REAL-TIME MOISTURE CONTROL IN IRRIGATION SYSTEMS FOR WATER USE EFFICIENCY AND CLIMATE CHANGE RESILIENCE. A REVIEW

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ABSTRACT

Due to the increasing water scarcity and uncertainties of climate change, improving crop water use efficiency and productivity, at the same time minimizing detrimental effects on the environment to meet the world's rising food demand. Thus, is necessary to adopt innovative irrigation strategies, such as drip irrigation. Smart irrigation has a potential of improving water use efficiency in precision agriculture. Conventionally, irrigation systems rely on heuristic methods in order to schedule irrigation which either leads to over-irrigation or under-irrigation which affects water use efficiency. In this paper, we are describing and comparing different methods of irrigation water control strategies for irrigation decisions with their impact on climate change resistance. Those are open loop strategies that include manual, time and volume-based control against closed loop types which are composed of optimal, artificial intelligence and linear controls. Furthermore, the paper is reflecting on automation in different irrigation systems.

This review paper has important implications for farmers and agricultural stakeholders, to adapt technologies, as it offers practical solutions to address the ongoing challenges emanated from water scarcity and climate change.

Keywords: Soil moisture control, Irrigation systems, Water use efficiency, Climate change.

INTRODUCTION

Climate change and increasing population do impose additional pressure to Global water resources use and scarcity, that are vital for agricultural production (Ungureanu *et al.*, 2020). According to the United Nations Department of Economic and Social Affairs (2019), the world population will hit 9.7 billion by 2050 translating into increased demand for nutritious food and water resources. The Food and Agricultural Organization (FAO) forecasts a more than 50 % increase in irrigated food production by 2050, which will require a 10 % increase in water abstracted for agriculture, provided water productivity improves (Food and Agriculture Organization, 2017). The land on which food is cultivated does not expand, which means agricultural cropping systems need to utilize the available water and land resources efficiently to feed the future population. Understanding the mechanisms that can improve water use efficiency and result in significant water savings and higher yield is therefore paramount (Saleem et al., 2013).

Smart irrigation control in precision agriculture is becoming popular due to water saving ability buy providing water to the desirable location (root zone) and maximizing yield. Sensor-based decision support and automation can reduce significantly manual intervention while operation irrigation systems (Klein et al., 2018). Moreover, irrigation soil moisture control strategies, take into consideration plants response to water stress, changing weather variables through Internet of Things (IoT) monitoring (Abioye et al., 2020).

This paper implication provides valuable insights into the potential benefits of smart irrigation control systems for water use efficiency and contribute to the development of more sustainable solution for climate change resilience through agricultural irrigation for food security.

MATERIALS AND METHODS

This review applied methods of selecting the works of literature that are published on precision irrigation and all its existing control strategies includes an extensive search through a different multidisciplinary online database, such as Elsevier, Springer, Taylor & Francis, Google Scholar, and other high ranked Scopus indexed journals. The emphases were placed on numerous research articles and books related to irrigation water control and monitoring strategies were considered too. The keyworks; soil moisture control strategies, irrigation systems, water use efficiency and climate change were followed to relate the articles. Therefore, the papers were selected, read and summarised to ensure the systematic flow of the ideas.

DISCUSSION

Irrigation Water Control Techniques in Precision Agriculture

Irrigation control strategies are divided into open-loop systems and closed-loop systems. While open-loop systems apply a preset action like in simple irrigation timers, closed-loop systems receive feedback from sensors, make decisions and apply the resulting decisions to the irrigation system. Figure 1 presents a detailed classification of irrigation control strategies derived from literature studies.

Climate Resilience Action

The data-driven models developed by the authors were able to estimate reference temperatures, enabled automated calculation of the crop-water-stress index for effective assessment of crop water stress (Vallejo-Gómez et al., 2023). There is a need to evaluate stochastic and Hybrid MPC strategies for efficient irrigation scheduling in open-field agriculture. There are many uncertainties and unpredictable disturbances from the environment unlike in a greenhouse where environmental conditions are controlled.

Application of Real - time Moisture Control Strategies in Agriculture

Owing to the similarity of agricultural processes to industrial processes, Model Predictive Control has been applied in product processing, agricultural production, greenhouses and irrigation systems (Bwambale et al., 2023) . Model predictive control has been applied in canal flow control and regulation, agricultural machinery, production, and processing and irrigation scheduling.

