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Determining the agricultural water-saving potential using various water-saving measures

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Abstract

Purpose: The purpose of the study is to determine the agricultural water-saving potential using various water-saving measures in the four districts of Haryana state namely Bhiwani, Sirsa, Rewari and Yamunanagar.

Methodology: Data of 120 farmers from each district has been collected by using purposive and multi stage random sampling method. Further the SPSS 26.0 has been used to analyze the data.

Findings: This study evaluated agricultural water-saving potential across districts by comparing water consumption and productivity under different irrigation methods. Results indicate that drip irrigation generally reduced water use but showed mixed yield outcomes, with higher efficiencies in mustard, pearl millet, and wheat, and limited gains in cotton. Canal irrigation in Sirsa consistently outperformed borewell irrigation, achieving higher productivity with lower water use, particularly for wheat. Flood irrigation remained dominant for rice and sugarcane, exhibiting high water consumption per unit output. Overall, irrigation efficiency varied significantly by crop, district, and method, highlighting the need for location-specific water management strategies.

1. Introduction

Water is becoming increasingly scarce globally (Rosegrant et al., 2002). The significant decrease in irrigation and water availability, combined with the continuous increase in population and economic activity in many nations, especially in arid and semi-arid regions, is predicted to exacerbate the issue of water scarcity (Rosegrant, 1997; Rosegrant et al., 2002). It is projected that by 2025, around one-third of the world's population will face an absolute water shortage, according to estimates from the International Water Management Institute (IWMI) in Colombo, based on macro-level statistics (D. Seckler et al., 1999; D. W. Seckler et al., 1998). It is anticipated that the semi-arid regions of Asia, the Middle East, and Sub-Saharan Africa would be the most severely impacted. These countries already have high rates of poverty.

Water should also be seen as an economic and social benefit, and management should strive for the most valuable usage by considering equality issues, efficiency, and environmental sustainability. Water planners, managers, users, and policymakers confront several difficulties as we enter the twenty-first century. One cannot stress the value of water as a priceless resource for agriculture too often. The rapid worldwide spread of irrigation is driven by the increasing demand for crop output to support the growing population (He et al., 2010).

Water is an essential and invaluable resource for a nation, playing a fundamental role in supporting life, ensuring food security, and preserving ecological balance. The need for fresh water in India has increased considerably over the last twenty years due to population growth, urbanization, industrial expansion, and inefficient agricultural methods.

According to the Falkenmark Water Stress Indicator, water stress is indicated when the per capita availability of water falls below 1,700 cubic metres (m^3). A per capita availability of less than 1,000 cubic meters (m^3) indicates a condition of water scarcity. Using these criteria, India is now classed as being water-stressed. In the absence of efficient and responsible water resource management, India is at considerable risk of experiencing water scarcity. This would have far-reaching consequences, including food insecurity and other associated problems (Bouwer, 2000).

Water resources are primarily utilized for four main purposes: irrigation, domestic use, industrial use, and additional applications such as meeting environmental needs and compensating for evaporation losses (Ward and Michelsen, 2002). Out of all these activities, Irrigation consumes the highest amount of water resources.

1.1 Evaluating Irrigation Systems

1.1.1 Drip Irrigation

The use of drip irrigation is on the rise in Haryana, India, especially in the field of agriculture, because of its effectiveness in water utilisation and its ability to improve crop productivity. Narayanamoorthy investigated the current total area under drip irrigation and the potential coverage area for the drip irrigation method. This report assessed the impact of using drip irrigation methods on various crops' productivity, production cost, total water savings, water use efficiency, and other economic aspects. The results showed that the drip irrigation system was successful in saving water and achieving water use efficiency in comparison to flood methods of irrigation. Moreover, this method achieved higher productivity and profits by using less water per crop and limited electrical energy (Narayanamoorthy, 2003). The author further suggested that the research findings could be used to promote drip irrigation systems in India. The report stated the importance of the textile industry for the Indian economy. Its contribution to the GDP of India is around 2 percent. This report intends to examine physical and regulatory water risks, investigate the water governance landscape, and shed light on textile water consumption in India, particularly in the Faridabad-Ballabhgarh cluster in the state of Haryana. The following are the two key contexts discussed in this report:

1) The textile industry's national and state-level landscapes, including its economic importance, prognosis for sustainability, and specialized water management difficulties, including water consumption intensity and effluent characteristics.

