesting are a few of the integrated strategies utilized by this strategy. Supporting policymakers to minimize vulnerability in the farming industry is the objective of the study. The article evaluates how irrigators might increase their biophysical and economic water productivity through employing the water productivity approach, but it also points out that there is disagreement on the technique's conceptual framework and that it is incapable of assessing the amount of water consumed on agriculture. Innovative strategies are tackling a significant challenge in sustaining enough water usage, especially in agriculture, to address the water emergency resulting from worldwide climate change. In particular for arboriculture, irrigation management, data analysis, and decision-making, the review highlights the significance of integrating UAV-ML-IoT technologies for data gathering and insights from diverse sensors, underscoring their potential across various sectors. Technological approaches to collect and redirect water are necessary due to water vulnerability in both established and developing regions, however these solutions may have unfavorable effects on the environment and society. Conventional water management techniques are making groundwater depletion more severe, threatening urban residents, rural communities, irrigation systems, and ecosystems. The primary factors driving modernization in the agricultural sector are identified in this study, which also looks at the influence of local knowledge and the role of the government on farmers' decision-making regarding the adoption of innovations.

Keywords

Biophysical Water Productivity, Climatic Change, Contemporary Water Management Innovations, Traditional Knowledge, Weir Irrigation

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1. Introduction

Since its adoption in the early 2000s, the water productivity approach has focused on enhancing the efficiency of on-farm water consumption by assessing the biophysical water productivity and the financial sustainability of irrigation techniques [1]. Effective water management in rain-fed and irrigated areas is crucial for strengthening food production and rural livelihoods. Innovative farming techniques, that include conservation farming, irrigation systems, and rainwater collecting, are essential and pertinent both domestically and globally [2]. Urban water supply, river ecosystem health, and rural livelihoods can all be enhanced by the combination of technological and ecosystem-based approaches. It is imperative that policies maintain a strong emphasis on extraction techniques and localized water recharging strategies [3]. According to the study, farmers are more likely to embrace innovations when they have access to local knowledge and government support, with the former having a stronger impact. It suggests that in agricultural research projects, innovation alignment with local wisdom should be given priority [4]. Water resources will become scarcer as a result of changes in the climate and the socioeconomic landscape that affect their availability and consumption. The co-evolution of energy-water-land systems depends on our ability to comprehend the interconnected interactions between human and climatic ecosystems [5]. Innovations related to judicious use of scarce water resources evolved by farmers and refined by non-formal researchers termed as Contemporary Water Management Innovations (CWMIs) are now being practiced in drylands by majority of farmers in India for human and crop survival during water crisis [6]. Figure 1 shows CWMIs techniques for smart water management. Currently producing 40% of all crops, irrigated agriculture occupies 20% of total cultivated area globally. In order to provide food security and reduce deforestation, it is anticipated that two thirds of agricultural production in the future will come from irrigated fields. The water flows, identified as “white water” and “gold water,” are essential for agricultural productivity [7]. Research indicates that technology minimizes the amount of water required for landscaping and grass care, but the benefits are frequently negligible in household settings. Successful behavior change in homeowners requires addressing their mindsets [8]. The adoption of weir irrigation methods is positively correlated with age, but it is inversely correlated with landholding size and farming location, according to the study. The irrigation plan with the water wheel provided the highest financial returns, indicating that other agricultural regions could find application for it [9]. Effective water conservation is achieved by the drip irrigation system; however, long-term adoption necessitates technical know-how and capacity building for beneficiaries to manage minor breakdowns and guarantee smooth functioning [10].

