Mysore J. Agric. Sci., 56 (2) : 308-314 (2022)

Determination of Drip Irrigation Adoption in Southern Karnataka : A Probit Model Application

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ABSTRACT

Water scarcity is one of the primary world issues and according to climate change projections, it will be more critical in the future. Indian agriculture is beset with water scarcity and becomes less remunerative and uncertain. Since water being a precious resource for agriculture, every drop of water available for irrigation is significant for overall farm efficiency. Hence there is prudent and paramount need for efficient use of the available water and micro irrigation is one such innovative technology. Economic return is very important for the adoption of any new technology. Unlike surface irrigation, drip irrigation is more suitable and economical if it is introduced in water scarce areas for widely spaced high value crops. The current study sought to determine the factors influencing farmers' decision to adopt drip irrigation system, using cross-sectional data from 160 randomly selected farmers from Kolar and Mandya districts of Karnataka. The study revealed that farm income from high valued crops such as fruits and vegetables increases the probability of drip irrigation adoption while depth of well and share of cereals and pulses decrease the probability of adoption. Dependency ratio and the credit accessibility to the farmers increase the probability of adoption. Drip irrigation is supportive in order to meet food needs and avoid excessive water consumption. The study recommends the interaction among various stakeholders such as government, non-government organizations, private sector, researchers, extension workers and farmers to ensure sustainability of micro-irrigation technologies like drip and sprinkler irrigation systems.

Keywords : Adoption, Drip irrigation, Water use efficiency, Technology

WATER is a key input for plant growth and also essential natural resource for the survival of life. Climate change and variability is a contributing factor to the persistent droughts and dry spells, which have resulted into noticeable increase in the support and use of micro-irrigation technologies. Water shortage is currently a global issue which leads negative impact on crop production and water resources (Kurylyk and Mac Quarrie, 2013). The country like India where agriculture is playing a vital role in the upliftment of rural livelihoods and it reports 50 per cent of the total work force is involved in the agriculture sector. Indeed, agriculture consumes lion's share of total diverted water in these regions (GoI, 2018). It is crucial for India to efficiently utilize the water resources, which shares 17 per cent of the global population with only 2.4 per cent of land and 4 per cent of the water resources. Further, the availability of average utilizable water resources per person was 5247 m^3 in 1951 (1453 m^3 in 2015) which is expected to diminish to 1170 m^3 by 2050 (Patle *et al*., 2015). Agricultural sector alone consumes 80 per cent of the ground water (Harsha, 2018). In the country, declining trend of groundwater level may indicates that the assured supply of good quality water will become a concern for country's development (Manivannan *et al*., 2017). Therefore, proper and long-term resilience solutions such as an innovative technology options are required to tackle these risks and to enable the efficient and sustainable utilization of water resources. Adoption of improved micro-irrigation technologies like drip irrigation system are associated with reduction of poverty, improved nutritional status, lower staple food prices, increased employment opportunities as well as earnings for landless labourers (Karsiye, 2013). Several studies have attempted to study the impact of micro irrigation technologies (drip and sprinkle irrigation) and have found that technologies produce the anticipated positive impacts (Kumar and Palanisami, 2010; Narayanamoorthy, 1997, 2003, 2005, 2007; Namara *et. al.,* 2005; Dhawan, 2002; Verma *et. al.,* 2004; Magar *et. al.,* 1988). A study conducted by Shivashankar *et al.,* (2021) revealed that, major crops used less water under drip irrigated farms (DIF) compared to Canal irrigated farms (CIF), to the tune of 42 per cent in bajra to 70 per cent in onion. It is shown that the micro irrigation technologies are technically viable and environmentally feasible, particularly when the farmers depend on groundwater sources (Kumar and Palanisami, 2010; Dhawan, 2000). Suhas Chandra (2018) in his study revealed that, net returns per acre under micro irrigation were higher (Rs.28325) than the one under conventional irrigation system (Rs.16348) by 58 per cent and the water use efficiency per acre inch was also higher under micro irrigation.

