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Water usage in crops using irrigation systems in Haryana

Ms. Prerna[1], Dr. Silender Singh[2]

[1]Research Scholar,Department of Commerce,Chaudhary Devi Lal University, Sirsa
prernacomphd@cdlu.ac.in
[2]Professor, Department of Commerce, Chaudhary Devi Lal University, Sirsa
Silendersingh2000@gmail.com

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ABSTRACT

Purpose: It is of the utmost importance to prioritize efforts in the management and reduction of water usage in a manner that does not adversely affect agricultural production. This study attempts to identify the agricultural water usage by farmers using various irrigation systems.

Approach Used: Primary data were collected from 480 farmers across four districts of Haryana state to identify agricultural water usage. The districts in question are Bhiwani, Rewari, Sirsa, and Yamunanagar. Participants were inquired about the irrigation method they employed. The study employed drip, sprinkle, and flood methods of irrigation. Purposive and multi-stage random sampling methods were employed for the selection of units and areas. The analysis of the study utilized descriptive statistics.

Findings: The study found that if sprinkle or drip method is used over flood method of irrigation in crops such as Maize, Cotton, Mustard, Pearl Millets and Wheat then the water saving ranges from 30 per cent to 80 per cent. Which shows that saved water can be used for other purposes like household, other agricultural activities and industrial activities. On the other hand, in the crops like rice and sugarcane farmers uses only FMI (flood method of irrigation). It is appeared that the above crops are not feasible for drip and sprinkle irrigation method, there is the greatest need for such hybrid seeds or mechanism so that these crops consume less water or farmers should explore for alternate crops.

1 Introduction

Water is a critical and indispensable resource for sustaining life and is essential for the functioning of our ecosystems. Nevertheless, the accessibility of water is progressively endangered by the impacts of climate change, population expansion, and ineffective water management techniques (Ghernaout, 2017).

Over 70% of the planet's surface consists of water, but only 3% is fresh water. Two-thirds of that 3% are either frozen in ice caps, glaciers, or permafrost, or they are buried well below the surface. Another source of freshwater is surface water, which may be found in lakes, rivers, dams, and streams (Mishra, 2023).

The significance of water conservation has reached an unprecedented level. Conserving water is not only a duty but also an essential requirement for achieving sustainable living. Conserving water helps alleviate the pressure on freshwater resources, save aquatic ecosystems, and guarantee water supply for future generations (Shroff & Miglani, 2024).

Furthermore, implementing effective water management strategies may result in financial savings and positive impacts on society and the environment.

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

1.1 Evaluating Irrigation Systems

1.1.1 DMI - Drip Method of Irrigation

Drip irrigation minimises water loss considerably in comparison to conventional flood irrigation techniques. Haryana experiences water scarcity problems, emphasising the importance of effective water use. Drip irrigation

optimises crop growth by supplying water and nutrients directly to the plant roots, ensuring sufficient moisture and nutrients, resulting in improve yield and quality.

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.

SMI – Sprinkle Method of Irrigation

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. Sprinklers provide regular water distribution over the field, which promotes uniform crop development and minimises the chances of water stress in various areas (Luhach et al., 2004). Sprinkler systems have the advantage of requiring less labour to operate when compared to manual watering techniques. This is particularly true in big agricultural areas. 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.

1.1.2 FMI – Flood Method of Irrigation

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 utilise gravity to spread the water out across the land.

2. Theoretical Foundation and Further Agenda

Hall and Buras (1961) Dynamic optimization was used in Buras' research to combine the usage of surface water and groundwater systems. Water balance equations were used to characterize both the stream and subsurface systems.

Bouwer (2000) identified issues and challenges associated with integrated water management. The purpose was to fulfill the water demand of the growing population. Further the author addressed the various sources of wastewater that helped in fulfilling the water demand of the huge population. These sources include municipal wastewater, aquifer recharge and sustainable usage to minimize water shortage. Also, the concept of virtual water and local water were discussed for sustainable water usage.

Narayanamoorthy (2003) examined the significance of the DMI (Drip method of irrigation) in the sustainable use of water resources in the agriculture sector. Data sources from both the primary and secondary 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 different crops in addition to increasing agricultural yield. Utilizing the net potential area of DMI is expected to save a total of 11.271 million hectares of water.