2. Water Wisdom Innovations in Irrigation Systems

Intelligent farming practices and creative farming methods are made possible by Internet of Things (IoT) and Agriculture 4.0 technologies. To monitor metrics and assist farmers make informed irrigation decisions, they employ microprocessors, sensors, Intelligent Actuation systems, and Single-Board Computers (SBCs) [11]. Water scarcity for dryland farmers is triggered by a lack of policies regarding groundwater resources and a disdain for development initiatives. In places where drought is a possibility, immediate effort is required to collect, store, preserve, and distribute water. Farmers are adopting advanced water management techniques, such as harvesting, budgeting, and micro-irrigation devices [12]. Current research indicates that computational intelligence technologies, such as IoT, Machine Learning (ML), and artificial intelligence (AI), have great potential to improve agricultural operations, especially

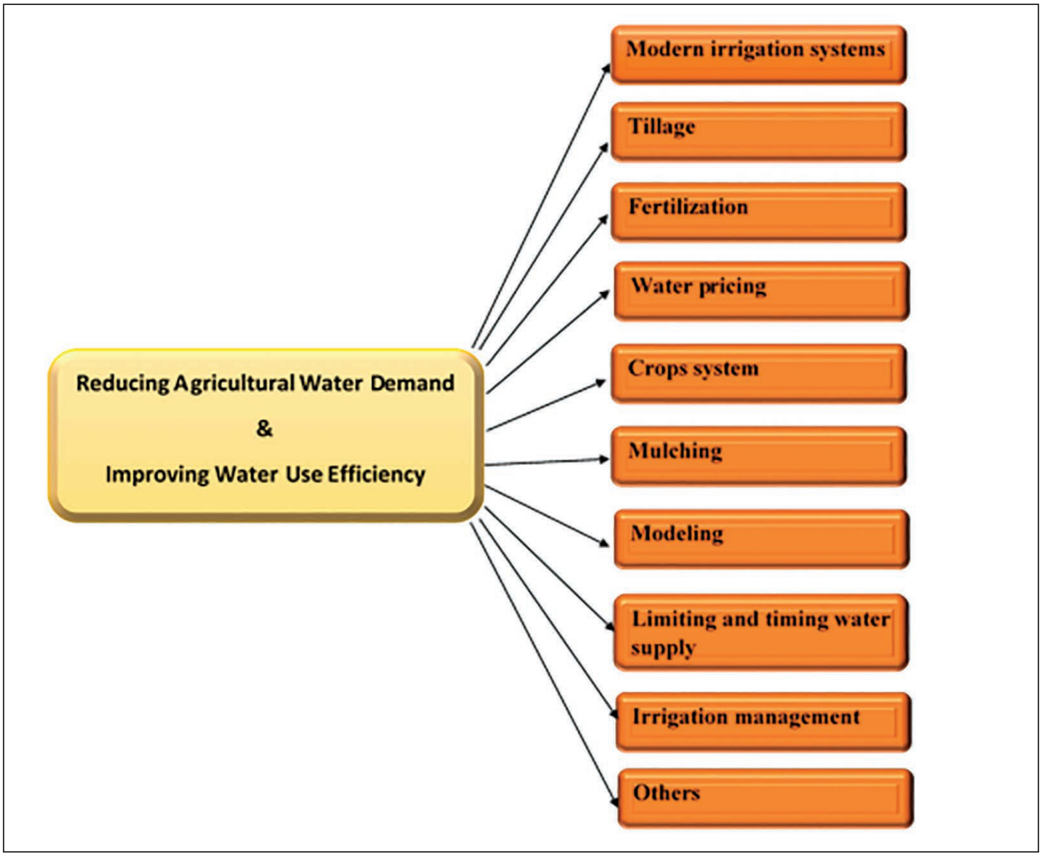

Figure 1. Contemporary Water Management Innovations approach

precision and smart irrigation [13]. Through the selection of suitable methods, strategies, and production objectives, precision irrigation strives for effective water usage in agriculture. The methods covered include both automatic and manual approaches for determining plant water stress and scheduling watering [14]. Addressing the Food, Energy, and Water (FEW) confluence and promoting productivity and sustainability require the implementation of information communication technology (ICT) and IoT technologies. Emerging technologies in IoT, Wireless Sensor Networks (WSN), and ICT can address technological, economic, and ecological problems [15]. Water efficiency is increased employing AI modeling, which expedites information processing and decision-making. To optimize environmental planning and management strategies, AI-driven Dynamic Water Resource Planning (AIDWRP) leverages the Markov Decision Process to address dynamic water resource management challenges [16]. Improved irrigation techniques are being investigated through the application of cutting-edge technologies like unmanned ariel vehicles (UAVs), Machine Learning ML, and IoT in agriculture, with the objective of minimizing losses and synchronizing supply with crop requirements, especially in arboriculture [17].