2) India's overall water resource management challenges.

Here is a comprehensive examination of its usage:

1. Government Initiatives: The Haryana government has been actively encouraging the adoption of drip irrigation by providing subsidies and incentives through programs such as the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) and the State Horticulture Mission.

2. Awareness and Training: Agricultural extension agencies and non-governmental organizations (NGOs) have a vital function in imparting knowledge to farmers about the advantages of drip irrigation, as well as delivering instruction on its proper installation and upkeep.

Advantages:

1. Water Conservation: Haryana experiences water scarcity problems, emphasizing the importance of effective water use. Drip irrigation minimises water loss considerably in comparison to conventional flood irrigation techniques.

2. Enhanced Crop Productivity and Quality: Drip irrigation optimizes crop growth by supplying water and nutrients directly to the plant roots, ensuring sufficient moisture and nutrients, resulting in improved yield and quality.

3. Weed Control and Labour Efficiency: Drip irrigation reduces water distribution to non-crop areas, hence minimising weed development and the requirement for human weeding. Additionally, it reduces the need for manual labour as compared to conventional watering techniques.

Opportunities:

1. Initial Cost: The upfront expenses associated with installing drip irrigation systems can be substantial, potentially discouraging small-scale farmers. Government subsidies and financial assistance programs aid in overcoming this obstacle.

2. Maintenance: Adequate maintenance is essential for the optimal operation of drip systems. Adequate training and assistance are necessary for farmers to ensure prompt repairs and replacements.

Application:

1. Horticulture: Drip irrigation is widely employed in horticultural crops, including fruits, vegetables, and flowers, due to its ability to provide accurate water and nutrient control, which is crucial for achieving high production and quality.

2. Field Crops: Although less prevalent in field crops such as wheat and rice due to factors such as size and expense, drip irrigation is being tested in valuable cash crops such as sugarcane and cotton.

Examples of specific situations and stories of achievement

1. Farmers' Experiences: Numerous farmers in Haryana have shown heightened profitability and decreased water expenses subsequent to implementing drip irrigation. Case studies demonstrate enhanced crop vitality and increased production consistency.

2. Demonstration Farms: Agricultural institutions and government agricultural agencies frequently establish demonstration farms to exhibit the advantages of drip irrigation to skeptical farmers.

Futuristic Vision

1. Growth: Due to continuous government assistance and rising awareness, the use of drip irrigation is projected to increase in Haryana, particularly in regions experiencing water scarcity.

2. Technological Advancements: Researchers are now investigating the potential of solar-powered drip systems and sensor-based irrigation scheduling to improve efficiency and user-friendliness.

To summarise, drip irrigation is becoming increasingly popular in Haryana's agriculture industry since it has the ability to alleviate water scarcity, raise crop output, and improve the livelihoods of farmers. The combination of on-going government backing and rapid technology improvements is expected to significantly contribute to the broad adoption of it in the upcoming years.

1.1.2 *Sprinkle Irrigation*

Another significant irrigation method that is seeing increased usage in agricultural activities in Haryana, India, is sprinkler irrigation.

Growth and Adoption:

1. Sprinkler irrigation, like drip irrigation, has received funding from government programs such as the State Horticulture Mission and the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY). In order to get farmers to use sprinkler irrigation systems, these programmes offer subsidies and other incentives.

2. Farmers' Associations and NGOs: Non-governmental organizations (NGOs), training programs, and agricultural extension services all do their part to spread the word about sprinkler irrigation.

Advantages:

1. Sprinkler irrigation systems are highly efficient in delivering water directly to crops, resulting in low water loss. Important in water-scarce areas like Haryana, this technology guarantees effective water usage by reducing evaporation losses.

2. Sprinklers provide regular water distribution over the field, which promotes uniform crop development and minimizes the chances of water stress in various areas (Luhach et al. 2004).

3. Sprinkler systems have the advantage of requiring less labor to operate when compared to manual watering techniques. This is particularly true in big agricultural areas.

4. Sprinkler irrigation is an excellent choice for many different types of crops. It works well with both field crops, such as wheat, maize, and sugarcane, and horticulture crops, such as fruits and vegetables.

Problems and Solutions:

1. Initial Investment: Sprinkler systems can be cost-prohibitive for small-scale farmers because of the upfront investment required. These systems may be made more inexpensive with the aid of government subsidies and financing alternatives.