Drip Irrigation

About 80 per cent of the world's irrigated area is under surface irrigation methods, which have a use efficiency of 30 - 50 per cent only. Drip irrigation was introduced in India for commercial adoption in early seventies and its growth has gained momentum in the last few years only, primarily due to the subsidy extended by Central and State Governments. India ranks first in the area under drip irrigation with 18,97,280 ha (ICID, 2015). Large chunk of money has been provided by Government agencies in India in the form of subsidy to farmers for installing micro irrigation methods including drip irrigation. Drip irrigation is an efficient method of providing water directly to the root zone, minimizing conventional losses such as deep percolation, runoff and soil erosion. Unlike surface irrigation, drip irrigation is more suitable and economical if it is introduced in water scarce areas with undulating topography, shallow and sandy soils and for widely spaced high value crops. It also permits the utilization of fertilizers, pesticides and other water-soluble chemicals along with irrigation water, resulting in higher profit and better yields and quality of product. Many researchers have attempted to study the impact of drip irrigation and found that it produces the desired positive impacts in terms of water and crop productivity (Narayanamoorthy, 2005; Narayanamoorthy, 2008; Thampan, 2004; Namara *et al*., 2005; Jat *et al.,* 2011, Indira Devi *et al*., 2012; Saskia van der Kooija *et al*., 2013; Jayakumar *et al*., 2014 and Jayakumar *et al*., 2015).

Keeping these concerns in view, the present paper has focused on the important issues, factors involved in influencing the adoption of drip irrigation technology in Southern Karnataka difficulties, and causes of non-adoption of micro irrigation technologies. At the macro level, very few studies attempted to study the potential and prospects of drip irrigation covering various states in India (Narayanamoorthy, 2007).

METHODOLOGY

The following section is a presentation of the methods used, a description of the study area, the data, as well as the empirical model for the study.

Study Area and Data

For the study purposive simple random sampling technique was used. The study was conducted in the southern part of Karnataka consisting of Kolar and Mandya district (Fig. 1) where two extreme situations were seen, one is highly drought prone area and another is command area. Two tehsils were selected randomly from each district so as to represent both drip adoption and control farmers. Farm households in the selected villages constituted the sample units. To examine the adoption and influencing factors for adoption of drip irrigation, 40 drip-adopting farmers

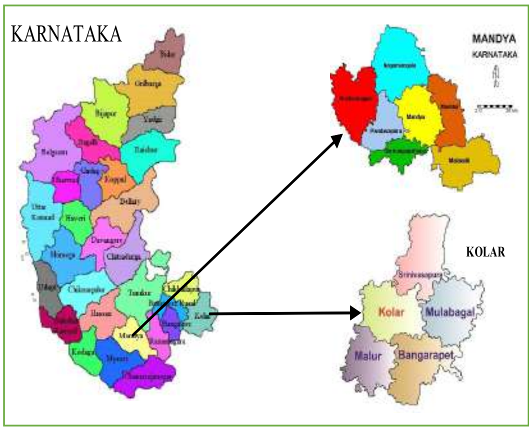

Fig. 1 : Karnataka map showing Mandya and Kolar districts

were selected in each district and correspondingly 40 non-drip adopters were selected from the same area. Drip adopters were selected randomly from the villages in each tehsils after discussions with the villagers. Thus, a sample of 160 farmers was studied.

The primary information collected from the farm households included details on well investment, groundwater use, extraction and management, crop production including input use and output realized, farm income, adoption of drip irrigation and investment on drip irrigation, pump set cost. This also included asset position, education, years of experience in farming and other socio-economic characteristics.

Analytical Framework and Empirical Model

The current study used the probit model to analyse adoption decisions of farmers due to the binary nature of the dependent variable. The probit model makes the assumption that while only the values of 0 and 1 for the dependent variable Yi are observed, there is a latent, unobserved continuous variable Yi* that determines the value of Yi. The probit model ensures that the estimated probabilities lie between 0 and 1. Suppose the response variable Yi is binary with only two possible outcomes (1 for adoption and 0 for non-adoption). Consider also a vector of independent variables xi which is assumed to influence Yi. Then the probit model takes the form:

$$Pr\ (Yi = 1|xi)= F\ (\beta\ `xi) = \phi\ (\beta\ `xi \text{ ---------------- } (1)$$

Where, Pr denotes probability, Yi is the binary choice variable representing adoption and ϕ is the cumulative distribution function (CDF) of the standard normal distribution. β is a vector of unknown parameters.

