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Impact of smart irrigation systems and water management on climate change

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Abstract. As a result of the rapid and unconscious consumption of existing natural resources in the world, climate change is accelerating negatively. It should be remembered that changing of climate has the potential to threaten the security of water, food and energy systems. One of the main problems causing this is improper water management. In this article, the effects of smart irrigation systems, which are a product of climate-smart agriculture and water management for the changing climate in the world, are reviewed in the literature and the effects of these systems on climate change are discussed. The aim of the study is to provide appropriate solutions against climate change. Water management is basically about being conscious of saving by making more use of irregularly used water resources and reducing wastage to zero in both agriculture and drinking water. Climate-friendly agriculture is practices that ensure sustainability in agriculture with climate resilience. Smart irrigation is a technological irrigation system applied to remotely control irrigation with artificial intelligence and minimize water waste. Considering that water resources will deplete more rapidly over time in the fight against climate change, necessary measures should be taken to minimize this loss.

1 Introduction

The term "*climate change*" refers to the warming, wetting, or drying of ordinary meteorological conditions [1]. Human activities, mainly greenhouse gas emissions, have caused global warming. As a result of these activities, there has been a 1.1°C increase in the Earth's surface temperature in the 2011-2020 period compared to the 1850-1900 period [2].

Water management uses a variety of water sources, including surface water, groundwater, rainwater harvesting, recycled wastewater, and desalinated water, to address a wide range of agricultural systems and climatic situations across the world [3]. Water management covers all types of planning, development, distribution, and management of water resources [4].

By tackling both the challenges of food security and the environment, climate-smart agriculture seeks to achieve sustainable development [5]. With the developing technology, the concept of climate-smart agriculture has emerged.

A new strategy called "*climate-smart agriculture*" is built on the following three pillars:

a) sustainably improve agriculture profits and production (productivity);
b) adapt to the effects of climate change and increase human and agri-food system resilience (adaptation);
c) minimizing or avoiding GHG emissions wherever feasible (mitigation) [6].

The hydrological cycle will be interrupted by global warming's increased rate of evaporation, and future irrigation demand will rise globally by an average of 5-20% because of the rise in temperature brought on by climate change [7].

Dozens of different projects have been put forward as cclimate change adaptation projects, and as a result, the Kyoto protocol was released in 1997 [8]. The main goal of this agreement signed in Japan is to control the use of fossil fuels. Sustainable agriculture depends on sustainable water supply. All the work done to understand the importance of this ensures that the ecological balance is maintained [6,9].

In this study, water management and smart irrigation practices applied in agriculture were investigated. The aim of the study is to determine the impacts of water management using smart irrigation practices on climate change.

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1.1 Water management options for improving adaptation and building resilience to climate change

According to the UN Water report, 72% of all water consumption is used for agriculture, which is also the biggest water user [10]. According to the Food and Agricultural Organization (FAO 2023) and other sources, water use is distributed, with 11% of it going to urban needs, 19% to industry, and 70% to agricultural [11].

For controlling and lowering the hazards associated with climate change, adaptation and mitigation are complimentary techniques [12]. Resilience can be increased or decreased through adaptation as well as specific mitigation strategies (such as carbon capture and storage through forest restoration) [12]. A human intervention known as mitigation aims to lessen the sources of greenhouse gases as well as other chemicals or to improve the sinks [12]. Adaptation is the process by which natural and human systems adjust in response to current and expected climatic stimuli and their consequences. This process either reduces harm or takes advantage of favorable opportunities [12]. Over the past fifty years, the rate of greenhouse gas emissions from agriculture and general land use in the atmosphere has almost doubled and mankind is responsible for almost all of the increase in greenhouse gases in the atmosphere over the past 150 years [13]. That is why it was imperative to apply mitigation practices against climate change in agriculture. These mitigation projects on water management prevent erosion and increase the water holding capacity of the soil [13]. However, mitigation and adaptation effects occur in different time and space factors. Measures implemented as mitigation against climate change are effective over several decades and over large areas. Adaptation impacts can be immediate (within 10 years) in a specific region [12]. A wide range of secondary co-benefits, including climate change adaptation, mitigation, and resilience, are provided by nature-based solutions (NBS), which are inspired by and supported by nature and use or replicate natural processes. NBS may also help with improved water management [12].