2. Regular maintenance is key to keeping sprinkler systems in good working order. This includes cleaning the nozzles, inspecting for leaks, and fixing any broken components. Agricultural extension services play an essential role in providing training and assistance.

Application Based on Crop:

1) Field Crops: In Haryana, sprinkler irrigation is widely utilized for field crops, including wheat, maize, and pulses. It helps with timely watering and improves crop productivity.

2. Horticultural Crops: Its precise water application and nutrient management capabilities make it a popular choice for orchards and vineyards growing citrus fruits, grapes, pomegranates, and other horticultural crops.

Successful Projects and Real-Life Examples:

1. Sprinkler irrigation has improved water management and lowered input costs, leading to increased yields and enhanced profitability. Many farmers in Haryana have experienced these benefits after using sprinkler irrigation.

2. Climate Resilience: Being able to react to changing weather conditions and have more flexibility in scheduling watering is one way that sprinkler irrigation systems help with climate resilience.

Looking Ahead:

1. The use of spray irrigation is anticipated to grow in Haryana, a state that is committed to sustainable agriculture, thanks to the persistence of government programs and the growing consciousness of farmers.

2. Improvements in technology, such as the ability to automate sprinkler systems using sensors, schedule irrigation using mobile apps, and integrate with weather predictions, are projected to increase the efficiency and use of these systems.

Finally, sprinkler irrigation is crucial to the sustainable development of Haryana's agricultural sector by increasing crop output while decreasing water use. Irrigation technology is advancing and will continue to get support from government initiatives, which will accelerate its use in the region.

1.1.3 *Flood Irrigation*

Even if more effective methods like drip and spray irrigation are becoming more popular, the ancient practice of flood irrigation continues to play an important role in Haryana's agriculture. The following is an analysis of its use:

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Present Situation and Methods:

1. Scope of Application: In parts of Haryana where there is an abundance of water or where farmers have not yet used contemporary irrigation techniques, flood irrigation is still widely used.

2. Irrigated Crops: The region's abundant harvest includes rice, wheat, sugarcane, and vegetables, among many others.

3. Water Source: In order to flood-irrigate their fields, most farmers depend on water that has been extracted from rivers, canals, or tube wells. They then utilize gravity to spread the water out across the land.

Benefits:

1. Efficient Use of Money: Compared to drip or sprinkler systems, the initial setup expenses are often cheaper.

2. Easy to use: It requires less specialized expertise and less frequent equipment servicing than contemporary irrigation techniques.

3. How Well It Works with Specific Crops: Perfect for rice and other crops that need standing water to develop.

Challenges:

1. Excessive loss of water by evaporation, runoff, and percolation outside the root zone causes water to be wasted and inefficiently used.

2. Crop health and output can be negatively impacted by uneven water distribution, which causes some regions to be overwatered and others to be submerged.

3. Compared to mechanized systems, field preparation and maintenance sometimes demand more labor.

Programmes and Policies Implemented by the State:

1. An attempt at modernization: The Haryana government has been subsidising and implementing projects to increase water usage efficiency and promote sustainable agricultural practices, with the goal of increasing the use of drip and sprinkler irrigation over flood irrigation.

2. Raising Awareness and Providing Training: Non-governmental organizations (NGOs) and agricultural extension agencies provide seminars and demonstrations to teach farmers how to use contemporary irrigation systems and why they are beneficial.

What Lies Ahead:

1. **Adopting New Practices**: Government laws and awareness campaigns are pushing for more efficient irrigation techniques, such as drip and sprinkler systems, and this transition is happening slowly but surely, despite the obstacles.

2. **Environmental Considerations**: With Haryana facing water shortage problems, there is

a growing chorus of voices calling for farmers to use less water. In the long term, this could encourage farmers to use irrigation systems that are more efficient.

To sum up, flood irrigation is still heavily employed in Haryana's agriculture, particularly for rice and other water-intensive crops. However, there are growing calls for more effective and sustainable irrigation methods to address this issue. In order to facilitate this transition and guarantee long-term water security and agricultural sustainability in the region, it is essential to have government backing and awareness campaigns.

3. Background of the study and identifying research gaps

Sidhu et al. (1984) performed an economic evaluation of several irrigation methods in Punjab. Findings showed a strong correlation between irrigation, fertilizer usage, flexibility, dependability, and water availability.