It is assumed that the latent variable Y* can be specified as follows:

$$Yi^* = \beta 0 + \sum_{n=1}^{n} \beta n\, Xni + ui \text{ --------------------(2)}$$

$$\text{And } Yi = \begin{Bmatrix} 1 \ \textit{if } Yi > 0 \\ 0 \ \textit{otherwise} \end{Bmatrix}$$

Where, xi represents a vector of explanatory variables, u_i is a random disturbance term, n is the total sample size, and β is a vector of unknown parameters to be estimated by the method of maximum likelihood.

Due to the non-linearity of the probit model, the parameters are not necessarily the marginal effects of the various independent variables. The marginal effects of the coefficients are more informative and useful for policy decision-making. To estimate the marginal effect, we differentiate equation (1) with respect to xi.

$$\frac{\partial yi}{\partial xi} = \phi(\beta\ `Xi)\ \beta i$$

where ϕ represents the probability density function of the standard normal distribution.

The empirical specification of the probit model for the study is given as follows:

$$Yi^*=\beta 0 + \sum_{n=1}^{10} + \beta n\ Xni + vi \text{ --------------------(3)}$$

Where,

Y_i = adoption of fertilizer (=1 if farmer adopted fertilizer, 0 otherwise)

x_1 = Years of schooling

x_2 = dependency ratio

x_3 = depth of well

x_4 = share of cereals and pulses

x_5 = share of fruits

x_6 = share of vegetables

x_7 = farm income

x_8 = farming experience

x_9 = non-farm income

x_{10} = credit accessibility

RESULTS AND DISCUSSION

The following section is a presentation of the results of the study and discussion of the main findings. The description of the characteristics of the respondents is followed by a presentation of the results of the Probit analysis and the discussion of the major findings.

Characteristics of the Respondents

A brief description of the characteristics of the respondents is presented in Table 1. The study shows

TABLE 1
Descriptive statistics of overall sample respondents

Variables	Pooled samples	
	Mean	Std. Deviation
Years of schooling	8.88	3.30
Dependency ratio (%)	77.15	41.25
Depth of well (feet)	539.46	422.40
Investment on pump (Rs.)	22873.00	15672
Share of cereals and pulses (%)	30.04	17.68
Share of fruits (%)	20.35	16.74
Share of vegetables (%)	28.28	21.79
Farm income (Rs.)	148919.00	190125
Non-farm income (Rs.)	22898.00	41169.00
Credit accessibility (Rs.)	45199.00	81923.00
Farming experience (Years)	25.83	14.57

that, the average farm size was 4.15 acres, which shows that the respondents are smallholder farmers. The average age of respondents was 47 years while the average household size was 5 with an average dependency ratio of 77 per cent, the average years of schooling was 8. The average farm income and non-farm income of respondents was Rs.1,48,919 and Rs. 22,898, respectively.

Table 2, shows the comparative analysis of the main characteristics of the respondents through descriptive statistics. Adopters had significantly higher farm income but were significantly younger and educated than the non-adopters. These variables were significantly influence adoption of drip irrigation by the respondents.

Adopters had significantly higher dependency ratio than non-adopters. Adopters had more number of bore wells with larger depth of wells than the non-adopters, however, the mean difference was not significant. There is larger significant share of fruits and vegetables with respect to cropping area by the adopters than non-adopters, whereas, non-adopters take higher significant share of cereals and pulses than the adopters.

Fig. 2, shows that major share of income to adopters was from farming which was likely due to high value crops grown by the adopters using water saving drip irrigation followed by meager income share from non-farm income.

Whereas, in case of non-adopters, though they took cereals and pulses as major crops, their major share of income was from farming which is relatively smaller than the adopter. The relative share non-farm income of non-adopters was larger than relative share of non-farm income of adopters.

TABLE 2
Descriptive statistics of the respondents according to adoption status

Variables	Adopters (Mean)	Non adopters (Mean)	't' value
Years of schooling	9.61	7.67	4.30 *
Dependency ratio	93.29	50.25	3.77 *
Depth of well (Feet)	768.00	158.58	1.04
Investment on pump (Rs.)	31153.00	9350.00	5.53 *
Share of cereals and pulses (per cent)	22.34	42.89	-3.62 *
Share of fruits (per cent)	27.78	9.53	8.02 *
Share of vegetables (per cent)	39.85	9.01	5.18 *
Farm income (Rs.)	225460.00	67989.00	2.79 **
Non farm income (Rs.)	15415.00	27479.00	2.15 **
Credit accessibility (Rs.)	65600.00	11198.00	2.10 **
Farming experience (Years)	23.72	29.35	-0.93

