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IMPACTS OF MICRO IRRIGATION TECHNOLOGIES IN MAHARASHTRA

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ABSTRACT

There is an urgent need for targeted policies and innovative strategies to be framed to popularise micro-irrigation technologies. Promotion and adoption of micro-irrigation technology in the farming sector pause persistent challenges that threaten its widespread adoption, like high implementation costs, the intricate nature of the technology, and the nuanced interplay of socio-economic factors that stand out as formidable barriers. If left unaddressed, these challenges pose significant obstacles to the broader integration of micro-irrigation. In Maharashtra, adopting Micro-Irrigation Systems (MIS) resulted in significant cost savings for farmers. Farming activity involves several other costs involved such as encompassing seed, planting material, Farm Yard Manure, and fertilizer expenses, alongside notable reductions in chemical and pesticide costs, substantial water savings, decreased labor, and machine hours. A secondary research conducted in Maharashtra on the significance of micro irrigation technology has revealed that, by following micro-irrigation, farmers are getting benefits of increased crop yields, enhanced water use efficiency, and economic gains, emphasizing its transformative potential in modern agricultur.

INTRODUCTION

Addressing the challenge of escalating groundwater scarcity and persistent depletion of groundwater resources in various states requires a dual approach—focused on both the supply and demand aspects of water management. Given that the agricultural sector accounts for approximately 80% of total water consumption in India, a pivotal strategy involves curtailing the overall demand for water to align it with anticipated future supplies. This approach aims to mitigate the extent of water stress that the country is anticipated to confront, as emphasized by Kumar (2003).

Implementing measures to augment water supply, such as the completion of storage dams, interlinking of rivers, desalination of seawater, and artificial recharge of groundwater, as well as the promotion of rainwater harvesting, represents substantial and long-term initiatives. In contrast, a suite of demand management strategies, including water pricing, the establishment of water users' associations, and turnover systems, has been introduced since the late 1970s. These strategies aim to enhance water-use efficiency and have emerged as crucial components in the comprehensive approach to managing scarce water resources, as highlighted by Molden et al. (2001).

Drip irrigation stands out as a highly efficient method of irrigation, as highlighted by Keller and Blisner (1990). The efficacy of micro-irrigation technologies in conserving water is subject to two contrasting perspectives. Firstly, proponents argue that the adoption of these technologies results in net water savings, offering a solution to prevailing water scarcity issues. The reduction in losses attributed to evaporation and inefficiencies in field conveyance and distribution systems serves as a primary mechanism for achieving water savings. This rationale has driven state governments in India to actively promote the widespread adoption of micro-irrigation technologies. However, farmers' motivations for embracing these technologies may differ from the policy objectives of the state. Farmers might prioritize other attributes of micro-irrigation technologies, such as increased yield, reduced labor requirements, and improved output quality, in their decision-making.

The second perspective reveals that while micro-irrigation technologies can indeed save water at the plot or field level, this may not necessarily translate into net water savings at a higher level of aggregation, such as the watershed or basin (Molden et al., 2001; Naryanmoorti et al., 1997). According to this viewpoint, net water savings could be only modest, especially considering the phenomenon of return flows, a significant portion of which contributes to recharging underground water sources. Consequently, the adoption of micro-irrigation technologies may not automatically lead to water savings at the basin level unless there are institutional and economic policy instruments in place to ensure the equitable distribution or allocation of the saved water.

REVIEW OF LITERATURE

The literature review on the impacts of micro-irrigation technologies reveals that these technologies are often advocated for several key objectives. Firstly, they are positioned as a crucial means of water conservation in irrigated agriculture to address the impending water crisis (Narayanamoorthy, 2003; Verma, 2004). Secondly, micro-irrigation is promoted as a strategy to increase income and alleviate poverty among rural communities. Additionally, it is identified as a tool to enhance the food and nutritional security of rural households, especially through the cultivation of vegetables (Upadhyay, 2003; 2004).

Research reveals that the adoption of micro-irrigation technologies has been associated with poverty reduction, primarily driven by increased farm income resulting from expanded cultivation areas, improved crop yields, enhanced output quality, early crop maturity, and reduced cultivation costs, especially for tasks like irrigation and weeding (Dhawan 2022). Micro-irrigation technology also contributes to nutritional security by enabling the production and consumption of vegetables, addressing dietary gaps in traditional staple diets.