Rao et al. (1988) used the irrigation optimization model, analyzed the functions of water production for a variety of crops, and determined that the simple heuristic multiplicative form was applicable over a wide range of stressful circumstances. The model proposed in the research study can be applied to a number of stress conditions. Regional water demand influencing factors can be estimated using the aforementioned model.

Parikh et al. (1995) examined whether farming in Pakistan could make money. According to the data, cost inefficiency can be cut down by giving credit, educating people in rural areas, and using outreach services to spread modern ways of making things.

Ward et al. (2002) discussed the issue in dry locations/areas was the development of institutions that focus on maximizing the benefit of water in the context of increasing demands for scarce and irregular supplies. Information provided on the economic value of water will help decision-makers make rational decisions about the development, usage, conservation, and allocation of water resources. This research study focused on several factors used to calculate water's economic worth. Some of these factors identified the viewpoint for value measurement that identified the adjustment period during which values are calculated. This study illustrated water values for agricultural usage.

Ahmed (2003) major policy challenges in agricultural technology adoption and other hindrances faced by the agricultural sector of Sudan. The author conducted interview-based surveys and collected data on various economic and technical variables required for the study. The author concluded that by implementing the research study's findings, Sudan can achieve a significant increase in productivity. The findings highlighted key issues that were hampering the technological transformation in various African countries.

Narayanamoorthy (2003) examined the significance of the Drip method of irrigation in the sustainable use of water resources in the agriculture sector. Both primary and secondary data sources were utilized to collect information. Results from the experimental station data demonstrated that water savings through DMI range from 12% to 84% per hectare for various crops in addition to raising agricultural yield. Utilizing the net potential area of DMI is expected to save a total of 11.271 million hectares of water.

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In their **2005** study, **Kumar et al.** examined the accessibility and requirements of water resources in India. They also discussed the variety of issues and tactics involved in establishing a comprehensive approach to develop and manage the country's water resources. It also emphasizes how virtual water transfer principles and the combination of blue and green flows may be used to manage water resources sustainably so that current demands are met without compromising those of future generations.

Narayanamoorthy (2007) discussed the relationship between adopting drip irrigation methods and respective electricity consumption for various crops. Researchers collected farm-level data from 200 farmers of Maharashtra using survey methods. The results after analyzing the data collected showed that 29 to 44 percent of electricity could be saved by the farmers who adopted drip irrigation method in comparison to the farmers that used flood irrigation method.

Sarkar (2011) highlighted the issue of farmers' livelihoods being negatively affected when the burden of resource depletion falls disproportionately on economically disadvantaged farmers. These farmers could not invest in capital and technology, which denies them the advantages of subsidized groundwater irrigation facilitated by free electricity. The situation became even more exploitative as scarcity led to unequal economic returns; at its worst, it allowed the "large landlords" to become "water lords" through surplus accumulation, leaving the small and marginal landholders with no choice but to work as agricultural laborers without land.

Zhang et al. (2013) states that existing techniques predict regional water demand by using prediction models and time series based on actual water demand. But they ignore the dynamic mutual-restriction relationship of various water demand influencing factors and their influence on water demand. To address this issue, this study used the Cobb-Douglas production function and created a regional water demand prediction model based on it.

Zhang and Guo (2016) applied the optimization model by focusing on water-saving potential in the agriculture area in the Fendong district of China. They used this model to decide the planting area for each crop, to better capture the use of surface water and groundwater for calculating the amount used for water irrigation, and to find out the incremental benefit that emerged from surplus water transfer from agriculture to secondary and tertiary industry. Economic benefits could be derived by transferring surplus water to secondary and tertiary industries rather than using it only for the agriculture industry.

Narayanamoorthy (2018) analyzed the technical and economic feasibility of using drip irrigation in Brinjal production in the state of Tamil Nadu. Author used survey data technique and found that agricultural productivity increased by 52 % with 40% water savings and 629 kwh/acre power savings. Overall, application of drip irrigation yields 54% more returns in Brinjal production.

3. Research Gaps

Previous studies have analyzed the water-saving potential in varied regions. As per the literature review, no such study is being conducted in the Indian context. This study fulfills this gap.

4. Research Objective

The objective of the study is to determine the agricultural water-saving potential using various water-saving measures.

