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Assessing the farmers' perception towards precision water application devices under the PMKSY scheme: a TAM-based structural equation modelling approach

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The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), which is initiated by the Government of India, is aimed at improving the irrigation and water-management structures to increase the efficiency of crop production by maximizing the utilisation of water. The current study aims to explore the attitude of the farmers towards precision water-application gadgets and the subsequent propensity to utilize such devices under the PMKSY program. The study has included beneficiaries and non-beneficiaries of the programme but has given specific attention to micro-irrigation devices. The sample comprised 3,134 farmers spread across seven different agro-climatic regions in Tamil Nadu and thus was representative in breadth. The structural-equation modelling on the basis of the technology-adoption paradigm was used to test the hypothesis based on SmartPLS software to perform a partial least squares path analysis. Findings have shown that the attitudes and perceived utility of farmers are the two main factors that influence micro-irrigation adoption; perceived ease of use has an indirect effect on the decision through these mediators but does not have a direct effect. Multi-group analysis also indicates that there are salient differences between beneficiary and non-beneficiary farmers. Among PMKSY beneficiaries, the pathways of perceived ease of use, perceived usefulness, and behavioural intention are stable, resulting in actual adoption. Conversely, in the non-beneficiaries, the choice to adopt is only weakly related with intention but rather affected more by the visibility and observational signals rather than the experience of learning. Such findings correspond with the available research on the adoption of agricultural technology. Therefore, the study promotes farmers' behavioural intention to micro-irrigation, which is complemented by the perceived usefulness and ease of use at once, as a successful approach to increase the level of adoption.

KEYWORDS
agricultural, micro-irrigation, partial least squares, PMKSY, TAM

1 Introduction

In the developing world, including India, agriculture performs two roles: not only does it become the primary driver of economic activity but also forms the backbone of the society (Park et al., 2021; Tripathy et al., 2023). In addition to its macroeconomic importance, the agricultural activity is intrinsically limited due to a scarcity of access and effective management of water resources in India. The water is the lifeblood of the agricultural human industry as one of the key resources needed to grow produce, raise animals, and the overall farm output (Kumari et al., 2022: Taufik and Ruzardi, 2021). As the global population increases and climate change intensifies, the significance of water in agricultural systems is more crucial than ever, making it essential to properly acknowledge the importance of this invaluable resource. Agricultural irrigation involves the intentional use of water to augment natural rainfall, ensuring optimal moisture levels for crops (Shankar and Mazhar, 2023). Adhikari et al. (2021) stated that the efficient utilization of resources such as land and water can enhance agricultural productivity.

India contributes to 2.5% of the total geographical area, 17.5% of the world's population and 4% of the world's renewable water resources encountering a water crisis (Adhikari et al., 2021). India uses more than 80% of its surface water for agricultural purposes alone (Sishodia et al., 2016); however, the inefficient use of irrigation systems led to poor groundwater development. The irrigation institutions should ensure openness in irrigation management, appropriate water availability, and infrastructure upgrades to meet farmer demands in all crop production as well as rice, sugarcane, cotton; moreover, the acceptance of improved irrigation technologies on a farmer level and their appropriate use is also crucial (Kumari et al., 2022).

To improve irrigation and water management, the Government of India launched the Pradhan Mantri Krishi Sinchai Yojana (PMKSY). Micro irrigation is a pivotal technology in modern agricultural practices, offering precise and efficient water delivery directly to plant roots, thereby maximizing water use efficiency and crop yield. Most of the studies related to PMKSY were focused on its economic effect, advantages, and contribution to plant physiology (Reddy et al., 2022; Sharma, 2020; Wani et al., 2016). Few studies have focused on the constraints faced by the rural community in the implementation of the PMKSY program (Rajaguru et al., 2023). More to the point, limited empirical studies have focused on the attitude of the farmers towards precision water application devices, and the degree to which these attitude influences their adoption behaviours.

Since the PMKSY program in irrigation was implemented, many studies have been conducted, but there is a gap in the literature pertaining to the farmers' perception, behavioural reactions of farmers are the determining factor of the success of irrigation interventions and not only technological availability. Hence, this study was taken up to fill the gap in analysing the farmers' perception towards precision water application devices on adoption decision. The Technology Adoption Model (TAM) was adopted to check the factors that need to be taken into consideration to augment the adoption of micro-irrigation by the farmers.

2 Literature review

Pradhan Mantri Krishi Sinchai Yojana (PMKSY), which was launched in 2015 by the Government of India, Ministry of Agriculture and Farmers Welfare, is a grand national program aimed at increasing the area under irrigation, improving the efficiency of water use, and encouraging sustainable water conservation practices (Shehrawat et al., 2020). The plan was developed to address long-standing irrigation issues in India, where approximately 54% of agricultural area is under irrigation, and a significant proportion of farmers still lives at the mercy of rain monsoons (Wani et al., 2016). Due to the increasing pressures caused by climate variability, drought, and groundwater depletion, PMKSY pursues a paradigm of demand driven approach that changes the focus on on-farm water-use efficiency instead of just increasing irrigation infrastructure.

PMKSY consists of four key parts: (1) Accelerated Irrigation Benefits Programme (AIBP), (2) Per Drop More Crop, (3) Har Khet Ko Pani, and (4) Integrated Watershed Management (Wani et al., 2016). The AIBP focuses on the completion of large and medium sized irrigation through the enhancement of irrigated lands. The Per Drop More Crop element is promoting micro irrigation technologies, including drip irrigation and sprinkler irrigation, to improve the water productivity (Ma et al., 2023; Zhang et al., 2025). Har Khet Ko Pani focuses more on the advancement of water bodies and their restoration, and the growth of irrigation facilities (Jinger et al., 2023), and Integrated Watershed Management focuses more on soil conservation, rainwater harvesting, and post-degraded land regeneration (Jinger et al., 2023). Taken together, these elements attempt to create a cohesive irrigation governance structure, which combines the growth of infrastructures with efficiency-based technological diffusion.