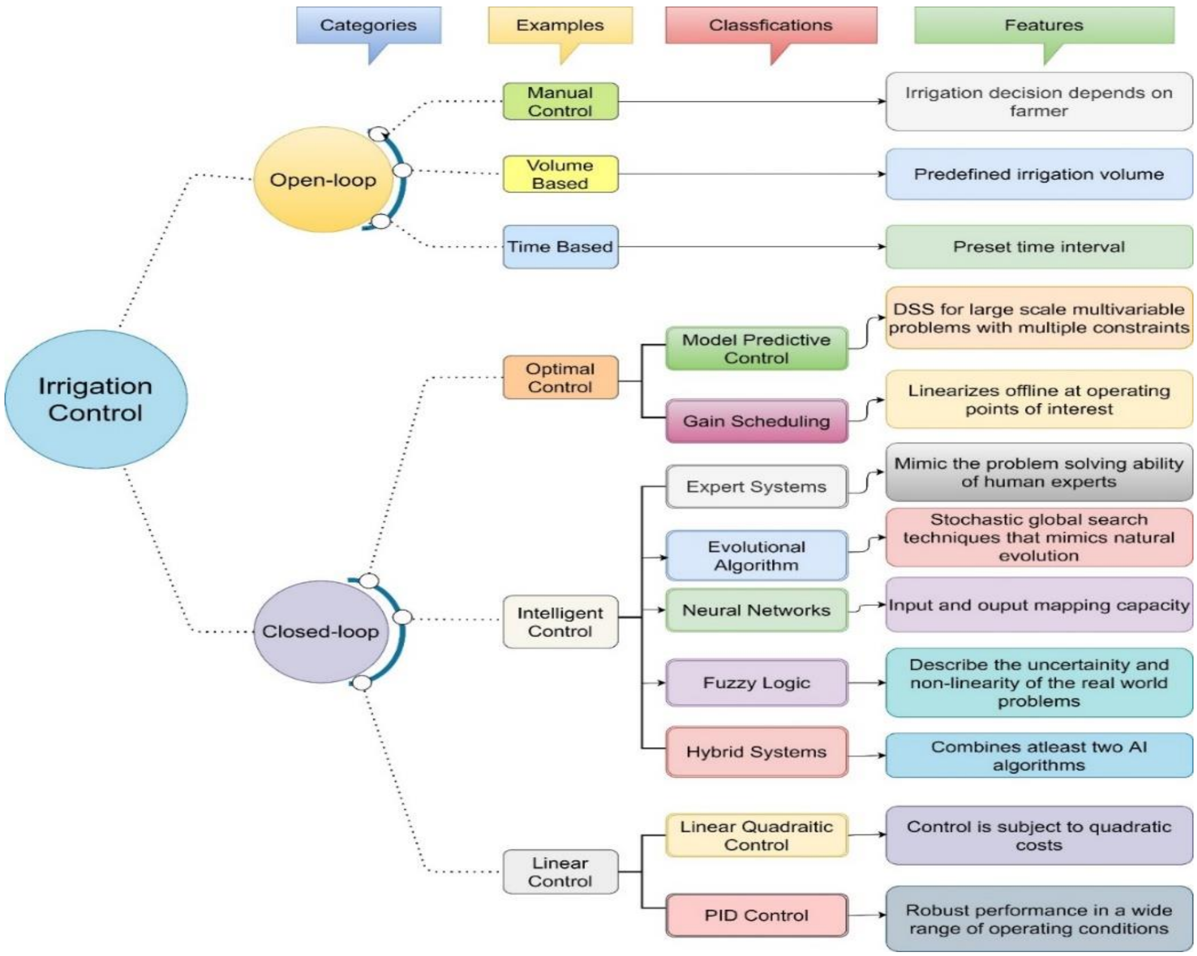

Figure 1. Classification of Irrigation Control Strategies. Adapted from (Abioye *et al*., 2020b; Erion *et al*., 2023).

CONCLUSION

In this review, the systematic review conducted here shows that the literature on smart irrigation control strategies shows a significant importance in agricultural water use efficiency as well as climate change resilience. Therefore, this is considered a rising research niche to which we can continue to contribute from many points of view, as mentioned throughout the text. Regarding the technological aspects of the analysed works, it became evident that embedded systems are preferred in the implementation of smart irrigation system prototypes, which use technologies considered to be of interest for this work, like Model Predictive Control. However, smart irrigation systems usually involve a significant cost, affordability must not be forgotten, and that implies the involvement of different stakeholders is a must as the availability and accessibility is not an issue.

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