Table: 1 Data Collection and Research Design

Sr. No.	Description	Contents
1	Who	480 Farmers who are using the Drip, Sprinkle, and Flood irrigation method.
2	What	To determine the agricultural water-saving potential using various water-saving measures.
3	Sampling Technique	Purposive sampling and multi-stage random sampling technique
4	Target Population	Four Districts of Haryana State namely **1.** Bhiwani **2.** Rewari **3.** Sirsa Yamuna Nagar
5	How	**4.** Survey
6	Research Instrument	Questionnaire

5. Data Analysis and Interpretation

The purpose of this objective is to determine the agricultural water-saving potential using various water-saving measures. For this purpose, water consumption and productivity were used to determine agricultural water-saving potential.

5.1 Agricultural water-saving potential using various water-saving measures in Bhiwani

Table 2: Water Use Efficiency in Bhiwani

Particulars	**Crop Name**	**Method of Irrigation**		**Benefit Over FIM**	
		DMI/SMI	FMI	Absolute	Percentage
Water Consumption (HP/hours/acre)	Cotton	1218	782	436	55.75448
	Mustard	42	216	-174	-80.5556
	Pearl Millet	21	72	-51	-70.8333
	Rice	NIL	766.8	NIL	NIL
	Sugarcane	NIL	23040	NIL	NIL
	Wheat	84	432	-348	-80.5556
Productivity (Quintal/acre)	Cotton	7	4.2	2.8	66.66667
	Mustard	8	12	-4	-33.3333
	Pearl Millet	10	16	-6	-37.5
	Rice	NIL	15	NIL	NIL
	Sugarcane	NIL	350	NIL	NIL
	Wheat	18	20	-2	-10
	Cotton	174	186.19048	-12.1904762	-6.54731
	Mustard	5.25	18	-12.75	-70.8333

Water Use Efficiency(HP hours/quintal)	Pearl Millet	2.1	4.5	-2.4	-53.3333
	Rice	NIL	51.12	NIL	NIL
	Sugarcane	NIL	65.828571	NIL	NIL
	Wheat	4.66666667	21.6	-16.9333333	-78.3951

Source: Field Survey

Note: Water Use Efficiency= Water Consumption (HP/hours/acre) / Productivity (Quintal/acre)

Table 2 provides information on Bhiwani District's water use efficiency. It benchmarks the water consumption efficiency between DMI and FMI or SMI and FMI. The water consumption and production in drip irrigated cotton surpasses that of flood irrigated cotton, with a value of 7 quintals compared to 4.2 quintals. Consequently, the water consumption efficiency achieved with DMI is around 7 percent. The water consumption and production in drip irrigated mustard is less that of flood irrigated mustard, with a value of 8 quintals compared to 12 quintals. Consequently, the water consumption efficiency achieved with DMI is around 70 percent. The water consumption and production in drip irrigated pearl millets is less that of flood irrigated pearl millets, with a value of 10 quintals compared to 16 quintals. Consequently, the water consumption efficiency achieved with DMI is around 53 percent. The water consumption and production in drip irrigated wheat is less that of flood irrigated wheat, with a value of 18 quintals compared to 20 quintals. Consequently, the water consumption efficiency achieved with DMI is around 78 percent. Further analysis reveals that only FMI was applied to Rice and Sugarcane. Although rice yields 15 quintals per acre, sugarcane yields 350 quintals per acre. Their respective water consumption efficiencies are 51 and 65 HP hours per quintal.

5.2 Agricultural water-saving potential using various water-saving measures in Rewari

Table 3: Water Use Efficiency in Rewari

Particulars	**Crop Name**	**Method of Irrigation**		**Benefit Over FIM**	
		DMI/SMI	FMI	Absolute	Percentage
Water Consumption (HP/hours/acre)	Cotton	306	831.6	-525.6	-63.2035
	Mustard	306	490	-184	-37.55102
	Pearl Millet	204	245	-41	-16.7347
	Rice	NIL	3450	NIL	NIL
	Sugarcane	NIL	NIL	NIL	NIL
	Wheat	714	1347.5	-633.5	-47.013
Productivity (Quintal/acre)	Cotton	7	9.2	-2.2	-23.913
	Mustard	8	10	-2	-20
	Pearl Millet	12	11.5	0.5	4.347826
	Rice	NIL	20	NIL	NIL
	Sugarcane	NIL	NIL	NIL	NIL
	Wheat	20	20	0	0
Water Use Efficiency(HP	Cotton	43.7142857	90.391304	-46.6770186	-51.6388
	Mustard	38.25	49	-10.75	-21.9388
	Pearl Millet	17	21.304348	-4.30434783	-20.2041

hours/quintal)	Rice	NIL	172.5	NIL	NIL
	Sugarcane	NIL	NIL	NIL	NIL
	Wheat	35.7	67.375	-31.675	-47.013