Research highlights that, in terms of demand management mechanisms, micro-irrigation, including drip and sprinkler irrigation, demonstrates superiority over traditional methods, showcasing benefits such as increased water use efficiency, energy savings, and yield improvements (Kumar and Palanisami, 2010). Sprinkler irrigation, in particular, creates a favorable microclimate for crop growth, leading to higher crop yield and water use efficiency (Yang et al., 2000).

Drip irrigation stands out for cost reduction in labor-intensive operations like plowing and weeding, while effectively addressing environmental issues associated with surface irrigation, such as waterlogging and salinity (Narayanamoorthy, 2005; 1997). Drip irrigation contributes to water conservation, increased water-use efficiency, decreased tillage requirements, higher product quality, enhanced crop yields, and improved fertilizer-use efficiency (Qureshi et al., 2001; Namara et al., 2005). Evidence suggests that water-use efficiency can increase up to 100% in well-designed and managed drip irrigation systems (Sivanappan, 1994). However, despite these advantages, only a few states in India, including Andhra Pradesh, Maharashtra, and Tamil Nadu, have adopted significant areas under micro-irrigation. Farmers are motivated to adopt drip irrigation due to the enhanced marginal productivity of water, water-use savings, and increased net returns per unit volume of groundwater (Chandrakanth et al., 2013).

The impact of micro-irrigation technologies on various crops has been extensively explored in a multitude of studies, providing valuable insights into the potential benefits and challenges associated with their adoption.

Some case studies of farmers post installation of micro-irrigation systems are as given below:-

BHASKAR *ET AL.* (2005) - MAHARASHTRA, INDIA:

Examining the impact of micro-irrigation on cotton crops, Bhaskar et al. revealed substantial yield improvements across different crops. Notably, cotton, castor, groundnut, and potato exhibited yield enhancements ranging from 15% to an impressive 66%.

BAHINIPATI AND VISWANATHAN (2016) - GUJARAT, WESTERN INDIA:

Focusing on the role of institutions and policies in micro-irrigation diffusion, this study highlighted the dynamism observed in Gujarat due to specific policies and institutional innovations. The state's approach, including targeted subsidies based on socio-economic status, contributed to the notable expansion of micro-irrigation compared to other regions.

KIRUTHIKA (2014) - TAMIL NADU, INDIA:

Examining the determinants of drip irrigation adoption in sugarcane cultivation, Kiruthika found that younger farmers and those with access to extension services were more likely to adopt drip irrigation. This underscores the importance of addressing demographic and outreach factors in promoting micro-irrigation technologies.

PALANISAMI *ET AL.* (2011) - NINE STATES, INDIA:

Studying the spread and economics of micro-irrigation in India, Palanisami et al. identified barriers to adoption, including high costs, technological complexity, and socio-economic issues like credit access and land fragmentation. The study emphasized the need for reduced capital costs and enhanced technical expertise for wider adoption.

REDDY *ET AL.* (2017) - GUNTUR, ANDHRA PRADESH:

Evaluating drip irrigation systems in selected villages, Reddy et al. highlighted significant benefits for farmers, including increased land cultivation and reduced operational costs. The adoption of drip irrigation led to a substantial improvement in both economic and agricultural aspects.

FUTURE PROSPECTS OF MICRO IRRIGATION IN INDIA (2016):

A strategy paper emphasized the pivotal role of micro-irrigation in accelerating agricultural growth in India. The paper underscored the technology's potential to increase productivity while conserving water, positioning micro-irrigation as a key player in the future of Indian agriculture.

IRFAN *ET AL.* (2014):

Evaluating different irrigation systems' impact on maize production, Irfan et al. concluded that drip irrigation was more efficient for saline water. The study recommended adopting drip irrigation in areas with marginal to hazardous groundwater quality for higher crop production and water use efficiency.

KUMAR *ET AL.* (2016) - MORADABAD, U.P.:

Investigating the effect of drip irrigation on brinjal yield and water use efficiency, Kumar et al. found that optimal water use efficiency was achieved at a 65% irrigation level. The study highlighted the potential water-saving benefits of drip irrigation in brinjal cultivation.

NAMARA *ET AL.* (2005) - MAHARASHTRA AND GUJARAT, INDIA:

Examining the adoption and impacts of micro-irrigation technologies, Namara et al. concluded that micro-irrigation increased the marginal productivity of water, contributing to more efficient water use

PAUL *ET AL.* (2013) - BHUBANESWAR, INDIA:

Assessing the effect of drip and surface irrigation on capsicum yield, Paul et al. reported significant yield increases with drip irrigation. The net profit was also substantially higher, emphasizing the economic advantages of adopting drip irrigation.

