Original Research Article

The Mechanization Trend and Economic Prospects of Micro Irrigation in India

Abstract

Agriculture is an important sector of the Indian economy, accounting for nearly 16 percent of the total GDP.Farm mechanization is the backbone of agriculture GDP. The farm mechanization status in India is analyzed by the growth trend of mechanically power-operated farm equipment over traditional human and animal power-operated equipment. Tractor and power tiller machinery are integral parts of farm mechanization. Owing to the development of farm mechanization, people are rapidly adopting precision farming.

Aim: - the study aims to know the growth trend in mechanization in agriculture and the status of micro-irrigation in India.

Duration: - Primary and secondary data were used for the study. Primary data was collected for the year 2022 and secondary was collected from the years 2004-05 to 2021-22.

Methodology: - Compound annual growth rate (CAGR) and correlation were used in the study. Further tabular analysis was performed.

Result:-Farm mechanization has made precision farming even easier. In this study purchasing trend of tractors was computed for 18 years of data from 2004-05 to 2021-22. For this annual growth computation linear trend equation was best with a 0.93 coefficient of determination (R^2) at a 1 percent level of significance. This equation shows a 6.78 percent annual growth in the purchasing pattern of tractors in India. Pearson correlation coefficient was found 0.76, which shows the purchasing trend of tractors and power tillers are highly correlated and significant 1 percent level of significance. Precision farming is a kind of farm management that makes use of information technology to make sure the crop and soil get exactly what they want for maximum health and productivity with minimization of the cost of production. Precision farming is a way to proceed from lower cost of production to higher return. India has two most widespread precision farming techniques under precise micro-irrigationtechniques viz. drip and sprinkler. These precision farming techniques proved to be a blessing in water-scarred areas. In India, medium to large progressive farmers practice precision farming, frequently on a single field, as an experiment, or on commercial farms.Precision farming generates profitable returns if we encourage this for high-value crops like fruits, flowers, vegetables, medicinal and aromatic plants. India has 13476804-hectare area under micro irrigation, in which 46.90 and 53.09 percent contributionsare made by drip and sprinkler respectively.

INTRODUCTION

Agriculture plays a vital role in the Indian economy that accounting for nearby 16 per cent of the total GDP.Farm mechanization is the backbone of agriculture GDP. The Indian agriculture sector has been growing at an average annual growth rate of 4.6 percent during the last six years. This sector grew by 3.0 percent in 2021-22. India produced 315.7 million tonnes of food grains during 2021-22. (Economic Survey 2022). The farm mechanization status in India is analyzed by the growth trend of mechanically power-operated farm equipment over traditional human and animal power-operated equipment. Tractor and power tiller machinery is an integral part of farm mechanization. Owing to the developed farm mechanization, people are rapidly adopting precision farming.Farm mechanization has made precision farming even easier.

Farm mechanization is a Key to Improving the Productivity of the farm. Farm mechanization helps increase productivity through the timely and efficient use of other inputs and natural resources while at the same time reducing the cost of cultivation and the drudgery associated with various farm operations. State governments are assisted as part of the Sub Mission on Agricultural Mechanization (SMAM) to set up Custom Hiring Centers(CHC), train and demonstrate agricultural machines, and aid farmers in buying various farm tools and equipment. As of December 2022, 21628 CHCs 467 Hi-Tech hubs and 18306 farm machinery banks have been established. Increasing fragmentation of farm holdings (with the average size of household ownership holdings declining from 1.23 ha in 2005-06 to 1.10 ha in 2010-11 and further to 1.08 ha in 2015-16) requires machines that are viable and efficient for small farm holdings (Agriculture Statistics at a glance 2021).

Precision farming is a kind of farm management that makes use of information technology to make sure the crop and soil get exactly what they want for maximum health and productivity with minimization of cost of production. Precision farming is a way to proceed from lower cost of production to higher return. India has two most widespread precision farming techniques under precise micro-irrigationtechniques viz. drip and sprinkler. These precision farming techniques proved to be a blessing in water-scarred areas. In India, medium to large progressive farmers practice precision farming, frequently on a single field, as an experiment, or on commercial farms. Precision farming generates profitable returns if we encourage this for high-value crops like fruits, flowers, vegetables, and medicinal and aromatic plants. During the financial year 2020-21, India had13476804 hectare area under micro irrigation, in which 46.90 and 53.09 percentcontributionswere made by drip and sprinkler respectively. In India, Karnataka standsin first position with 2093262 hectare area under micro irrigation followed by Rajasthan, Maharashtra, and Andhra Pradesh with 2018495, 1926304, and 1907291 hectare area respectively.