Source: Field Survey

Table 3 provides information on Rewari District's water use efficiency. It benchmarks the water consumption efficiency between DMI and FMI or SMI and FMI. The water consumption and production in drip irrigated cotton is less that of flood irrigated cotton, with a value of 7 quintals compared to 9.2 quintals. Consequently, the water consumption efficiency achieved with DMI is around 51 percent. The water consumption and production in drip irrigated mustard is less that of flood irrigated mustard, with a value of 8 quintals compared to 10 quintals. Consequently, the water consumption efficiency achieved with DMI is around 21 percent. The water consumption and production in drip irrigated pearl millets surpasses that of flood irrigated pearl millets, with a value of 12 quintals compared to 11.5 quintals. Consequently, the water consumption efficiency achieved with DMI is around 20 percent. The water consumption and production in drip irrigated wheat is the same as flood irrigated wheat, with a value of 20 quintals. Consequently, the water consumption efficiency achieved with DMI is around 47 percent. Further analysis reveals that only FMI was applied to Rice. Although rice yields 20 quintals per acre, its water consumption efficiency is 172.5 HP hours per quintal.

5.3 Agricultural water-saving potential using various water-saving measures in Sirsa

Table 4: Water Use Efficiency in Sirsa

Particulars	**Crop Name**	**Method of Irrigation**		**Benefit Over Borewell**	
		Canal	**Borewell**	**Absolute**	**Percentage**
Water Consumption (HP/hours/acre)	Cotton	79.04	432	-352.96	-81.7037
	Mustard	30.4	144	-113.6	-78.8889
	Pearl Millet	22.8	100.8	-78	-77.381
	Wheat	68.4	403.2	-334.8	-83.0357
Productivity (Quintal/acre)	Cotton	9.11	8.6	0.51	5.930232558
	Mustard	10.15	11	-0.85	-7.727272727
	Pearl Millet	10.15	10.5	-0.35	-3.333333333
	Wheat	23.18	23	0.18	0.782608696
Water Use Efficiency(HP hours/quintal)	Cotton	8.67618002	50.23256	-46.677	-92.92184258
	Mustard	2.99507389	13.09091	-10.75	-82.11805556
	Pearl Millet	2.24630542	9.6	-7.3537	-76.60098522
	Wheat	2.95081967	17.53043	-31.675	-180.6857639

Source: Field Survey

Table 4 provides information on Sirsa District's water use efficiency. It benchmarks the water consumption efficiency between Canal and Borewell irrigation systems. The water consumption is less and production is more in canal irrigated cotton, with a value of 9.11 quintals compared to 8.6 quintals. Consequently, the water consumption efficiency achieved with the canal is around 92 percent. The water consumption and production in canal irrigated mustard is less than that of borewell irrigated mustard, with a value of 10.15 quintals compared to 11 quintals. Consequently, the water consumption efficiency achieved with the canal is around 82 percent. The water consumption and production in canal-irrigated pearl millets are less than those of borewell-irrigated pearl millets, with a value of 10.15 quintals compared to 10.5 quintals. Consequently, the water consumption efficiency achieved with the canal is around 76 percent. The water consumption is less, and production in canal irrigated wheat is more as compared to borewell irrigated wheat, with a value of 23.18 and 23 quintals. Consequently, the water consumption efficiency achieved with the canal is around 180 percent.

5.4 Agricultural water-saving potential using various water-saving measures in Yamunanagar

Table 5: Water Use Efficiency in Yamunanagar

Particulars	**Crop Name**	**Method of Irrigation**
		FMI
Water Consumption (HP/hours/acre)	Maize	75.6
	Mustard	73.71
	Pearl Millet	NIL
	Rice	1077.3
	Sugarcane	430.92
	Wheat	94.5
Productivity (Quintal/acre)	Maize	15
	Mustard	6
	Pearl Millet	NIL
	Rice	30
	Sugarcane	420
	Wheat	20
Water Use Efficiency (HP hours/quintal)	Maize	5.04
	Mustard	12.285
	Pearl Millet	NIL
	Rice	35.91
	Sugarcane	1.026
	Wheat	4.725

Table 5 presents data specifically on the water consumption efficiency of Yamunanagar District. The water consumption efficiency is benchmarked exclusively in FMI parameters. No farmer has been identified who utilizes DMI or SMI. Additional data revealed that the output of maize amounted to 15 quintals, mustard to 06 quintals, rice to 30 quintals, sugarcane to 420 quintals, and wheat to 20 quintals. Conversely, the water usage efficiency for maize is 5 HP hours per quintal, mustard is 12 HP hours per quintal, rice is 35.91 HP hours per quintal, sugarcane is 1.02 HP hours per quintal, and wheat is 4.725 HP hours per quintal.