Narayanmoorthy (2003) focused on studying the importance of drip irrigation in two major crops namely Sugarcane and Banana in the state of Maharashtra. Productivity and economic viability under surface and drip irrigation methods for both the crops were calculated and compared. The data were collected from 50 drip adopters and 50 non-drip adopters. The results, as per the field survey data, showed that water saving under DMI is 47 per cent in sugarcane and 29 per cent in banana cultivation when compared to the Flood method of irrigation.

Luhach et al. (2004) conducted a study to examine Water use efficiency and to gain insights regarding economic worth of investment in different irrigation systems in Haryana. Using the Primary data for analysis, it was found that Drip and Sprinkle methods were significant Irrigation systems. Moreover, the Sprinkler Irrigation system was the most appropriate technique with respect to Operating costs.

Water saving techniques in irrigated agriculture in a Rio Grande sub-basin in North America were examined by **Dagnino and Ward (2012)**. Their approach was to calculate the amount of water that farmers in irrigated agriculture would save if they switched from surface to drip irrigation, thanks to government incentives. The

approach took into consideration how farmers' decisions on crop mix, irrigation technology, water application, and water depletion were influenced by financial incentives. Research findings indicated that farmers choose to invest in water-saving technology when the cost of switching to drip irrigation was cheaper. Drastic irrigation subsidies lower the quantity of water used on crops, boost agricultural revenue, and enhance the value of food produced. The adoption of drip irrigation, which was encouraged by water saving incentives, had an unanticipated side effect of raising crop water depletion demands.

Tagar et al. (2012) conducted a field experiment to compare drip and furrow irrigation methods in Umarkot. The study area was divided into two equal parts of 40m * 50m each and coefficient of variation and emission uniformity were calculated to check the performance under each irrigation system. The findings of the experiment suggested that drip irrigation method is more water efficient and produces more output in comparison to traditional flood irrigation method.

Zande et al. (2024) investigated the new possibilities in irrigation solutions specifically designed for East African farmers. A market evaluation was carried out through interviews to determine the primary market categories and the distinct values that farmers in each category might possess for an irrigation system. Subsequently, a techno-economic feasibility study was employed to identify the irrigation systems and energy sources that provide favorable prospects for each sector. Four clearly defined market categories were identified. Generally, the conventional small-scale farmer would probably prioritize a system that utilizes photovoltaic (PV) energy and manual watering. Semi-commercial smallholders might explore favorable prospects in utilizing photovoltaic (PV) electricity and butterfly sprinkler systems. Systems based on PV panels and drip irrigation would probably be valued by distant farm owners and medium-scale contract farmers.

Shroff and Miglani (2024) evaluated the water and electricity savings, as well as the economic benefits, of the "Per Drop More Crop" micro irrigation program implemented by the Government of India. The study focused on the production of crops namely sugarcane, banana, and cotton in specific regions of Maharashtra, India. The comparative before-after approach was utilized by studying the data received from pre-tested interview schedules conducted with a total of 116 individuals who supported drip irrigation in Maharashtra. The authors suggested that farmers achieved increased agricultural yields, income, and water conservation after implementing drip irrigation. The yield per hectare of banana, sugarcane, and cotton had respective increases of 73%, 36%, and 80%. Following the implementation of drip irrigation, the energy consumption per hectare from irrigation decreased by around 50% for both the crops namely banana and sugarcane, and by 86% for cotton. By implementing drip method of irrigation, farmers may cultivate crops with increased intensity.

Objective of the Study

The objective of the study is to identify agriculture water usage by farmers using various irrigation systems.

3. Research Methodology

Table 3.1. Sample Design

Sr. No	Description	Contents
1	Population	Four Districts of Haryana State, namely 1. Bhiwani 2. Rewari 3. Sirsa 4. Yamuna Nagar
2	Sample Size	120 (Farmers) * 4 (Districts) = 480
3	Sampling Units	Farmers using Drip, Sprinkle and Flood Method of Irrigation
4	Sampling Method	Probability and non-probability sampling method
5	Sampling Technique	Purposive sampling and multi-stage random sampling technique

Table 3.2 shows demographic profile of respondents from 4 districts of Haryana, namely, Bhiwani, Rewari, Sirsa

and Yamunanagar. The overall sample size is 480 respondents with 120 respondents from each district. The age-wise population, Gender, Qualification, Income distribution, Landholding size and Farming experience of various districts are presented in Table. About 50 percent of the farmers are aged 50 and above years.
Majority of the farmers are male and approx. 10 percent are female farmers. Educationally, majority of the farmers are either graduates or senior secondary pass out. Average income of the farmers identified from survey studies is 1 lakh to 3 lakh rupees. ¾ of the farmers holds upto 8 acres of Land. If we talk about farming experience then majority of the respondents holds more than 15 years of exposure to farming activities.