Drip irrigation (trickle irrigation) has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface.Water is applied directly to the root zone to reduce evaporation. Water is distributed through drip irrigation systems using a series of emitters, pipelines, and valves. Modern drip irrigation has probably grown to be the world's most prized agricultural

innovation. With the development of the impact sprinkler in the 1930s, this provided the first useful alternative to surface irrigation. India has a 6320945-hectare area under drip irrigation in the financial year 2020-21. Andhra Pradesh is the leading state with 1388126 hectare area under drip irrigation and this is followed by Maharashtra and Gujarat with 1349979 and 865959 hectare area.Drip irrigation is adopted extensively in areas of acute water scarcity and is mostly used in farms, commercial greenhouses, and residential gardens.

Sprinkler irrigation is a method of applying irrigation water as similar to natural rainfall. In this system, water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground.Sprinkler irrigation may be used on any farmable slope, whether it is flat or undulating.It is best suited to sandy soils with high infiltration rates although it is adaptable to most soils also. India has a 7155859-hectare area under a sprinkler system. Sprinkler system is used, in large proportion in Rajasthan state due to sandy soil and undulating topography. For what Rajasthan standsin first position with 1730876 hectare area under sprinkler system, followed by Karnataka with 1304281 hectare area during the financial year 2020-21.

RESEARCH METHODOLOGY

The purchasing trend of tractors in India was computed based on the high R^2 (coefficient of determination) and low Root Mean Square Error (RMSE) values, this linear model function was evaluated. The analysis of growth rate was explained using the best-fitted model (Linear trend Equation), one of the growth model functions.

Linear function

$Y= a_0+ a_1 x_1+ \dots + a_n x_n$

Where,

Y = Purchasing of Tractor

a_0 = Constant

β_1=Coefficient factor

x_1 = Year factor

The annual linear growth rate was computed as follows

$$r=\frac{\beta 1}{\bar{y}} X\ 100$$

After fitting the first linear trend function by the least-square method, we get the estimate of β1.

Correlation between the purchasing trend of tractor and power tiller was also computed by using the following formula

$$r = \frac{\sum(xi - x)(yi - y)}{\sqrt{\sum(xi - x)^2(yi - y)^2}}$$

r= Correlation coefficient

Xi = Values of X- variable in the sample

X = mean of the value of x variable

Yi = Values of Y- variable in the sample

Y = mean of the value of Y variable

RESULT AND DISCUSSION

Tractors are a fundamental requirement of farming since they supply the machine power needed to carry out farm tasks. Tractors are used to pull a range of agricultural equipment for plowing, planting, harvesting, and growing crops, in addition to normal landscape maintenance, grass care, removing brush, and fertilizer application. During the year 2004-05, 248 thousand tractors were purchased in India and it was 842 thousand in number during the year 2020-21. Uttar Pradesh stands on first position in purchasing of tractor with 117563 in number. This is followed by Maharashtra and Madhya Pradesh with 104301 and 100551 respectively. In 2020-21, 899000 tractors were purchased in India that shows purchasing peak of the tractors. In this study purchasing trend of tractors was computed for 18 years of data from 2004-05 to 2021-22. For this annual growth computation linear trend equation was best with a 0.93 coefficient of determination (R^2) at a 1 percent level of significance. This equation shows 6.78 percent annual growth in the purchasing pattern of tractors in India. Pearson correlation coefficient was also computed for find out the correlation between the sale of a tractor and a power tiller. Pearson correlation coefficient was found 0.76, which shows the purchasing trend of tractors and power tillers are highly correlated and significant at a 1 percent level of significance.