6. Conclusion

This study determined the agricultural water-saving potential using various water-saving measures. For this purpose, water consumption and productivity were used to determine agricultural water-saving potential. The following findings determined the agricultural water-saving potential using various water-saving measures:

In Bhiwani, the water consumption and production in drip irrigated cotton surpasses that of flood irrigated cotton, with a value of 7 quintals compared to 4.2 quintals. Consequently, the water consumption efficiency achieved with DMI is around 7 percent. The water consumption and production in drip irrigated mustard is less that of flood irrigated mustard, with a value of 8 quintals compared to 12 quintals. Consequently, the water consumption efficiency achieved with DMI is around 70 percent. The water consumption and production in drip irrigated pearl millets is less that of flood irrigated pearl millets, with a value of 10 quintals compared to 16 quintals. Consequently, the water consumption efficiency achieved with DMI is around 53 percent. The water consumption and production in drip irrigated wheat is less that of flood irrigated wheat, with a value of 18 quintals compared to 20 quintals. Consequently, the water consumption efficiency achieved with DMI is around 78 percent. Further analysis reveals that only FMI was applied to Rice and Sugarcane. Although rice yields 15 quintals per acre, sugarcane yields 350 quintals per acre. Their respective water consumption efficiencies are 51 and 65 HP hours per quintal.

In Rewari, the water consumption and production in drip irrigated cotton is less that of flood irrigated cotton, with a value of 7 quintals compared to 9.2 quintals. Consequently, the water consumption efficiency achieved with DMI is around 51 percent. The water consumption and production in drip irrigated mustard is less that of flood irrigated mustard, with a value of 8 quintals compared to 10 quintals. Consequently, the water consumption efficiency achieved with DMI is around 21 percent. The water consumption and production in drip irrigated pearl millets surpasses that of flood irrigated pearl millets, with a value of 12 quintals compared to 11.5 quintals. Consequently, the water consumption efficiency achieved with DMI is around 20 percent. The water consumption and production in drip irrigated wheat is the same as flood irrigated wheat, with a value of 20 quintals. Consequently, the water consumption efficiency achieved with DMI is around 47 percent. Further analysis reveals that only FMI was applied to Rice. Although rice yields 20 quintals per acre, its water consumption efficiency is 172.5 HP hours per quintal.

In Sirsa, the water consumption is less, and production is more in canal-irrigated cotton, with a value of 9.11 quintals compared to 8.6 quintals. Consequently, the water consumption efficiency achieved with the canal is around 92 percent. The water consumption and production in canal irrigated mustard is less than that of borewell irrigated mustard, with a value of 10.15 quintals compared to 11 quintals. Consequently, the water consumption efficiency achieved with the canal is around 82 percent. The water consumption and production in canal-irrigated pearl millets are less than those of borewell-irrigated pearl millets, with a value of 10.15 quintals compared to 10.5 quintals. Consequently, the water consumption efficiency achieved with the canal is around 76 percent. The water consumption is less, and production in canal irrigated wheat is more as compared to borewell irrigated wheat, with a value of 23.18 and 23 quintals. Consequently, the water consumption efficiency achieved with the canal is around 180 percent.

In Yamunanagar, water consumption efficiency is benchmarked exclusively in FMI parameters. No farmer has been identified who utilises DMI or SMI. Additional data revealed that the output of maize amounted to 15 quintals, mustard to 06 quintals, rice to 30 quintals, sugarcane to 420 quintals, and wheat to 20 quintals. Conversely, the water usage efficiency for maize is 5 HP hours per quintal, mustard is 12 HP hours per quintal, rice is 35.91 HP hours per quintal, sugarcane is 1.02 HP hours per quintal, and wheat is 4.725 HP hours per quintal.

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