India is still struggling with acute water stress despite the efforts of the policies (Jayasankar et al., 2020). Only 4% of the world freshwater resources are located in the country, which contains close to 17% of the world population (Kumar et al., 2023). The efficiency of irrigation is minimal, about 35-40% most of which can be explained by the predominance of flood irrigation methods that play a significant role in the waste of water (Singh and Gandhi, 2023). Micro-irrigation systems have shown the potential to achieve a 40-60% higher water-use efficiency and increase crop productivity, but the adoption of micro-irrigation systems is low (less than 14% of the nation) (Singh and Gandhi, 2023). The recent developments in precision farming, such as GPS-controlled systems, IoT-based sensors, or smart irrigation systems, have further illustrated the ability to improve yields by 20-30% and reduce the inputs wastage (Xing and Wang, 2024; Xie, 2025). These technologies are in line with the aims of the Per Drop More Crop section of PMKSY.

However, the effectiveness of PMKSY cannot be assessed only using infrastructural or technological measures. It has been shown that institutional support, including subsidies, extension services and dissemination of information, have a significant impact on the adoption decision of the farmers (Singh and Gandhi, 2023). Technical training and capacity building programs are also essential towards empowering farmers to have the necessary knowledge to use the precision irrigation technologies (Xie, 2025). On the other hand, the obstacles such as large expenses of initial investments, technological illiteracy, lack of access to credit, and opposition to regulations remain to hinder the widespread adoption, especially among smallholders (Xie, 2025). In addition, other researchers warn that excessive dependence on technological solutions can overshadow the traditional water-management practices and the overall governance reforms that are necessary to achieve long-term sustainability (Shah and Vijayshankar, 2022).

In light of these complications, it will be essential to learn about the behavioural and perceptual determinants of farmers. Although PMKSY promotes the use of innovative irrigation technologies, the eventual adoption will depend on how useful, convenient, and economical to farmers precision water-application gadgets are (Abhilash et al., 2020; Xie, 2025). The intention of farmers to embrace these types of technologies is not only moulded by the economic incentives, but also by the psychological, institutional, and socio-cultural forces. In line with this, when evaluating adoption using theoretical models of behaviour like the Technology Acceptance Model (TAM), a theoretically based method is provided to examine the effect of the above-mentioned constructs on the intention and actual usage behaviour of the farmers.

In this regard, the current study broadens the policy discussion outside of infrastructural accomplishments and focuses on the behavioural aspect of PMKSY application. This study, by employing a Structural Equation Modelling framework based on TAM, addresses the gap in the literature by carrying out an empirical study of the perception of farmers concerning precision water-application devices as a part of PMKSY, thus filling the gap between irrigation policy design and the technology acceptance of farmers.

2.1 Technology acceptance model

Research on the Technology Acceptance Model indicates that individual behavioural intention (BI) and attitude towards technology (AT) are significantly affected by the dimensions of perceived ease of use (PE) and perceived usefulness (PU) (Davis, 1989). The emotional disposition towards a specific behaviour significantly impacts behavioural intention in both the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) (Ajzen, 1991; Davis, 1989). Attitude (AT) is described as an individual's evaluative disposition, either positive or negative, towards a particular behaviour. Consequently, attitude is capable of modifying an individual's predisposition towards the designated behaviour (Susanti and Astuti, 2019; Verma and Tandon, 2022).

It has been empirically proven that consumer attitude (AT) is a decisive variable that influences behavioural intention (BI) in the context of online shopping of groceries (Hansen et al., 2004). The deployment of mobile applications in the food purchase sector necessitates further research, underscoring the significance of attentional disposition in elucidating behavioural intention (Cho et al., 2019; Troise et al., 2021). Although these studies are situated in non-agricultural contexts, they provide strong theoretical support for applying TAM to decision-making environments where technology adoption involves perceived risk, learning costs, and expected performance gains, conditions that are equally relevant in agricultural technology adoption.

The Technology Acceptance Model has been extended in a number of ways to include constructs like social influence and facilitating conditions to internalize contextual influences on adoption behaviour. Nonetheless, in the framework of micro-irrigation through PMKSY, this research selectively focuses on core TAM constructs in addition to the selected external variables, which have a direct relationship with the nature of technologies. This approach provides a simple yet context-sensitive model, well-suited for large samples and structural equation analysis in rural settings. In such environments, factors like how visible the technology is, how complex it seems, and the advantages it offers matter more directly than broader social influences.

The conceptual model incorporates the fundamental TAM constructs and external variables such as relative advantage, complexity, and visibility in explaining the decision to adopt by farmers. Relative advantage is how much precision water application devices are perceived to perform and provide an economic advantage; complexity measures how difficult perceived to be; and visibility is observational learning by being exposed to other adopters. It is hypothesized that these variables have an effect on perceived usefulness and perceived ease of use, which in turn have an impact on attitude, behavioural intention, and adoption decisions. This framework gives hypothesis a rational theoretical foundation to draw both direct and indirect hypotheses that underwent test in the study.

The external variables represented here are the relative advantage, complexity, and visibilities of precision water application devices. These characteristics are intended to enhance the perceived utility and use of the devices for farmers, hence facilitating their decision to adopt the micro-irrigation system (Abdullah et al., 2016; Chen and Aklikokou, 2019; Cohen, 1988; Lewis and Devi, 2025).

Therefore, the main hypothesis might be stated as follows (Figure 1):

Direct effect

- H1 Attitude toward precision water application devices positively influences behavioural intention to use precision water application devices.
- H2 Perceived ease of use positively affects attitude toward the use of precision water application devices.
- H3 Perceived Usefulness positively affects attitude toward the use of precision water application devices.
- H4 Perceived ease of use positively affects perceived usefulness of precision water application devices.
- H5 Perceived usefulness positively affects behavioural intention to use precision water application devices.
- H6 Behavioural intention positively affects the adoption decision of the use of precision water application devices.
- H7 Attitude toward precision water application devices positively affects the adoption decision of the use of precision water application devices.