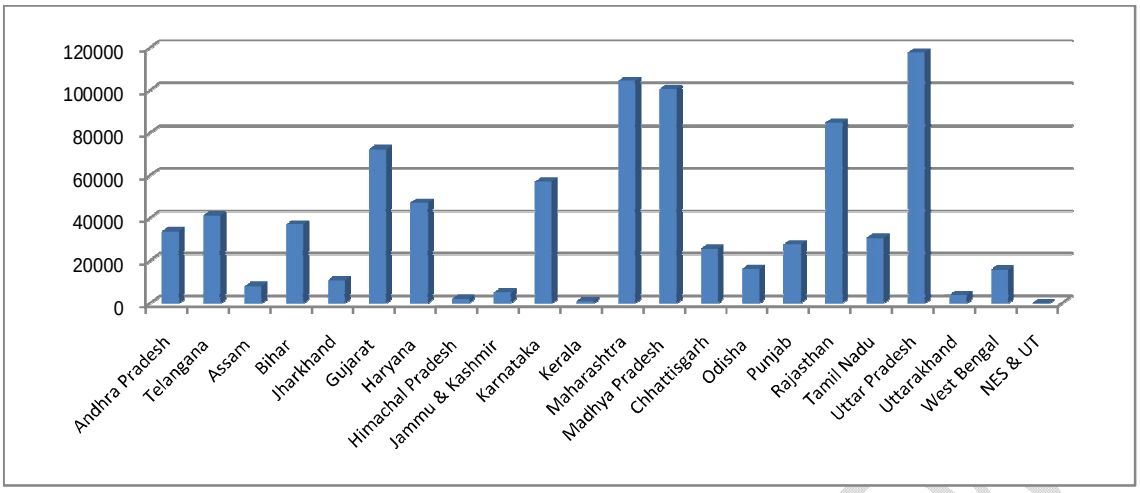

Fig. 1 State-wise Sales of Tractors in India during 2021-22.

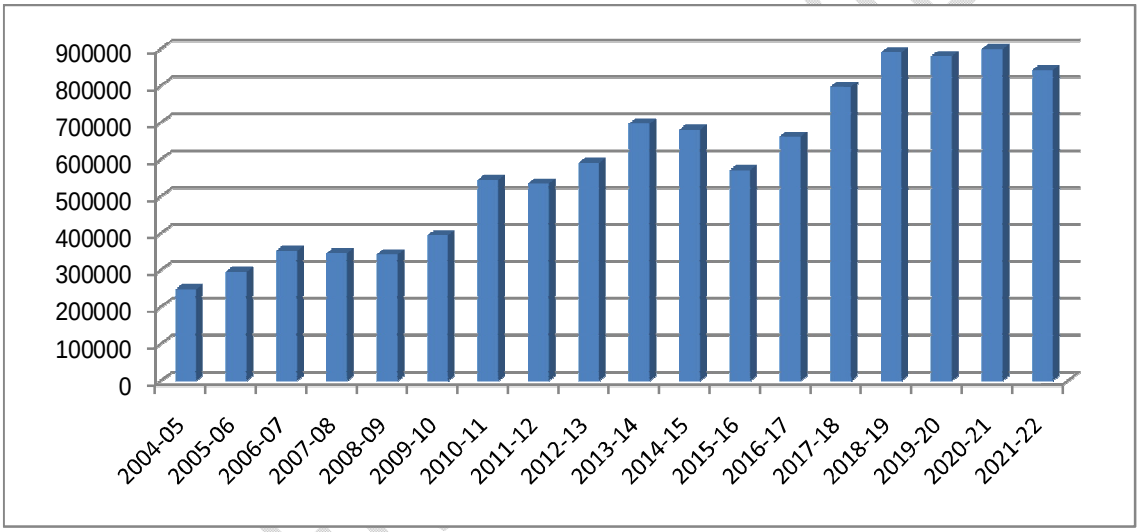

Fig. 2 Year-wise sale of tractors in India

A power tiller is an agricultural implement, fitted with rotary tillers, that is fast gaining traction in the Indian agricultural scene for its multi-purpose uses. Power tillers may be used on both small and big farms, but they are especially suggested for farms with tiny plots of land or rocky, uneven terrain that would make maneuvering a tractor difficult. Power tillers can be used for a variety of tasks in addition to tilling the ground, including plowing, sowing seeds, planting seedlings, adding fertilizer, spraying fertilizer, herbicides, and water, pumping water, harvesting, threshing, and conveying crops. In India during the year 2004-05, 17000 power tillers were purchased; it was purchased 54000 in number during the year 2020-21. 2011-12 was the peak year for purchasing of power tillers*i.e.* 60 thousand.