WRACHIENB *ET AL.* (2014) - MAHARASHTRA, INDIA:

Analyzing the potential of micro-irrigation for poor rural communities, Wrachienb et al. found increased productivity for banana, grapes, and sugarcane with micro-irrigation. The study highlighted the economic benefits and resource efficiency associated with micro-irrigation.

BHAMORIYA AND MATHEW (2014) - GUJARAT, INDIA:

Analyzing the impact of micro-irrigation technology in Gujarat, Bhamoriya and Mathew reported increased vegetable yields and improved produce quality with drip irrigation. Farmers were able to command higher prices for their yield, showcasing the economic advantages.

CHANDRAKANTH *ET AL.* (2013) - KARNATAKA, INDIA:

Examining the economic benefits of micro-irrigation for dryland crops, Chandrakanth et al. observed a substantial increase in net returns per farm and marginal productivity of water with drip irrigation.

CHANDRAN & SURENDRAN (2016) - KERALA, INDIA:

Investigating factors influencing drip irrigation adoption in humid tropical Kerala, Chandran & Surendran found that socio-economic characteristics positively influenced adoption. Yield improvements ranging from 13% to 47% were observed across different crops.

PANIGRAHI *ET AL.* (2010) - ODISHA, INDIA:

Examining water use and yield response of tomato under drip and furrow irrigation, Panigrahi et al. revealed that drip irrigation could increase tomato yield by 15.4% while saving 17.9% more water compared to furrow irrigation.

PRIYAN AND PANCHAL (2017) - INDIA:

Investigating the benefits of micro-irrigation technology in India, Priyan and Panchal reported increased yield, improved water use efficiency, and reduced costs associated with water, fertilizers, and weed removal. The study highlighted the overall economic benefits of optimized water utilization.

TIWARI *ET AL.* (2014) - KHARAGPUR, INDIA:

Examining the influence of drip irrigation and plastic mulch on Sapota yield and soil nutrients, Tiwari et al. reported positive effects on Sapota growth and yield. Drip irrigation and mulching contributed to increased yields compared to traditional irrigation methods.

NARAYANAMOORTHY (2008) - MAHARASHTRA, INDIA:

Investigating the nexus between drip irrigation and rainfed crop cultivation, Narayanamoorthy found that drip irrigation reduced electricity consumption by about 140 Kwh/acre compared to conventional irrigation. The economic analysis revealed significant impacts on resource savings, cultivation costs, crop yields, and farm profitability.

SURESH KUMAR & PALANISAMI (2010):

The analysis of the economics of crop cultivation under drip and conventional irrigation methods revealed a significant impact on resource savings, cost of cultivation, crop yields, and farm profitability.


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RESULT AND DISCUSSION

The efficacy of various micro-irrigation technologies in achieving water conservation, energy efficiency, input optimization, and their impact on employment and income has been analyzed based on case studies and recent scientific reports. Table 1 offers a comprehensive overview of the advantages associated with micro-irrigation, as documented by researchers in previous studies.

Table 1: State wise review of studies on micro-irrigation conducted by different researchers

Studies and Sources	Study Area/ region	Water saving (%)	Yield increased/ Income (%)	Additional area under irrigation(%)	
Rahul Kapur et al. 2015	Maharashtra	50 to 90	42.4 to 52.7	31.9	30 to 45 &30.4
Narayanamoorthy, 2008, 2006	Maharashtra	12 to 84 &8-60	114		50
Wrachienb et al, 2014	Maharashtra	37	19 to 29		
Bhaskar et al, 2005	Maharashtra	40 to 50	30 to 100		
Reddy et al., 2017	Guntur District, AP			55 to 60	25 to 40
Paul et al, 2013	Bhubaneswar, Odisha		57	54	
Tiwari et al, 2014	Kharagpur, W.B.		21.05		
Kumar et al, 2016	Moradabad,Uttar Pradesh	35			
Chandrakanth et al, 2013	Karnataka		65		
Panigrahi et al, 2010	Odisha		15.4		17.9
Chandran & Surendran, 2016	Kerala		13 to 47		
Bhamoriya and Mathew,2014	Gujarat		20 to 30		
Sharda R et.al, 2017	Punjab	40 to 42	9.13		
Govind, R et. al. 2012 Vanitha & Mohandass,2014	Tamil Nadu	50	19.05		