Table 3.2 Demographic Profile of Respondents

Contents		Absolute	Percentage
Age (in years)	upto 20	30	6.25
	20-30	62	12.916667
	30-40	68	14.166667
	40-50	105	21.875
	Above 50 years	215	44.791667
Total		**480**	**100**
Gender	Male	432	90
	Female	48	10
Total		**480**	**100**
Qualification	Upto Matriculation	156	32.5
	Senior Secondary	103	21.458333
	Graduate	187	38.958333
	Post- Graduate	34	7.0833333
Total		**480**	**100**
Income	Upto 1,00,000	82	17.083333
	1 L - 3L	220	45.833333
	3L - 5L	108	22.5
	5 L - 7L	40	8.3333333
	More Than 7 L	30	6.25
Total		**480**	**100**
Land Holding Size	Upto 4 acres	170	35.416667
	4 acre-8acre	188	39.166667
	8 acre - 12 acre	46	9.5833333
	12 acre - 16 acre	49	10.208333
	More than 16 acre	27	5.625
Total		**480**	**100**
Farming Experience	upto 5 years	30	6.25
	05 years - 10 years	64	13.333333
	10 years - 15 years	110	22.916667
	More than 15 years	276	57.5
Total		**480**	**100**

Source: Primary Data

Table 3.3 reflects that 90% of the farmers are aware about both – Ground water and Surface water sources. The usage of sources also depends upon the awareness and availability of water resources.

Table 3.3 Sources of Water

Source	Absolute	Percentage
Ground Water	24	5
Surface Water	24	5
Both	432	90
Total	**480**	**100**

Source: Primary Data

Table 3.4 studies the number of farmers using Drip irrigation/ Sprinkle irrigation and Flood irrigation in various crops. The usage of Flood method of irrigation is more likely among farmers. In crops like Cotton, Mustard, Pearl Millets and Wheat, farmers are also using DMI/SMI. Rice and Sugarcane crops are produces using Flood method of irrigation only.

Table 3.4 Different Crops produced by Farmers

Crop	DMI/SMI	FMI	Total
Cotton	120	240	**360**
Maize	0	120	**120**
Mustard	120	360	**480**
PearlMillets	120	240	**360**
Rice	0	185	**185**
Sugarcane	0	124	**124**
Wheat	120	360	**480**

Source: Primary Data

The Table 3.5 examines the distribution of farmers on the basis of purpose behind selecting and producing particular crops. Labour availability, Production Cost, Water consumption etc. are the key factors in selecting crops.

Table 3.5 Purpose behind Sowing Crops

Purpose Behind Sowing	Number of Farmers
Availability of labour	389
Cost of Cultivation	267
Easy Availability of Market	405
Productivity	319
Water Consumption	417

Source: Primary Data

To identify the agricultural water usage by farmers using various irrigation systems

The purpose of this objective is to identify the agricultural water usage by farmers using various irrigation systems. For this purpose, Pumpset HP, no. of irrigation/acres, hours required per irrigation/acre and HP hours of water used/acre were used to identify the agriculture water usage.

NOTE: HP hours of water used/acre = Pump set HP * Number of irrigation/acres * Hours required per irrigation/acre (Narayanamoorthy et al., 2018).

4.1 Agricultural water usage by farmers using various irrigation systems in Bhiwani

This section covers the agricultural water usage by farmers using irrigation systems in Bhiwani on the basis of various crops. Irrigation systems include Drip Method of Irrigation (DMI), Flood Method of Irrigation (FMI) and Sprinkle Method of Irrigation (SMI). Crops used are Cotton, Mustard, Pearl Millets, Sugarcane, Wheat and Rice.

