INNOVATIVE APPROACHES FOR SUSTAINABLE WATER MANAGEMENT IN AGRICULTURE

Dr V Saravana Kumar[1], Prof. Harinath K[2]

[1] Associate Professor, School of Business, AIMS Institutes,Peenya, Bangalore,India
[2] Assistant Professor, School of Business, AIMS Institutes,Peenya, Bangalore,India

ABSTRACT

This study explores the latest innovative approaches to sustainable water management in agriculture, aiming to address the increasing challenges posed by climate change, water scarcity, and the growing demand for food production. It examines methods such as precision irrigation, rainwater harvesting, soil moisture sensors, and the use of drought-resistant crop varieties. By analysing case studies from various regions, the research highlights the effectiveness, economic viability, and environmental benefits of these techniques. The findings underscore the importance of integrating advanced technologies and traditional practices to enhance water efficiency, reduce waste, and promote sustainable agricultural practices. This comprehensive analysis serves as a valuable resource for policymakers, farmers, and researchers striving to develop and implement effective water management strategies that ensure long-term agricultural sustainability and food security.

Keywords- *Sustainable agriculture, water management, precision irrigation, rainwater harvesting, soil moisture sensors, drought-resistant crops, agricultural sustainability, water efficiency.*

---

1. Introduction

Sustainable agriculture is a holistic approach to farming that seeks to balance environmental health, economic profitability, and social and economic equity. This method of farming emphasizes the long-term viability of agricultural systems and their ability to meet the needs of current and future generations.

Sustaining agricultural productivity depends on quality and availability of natural resources like soil and water. Agricultural growth can be sustained by promoting conservation and sustainable use of these scarce natural resources through appropriate location specific measures. Indian agriculture remains predominantly rainfed covering about 60% of the country's net sown area and accounts for 40% of the total food production. Thus, conservation of natural resources in conjunction with development of rainfed agriculture holds the key to meet burgeoning demands for food grain in the country. Towards this end, National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

NMSA derives its mandate from Sustainable Agriculture Mission which is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). The strategies and programmers of actions (POA) outlined in the Mission Document, that was accorded 'in principle' approval by Prime Minister's Council on Climate Change (PMCCC) on 23.09.2010,aim at promoting sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely; 'Improved crop seeds, livestock and fish cultures', 'Water Use Efficiency', 'Pest Management', 'Improved Farm Practices', 'Nutrient Management', 'Agricultural insurance', 'Credit support', 'Markets', 'Access to Information' and 'Livelihood diversification'. During XII Five

Year Plan, these measures are being embedded and mainstreamed onto ongoing/proposed Missions/ programmes / Schemes of Dept. of Agriculture & Cooperation (DAC&FW) through a process of restructuring and convergence. NMSA architecture has been designed by converging, consolidating and subsuming all ongoing as well as newly proposed activities/programmes related to sustainable agriculture with a special emphasis on soil & water conservation, water use efficiency, soil health management and rainfed area development. The focus of NMSA will be to infuse the judicious utilization of resources of commons through community based approach

2. WATER MANAGEMENT

Water management plays a vital role in the agricultural productivity and agricultural growth. . Innovative approaches in agricultural water management can enhance water efficiency, gaining an economic advantage while also reducing environmental problems. In some cases, the necessary knowledge has been provided by extension services, helping farmers to adapt and implement viable solutions, thus gaining more benefits from irrigation technology. There is no doubt that modernization of irrigation systems, such as pressurized irrigation, concrete lining to the inner surface of the open channel, canal automation, etc., will save water significantly. However, these methods need a great deal of capital investment, hence, uneasy to adopt[1].

Maintaining an efficient irrigation system is pivotal for smart agriculture while ensuring the conservation of precious water resources. With the challenges of climate change, water resources have been severely impacted globally. Inclement weather has raised the water requirements for crop cultivation. Besides climate change, the steadily rising global population has also trained the food systems globally. Therefore, irrigation methods are at the forefront of all discussions on sustainable agricultural practices[2].