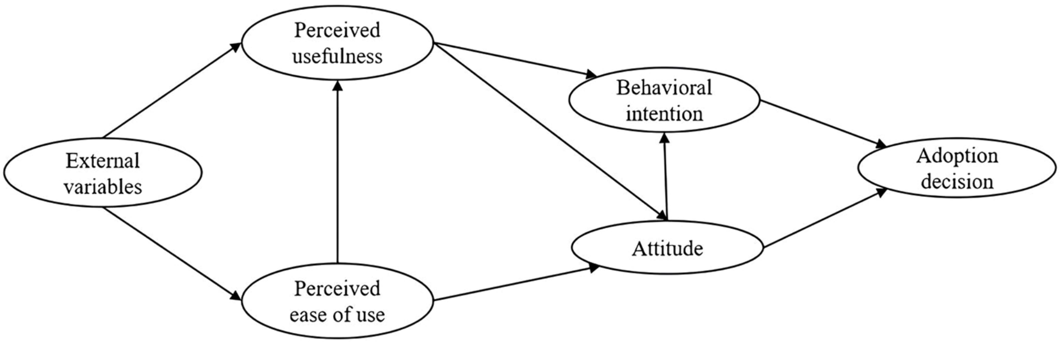

FIGURE 1
The theoretical framework. Source: Authors' compilation.

Indirect effect

H8 Perceived usefulness positively and indirectly affects the adoption decision of the use of precision water application devices.

H9 Perceived ease of use positively and indirectly affects the adoption decision of the use of precision water application devices.

H10 Attitude toward precision water application devices positively and indirectly affects the adoption decision of the use of precision water application devices.

3 Methodology

This study was conducted in the seven agro-climatic areas of Tamil Nadu, namely the northeast, northwest, west, Cauvery delta, south, hilly high-altitude, and high rainfall zones. Tamil Nadu was specifically chosen as the study region due to its comprehensive application of the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) and the presence of a very large agro-climatic diversity and the prevalence of micro-irrigation technologies across both water-scarce and water-abundant regions, making it an appropriate setting for examining variations in farmers' adoption behaviour.

A mixed-method research approach with a cross-sectional survey design was employed in the study. The target population comprised farmers who had adopted precision water application devices, including both PMKSY beneficiaries and non-beneficiaries. The beneficiaries were considered as those farmers who obtained the financial aid in PMKSY to install micro-irrigation, whereas non-beneficiaries were those farmers who installed micro-irrigation without receiving any government subsidy.

A multi-stage sampling procedure was followed. In the first stage, two districts were purposively selected from each agro-climatic zone, one with maximum and one with minimum micro-irrigation coverage, except in the hilly high-altitude and high rainfall zones, where one district was selected from each zone due to limited district representation. In the second stage, villages with the highest and lowest area under micro-irrigation were purposively selected from each district. In the final stage, farmers were selected from the chosen villages using probability-based methods. PMKSY beneficiaries were selected using the probability proportion to size (PPS) technique, while non-beneficiaries were selected through simple random sampling, with 50 non-beneficiaries drawn from each selected district.

The sample size was estimated using Slovin's formula, considering the total number of PMKSY beneficiaries in Tamil Nadu during 2022–23 (N = 70,522) and a margin of error of 2%:

$$n = \frac{N}{1 + Ne^2}$$

This yielded a minimum sample size of 2,414 beneficiary farmers. To enable comparative analysis, an additional sample of 720 non-beneficiary farmers was included, resulting in a final sample size of 3,134 respondents (2,414 beneficiaries and 720 non-beneficiaries).

The Structural Equation Modelling (SEM) technique was employed to analyse farmers' perceptions and adoption decisions regarding micro-irrigation. Partial Least Squares SEM (PLS-SEM) was selected due to its appropriateness in theory-driven exploratory models, the ability to address intricate relationships involving many latent constructs and mediating effects, its ability to work with large samples, and few distributional assumptions. Furthermore, PLS-SEM can be specifically used in studies that are based on TAM and in which the main aim of the investigation is prediction and vagueness instead of the sole model fit.

3.1 Variables measurements

The study employed a structured questionnaire using a five-point Likert scale to measure farmers' perceptions toward precision water application devices. The instrument consisted of 41 items grouped into eight constructs, including perceived usefulness (5 items), perceived ease of use (4 items), attitude toward use (8 items), behavioural intention (4 items), adoption decision (3 items), and external variables (17 items). Responses were recorded on a scale ranging from 1 (Strongly disagree) to 5 (Strongly agree).

The questionnaire was first built through a wide analysis of the literature on TAM and previous literature on agricultural technology adoption. A pilot survey was done to evaluate clarity, relevancy and contextual fit of the items. Pilot study was used to make the necessary corrections aimed at refining the wording and construct alignment. Since the study was part of a bigger research project, the final questionnaire and the research methodology were discussed and tested by the ICSSR project coordinators before the full-scale data collection.

To ensure the robustness of the measurement model, reliability and validity assessments were conducted. Indicator reliability was evaluated using outer loadings, with values above 0.70 considered acceptable (Hair et al., 2011). Internal consistency reliability was assessed using Jöreskog's rho (ρc). Convergent validity was examined using Average Variance Extracted (AVE), with values exceeding 0.50 indicating adequate construct validity (Fornell and Larcker, 1981).