4.1.1 Water consumption in Drip irrigated and Flood irrigated Cotton in Bhiwani

Table 1 compares water usage in DMI versus FMI. Although the numbers of irrigations are higher with DMI, the number of hours required in irrigation is less; 1.45 hours/acre in comparison to 8.5 hours/ acre in FMI. Consequently, the total water usage in drip-irrigated crops is 1218 HP hours/acre, contrary to 782 HP hours/acre in FMI. That is to say, flood irrigation saves about 56% of the water.

Table 1: Water consumption in Drip and Flood irrigated Cotton in Bhiwani

Particulars	**DMI**	**FMI**	**Change over FMI**		**Test of significance of mean value**
			Absolute	Percent	
Pump set HP	7	8	-1	-12.5	**
Number of irrigation/acres	120	11.5	108.5	943.4783	**
Hours required per irrigation /acre	1.45	8.5	-7.05	-82.9412	**
HP hours of water used/acre	1218	782	436	55.75448	**
Source: Field survey. ** - Significant difference at 5% level					

The findings of the "t" test demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of pumpset used in Cotton production. The research region exhibits substantial differences in the number of irrigation hours for each turn, as indicated by the results of the "t" test. Using the "t" test to analyze the HP hours of water usage under DMI and FMI, it is discovered that there is a statistically significant difference between the two.

4.1.2 Water consumption in Sprinkle and Flood irrigated Mustard in Bhiwani

Table 2 compares water usage under SMI and FMI. Although the numbers of irrigations are higher with SMI, the time spent on each irrigation session is less; 1.50 hours/acre compared to 9 hours/ acre with FMI. Therefore, the total water usage in sprinkle-irrigated crop is 42 HP hours/acre in comparison to 216 HP hours/acre in FMI. In conclusion, Sprinkle irrigation saves about 81% of the water.

Table 2 Water consumption in Sprinkle and Flood irrigated Mustard in Bhiwani

Particulars	**SMI**	**FMI**	**Change over SMI**		**Test of significance of mean value**
			Absolute	Percent	
Pump set HP	7	8	-1	-12.5	**
Number of irrigation/acres	4	3	1	33.33333	**
Hours required per irrigation/acre	1.50	9	-7.5	-83.3333	**
HP hours of water used/acre	42	216	-174	-80.5556	**
Source: Field survey. ** - Significant difference at 5% level					

The findings of the "t" test demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of pumpset used in Mustard production. The research region exhibits substantial differences in the number of irrigation hours for each turn, as indicated by the results of the "t" test. Using the "t" test to analyze the HP hours of water usage under DMI and FMI, it is discovered that there is a statistically significant difference between the two.

4.1.3 Water consumption in Sprinkle and Flood irrigated Pearl Millets in Bhiwani

Table 3 analyzed water usage in SMI versus FMI. Although the numbers of irrigations are higher with SMI, the time spent on each irrigation session (in terms of hours used) is less; 1.50 hours/acre compared to 9 hours/ acre

with FMI. Consequently, the total water usage in sprinkler-irrigated crop is 21 HP hours/acre in comparison to 72 HP hours/acre in FMI. In conclusion, Sprinkle irrigation saves about 71% of the water.

Table 3 Water consumption in Sprinkle and Flood irrigated Pearl Millets in Bhiwani

Particulars	SMI	FMI	Change over SMI		Test of significance of mean value
			Absolute	Percent	
Pump set HP	7	8	-1	-12.5	**
Number of irrigation/acres	2	1	1	100	**
Hours required per irrigation/acre	1.50	9	-7.5	-83.3333	**
HP hours of water used/acre	21	72	-51	-70.8333	**
Source: Field survey. ** - Significant difference at 5% level					

The findings of the "t" test demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of pumpset used in Pearl Millet production. The research region exhibits substantial differences in the number of irrigation hours for each turn, as indicated by the results of the "t" test. Using the "t" test to analyze the HP hours of water usage under DMI and FMI, it is discovered that there is a statistically significant difference between the two.

4.1.4 Water consumption in Flood irrigated Sugarcane in Bhiwani

Table 4 identifies FMI used in the sugarcane. Number of Irrigation/acres is 320. Hours required per irrigation/acre are 9 HP. As a result, total water used in Sugarcane is 23040 HP. Main point is that no one applied the drip and sprinkle method of irrigation in Sugarcane cultivation.