3. NEED FOR WATER CONSERVATION IN AGRICULTURE

A critical need for water conservation in farming operations is highlighted by the growing worldwide water scarcity crisis, which has a substantial influence on agriculture in nations like India. Using advanced irrigation systems is one way to cut down on water waste. Making the switch from conventional flood irrigation to micro-irrigation techniques like drip and sprinkler systems can have a significant impact. By using these micro-irrigation techniques, the Indian government's Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) seeks to improve farm-level water use efficiency. Water-smart agriculture practices, such as crop rotation, rainwater gathering, and growing drought-resistant crop types, can also be used to further improve water conservation. Water scarcity problems are made worse by climate change, which modifies precipitation patterns and causes irregular and unexpected rainfall. This creates additional challenges for agricultural water management.

3.1Traditional Water Management practices in agriculture

Region	Irrigation System	Description
North India	Zing	It was used in Jammu and Kashmir. Here, melted glacier water was collected in tanks and used in irrigation.
	Naula	This method was used in Uttaranchal. Here, stream water was collected in small wells for irrigation.
	Kuhl	It was used in Himachal Pradesh. Here, surface channels were made to collect river water for irrigation.
	Guhl	In this method, diversion channels were used to irrigate lands.

	Baudi	It was mainly used in some districts of Himachal Pradesh such as Kangra, Mandi etc. Here, water tanks were used to irrigate lands.
	Khatri	In this method, pits were made to collect the rainwater that seeps through the rocks.
	Ahar Pynes	It was mainly found in Bihar. It was a form of rainwater conservation. Ahar for collection of water and pynes means channels to supply water to the land.
South India	Eri System	It was found in Tamil Nadu. Eri means water tanks. They were used to collect and store rainwater for irrigation.
	Kattas	This method was found in Karnataka and Andhra Pradesh. Kattas are small tanks that were used to collect and store rainwater.
	Keres	This was also found in Karnataka. Keres are tanks that were connected by canals and were used to collect rainwater for irrigation.
	Ahar Pynes	In South India, It was mainly found in Kerala. Ahar is the water storage system and pynes are channels that were used to supply water to the land.
	Check Dams	It was mainly found in the hilly region of south India. In this method, small dams were made on the seasonal rivers and thus water is collected for irrigation purposes.
	Anicut System	This system was found in Kerala and Tamilnadu. Dams were made on the rivers and thus water was collected for irrigation purposes.
North-East India	Bamboo Drip Irrigation	This method was seen in Meghalaya. Here, Bamboo pipes were used to supply the spring water to the field.
	Zabo and Dongs	This method was mainly used in Assam. Zabo are the bamboo pipes used to supply stream water to the land and Dongs are small ridges that were made along the sloping area to preserve water for irrigation.
	Paddy cum fish culture	This was mainly found in Manipur. Here, small fish ponds were made within paddy fields.
	Apatani paddy and fish culture	It was seen in Arunachal Pradesh. "Apangs" or channels were made to supply water from mountain rivers to the land. Small fishes were cultured in the crop fields also.

Source : https://www.geeksforgeeks.org/traditional-methods-of-irrigation/#traditional-methods-of-irrigation-in-india **5**

3.1Advantages of Traditional Methods of Irrigation

- ✓ These irrigation techniques are very simple. So, they do not require any prior technical knowledge to use them. They can be used properly by any common people.
- ✓ These techniques of irrigation are best to use for the levelled fields.
- ✓ Traditional methods of irrigation are performed under human supervision. So, crops get adequate water and more land area can be irrigated properly.

- ✓ These methods of irrigation cause less or no soil erosion.
- ✓ The traditional methods are cheap and can be done with little economic investment.