4 Results

4.1 Measurement model analysis

As shown in Table 1, the measurement model has a strong construct reliability and convergent validity. The values of the outer loadings range between 0.761 and 0.905, above the recommended value of 0.70, thus supporting the fact that the indicators have strong correlations with their latent constructs (Hair et al., 2021). The composite reliability (CR) scores are also above 0.70, which is a good sign of internal consistency between the items (Fornell and Larcker, 1981), thereby fulfilling the criteria for convergent validity. In addition, all dimensions exhibit satisfactory average variance extracted (AVE), with the following values: PU = 0.667, PE = 0.705, RA = 0.621, CP = 0.673, VS = 0.767, and AD = 0.674. The statistics demonstrate strong convergent validity of the construct. All AVE values exceed 0.50. Thus, confirming that each construct measures more than half of the variance in their indicators, satisfying the requirements of convergent validity (Fornell and Larcker, 1981). Lastly, the values of VIF are less than 5, which means that there is no multicollinearity and the indicators act independently as expected (Hair et al., 2021). Overall, these results confirm that the constructs meet high standards of reliability and convergent validity.

Multicollinearity was tested using the variance inflation factor (VIF). The VIF values in Table 1 are significantly lower than the recommended value of 3.3 according to Kock (2015), and this indicates that there is an absence of any significant multicollinearity. Hence, the distinct effects of the predictors on the dependent variable significantly enhance the robustness of our regression analysis.

Table 2 tests discriminant validity through Fornell Fornell-Larcker criterion. The diagonal values that depict the square roots of the AVE of each construct are greater than 0.50 and, more importantly, higher than the values of the correlation of each row and column. It is observed that such a pattern reflects the fact that an individual construct is more likely to have a large amount of variance with its own indicators, compared to the indicators of other constructs; thus, defining empirical distinctiveness (Fornell and Larcker, 1981). Therefore, the discriminant validity is very strongly supported, and each of the constructs measures a distinct conceptual entity of the study (Henseler et al., 2015). This will bring conceptual clarity and will support the quality of the measurement model.

TABLE 1 Constructs' reliability and convergent validity.

Constructs	Loading	rho_c	AVE	VIF
Adoption Decision	0.761-0.877	0.804	0.674	1.43-1.44
Complexity	0.808-0.833	0.804	0.673	1.35-1.36
Perceived Ease of Use	0.806-0.879	0.878	0.705	1.61-2.05
Perceived Usefulness	0.781-0.851	0.800	0.667	1.26-1.27
Relative Advantage	0.768-0.808	0.766	0.621	1.06-1.10
Visibility	0.849-0.905	0.868	0.767	1.40-1.41

Survey data (2023-2024).

TABLE 2 Discriminant validity (Fornell-Larcker Criterion).

Constructs	AD	A	BI	CX	PEU	PU	RA	VS
Adoption Decision	0.821							
Attitude toward MI	-0.005	1.000						
Behavioural Intention	0.066	0.337	1.000					
Complexity	0.058	0.079	0.305	0.820				
Perceived Ease of use	0.058	0.142	0.296	0.522	0.840			
Perceived Usefulness	0.049	0.305	0.313	0.204	0.315	0.816		
Relative advantage	0.055	0.245	0.203	0.140	0.221	0.328	0.788	
Visibility	0.020	0.179	0.299	0.350	0.584	0.207	0.186	0.876

Survey data (2023-2024).

The Fornell-Larcker criterion (Fornell and Larcker, 1981) was then used to assess the discriminant validity between the latent constructs. Based on this metric, the square root of the mean variance extracted (AVE) of any single construct should be greater than its correlations with all the rest of the constructs of the model (Fornell and Larcker, 1981). Table 2 demonstrates that this condition was satisfactorily met, indicating a strong level of discriminant validity, which in turn suggests robust levels of construct validity and reliability.

Table 3 offers empirical evidence to the fact that the model achieves an acceptable fit. The values of SRMR of the saturated and estimated models are close to the generally acceptable value of 0.08 and indicate that the empirical covariance matrix and the model-implied structure are reasonably close (Hu and Bentler, 1999). The d ULS and d G values also are within workable ranges, which means that the model does not reflect troubling differences concerning Euclidean or geodesic distances (Henseler et al., 2016). Therefore, the model shows a good fit, which proves that the mentioned structure aligns with the observed data.

4.2 Path analysis

An analysis to evaluate the proposed hypotheses is conducted using partial least squares (PLS) path modelling through SmartPLS 4 software. The partial least squares structural equation modelling (PLS-SEM) makes it easy to study the relationships between the latent variables within a structural framework. It enables researchers to perform hypothesis testing, which takes into account both direct and indirect impacts as well as determine the strength, direction, and statistical significance of construct relationships (Hair et al., 2019).

The research applied the PLS bootstrapping with 999 iterations and a sample of 3,134 cases as an estimation of the path coefficients and their statistical significance. A variety of statistical measures were incorporated in this model: path coefficients, levels of significance, coefficients of determination, and effect sizes (Figure 2).

TABLE 3 Model fit.

Indicators	Saturated model	Estimated model
Standardized Root Mean Square Residual (SRMR)	0.08	0.10
d_ULS	0.94	1.26
d_G	0.35	0.38

Survey data (2023-2024).

4.2.1 Model estimation based on beneficiary and non-beneficiary farmers

Direct effect

The findings of the path analysis are presented in Table 4. The table exclusively presents the coefficient and the probability value of the direct effect of latent variables such as behavioural intention, attitude, perceived usefulness, and perceived ease of use. As for the hypotheses related to direct effects, all were statistically significant and supported except hypothesis 7. There exists a positive significant relationship between farmers' perceived usefulness of precision water application devices and their attitude towards using it at 1% level; then a positive significant relationship between farmers' perceived usefulness of precision water application devices and their behavioural intention. The result also shows that perceived ease of use and perceived usefulness had a significant influence on attitude toward using precision water application devices. The attitude has a positive and significant effect on the farmer's behavioural intention on the adoption of precision water application devices, and behavioural intention has a positive and significant effect on the farmer's adoption decision on precision water application devices. However, the anticipated direct