Rao, KVR.,2017	MP		11.03		
AICRP-IWM 2016	MP	33	10		
National Mission on Micro MIS, Impact study for the Govt. of India, June 2014	India	22.96 to 42.73	19.37 to 73.48	32.6 to 68.02	
Raina et al, 2011	India	30 to 35			41.37
Priyan & Panchal, 2017	India	50-90			
Global Agri. System and their Impact EvaluationStudy, 2014	India	20 to 40	20 to 25		
National committee on plasticulture application in horticulture, (https://www.ncpahindia.com)	India	25 to 40	30	30	40
Chand.S, 2019	India	17 to 50	12 to 43		11 to 36

The majority of these investigations demonstrate noteworthy savings in water, energy, and fertilizers, accompanied by increased yields, expanded crop areas, and an overall reduction in production costs attributable to the adoption of micro-irrigation techniques. Nevertheless, it is essential to recognize that the magnitude of these benefits fluctuates based on various factors, including differences in methodology, farming systems, climatic conditions, socio-economic contexts, and other pertinent variables. The National Committee on Plasticulture Applications in Horticulture (NCPAH) conducted extensive experimental studies and observed that different crops exhibit distinct input savings when subjected to micro-irrigation, specifically through drip and sprinkler systems (Table.2).

STATUS OF MICRO-IRRIGATION IN MAHARASHTRA

In the state of Maharashtra, an in-depth analysis was conducted by ICAR- National Institute of Agricultural Economics and Policy Research on Efficiency of Micro-Irrigation in economizing water use in India: Learning from potential and under explored states in May 2019. Study focusing on six major crops cultivated by both adopters and non-adopters of Micro-Irrigation Systems (MIS). The findings reveal substantial economic advantages for adopters, particularly in the realms of cost savings and enhanced productivity.

Comparing adopters to non-adopters, adopters exhibited significant savings in seed and planting material costs, ranging from 4.91% to an impressive 36.31%. Furthermore, the adoption of MIS resulted in noteworthy savings in Farm Yard Manure (FYM) costs, ranging from 2.94% to an astonishing 96.01%. Adopters also experienced substantial fertilizer cost savings, ranging from 12.98% to 52.09%, potentially attributed to the adoption of liquid fertigation practices, leading to reduced quantity requirements.

The economic impact extended to savings in chemical and pesticide costs, with percentages varying from 5.08% to a substantial 50.0%, particularly notable in cotton cultivation. Water savings, a critical aspect, ranged from 16.43% to an impressive 85.81%(ICAR 2020) The adoption of MIS also translated into reduced labor and machine hours, with savings ranging from 8.35% to 51.15% across different crops.

When considering the overall cost savings, adopters experienced reductions ranging from 7.76% to 35.15% across various crops. Importantly, the net returns for adopters demonstrated a substantial increase, varying from 20.95% to an impressive 58.69% across different crops, as highlighted in Table 2. These findings solidify the assertion that the adoption of MIS not only enhances net income but also significantly reduces input costs, showcasing the economic and agronomic benefits of micro-irrigation in the context of Maharashtra.

Table 2: Saving in inputs costs, increase in yield, income adoption of micro irrigation in Maharashtra.

(Percent)

Particulars	Name of crops					
	Cotton	Bajra	Maize	Onion	Soybean	Sugarcane
Seed/Planting material	-32.27	-9.21	19.65	-36.31	-4.91	-11.59
FYM	-2.94	-20.45	-	-10.85	-8.33	-96.01
Fertilizer	-15.04	-22.37	-16.41	-12.98	-36.10	-52.09
Chemical	-50.00	-	-	-5.08	-38.84	-43.66
Irrigation	-27.50	-42.14	-16.43	-85.81	-31.13	-28.33
Labour	-51.15	-12.94	-19.92	-8.25	-25.88	-10.05
Machine use	-35.81	-47.47	-12.67	-7.64	-35.61	-4.22
Total cost	-35.15	-31.31	-7.76	-12.74	-24.08	-17.10
Yields	18.64	17.37	15.56	12.54	8.69	10.01
Net income	35.26	58.69	39.35	20.95	25.88	25.74

Source: Report of ICAR- National Institute of Agricultural Economics and Policy Research on Efficiency of Micro-Irrigation in economizing water use in India: Learning from potential and under explored states (May 2019)

PRESENT STATUS AND PROSPECTUS OF RASHTRIYA KRISHI VIKAS YOJANA - PER DROP MORE CROP MICRO-IRRIGATION SCHEME IN MAHARASHTRA

As per the 'Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) - Per Drop More Crop' micro-irrigation scheme, initiated in 2015-16, the subsidy criteria stand at 55% for small and marginal farmers and 45% for others, limited to a five-hectare area.. As per the records of Economic Survey Maharashtra 2022-23, the micro-irrigation coverage reached approximately 8.86 lakh hectares by 2021-22. In the same year, a subsidy of ₹532.88 crore was disbursed to 2,12,964 eligible farmers, In 2022-23, until October, 4,48,351 applications were received, 3,50,674 farmers were selected via lottery, and subsidy distribution to 83,611 farmers with installed micro-irrigation sets is in progress(Table 3 & Fig1).