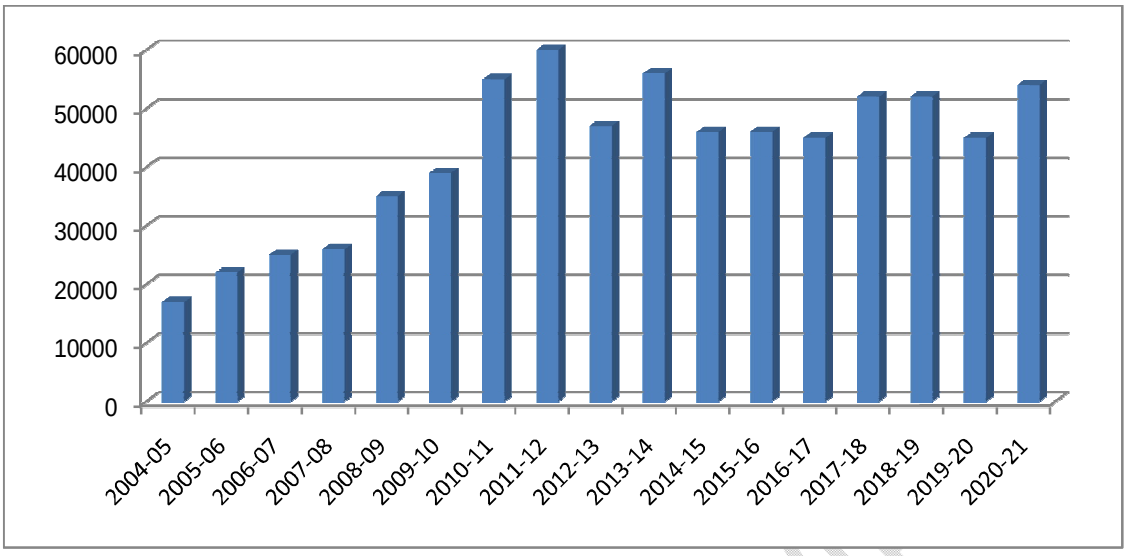

Fig. 3 Year wise sale of Power Tiller in India

Micro Irrigation

Precision farming, also known as site-specific farming, has emerged as a potential combination of technologies that might boost agricultural output while practicing environmental stewardship. With the use of precision farming, farmers can precisely apply the right quantity of seeds, water, pesticides, fertilizer, and other inputs when and where they're needed for the best crop development. Precision farming can boost yields, lower costs, minimize pollution, and improve economic efficiency. It will improve control production process and lead to more efficient use of labour hours, which will raise profits.

Micro irrigation is a modern method of irrigation; by this method water is irrigated through drippers, sprinklers, foggers and by other emitters on surface or subsurface of the land. During the financial year 2020-21, India hada 13476804-hectare area under micro irrigation, in which 46.90 and 53.09 percent were contributions made by drip and sprinkler respectively. In India, Karnataka standsin first position with 2093262 hectare area under micro irrigation followed by Rajasthan, Maharashtra, and Andhra Pradesh with 2018495, 1926304, and 1907291 hectare area respectively.

Table 1 State-wise Area Covered under Micro Irrigation in Hectare (as of 31.03.2021)

Name of the state	**Drip irrigation**	**Sprinkler irrigation**	**TotalMicro irrigation**
Andhra Pradesh	1388126	519165	1907291
Arunachal Pradesh	4017	3494	7511
Assam	4208	16217	20425
Bihar	13763	106979	120742
Chhattisgarh	31311	331283	362594