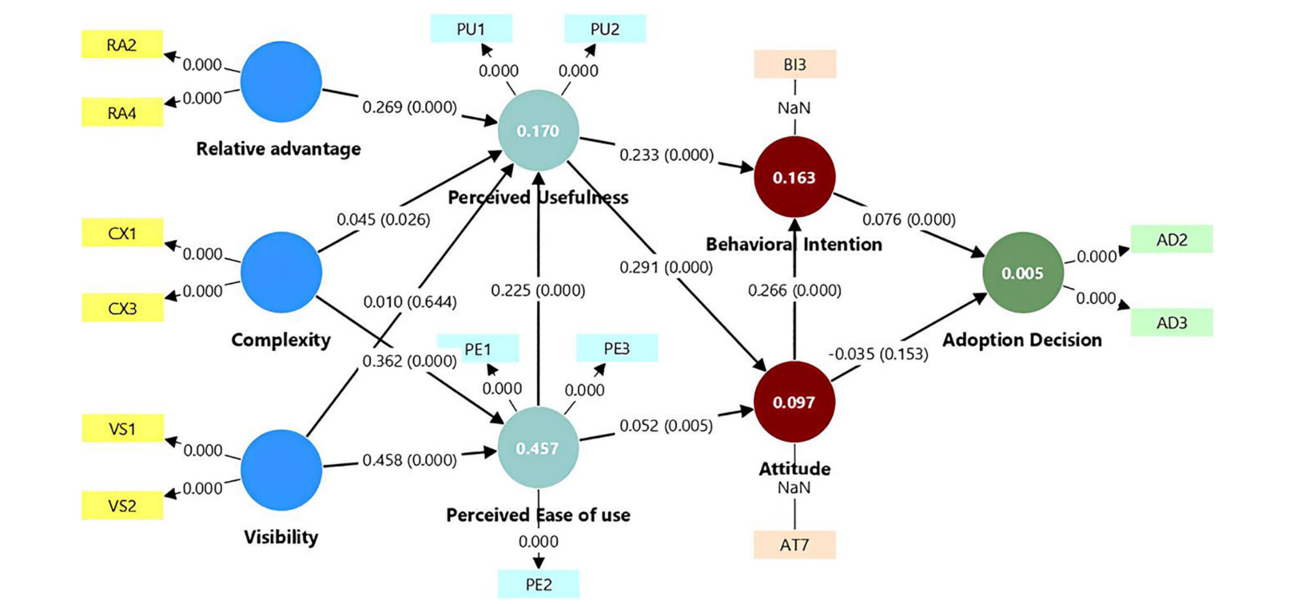

FIGURE 2
Structural equation modelling. Source: survey data (2023-2024).

TABLE 4 Path coefficient of direct relationship.

Effect	Coef.	STDEV	T statistics	P values
H1: Attitude -> Behavioural Intention	0.266	0.018	14.947	0.000
H2: Perceived Ease of use -> Perceived Usefulness	0.224	0.026	8.499	0.000
H3: Perceived Usefulness -> Attitude	0.291	0.018	15.830	0.000
H4: Perceived Ease of use -> Perceived Usefulness	0.224	0.026	8.499	0.000
H5: Perceived Usefulness -> Behavioural Intention	0.232	0.018	13.025	0.000
H6: Behavioural Intention -> Adoption Decision	0.078	0.020	3.876	0.000
H7: Attitude -> Adoption Decision	-0.036	0.025	1.428	0.153
Complexity -> Perceived Ease of use	0.363	0.015	24.791	0.000
Complexity -> Perceived Usefulness	0.046	0.020	2.227	0.026
Relative advantage -> Perceived Usefulness	0.270	0.016	16.504	0.000
Visibility -> Perceived Ease of use	0.457	0.013	34.022	0.000
Visibility -> Perceived Usefulness	0.010	0.022	0.462	0.644

Survey data (2023-2024).

effect of attitude toward precision water application devices on farmers' adoption decisions demonstrated a non-significant relationship. These results confirmed the hypotheses 1 to 6, only the H 7 is not supported.

The findings of the structural model give a strong indication to most of the hypothesized direct effects in the Technology Acceptance Model (TAM). To start with, Attitude has a great effect on Behavioural Intention (H1: 0.266, p = 0.000), meaning that the more positive the attitude of farmers about drip irrigation, the more they are willing to adopt it. Perceived Ease of Use shows a considerable positive influence on Perceived Usefulness (H2: 0.224, p = 0.000), therefore, proving the fact that farmers who find the system operationally uncomplicated believe it to be more beneficial.

In the same way, Attitude also has a positive impact on the Perceived Usefulness (H3: 0.291, p = 0.000), which means that the more farmers understand the positive side of the use of drip irrigation, the more positive is their attitude toward this practice. Perceived Ease of Use enhances Perceived Usefulness with H4 (0.224, p = 0.000), so affirming the longstanding TAM link that ease of use serves as a determinant of perceived benefit. Furthermore, Perceived Usefulness significantly influences Behavioural Intention (H5: 0.232, p = 0.000), suggesting that farmers engage with technologies they deem beneficial. Behavioural Intention is strongly correlated with Adoption Decision (H6: 0.078, p = 0.000), which depicts that intention is an important antecedent to actual adoption among PMKSY beneficiaries and non-beneficiaries. The only non-significant correlation is Attitude effect on Adoption Decision (H7: -0.036, p = 0.153), which indicates that an even positive attitude to drip irrigation alone is not a direct immediate adoptive decision-making factor, presumably due to other extraneous factors like the price, water supply, or subsidy presence. In general, the TAM pathways are reasonably justified in this agrarian setting with intention and perceived usefulness becoming the key factors with regard to adopting drip irrigation.