1.2 Water management options for climate adaptation and mitigation

The aims of options of climate adaptation are to developing the management of water resources and increase reach to them, as well as to enable producers to produce more products with less water [14].

Rainwater harvesting, groundwater recharge, drip irrigation, sewage water treatment, circular use, aquifer storage and recovery, and desalination are among the nature-based solutions (NBS) [12] systems used for water management [15]. In addition, smart irrigation systems combined with technology have enabled the prediction, optimization and monitoring of the equitable supply and distribution of water for sustainable agricultural practices [11]. Thus, NBS can support sustainable food production, enhance human settlements, offer access to water supply and sanitation services, and lower the likelihood of water-related disasters in order to address the effects of climate change on water resources and improve people's health and quality of life [12].

1.2.1 Rainwater harvesting (RHW)

Rainwater harvesting is the process of gathering, preserving, and using precipitation for agricultural and other purposes, acting as additional irrigation in times of water scarcity [17]. By storing water, rainwater collection helps reduce the fluctuation of rainfall. Both flood protection and the availability of water depend on it [12]. Utilizing rainwater effectively can aid in the recovery of damaged aquatic habitats and the reduction of global warming. On the other hand, agriculture may be expanded using rainwater re-distribution systems [12].

1.2.2 Groundwater recharge

Recharging groundwater refers to increasing natural groundwater supplies via artificial means, such as aquifers infiltration basins, trenches, dams, or injection wells [15]. Aquifers are the main source of water storage in many regions of the world. They frequently have a much more storage space than surface water storage does [12]. In many nations, access to drinking water sources depends on the proper management and usage of groundwater [12]. It also makes the soil more resistant to drought [18].

1.2.3 Drip irrigation

Drip irrigation increases food security by limiting runoff and percolation losses while reducing agricultural water consumption by supplying water and nutrients directly to plant roots [15]. By supplying the appropriate water resources directly to the plant as needed, drip irrigation lowers the demand for water during periodic droughts and lowers water evaporation losses [16].

1.2.4 Desalination

Desalination is a method used to remove minerals from saltwater [15]. Desalination can increase freshwater supplies, which can be a source of drinking water, especially in countries where drinking water is in short supply. It can also reduce soil salinity in agricultural irrigation [12].

1.3 Smart irrigation system

The conventional irrigation methodology and the intelligent irrigation methodology are the two types of current irrigation systems techniques. Surface irrigation, drip irrigation, and sprinkler irrigation are examples of traditional irrigation [19].

Smart irrigation is the application of cutting-edge technology to crop management to facilitate remote monitoring, resource optimization, and system automation [20]. The most applied technologies in smart irrigation are IoT, automation and artificial intelligence [20].

Using the Internet of Things (IoT), physical components like moisture sensors, pots, watering cans, and plants can be turned into online objects on the Internet and given distinctive identifiers. The ability to monitor and manage these components online minimizes labor [20].
However, the disadvantages include high cost, dependence on technology, and the need for constant maintenance [20].

1.4 Water Management and Smart Irrigation Systems Impacts on Climate Change

Reduced crop quality and water waste are the results of inefficient water management and inconsistent irrigation [21]. Building resilience, safeguarding health, and saving lives via sustainable water management aids in society's adaptation to climate change [22]. By preserving ecosystems and lowering carbon emissions from the transportation and treatment of water and sewage, water management also helps to combat climate change [22].

Smart irrigation systems that are used to water agricultural land make such places less vulnerable to climate-related dangers than dry areas. Smart irrigation lessens this hazard by maximizing the effectiveness of irrigation water usage and reducing freshwater withdrawals to assure water availability [23]. Smart irrigation systems also ensure crop diversity which subsequently acts as a climatic variability buffer [23].