Goa	1386	1346	2732
Gujarat	865959	764933	1630892
Haryana	40018	600461	640479
Himachal Pradesh	7934	6403	14337
Jammu & Kashmir	1779	280	2059
Jharkhand	17713	17713	43399
Karnataka	788981	1304281	2093262
Kerala	24168	9096	33264
Madhya Pradesh	330335	258600	588935
Maharashtra	1349979	576325	1926304
Manipur	358	7039	7397
Meghalaya	308	307	615
Mizoram	5551	1744	7295
Nagaland	3589	6210	9799
Odessa	29425	115396	144821
Punjab	36416	14055	50471
Rajasthan	287619	1730876	2018495
Sikkim	6667	7943	14610
Tamil Nadu	805282	348010	1153292
Telangana	203279	74871	278150
Tripura	444	1651	2095
Uttar Pradesh	41273	227897	269170
Uttrakhand	12737	10300	23037
West Bengal	10347	92984	103331
Total	**6320945**	**7155859**	**13476804**

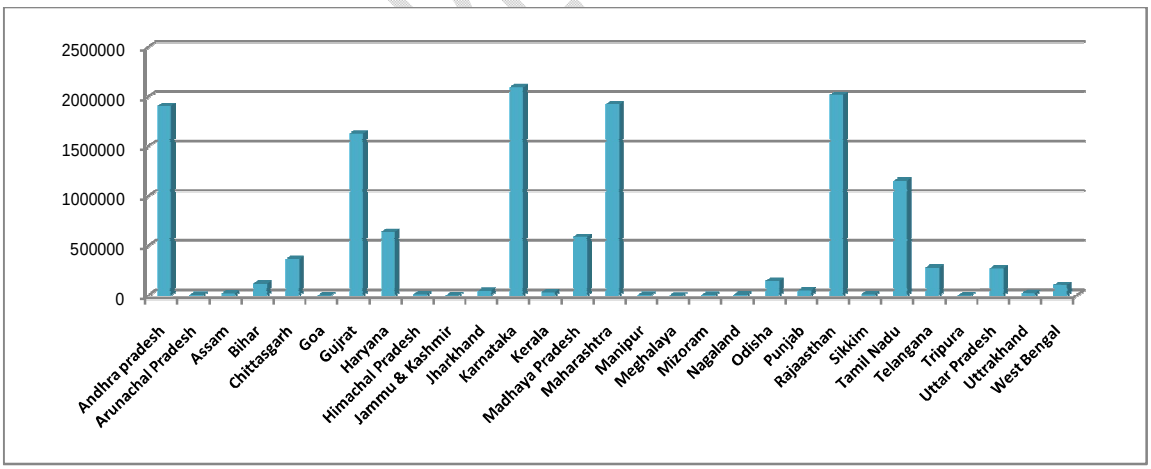

Fig. 4 in India State-wise Area Covered under Micro Irrigation in 2021

Drip Irrigation

A paradigm change in agricultural watering is represented by drip irrigation. India has 6320945 hectare area under drip irrigation in the financial year 2020-21. Andhra Pradesh is the leading state with 1388126 hectare area under drip irrigation and this is followed by Maharashtra and Gujarat with 1349979 and 865959 hectare area. Drip systems are based on

management units including integrated valves and mains and sub-main pipes to control and distribute water to individual plots. Valve-piping combinations can be designed to irrigate pre-determined management zones based either on soil-landscape properties or on plant properties including yield and yield quality following seasonal history of monitoring spatial variability and a subsequent re-designing of the drip system. It has been suggested that, in orchards, irrigation systems should be designed, based on soil variability, from the beginning to achieve variable rate irrigation. The zonal separation criteria are suggested to be soil texture and soil elevation (Gemtos*et al*., 2011).