Along with the fundamental TAM constructs, the external variables included into the model also contribute to valuable results concerning the perception of the farmers about drip irrigation. The results indicate that perceived complexity has a strong positive effect on ease-of-use perception (β = 0.363, p = 0.000) and a weaker but significant positive effect on perceived usefulness (β = 0.046, p = 0.026). These results suggest that the farmers who view drip irrigation as technically complicated also find it easy to use and more beneficial, which can be explained by the correlation between the perceived complexity and extended features, which consequently lead to increased efficiency. Notably, perceived complexity does not seem to dishearten adoption, in fact, it appears to affirm positive appraisal of both usability and utility, which depends on whether they receive sufficient training and technical support. To this end, the PMKSY plays a strategic role by providing the beneficiaries with systematic training sessions and regular follow-up after implementation, thus, enabling the farmers to effectively oversee and get the full benefits of the technology. The positive influence of Relative Advantage on Perceived Usefulness is very strong and have a high level of significance (0.270, p = 0.000), which means that the farmers who think that the use of drip irrigation will give them greater advantages (better and higher yields, greater water efficiency, and less labour) are more likely to appreciate the technology. Visibility is also one of the most significant factors: it has an excellent impact on Perceived Ease of Use (0.457, p = 0.000), i.e., seeing other farmers using drip irrigation successfully makes one have more confidence and a sense of ease of use. Its influence on Perceived Usefulness is not significant (0.010, p = 0.644), though, implying that simple observation does not always lead to the change in the perception of the usefulness of the technology by the farmers. All these external variables reveal that the presence of actual exposure, perceived benefits, and complexity alleviation, are all critical complementary issues that enable the introduction of micro-irrigation systems in Tamil Nadu.

Indirect effect

The findings regarding the indirect relationships indicate mixed significant levels of the three overall hypotheses depicted in Table 5. First, Perceived Usefulness is not a significant predictor of Adoption Decision (H8: 0.014, p = 0.117), which means that even in cases

TABLE 5 Path coefficient of indirect relationship.

Effect	Coef	STDEV	T statistics	P values
H8: Perceived Usefulness -> Adoption Decision	0.014	0.009	1.567	0.117
H9: Perceived Ease of use -> Adoption Decision	0.002	0.003	0.719	0.472
H10: Attitude -> Adoption Decision	0.021	0.005	3.754	0.000
Complexity -> Adoption Decision	0.001	0.002	0.925	0.355
Complexity -> Attitude	0.056	0.009	6.284	0.000
Complexity -> Behavioural Intention	0.045	0.007	6.458	0.000
Complexity -> Perceived Usefulness	0.081	0.010	8.016	0.000
Perceived Ease of use -> Attitude	0.065	0.007	8.961	0.000
Perceived Ease of use -> Behavioural Intention	0.084	0.010	8.799	0.000
Perceived Usefulness -> Behavioural Intention	0.077	0.007	10.773	0.000
Relative advantage -> Adoption Decision	0.004	0.002	1.551	0.121
Relative advantage -> Attitude	0.079	0.008	10.390	0.000
Relative advantage -> Behavioural Intention	0.084	0.007	11.350	0.000
Visibility -> Adoption Decision	0.001	0.002	0.761	0.447
Visibility -> Attitude	0.057	0.010	5.900	0.000
Visibility -> Behavioural Intention	0.041	0.006	6.586	0.000
Visibility -> Perceived Usefulness	0.103	0.013	8.140	0.000

Survey data (2023-2024).

when the farmers think that drip irrigation will improve their performance, the stated perception alone does not help to make them adopt the technology in question. In the same fashion, Perceived Ease of Use has no meaningful indirect impact on Adoption Decision (H9: 0.002, $p = 0.472$) so that ease of use in itself has no significant impact on Adoption Decision. Comparatively, Attitude shows a large indirect effect on Adoption Decision (H10: 0.021, $p = 0.000$) i.e. though attitude does not have a direct effect on adoption in the previous model, it does have a significant effect when other behavioural constructs are used to mediate the inference. This observation supports the role of attitudinal channels of TAM model in determining the psychological preparedness of farmers towards drip irrigation.

The rest of the indirect effects bring more knowledge on the interaction of external and TAM-related constructs in the adoption behaviours of farmers. Complexity has always demonstrated significant mediating effect on various internal variables like attitude, behavioural intention, and perceived usefulness, which implies that the perceptions of difficulty interact in a multidimensional indirect way in the adoption process. Perceived ease of use also promotes a number of indirect channels that strengthen behavioural intention and attitudes development with perceived usefulness. Relative advantage presents indirect behavioural intention contribution and attitude, which proves its relevance as an external factor. Visibility also influences internal constructs indirectly, and it primarily influences the perceptions and intentions of the farmers. On the whole, these discussion avenues highlight the significance of psychological, experience and contextual variables in elucidating how farmers slowly develop adoption choices on drip irrigation.

4.2.2 Model estimation based on beneficiary farmers

In the cases of PMKSY beneficiaries, the interrelations are more orderly and combined in the perception of micro-irrigation. The Technology Acceptance Model internalizes well among the beneficiaries whereby the perceived ease of use, perceived usefulness and behavioural intention are in a stable chain, which provides influence on adoption. Visibility and complexity also play more active roles: the real-life experience and practicality with the system are the causes of how the beneficiaries will consider the system in terms of convenience and practicality. Notably, the behavioural intention pathway to adoption is not only significant but it is positive implying that more the farmers intend to use the system, the more they will tend to translate this intention into actual adoption. Even though attitude is not a direct predictor of adoption, it has an indirect effect on behavioural intention, which means that emotional and cognitive evaluations do matter. Concisely, the beneficiaries are more likely to view the drip system as working, applicable, and becoming even easier to operate due to exposure to the PMKSY support, training, or through subsidies, which strengthens the behavioural pathways to adoption. This is depicted in Figure 3.