Table 3. Sprinkler & drip irrigation sets and subsidy distributed in Maharashtra

anticipated

Year	Sprinkler irrigation sets		Drip irrigation sets		Subsidy(₹ Crore)
	No. of sets	Area (ha)	No. of sets	Area (ha)	
2019-20	77,279	46,538	1,21,979	1,05,190	505.44
2020-21	47,889	35,322	39,655	33,960	163.37
2021-22	1,01,899	66,277	1,11,980	185,534	532.88
2022-23 (Target)	90,482	65,943	1,52,866	1,22,754	666.66#

Source:Commissionerate of Agriculture, Government of Maharashtra, Economic Survey of Maharashtra 2022-23

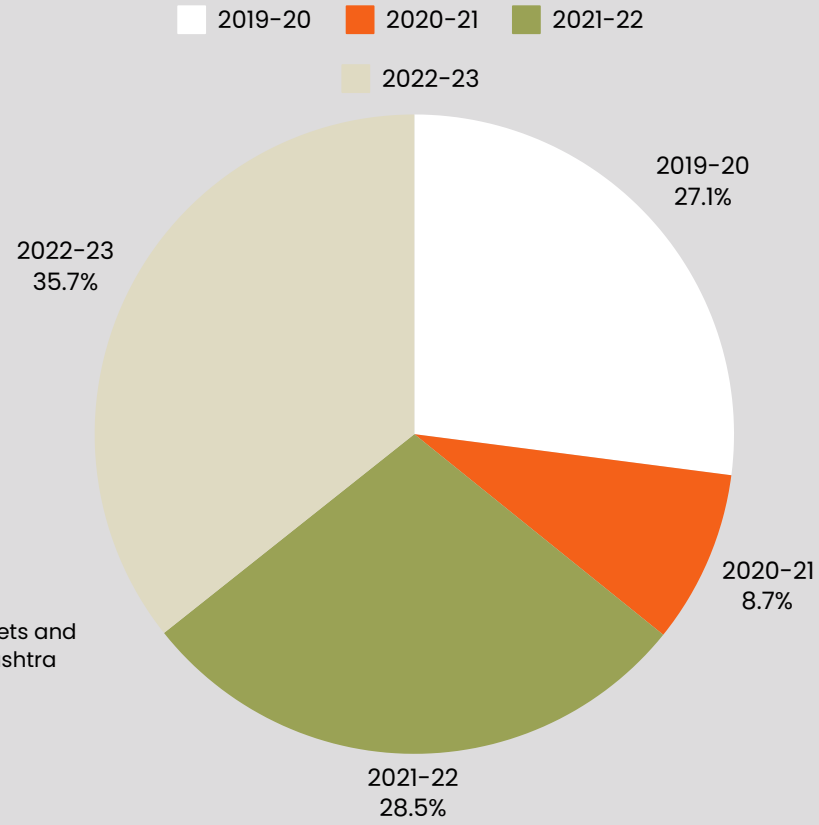

Fig 1. Sprinkler & drip irrigation sets and subsidy distributed in Maharashtra

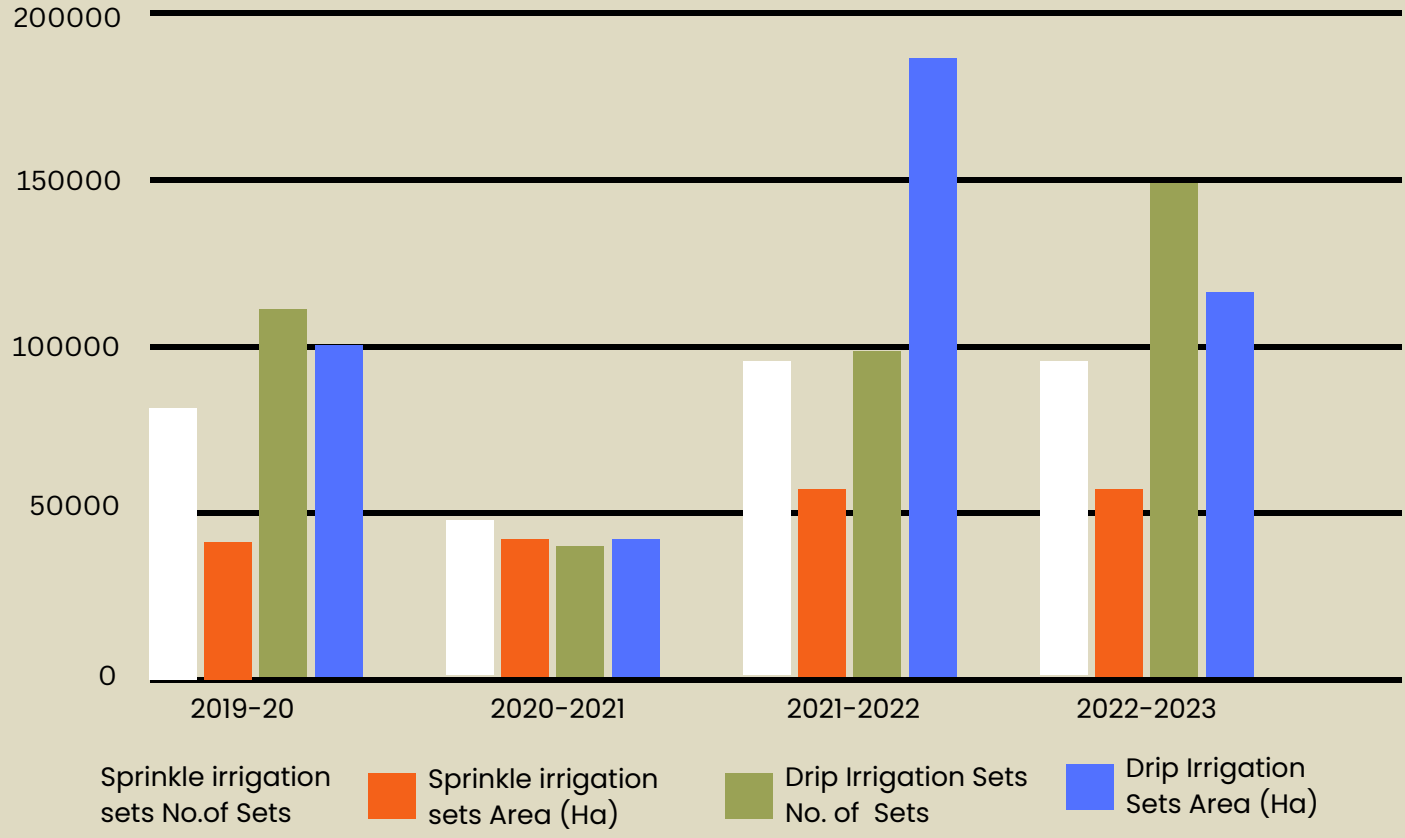

Fig 2. Sprinkler & drip irrigation sets and subsidy distributed in Maharashtra

CONCLUSION

The secondary research conducted had revealed the extensive benefits of micro-irrigation, including increased crop yields, enhanced water use efficiency, and economic gains, emphasizing its transformative potential in modern agriculture. However, formidable challenges, such as high implementation costs and socio-economic intricacies, must be addressed to ensure widespread adoption. Urgent action is needed through targeted policies and innovative strategies that not only mitigate existing challenges but also create an environment conducive to micro-irrigation acceptance. Crucially, unlocking the full potential of micro-irrigation requires dynamic and adaptive approaches, encompassing strategic policies that address economic barriers, simplify technology, and consider socio-economic nuances. Such efforts can surmount obstacles, ushering in sustainable agriculture marked by heightened productivity, resource efficiency, and economic prosperity.

The study on Micro-Irrigation Systems (MIS), conducted in Maharashtra revealed significant economic advantages for the farmers including substantial savings in seed, planting material, Farm Yard Manure, and fertilizer costs. Adopting micro-irrigation resulted in remarkable reductions in chemical and pesticide expenses, water savings ranging from 16.43% to 85.81%, and decreased labor and machine hours. The overall cost savings for adopters ranged from 7.76% to 35.15%, with net returns witnessing a noteworthy increase of 20.95% to 58.69%. This comprehensive analysis solidifies the argument that MIS adoption in Maharashtra not only boosts net income but also markedly reduces input costs, establishing micro-irrigation as an economically and agronomically beneficial practice.

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