Table 4 Water consumption in Flood irrigated Sugarcane in Bhiwani

Particulars	FMI
Pump set HP	8
Number of irrigation/acres	320
Hours required per irrigation/acre	9
HP hours of water used/acre	23040
Source: Field Survey	

4.1.5 Water consumption in Flood irrigated Rice in Bhiwani

Table 5 identifies FMI used in the Rice. Number of Irrigation/acres is 16.8. Hours required per irrigation/acre are 5.7 HP. As a result, total water used in Rice is 766.8 HP. Main point is that no one used the drip and sprinkle method of irrigation in Rice.

Table 5 Water consumption in Flood irrigated Rice in Bhiwani

Particulars	FMI
Pump set HP	8

Number of irrigation/acres	16.8
Hours required per irrigation/acre	5.7
HP hours of water used/acre	766.8
Source: Field Survey	

4.1.6 Water consumption in Sprinkle and Flood irrigated Wheat in Bhiwani

Table 6 compares water usage in SMI versus FMI. Although the numbers of irrigations are similar under both the methods i.e SMI and FMI, the time spent on each irrigation session (in terms of hours used) is less; 2 hours/acre compared to 9 hours/ acre with FMI. Thus, the total water usage in prinkle-irrigated crop is 84 HP hours/acre in comparison to 432 HP hours/acre in FMI. Consequently, Sprinkle irrigation saves about 81% of the water.

Table 6 Water consumption in Sprinkle and Flood irrigated Wheat in Bhiwani

Particulars	**SMI**	**FMI**	**Change over SMI**		**Test of significance of mean value**
			Absolute	Percent	
Pump set HP	7	8	-1	-12.5	**
Number of irrigation/acres	6	6	0	0	NSD
Hours required per irrigation/acre	2	9	-7	-77.7778	**
HP hours of water used/acre	84	432	-348	-80.5556	**
Source: Field survey. ** - Significant difference at 5% level; NSD - No Significant Difference.					

The findings of the "t" test demonstrate that there is a considerable difference between DMI and FMI in HP of pumpset used in Wheat production. The findings revealed no significant difference in the number of irrigation in Wheat production. The research region exhibits substantial differences in the number of irrigation hours for each turn, as indicated by the results of the "t" test. Using the "t" test to analyze the HP hours of water usage under DMI and FMI, it is discovered that there is a statistically significant difference between the two.

4.2 Agricultural water usage by farmers using various irrigation systems in Rewari

This section covers the agricultural water usage by farmers using irrigation systems in Rewari on the basis of various crops. Irrigation systems include Drip Irrigation System (DMI), Flood Irrigation System (FMI) and Sprinkle Method of Irrigation (SMI). Crops used are Cotton, Mustard, Pearl Millets, Sugarcane, Wheat and Rice.

4.2.1 Water consumption in Sprinkle and Flood irrigated Cotton in Rewari

Table 7 compares water usage in SMI and FMI. Although the numbers of irrigations are higher with SMI, the time spent on each irrigation is less; 12 hours/acre in comparison to 22 hours/ acre under FMI. Thus, the total water usage for sprinkle-irrigated crops is 306 HP hours/acre as against 831.6 HP hours/acre in FMI. As a result, sprinkle irrigation saves about 63% of the water.

Table 7 Water consumption in Sprinkle and Flood irrigated Cotton in Rewari

Particulars	SMI	FMI	Change over FMI		Test of significance of mean value
			Absolute	Percent	
Pumpset HP	8.5	14	-5.5	-39.28571429	**
Number of irrigation/acres	3	2.7	0.3	11.11111111	**
Hours required per irrigation/acre	12	22	-10	-45.45454545	**
HP hours of water used/acre	306	831.6	-525.6	-63.2034632	**
Source: Field survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Cotton production in Rewari. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.2.2 Water consumption in Sprinkle and Flood irrigated Mustard in Rewari

Table 8 analyzed water usage in SMI versus FMI. Although the numbers of irrigations are higher with SMI, the time spent on each irrigation session (in terms of hours used) is less; 12 hours/acre in comparison to 17.5 hours/ acre under FMI. Consequently, the total water used for sprinkle-irrigated crops is 306 HP hours/acre as against 490 HP hours/acre in FMI. As a result, sprinkle irrigation saves about 38% of the water.