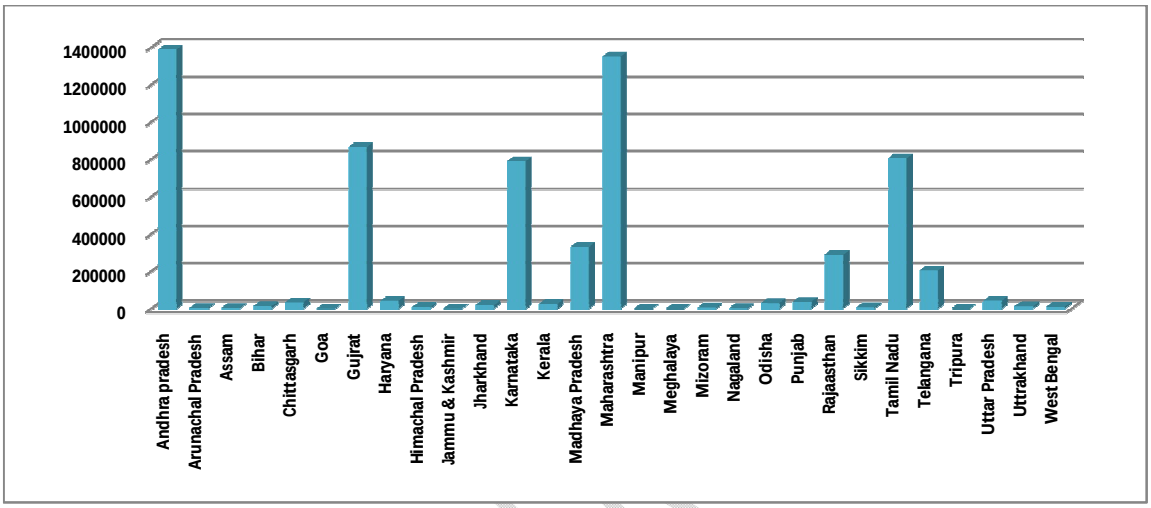

Fig. 5 In India State-wise Area covered under drip Irrigation in 2021

Installation cost of Drip system in India

1 hectare area required 10000 meter square lldpe plain lateral pipe. Farmer mostly used 16 mm drip pipe with 2 kg presser.In-line (emitting pipe) drip pipes have already been installed emitters at 30 to 40 cm distance and the value of this pipe is 8.50 rupees per meter. While on-line (lldpe plain lateral pipe) drip pipesneed to be installed emitters by farmer according to their need and crop. The value of this pipe is 7.20 rupees per meter.Farmer has needed to spend 1.35 to 1.50 lakh per hectare for install drip irrigation system at field.After the installation, govt. of India provides subsidy up to 50-65 percent on the drip system.

Sprinkler System

Precision irrigation meets the demands of plants by enabling the delivery of water and nutrients without wastage, at the proper time, in the proper location, and in the proper quantity. India has a 7155859-hectare area under a sprinkler system. Sprinkler system is used, in large proportion in Rajasthan state due to sandy soil and undulating topography. For what Rajasthan stand on first position with 1730876 hectare area under the sprinkler system, followed by Karnataka with 1304281 hectare area during the financial year 2020-21.Sprinkler irrigation was initially invented for home lawn care and garden water use.But while spray

irrigation technology was originally about personal use, it is such helpful technology that it was rapidly adopted into agriculture as one of the most common types of irrigation systems.