4.2.3 Model estimation based on non-beneficiary farmers

In non-beneficiaries, the relations between path variables would be more discontinuous and less continuous implying that internalization of the TAM constructs would be weak. Unlike

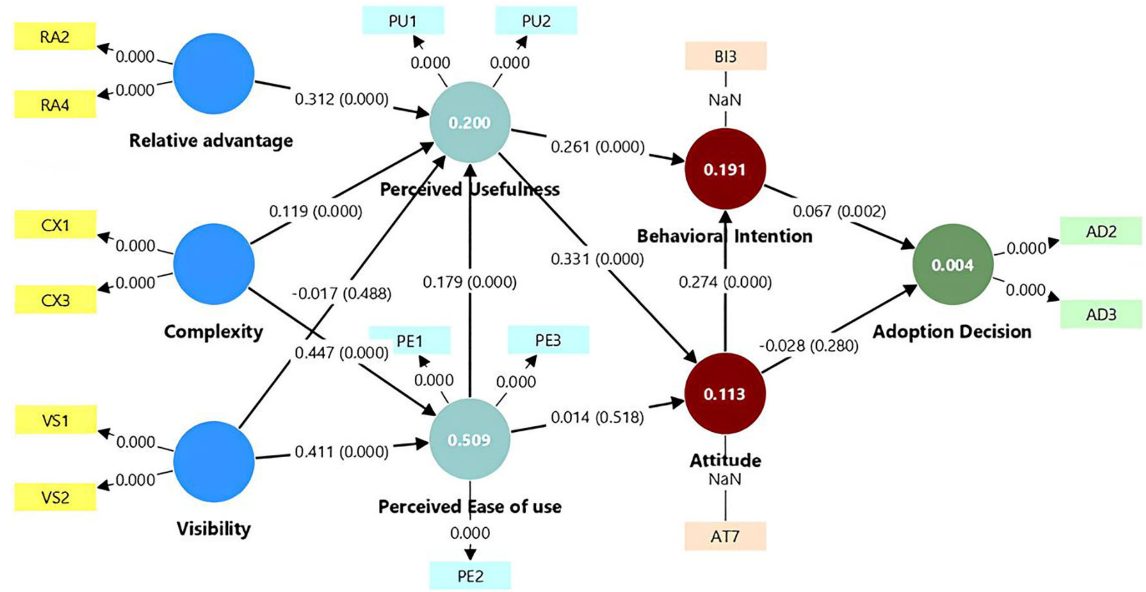

FIGURE 3
SEM of beneficiary farmers. Source: survey data (2023-2024).

beneficiaries, the intention-to-adopt relationship is not substantial; hence, even the non-beneficiary farmers who are willing or interested in adopting it do not translate their intentions into practical adoption. This could be due to financial constraints, absence of technical assistance or even due to doubt about the effectiveness of the system. Perceived ease of use is still significant, yet visibility is the new explanatory variable, which implies that non-beneficiaries are guided more by observing other people not by themselves. The complexity is also less evident in their general decision-making process, and it may indicate that without practical training, farmers will not be able to properly estimate the level of difficulty of micro-irrigation deployment. The attitude was not readily relevant to intention or adoption among non-beneficiaries, indicating a disconnect between their conceptual knowledge of the system and their practical implementation capabilities. Generally, non-beneficiaries exhibit a perceptual framework that is predominantly shaped by observation and cautious interest rather than experiential learning or confidence, hence hindering the establishment of an effective adoption channel. The illustration of the information can be observed in Figure 4.

5 Discussions

Empirical data supports the main principles of the Technology Acceptance Model and, at the same time, have a revelatory impact on the complex interactions between the psychological appraisals of the farmers and the extrinsic constraints that eventually dominate adoption behaviour. The strong and stable impact of attitude on behavioural intention proves the existence of the predisposition in the farmers with the positive attitude toward drip irrigation to express their readiness to adopt this technology, which is consistent with previous research by Doss et al. (2024) and Valizadeh et al. (2020). But the research also proves the fact that attitude is not a direct force of actual adoption. The non-significance of attitude and adoption shows that an optimistic attitude cannot overcome the practical obstacles that relate to cost, water supply, or subsidy, which have been observed in previous studies of limited decision-making conditions (Doss et al., 2024). This strengthens the overriding view that intentions are driven by attitude, but not all the intentions are converted into action.

Policy-wise, the results indicate that the PMKSY interventions should move beyond creation of awareness and attitudinal change towards mechanisms that positively reinforce the intention to adoption. However, despite the fact that PMKSY has been effective in creating an image of favourable perception about micro-irrigation, the absence of an established attitude-to-adoption relationship suggests the need to deploy complementary policy instruments, including timely subsidy delivery, post-installation technical support, and flexible funding solution. Treatment of these practical obstacles identified can be achieved by strengthening these operational aspects of PMKSY which motivate positive behavioural intentions into actual adoption.

The canonical TAM pathway is followed by the perceived usefulness and perceived ease of use. Perceived usefulness is boosted by perceived ease of use, and this fact corroborates the fact that when farmers understand the system and they feel that it is manageable, they also are aware of its advantages. Doss et al. (2024) and Valizadeh et al. (2020) have described these relationships. On its part, perceived usefulness reinforces attitude and behavioural intention, which is consistent with the results presented by Ibnu and Hutabarat (2016). These findings corroborate the previous assertion that perceived usefulness is a significant psychological factor in intention formation, a view also supported by Sugandini et al. (2018), who regard it as a direct influence on behavioural intention.