Table 8 Water consumption in Sprinkle and Flood irrigated Mustard in Rewari

Particulars	SMI	FMI	Change over FMI		Test of significance of mean value
			Absolute	Percent	
Pumpset HP	8.5	14	-5.5	-39.28571429	**
Number of irrigation/acres	3	2	1	50	**
Hours required per irrigation/acre	12	17.5	-5.5	-31.42857143	**
HP hours of water used/acre	306	490	-184	-37.55102041	**
Source: Field survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Mustard production in Rewari. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.2.3 Water consumption in Sprinkle and Flood irrigated Pearl Millet in Rewari

Table 9 compares and examines water usage in SMI and FMI. Although the numbers of irrigations are higher with SMI, the time spent in each irrigation is less; 12 hours/acre compared to 17.5 hours/ acre with FMI. In other words, the total water usage for sprinkle-irrigated crops is 204 HP hours/acre in comparison to 245 HP hours/acre

in FMI. Consequently, sprinkle irrigation saves about 17% of the water.

Table 9 Water consumption in Sprinkle and Flood irrigated Pearl Millet in Rewari

Particulars	SMI	FMI	Change over FMI		Test of significance of mean value
			Absolute	Percent	
Pumpset HP	8.5	14	-5.5	-39.28571429	**
Number of irrigation/acres	2	1	1	100	**
Hours required per irrigation /acre	12	17.5	-5.5	-31.42857143	**
HP hours of water used/acre	204	245	-41	-16.73469388	**
Source: Field survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Pearl Millet production in Rewari. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference

4.2.4 Water consumption in Flood irrigated Rice in Rewari

Table 10 identifies FMI used in the Rice. Number of Irrigation/acres is 15. Hours required per irrigation/acre are 20 HP. As a result, total water used in Rice is 3450 HP. Main point is that no one used the drip and sprinkle method of irrigation in Rice.

Table 10 Water consumption in Flood irrigated Rice in Rewari

Particulars	FMI
Pump set HP	11.5
Number of irrigation/acres	15
Hours required per irrigation/acre	20
HP hours of water used/acre	3450
Source: Field Survey	

4.2.5 Water consumption in Sprinkle and Flood irrigated Wheat in Rewari

Table 11 compares water usage in SMI versus FMI. Although the numbers of irrigations are higher with SMI, the duration of hours used for each irrigation is less; 12 hours/acre in comparison to 17.5 hours/ acre with FMI. Therefore, the total water used for sprinkle-irrigated crops is 714 HP hours/acre as against 1347.5 HP hours/acre in FMI. That is to say, sprinkle irrigation saves about 47% of the water.

Table 11 Water consumption in Sprinkle and Flood irrigated Wheat in Rewari

Particulars	SMI	FMI	Change over FMI		Test of significance of mean value
			Absolute	Percent	
Pumpset HP	8.5	14	-5.5	-39.28571429	**

Number of irrigation/acres	7	5.5	1.5	27.27272727	**
Hours required per irrigation/acre	12	17.5	-5.5	-31.42857143	**
HP hours of water used/acre	714	1347.5	-633.5	-47.01298701	**
Source: Field survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Wheat production in Rewari. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.3 Agricultural water usage by farmers using various irrigation systems in Sirsa

This section covers the agricultural water usage by farmers using irrigation systems in Sirsa on the basis of various crops. Irrigation systems include Drip Method of Irrigation (DMI), Flood Method of Irrigation (FMI) and Sprinkle Method of Irrigation (SMI). Crops used are Cotton, Mustard, Pearl Millets and Wheat.

4.3.1 Water consumption in Flood irrigated Cotton in Sirsa

Table 12 compares water use in Canal and Borewell in FMI. From the information available, we can say that, the numbers of irrigations are higher with borewell, the duration of hours used for each irrigation is more; 7.5 hours/acre in comparison to 1.9 hours/ acre with Canal irrigation. As a result, the total water usage under canal irrigated crops is 79.04 HP hours/acre as against 432 HP hours/acre in Borewell. Therefore, canal irrigation saves about 81 % of the water.