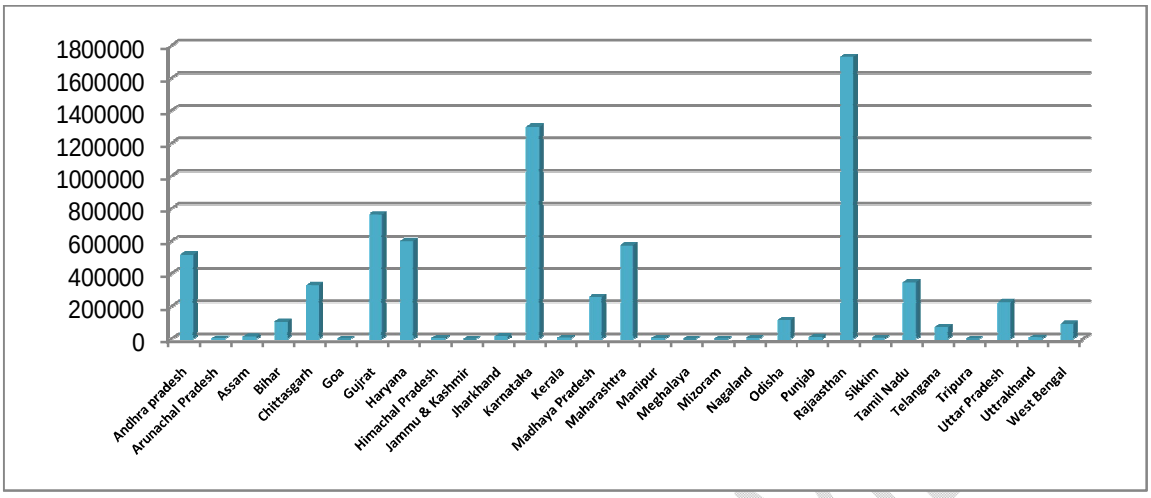

Fig. 6 In India State-wise Area Covered under Sprinkler Irrigation 2021

Installation cost of Basic Sprinkler system in India

Sprinkler system of irrigation is most popular system in India as well as Rajasthan. Rajasthan standsin first position in the area under irrigation through the sprinkler system. The sprinkler system is an economic system for the farmer as well as an environment for saving 40 per cent of water as compare to traditional approaches. Installation cost of this system is also low. 56.74 percent of Installation cost is occupied by pipes and a nearby 20 percent cost is spenton Sprinkler Nozzles. The range of this installation cost may vary according to non-availability of the pump set and main pipe line. Use of a presser gauge filter chamber and water tank also variesfrom region to region.

Table 2 Installation cost of Basic Sprinkler system in India

Component of Sprinkler	Number of Components	Amount of per component in Rupees	Total Amount	Percentage share of Component
Pipe with coupler 6 m. long	20	570	11400	56.74
Sprinkler Nozzles	10	400	4000	19.91
Rizer Pipe	10	110	1100	5.48
Sprinkler coupler with Foot baton	10	225	2250	11.20
Connecting nipple	1	150	150	0.75
Bend with coupler	2	250	500	2.49

T- with coupler	2	275	550	2.74
End Plug	2	70	140	0.70
Basic System cost per Hectare	-	-	20090	100

Irrigated area under principal crops

Irrigation is the artificial application of water to land. Some land requires irrigation before it is possible to use it for any agricultural production. Some land has to be irrigated before it can be used for any type of agricultural output. In other regions, irrigation primarily helps to boost productivity and supplement rainfall. Total cereals crops have the largest area under irrigation. According to the year 2018-19, out of the total area under cereals cultivation, 63 percent area was irrigated. Sugarcane is long duration crop, so it has a strong need for irrigation throughout the year. Out of the total area under sugarcane, 96.6 percent area was irrigated during the year 2018-19. Although most of the pulses are grown in the monsoon season even then 23.2 percent area of total pulses was irrigated. 31.4 per cent area of oilseed, 45.1 per cent of area of cotton and 67.9 per cent area of tobacco were also irrigated during the year 2018-19. If we go for general, 52 percent that is more than half of the total area were irrigated in the same period.

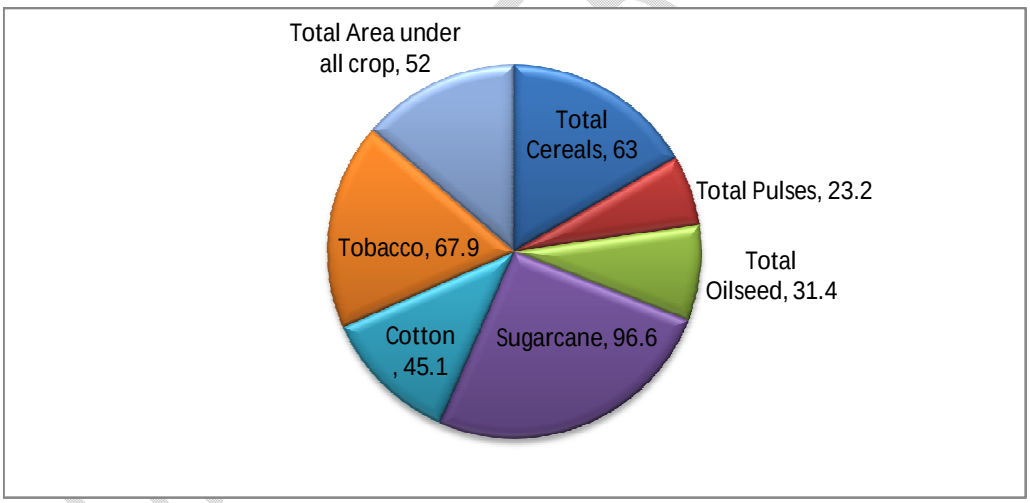

Fig. 7 Percent Coverage of Irrigated Area under Principal Crops during 2018-19 (Provision)