3.2Disadvantages of Traditional Methods of Irrigation

- ✓ These methods of irrigation have numerous drawbacks. They are:
- ✓ Traditional methods of irrigation require lots of physical effort and they are also time consuming methods.
- ✓ These methods sometime cause water-logging.
- ✓ Wastage of water can be seen during the traditional methods of irrigation.

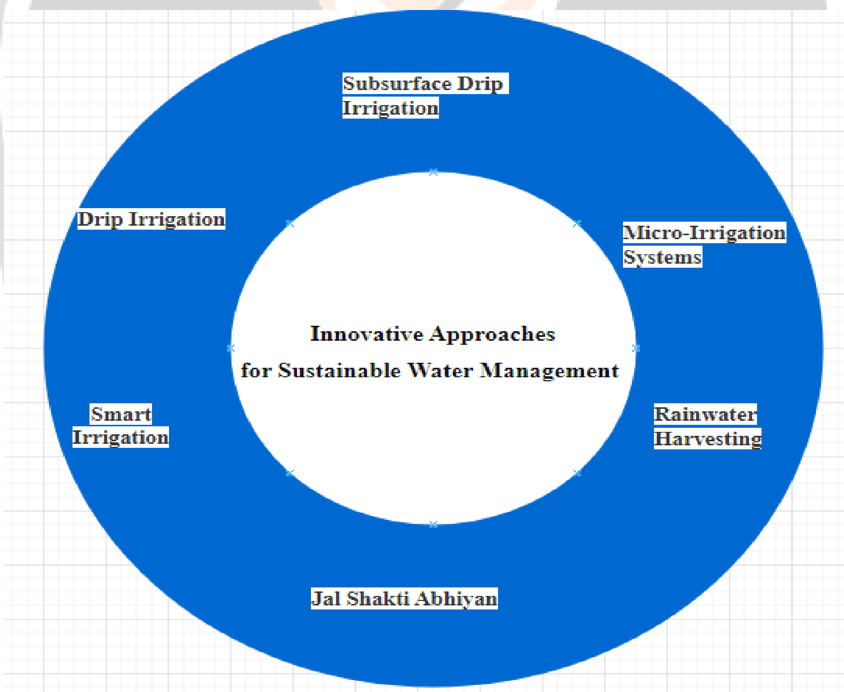
4.INNOVATIVE IRRIGATION SYSTEMS

Irrigated agriculture plays a key role in food production. However, agriculture, as it is practiced today, is responsible for 70% of all freshwater withdrawals in the world, according to FAO. With the growing population, the need for food production will be higher, as well as the need for a lot more water. FAO estimates that global water demand for agriculture is expected to increase by 35% by 2050.

To address this challenge, the key is to make agriculture irrigation systems more productive and less damaging for the planet, which means producing more food while using less water, building the resilience of farming communities to cope with floods and droughts, and applying clean water technologies that protect the environment.

Sustainable water management for farmers means managing water they have access to for its best and highest use but also considering their ecosystem and future water needs. Improving water productivity in agriculture is essential and includes a thorough monitoring of water usage efficiency[6].

Innovative Approaches For Sustainable Water Management



4.1Smart & Drip Irrigation:

Smart irrigation refers to the use of advanced technologies and systems to optimize the use of water in agricultural practices. Unlike traditional methods, smart irrigation incorporates real-time data, weather forecasts, soil moisture levels, and crop water needs to efficiently manage water resources. The goal is to enhance water use efficiency, reduce wastage, and improve crop yield, contributing to sustainable agriculture and water management.