Table 12 Water consumption in Flood irrigated Cotton in Sirsa

Particulars	**FMI**		**Change over Borewell**		**Test of significance of mean value**
	Canal	**Borewell**	**Absolute**	**Percentage**	
Pump set HP	8	9.6	-1.6	-16.6667	**
Number of irrigation/acres	5.2	6	-0.8	-13.3333	**
Hours required per irrigation/acre	1.9	7.5	-5.6	-74.6667	**
HP hours of water used/acre	79.04	432	-352.96	-81.7037	**
Source: Field Survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Cotton production in Sirsa. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.3.2 Water consumption in Flood irrigated Mustard in Sirsa

Table 13 compares water use in Canal and Borewell in FMI. Although the numbers of irrigations are same with borewell, the number of hours used for each irrigation is more; 7.5 hours/acre in comparison to 1.9 hours/ acre with Canal. Therefore, the total water usage for canal irrigated crops is 30.04 HP hours/acre as against 144 HP

hours/acre in Borewell irrigation. That is to say, canal irrigation saves about 78 % of the water.

Table 13 Water consumption in Flood irrigated Mustard in Sirsa

Particulars	FMI		Change over Borewell		Test of significance of mean value
	Canal	Borewell	Absolute	Percentage	
Pump set HP	8	9.6	-1.6	-16.6667	**
Number of irrigation/acres	2	2	0	0	NSD
Hours required per irrigation/acre	1.9	7.5	-5.6	-74.6667	**
HP hours of water used/acre	30.4	144	-113.6	-78.8889	**
Source: Field Survey. ** - Significant difference at 5% level; NSD - No Significant Difference.					

The "t" test findings demonstrate that there is a no considerable difference between DMI and FMI in the number of irrigation applied but substantial difference in HP of Pump set used in Mustard production in Sirsa. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.3.3 Water consumption in Flood irrigated Pearl Millet in Sirsa

Table 14 compares water use in Canal and Borewell in FMI. Although the numbers of irrigations are less with Borewell, the time spent on each irrigation session (hours used per irrigation) is more; 7.5 hours/acre in comparison to 1.9 hours/ acre with Canal. Consequently, the total water used for canal irrigated crops is 22.8 HP hours/acre as against 100.8 HP hours/acre in Borewell. As a result, canal irrigation saves about 77 % of the water.

Table 14 Water consumption in Flood irrigated Pearl Millet in Sirsa

Particulars	FMI		Change over Borewell		Test of significance of mean value
	Canal	Borewell	Absolute	Percentage	
Pump set HP	8	9.6	-1.6	-16.6667	**
Number of irrigation/acres	1.5	1.4	0.1	7.142857	**
Hours required per irrigation /acre	1.9	7.5	-5.6	-74.6667	**
HP hours of water used/acre	22.8	100.8	-78	-77.381	**
Source: Field Survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Pearl Millet production in Sirsa. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.3.4 Water consumption in Flood irrigated Wheat in Sirsa

Table 15 compares water use in Canal and Borewell in FMI. Although the numbers of irrigations are more with borewell, the duration of hours utilized for each irrigation is more; 7.5 hours/acre in comparison to 1.9 hours/ acre with Canal. Therefore, the total water used for canal irrigated crops is 68.4 HP hours/acre as against 403.2 HP hours/acre in Borewell. As a result, canal irrigation saves about 83 % of the water.

Table 15 Water consumption in Flood irrigated Wheat in Sirsa

Particulars	FMI		Change Over Borewell		Test of significance of mean value
	Canal	Borewell	Absolute	Percentage	
Pump set HP	8	9.6	**	-16.6667	**
Number of irrigation/acres	4.5	5.6	**	-19.6429	**
Hours required per irrigation /acre	1.9	7.5	**	-74.6667	**
HP hours of water used/acre	68.4	403.2	**	-83.0357	**
Source: Field Survey. ** - Significant difference at 5% level					

The "t" test findings demonstrate that there is a considerable difference between DMI and FMI in the amount of irrigation applied and HP of Pump set used in Wheat production in Sirsa. The findings of the "t" test indicate that there are notable differences in the number of irrigation hours for every turn in the studied area. Water usage under DMI and FMI is analyzed using the "t" test, revealing a statistically significant difference.