Conclusion and Recommendation

Micro irrigation plays a most important role in conserving water and increasing production. This irrigation system is suitable for all soil types and all agronomic and horticulture crops. This method helps in reducing the cost of labor and field preparation.It has been suggested that, in orchards, irrigation systems should be designed, based on soil variability, from the beginning to achieve variable rate irrigation.An extensionprogram should be implemented for the rapid adoption of such precision farming techniques. Subsidy

may be the best part for enhance the adoption of precision farming. The result shows a 6.78 percent annual growth in the purchasing pattern of tractors in India. Pearson correlation coefficient was found 0.76, which shows the purchasing trend of tractors and power tillers are highly correlated and significant at a 1 percent level of significance.India has two most widespread precision farming techniques under precise micro-irrigationtechniques viz. drip and sprinkler. These precision farming techniques proved to be a blessing in water-scarred areas. During the financial year 2020-21, India had13476804 hectare area under micro irrigation, in which 46.90 and 53.09 percent contributed made by drip and sprinkler respectively. India has a 6320945-hectare area under drip irrigation in the financial year 2020-21. Andhra Pradesh is the leading state with 1388126 hectare area under drip irrigation and this is followed by Maharashtra and Gujarat with 1349979 and 865959 hectare area.India has a 7155859-hectare area under a sprinkler system. The installation cost of a drip system is 1.35 to 1.50 lakh per hectare. Sprinkler system is used, in large proportion in Rajasthan state due to sandy soil and undulating topography. For what Rajasthan stand on first position with 1730876 hectare area under the sprinkler system, followed by Karnataka with 1304281 hectare area during the financial year 2020-21. Installation coat of this basic system is nearly 20000 rupees for one hectare.

References:

Aggelopoulou, A. D., Bochtis, D., Fountas, S., Swain, K. C., Gemtos, T. A. and Nanos, G. D. (2011). Yield prediction in apple orchards based on image processing. *Precision Agriculture*, ***12***, 448-456.

Agriculture Statistics at a glance 2021.

Bongiovanni, R. and Lowenberg-DeBoer, J. (2004). Precision agriculture and sustainability. *Precision agriculture*, ***5***, 359-387.

Economic Survey 2022.

McBratney, A., Whelan, B., Ancev, T. and Bouma, J. (2005). Future directions of precision agriculture. *Precision agriculture*, ***6***, 7-23.

Mehta, C. R., Chandel, N. S., Senthilkumar, T., and Singh, K. K. (2014). Trends of agricultural mechanization in India. *Economic and Social Commission for Asia and the Pacific (ESCAP) Policy Brief*, *2*.

Pierce, F. J. and Nowak, P. (1999). Aspects of precision agriculture. *Advances in agronomy*, ***67***, 1-85.

Rehman, T. and Khan, M. U. (2019). Early trends, current status and future prospects of farm mechanization in Asia. *Agricultural Engineering International: CIGR Journal*, ***21***(3), 76-87.

Srinivasan, A. (1999, January). Precision farming in Asia: progress and prospects. In *Proceedings of the Fourth International Conference on Precision Agriculture* (pp. 623-639).

Tekin, A. B. and Sindir, K. O. (2002). Prospects and challenges for precision farming in Turkey. *Proceedings of the Union of Scientist Rousse, Energy and Efficiency and Agricultural Engineering (EE & AE 2002), 4–6 April, Rousse, Bulgaria*.

Tiwari, P. S., Singh, K. K., Sahni, R. K. and Kumar, V. (2019). Farm mechanization–trends and policy for its promotion in India. *Indian Journal of Agricultural Sciences, **89***(10), 1555-1562.

Zhang, N., Wang, M. and Wang, N. (2002). Precision agriculture—a worldwide overview. *Computers and electronics in agriculture, **36***(2-3), 113-132.