2 Conclusion

With increasing population and production, water resources available in the world are rapidly depleting due to improper water management. For this reason, water management has become a very important issue in terms of effective use of water resources and climate change.
Various water management options are being implemented for climate change adaptation and mitigation. Adaptation and mitigation techniques have contributed to the development of nature-based solutions (NBS) systems along with resilience to climate change. These systems are a source of drinking water, especially in arid areas, but may not always achieve the desired level of water reduction. For this reason, smart irrigation systems have been developed as a new water management option for producers.

Smart irrigation systems aim to use less water quantitatively but more efficiently in terms of crops. Smart irrigation technologies provide product diversity against climate change. Areas irrigated with smart irrigation are more resilient to climate change than dry areas. Being technologically remotely controllable allows water use to be intervened at any time.

The findings of the research clearly show the advantages of smart irrigation systems. Studies have shown that smart irrigation systems have advantages such as reducing labor force, reducing the amount of water used and minimizing the negative effects of climate change. Considering the cost of these systems in the future, the use of smart irrigation systems should be encouraged by the government and agricultural organizations and farmers should be supported.

References

1. World Bank Climate Change Knowledge Portal. Home | Climate Change Knowledge Portal (n.d.)
2. IPCC, Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35 (2023)
3. OECD, Sustainable Management of Water Resources in Agriculture, OECD Studies on Water, OECD Publishing, Paris (2010)
4. D.P. Loucks, E. van Beek, Water Resources Planning and Management: An Overview. In: Water Resource Systems Planning and Management. Springer, Cham (2017)
5. FAO, Climate-Smart Agriculture Sourcebook. Rome (2013)
6. FAO, Water management and climate change, (2021)
7. A.L. Srivastav, R. Dhyani, M. Ranjan, et al., Environ Sci Pollut Res 28, 41576–41595 (2021)
8. B.P. Bose, D.H.A.R. Moumita, D. Ghosh, International Journal of Earth Sciences Knowledge and Applications, **4**, 2, 338-350 (2022)
9. T. Francesco, V. Marijn, Land and water use options for climate change adaptation and mitigation in agriculture (2011)
10. UN Water, Summary Progress Update 2021-SDG 6 water and sanitation for all. Version: July 2021. Geneva, Switzerland (2021)
11. N. Hasan, R. Pushpalatha, V.S. Manivasagam, et al., Global Sustainable Water Management: A Systematic Qualitative Review. Water Resour Manage (2023)
12. UNESCO, UN-Water, United Nations World Water Development Report 2020:Water and Climate Change, Paris, UNESCO (2020)
13. EPA, Sources of Greenhouse Gas Emissions, (2019)
14. FAO, Water management options for climate change adaptation (2021a)
15. Different types of water management methods - Constro Facilitator, Constro Facilitator (n.d.)
16. Technology Needs Assessment (TNA). Technology Fact Sheet for Adaptation Drip Irrigation (n.d.)
17. J.F. Velasco-Muñoz, J.A. Aznar-Sánchez, A. Batlles-delaFuente, M.D. Fidelibus, Water (Switzerland) **11**, 1–18 (2019)
18. A.C. Amanambu, O.A. Obarein, J. Mossa, L. Li, S. S. Ayeni, O. Balogun, A. Oyebamiji, F. U. Ochege, Journal of Hydrology, **589**, 125163, ISSN 0022-1694 (2020)

19. Y. Gamal, A. Soltan, L.A. Said, A.H. Madian, A.G. Radwan, Smart Irrigation Systems: Overview. IEEE Access, 1 (2023)
20. D. Vallejo-Gómez, M. Osorio, C.A. Hincapié Agronomy, **13**, 2, 342 (2023)
21. W.Hamdoon, An IoT based smart irrigation recommendation system [Unpublished M.Sc. thesis] Sakarya University (2022)
22. Water and Climate Change | UN-Water, UN-Water (n.d.)
23. E.K. Bwambale, F. Abagale, K.G. Anornu, Smart Irrigation for Climate Change Adaptation and Improved Food Security (2023)