Figure 2. Hydroponic-Epiphytic water system

Water application depth in a field is adjusted adopting Variable Rate Irrigation (VRI) to accommodate different soil types, crops, and environmental factors. Leveraging intelligent decision-making system-generated speed control maps for central pivots is a feasible substitute. This approach decreases pivot speed and increases water application in impacted regions to adjust for geographic variability in crop conditions [18]. To enhance the biophysical and socioeconomic conditions in watersheds, the strategic technique integrates traditional knowledge (TK) and local wisdom with contemporary research. This includes TK documentation and patenting, active farmer participation, developing and implementing watershed management technology, and transferring TK to future generations [19]. Incorporating significant parameters, expert perspectives on the development of hydroponic-epiphytic water systems have been analyzed. Economic profitability, low initial cost, and social values were all met in a substantial benefit. On the other hand, areas for time and effort savings were found to demand improvement [20]. Figure 2 shows hydroponic-epiphytic water system employed for intelligent irrigation and better water management.

3. Recommendations

After critically examine the research literature available on the Water Wisdom Innovations techniques that are currently being implemented globally, we propose following recommendations.

- Expert opinions and evaluations should be strengthened by a thorough investigation that takes into account variables like perceived benefits, immediate benefits, concept compatibility, and visibility to potential users for a more sophisticated evaluation.
- Optimization of natural resources, institutional frameworks, advancements in technology, sustainable funding, and collaboration and coordination amongst stakeholders and initiatives are all necessary components of sustainable watershed management.
- Local knowledge has a big impact on how innovations are adopted, thus in order to guarantee that farmers embrace innovations at the best rate possible, researchers and the government should collaborate with local knowledge in agricultural research.
- Precision agriculture and irrigation management are achievable by using new technology like UAVs, IoT sensors, and ML algorithms. They provide a spatial depiction of the distribution of humidity and water stress by linking data to specific crop regions.

- The study highlights the advantages of water sharing organizations for farmers in arid places; nonetheless, difficulties in propagating these innovations have been solved by expert opinion and Delphi agreement.
- Traditional knowledge (TK) protection avoids illicit use, promotes moral and financial rights, and stops deceptive activities that don't give acknowledgment where recognition is deserved.
- Researchers are looking into other energy choices like solar panels for sustainable operation because the enhanced water system's dependency on power makes it less economically feasible.

Conclusion

The study analyzes the interplay between human and climate systems and water shortages, proposing that human component variations between "Human Only" and "The Human and Sustainability" scenarios should be taken into account in future classification modifications. The recently developed fuzzy irrigation control system is an innovative approach that promises efficacy based on velocities throughout management zones and provides central pivot speed control maps. For sustainable development and food security, scientific intervention is necessary in response to the global water stress in agriculture. Analyzing crop water status and managing irrigation are greatly impacted by UAV-ML-IoT technologies. Water requirements are estimated using ML algorithms, while sensors gather important data. Smart irrigation systems require wirelessly connected sensors. It is essential for establishing an integrated strategy for irrigation management that makes utilization of Drone-IoT-ML given the nature of water scarcity and the effectiveness of these technologies. Particularly for forest crops in arid and semi-arid areas, precision irrigation can save a substantial amount of water in agriculture. Although communication networks and technological devices are encouraging its implementation, specialists need to be properly trained in innovative irrigation technology and agricultural reactions to water stress. Half of homes have rain-shutoff devices, and around one-third utilize low-volume irrigation to hydrate their landscapes. The integration of conservation technology and equipment surpasses prior anticipations. The economic returns per unit of crop area for three irrigation methods were examined, together with the institutional, social, and demographic aspects influencing their adoption.

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