4.4 Agricultural water usage by farmers using various irrigation systems in Yamunanagar

This section covers the agricultural water usage by farmers using irrigation systems in Yamunanagar on the basis of various crops. Irrigation systems include Drip Method of Irrigation (DMI), Flood Method of Irrigation (FMI) and Sprinkle Method of Irrigation (SMI). Crops used are Maize, Mustard, Rice, Sugarcane and Wheat.

4.4.1 Water consumption in Flood irrigated Maize in Yamunanagar

Table 16 identifies FMI used in the Rice. Number of Irrigation/acres is 4. Hours required per irrigation/acre are 3 HP. As a result, total water used in Maize is 75.6 HP. Main point is that no one used the drip and sprinkle method of irrigation in Maize.

Table 16 Water consumption in Flood irrigated Maize in Yamunanagar

Particulars	FMI
Pump set HP	6.3
Number of irrigation/acres	4
Hours required per irrigation/acre	3
HP hours of water used/acre	75.6

Source: Field Survey

4.4.2 Water consumption in Flood irrigated Mustard in Yamunanagar

Table 17 identifies FMI used in the Rice. Number of Irrigation/acres is 3.9. Hours required per irrigation/acre are 3 HP. As a result, total water used in Mustard is 73.71 HP. Main point is that no one used the drip and sprinkle method of irrigation in Mustard.

Table 17 Water consumption in Flood irrigated Mustard in Yamunanagar

Particulars	**FMI**
Pump set HP	6.3
Number of irrigation/acres	3.9
Hours required per irrigation/acre	3
HP hours of water used/acre	73.71
Source: Field Survey	

4.4.3 Water consumption in Flood irrigated Rice in Yamunanagar

Table 18 identifies FMI used in the Rice. Number of Irrigation/acres is 57. Hours required per irrigation/acre are 3 HP. As a result, total water used in Rice is 1077.3 HP. Main point is that no one used the drip and sprinkle method of irrigation Rice.

Table 18 Water consumption in Flood irrigated Rice in Yamunanagar

Particulars	**FMI**
Pump set HP	6.3
Number of irrigation/acres	57
Hours required per irrigation/acre	3
HP hours of water used/acre	1077.3
Source: Field Survey	

4.4.4 Water consumption in Flood irrigated Sugarcane in Yamunanagar

Table 19 identifies FMI used in the Rice. Number of Irrigation/acres is 22.8. Hours required per irrigation/acre are 3 HP. As a result, total water used in Sugarcane is 430.92 HP. Main point is that no one used the drip and

sprinkle method of irrigation Sugarcane.

Table 19 Water consumption in Flood irrigated Sugarcane in Yamunanagar

Particulars	FMI
Pump set HP	6.3
Number of irrigation/acres	22.8
Hours required per irrigation/acre	3
HP hours of water used/acre	430.92
Source: Field Survey	

4.4.5 Water consumption in Flood irrigated Wheat in Yamunanagar

Table 20 identifies FMI used in the Rice. Number of Irrigation/acres is 5. Hours required per irrigation/acre are 3 HP. As a result, total water used in Wheat is 94.5 HP. Main point is that no one used the drip and sprinkle method of irrigation Wheat.

Table 20 Water consumption in Flood irrigated Wheat in Yamunanagar

Particulars	FMI
Pump set HP	6.3
Number of irrigation/acres	5
Hours required per irrigation/acre	3
HP hours of water used/acre	94.5
Source: Field Survey	

Conclusions

Prioritizing the management and reduction of water usage is essential, ensuring that agricultural production remains unaffected. This study aims to identify the agricultural water usage by farmers employing various irrigation systems. The study indicated that utilizing sprinkle or drip irrigation methods instead of flood irrigation for crops like Maize, Cotton, Mustard, Pearl Millets, and Wheat can result in water savings ranging from 30 percent to 80 percent. This demonstrates that conserved water can be utilized for various applications, including household use, additional agricultural endeavors, and industrial processes. Conversely, in crops such as rice and sugarcane, farmers exclusively utilize the flood method of irrigation. It indicates that either these crops are unsuitable for drip and sprinkle irrigation methods, there is a significant demand for hybrid seeds or mechanisms that enable these crops to utilize less water, or farmers should consider alternative crops.

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