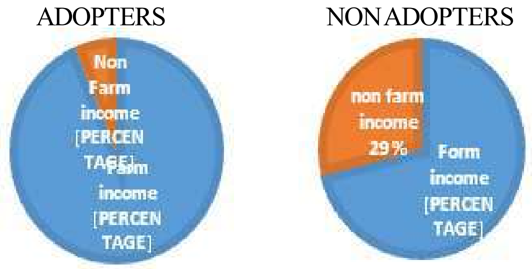

Fig. 2 : Share of farm and non-farm income to adopters and non-adopters

Determinants of Drip Irrigation Adoption

Table 3, is a presentation of the maximum likelihood estimates of the parameters of the probit analysis of drip irrigation adoption by farmers of study area. The diagnostic statistics reveal a good fit of the model, as indicated by the highly significant Chi-square test statistic and the percentage of the variables correctly classified. The result shows that the explanatory variables included in the model are relevant and jointly explain the adoption decision of farmers. The share of vegetables was positively related to adoption and significant at the 1 per cent level. The result indicated that an increase in share of vegetables increases the probability of adoption of drip irrigation by the farmers.

A unit increase in the share of vegetables increase the probability of adoption by 0.10. Dependency ratio, share of fruits, farm income and credit accessibility were also positively significant at 5 per cent. Therefore, an increase in one unit of dependency ratio, share of fruits, farm income and credit accessibility the probability of adoption increases by 0.06, 0.13, 0.05 and 0.03, respectively. Share of wealth and depth of well were negatively related to adoption of drip irrigation and are non-significant.

Conclusion and Policy Recommendations

The study employed a probit model to analyse the determinants of drip irrigation adoption by farmers of water scarce area Kolar and cauvery command tail end area of Mandya district. The study revealed that dependency ratio, share of fruits, share of vegetables, farm income and credit accessibility were the critical determinants of adoption. The implication of findings are that households having higher dependency ratio are more likely to adopt drip irrigation since they have less number of own family labour, that encourages them to go for labour efficient technology like drip irrigation. As share of area under fruits and vegetable crops increases, adoption rate increases. Since the adopters have taken high value crops like fruits and vegetables, their farm income is more likely higher than the non-adopters whose major area goes under cereals and pulses cultivation. This shows that farmers with very low incomes are likely to be non-adopters. This point is buttressed by the high

TABLE 3

Probit model of determinants of adoption of drip irrigation

Variables	Co-efficient	Marginal effect	'p' value
Years of schooling	0.96	0.03	0.51
Dependency ratio	0.02**	0.06	0.02
Depth of well (Feet)	-0.001	-0.03	0.38
Share of cereal and pulses (%)	-0.005	-0.00	0.85
Share of fruits (%)	0.11**	0.13	0.01
Share of vegetables (%)	0.07*	0.10	0.00
Farm income (Rs.)	0.00001**	0.05	0.04
Farming experience (Years)	0.018	0.02	0.53
Non-farm income (Rs.)	0.000014	0.01	0.35
Credit accessibility (Rs.)	0.000023**	0.03	0.02
Constant	-8.35	-	0.01

Note: Pseudo R2= 0.86, Prob> chi2= 0.00, Log likelihood = -13.74, * - Significant at 1 %, ** - Significant at 5 %

significance of the farm income variable in the model. Hence, farmers more likely to adopt drip irrigation when their income increases. Efforts to enhance the water use efficiency and income of farmers will therefore enhance the adoption of drip irrigation which in turn has the potential to increase productivity of water.

Drip irrigation is supportive in order to meet food needs and avoid excessive water consumption. Firstly, the study recommends the interaction among various stakeholders such as government, non-government organizations, private sector, researchers, extension workers and farmers to ensure sustainability of micro-irrigation technologies like drip and sprinkler irrigation systems.

Secondly, government should concentrate on introducing small farmer friendly subsidies and rather facilitate tie-ups with non-government organizations, so that poor friendly technologies becomes available at affordable prices for a needed broader population. Provision of mortgage free loan to marginal and landless farmers which enables them to take land for lease and get subsidy in order to install the water saving technology which can be an appropriate policy response to the constraints of poorest.

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(*Received :* August 2021 *Accepted :* April 2022)