Methods	Functions	Benefits
Soil Moisture Sensors	Measure the moisture content in the soil in real-time.	Ensure that plants receive water only when necessary, preventing over-irrigation and under-irrigation.
Weather-Based Controllers (ET Controllers)	se local weather data to adjust irrigation schedules.	Optimize watering schedules based on current weather conditions, reducing unnecessary water use.
Drip Irrigation Systems	Deliver water directly to the root zone of plants through a network of valves, pipes, tubing, and emitters.	Minimizes evaporation and runoff, ensuring that water is used efficiently.
Smart Sprinkler Systems	Equipped with sensors and Wi-Fi connectivity to control water flow based on specific needs.	Adjust watering schedules and amounts remotely, based on plant requirements and environmental conditions.
Automated Irrigation Systems	Integrate various technologies such as IoT (Internet of Things) to automate and control irrigation processes.	Provide precise irrigation management, reduce labor, and ensure optimal water use.
Flow Meters and Pressure Regulators	Monitor and control the amount of water flow and pressure within the irrigation system.	Prevents water wastage due to leaks or pressure fluctuations.

4.2 Subsurface Drip Irrigation:

Sub-surface drip irrigation is a technique for watering crops by burying the drip tubes with embedded emitters that are spaced regularly. Subsurface drip irrigation system is similar in design to surface drip irrigation system except subsurface placement of drip lines and specific emitter[7]. Subsurface drip irrigation is a modern and sustainable system that delivers water directly to the root zones of crops using buried drip lines or drip tape. Unlike surface irrigation, where water is applied above the soil, SDI places the drip tubes below the soil surface.

Types	Methods	Usage
Shallow Burial SDI	The drip line or tape is buried just a few centimetres beneath the soil surface.	Commonly used for single-season vegetables, melons, and strawberries.
Deep Burial SDI	The drip line is buried at least 10 centimetres (4 inches) below the surface.	Suitable for a wide range of crops, including corn, cane, vineyards, cotton, orchards & tomatoes,

4.3 Micro-Irrigation Systems:

Micro irrigation is a modern method of irrigation; by this method water is irrigated through drippers, sprinklers, foggers and by other emitters on surface or subsurface of the land. Major components of a micro irrigation system are Water source, pumping devices (motor and pump), ball valves, fertigation equipments, filters, control valves, PVC joining accessories (Main and sub main) and emitters. In this system water is applied drop by drop nearer the root zone area of the crop[8].

Types	Methods	Usage| Benefits
Drip Irrigation	Water is delivered directly to the root zone of the plants through emitters, usually at a low rate.	It minimizes evaporation and runoff, ensuring that plants receive a consistent supply of moisture.
Sprinkler Irrigation	Water is sprayed over the crop area through sprinkler heads, mimicking natural rainfall.	This method is suitable for a variety of crops and can cover large areas effectively.
Micro-Sprinklers	These are similar to sprinkler systems but on a smaller scale, suitable for individual plants or small plots.	They provide a fine mist of water, which is useful for delicate plants and seedlings
Bubbler Irrigation	Water is bubbled out at the base of the plant, providing deep watering with minimal evaporation.	This method is often used for trees and larger plants.

4.3 Rainwater Harvesting:

Rainwater harvesting is defined as a method of collecting, storing and conserving local surface runoff for agriculture. Effective water management and rainwater harvesting methods can bring about a relief regarding water shortage issues for various villages. It is one of the easiest ways to store rainwater for irrigation. Rainwater is good for plants because it is not subjected to chemicals and therefore is ideal for irrigation as well as for watering plants in the garden.

Rainwater harvesting is a technique of developing surface water resources that can be used in dry regions to provide water for livestock, for domestic use, and for agro-forestry and farming. Connecting an irrigation system to a rainwater supply makes it the most sustainable and therefore most environmentally friendly way of watering plants[9].

4.4 Jal Shakti Abhiyan:

Jal Shakti Abhiyan is a water conservation campaign launched by the Government of India. The initiative aims to promote water conservation and water resource management across the country, focusing on five major interventions: Water conservation and rainwater harvesting, Renovation of traditional and other water bodies/tanks, Reuse of water and recharging of structures, Watershed development & Intensive afforestation

The campaign is particularly focused on water-stressed districts and aims to mobilize resources from various stakeholders, including government departments, local communities, and NGOs, to enhance water availability in rural and urban areas.

Methods of Jal Shakti Abhiyan

Water Conservation and Rainwater Harvesting:

Encourages the construction of check dams, percolation tanks, and contour trenches.Promotes rooftop rainwater harvesting in both rural and urban areas.

Renovation of Traditional and Other Water Bodies/Tanks:

Involves cleaning and desilting of traditional water bodies to enhance their storage capacity. Restoration of ponds, lakes, and step-wells to revive their utility.

Reuse of Water and Recharging Structures:

Implementation of grey water recycling systems. Construction of recharge pits, soak pits, and borewell recharge structures to improve groundwater levels.

Watershed Development:

Focuses on holistic watershed management practices to prevent soil erosion, enhance water retention, and improve agricultural productivity. Involves the construction of contour bunds, gully plugs, and farm ponds.

Intensive Afforestation:

Promotes large-scale tree planting to enhance green cover, reduce soil erosion, and improve water retention in the soil.

5.CONCLUSION

Innovative approaches to sustainable water management in agriculture are crucial for addressing the growing challenges posed by climate change, water scarcity, and the increasing demand for food production. Techniques such as precision irrigation, rainwater harvesting, and the use of soil moisture sensors and drought-resistant crops significantly enhance water efficiency, reduce waste, and improve crop yields. These methods, supported by traditional practices and community-based initiatives like the Jal Shakti Abhiyan, ensure a holistic approach to water conservation. The National Mission for Sustainable Agriculture (NMSA) further underscores the importance of integrated farming, water use efficiency, and soil health management. By adopting these advanced technologies and practices, farmers can achieve long-term agricultural sustainability, ensuring food security and environmental conservation. This comprehensive approach not only optimizes resource use but also builds resilience against climate variability, ultimately contributing to the economic viability and environmental sustainability of agricultural systems. Policymakers, researchers, and farmers must collaborate to implement these strategies effectively, ensuring that sustainable water management becomes a cornerstone of modern agriculture. This synergy of innovative and traditional methods forms the backbone of a sustainable agricultural future, capable of meeting the needs of present and future generations.

6. REFERENCES

1. https://www.mdpi.com/journal/agriculture/special_issues/innovative_approaches_agricultural_water_management
2. https://fsii.in/innovative-options-for-sustainable-irrigation/
3. https://www.ijraset.com/best-journal/traditional-water-conservation-techniques-in-india
4. https://nmsa.dac.gov.in/
5. https://www.geeksforgeeks.org/traditional-methods-of-irrigation/#traditional-methods-of-irrigation-in-india
6. https://www.agrivi.com/blog/technology-helps-improving-sustainable-water-management-in-agriculture/
7. https://cssri.res.in/PSSU/Publications/Folder%20and%20Bulletins/2023/CIMMYT%20-%20SSD%20Manual%20Final.pdf
8. https://agritech.tnau.ac.in/agriculture/agri_irrigationmgt_microirrigation.html
9. https://www.neoakruthi.com/blog/rainwater-harvesting-for-irrigation.html
10. Patel, R., & Shah, V. (2020). "Impact of Climate Change on Agricultural Water Management." Climate Change and Agriculture Journal.
11. Rodriguez, L., & Thompson, H. (2021). "Economic Viability of Micro-Irrigation Systems." Journal of Agricultural Economics.
12. Johnson, M., & Taylor, S. (2022). "Integrating Traditional and Modern Water Management Practices." Journal of Sustainable Agriculture.
13. Johnson, M., & Taylor, S. (2022). Integrating Traditional and Modern Water Management Practices. Journal of Sustainable Agriculture.
14. Hernandez, F., & Lopez, A. (2018). Water Use Efficiency in Agriculture: A Global Perspective. International Journal of Agricultural Sustainability.
15. Smith, T., & Johnson, M. (2020). Smart Irrigation Systems for Water Conservation. Environmental Science and Technology.