Such relations are closely related to the design logic of PMKSY, especially, the section named Per Drop More Crop, which focuses

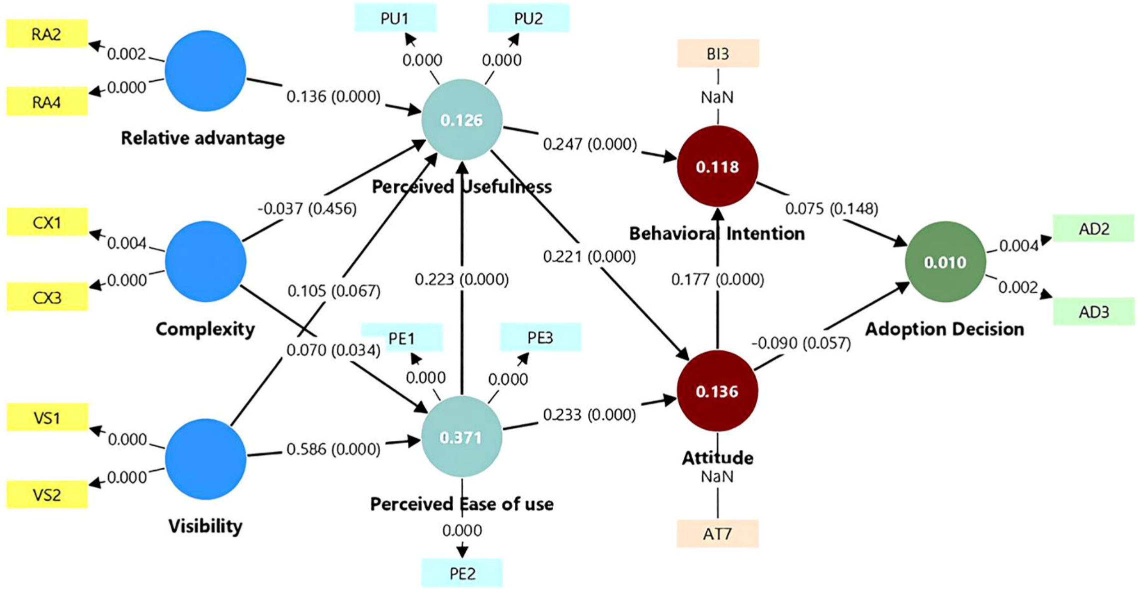

FIGURE 4
SEM of non-beneficiary.

on advantages of efficiency through micro-irrigation technologies. The perceived usefulness has a powerful effect on the behavioural intention, which proves that the focus on PMKSY on provable yield improvement and water saving is consistent with the decision-making of farmers. However, the results suggest that usability support and long-term engagement should be considered equally important in the design of the programme, and perceived benefits should not be expected to ensure adoption automatically.

In spite of its strong indirect effect, perceived usefulness is not a predictor of adoption by itself. This is also reflected in the findings of Nejadrezaei et al. (2018), who also concluded that usefulness is not sufficient to lead to adoption, especially in scenarios where farmers are focused on practical benefits of task-oriented nature than abstract performance demands, which is emphasized by Pickering et al. (2020). The same is the case with perceived ease of use. While it contributes to perceived utility and indirectly influences intention, it does not directly affect adoption decisions. This observation aligns with Nejadrezaei et al. (2018), who noted a diminished direct influence of ease of use on adoption, contrasting with findings from Caffaro et al. (2020), where the indirect effect through behavioural intention was deemed insignificant. The existing findings show that ease of use is important, albeit being influenced mainly by influences on the cognitive processes leading to intention.

The contextuality of these results is more relevance in Tamil Nadu, where agro-climatic heterogeneity, unevenly distributed groundwater and unevenly distributed access to extension services control the irrigation choices undertaken by the farmers. In regions with acute water stress, usefulness as perceived is probably enhanced by immediate water-saving demands, and adoption may be delayed even in favourably perceived regions in an otherwise water-rich environment. This local difference highlights the significance of localizing the strategies of implementation of PMKSY to local hydrological conditions and institutional potential of the state.

Behavioural intention becomes the leading and the only direct psychological determinant of adoption. This supports the TAM postulation that intention is the direct antecedent of actual behaviour a finding that has been supported in multiple studies on technology adoption by farmers (Doss et al., 2024; Valizadeh et al., 2020). The importance of intention is also supported by the fact that both perceived usefulness and attitude only have their effect on adoption when intention is between the two, thus validating the previous point of view that intention mediates the effects of these two constructs on decisions made in the real world.

The convoluted pathways reveal an additional dimension of understanding. Attitude demonstrates a substantial indirect effect on adoption through perceived usefulness and behavioural intention, corroborating the findings of Nejadrezaei et al. (2018) and Sudaryati et al. (2017), which highlight the mediating role of the attitudinal construct in shaping psychological readiness for new technologies. Attitude cannot directly induce the adoption process; however, it will initiate a series of cognitive processes that ultimately result in behavioural intention. This underscores that attitude-specific attention is insufficient, as extraneous variables and complementary behavioural concepts must also be considered, as noted by Sudaryati et al. (2017). The data indicate that farmers exhibit greater reaction to perceived relevance and hard-to-soften benefits rather than to ease of use or general positive affect. This implies that enhancing the adoption process can be achieved by reinforcing the factors that create and sustain behavioural intention. Training emphasizing technical aspects that improve usability, demonstrations showcasing benefits, and support systems addressing external constraints can effectively transform a farmer's intention into actual adoption behaviour.

Overall, the findings underscore that PMKSY's effectiveness depends not only on promoting positive perceptions but also on strengthening institutional mechanisms that facilitate adoption. Program components such as extension-led demonstrations, farmer-to-farmer learning platforms, and continuous technical training play a critical role in reinforcing perceived ease of use and sustaining behavioural intention. Embedding these support structures more explicitly within PMKSY implementation can enhance the program's capacity to achieve durable and widespread adoption of precision water application technologies.

6 Conclusion

The empirical findings indicate that the intention to use micro-irrigation (MI) in its behavioural form by the farmer is the most salient determinant of adoption. Such intention is indirectly affected by the perceived usefulness and positive attitude. Although the ease of use is something that is perceived to be an essential element in developing confidence, it does not convert to a direct influence on the adoption decision. The findings are supported by the previous studies of adoption of technological practices in agriculture. Based on this, the program focused on enhancing the adoption of modern innovations should focus on creating the intentions of farmers to adopt these technologies, proving their usefulness, and addressing the problems in usability. This suggestion is true in the heterogeneous sample of both beneficiaries and non-beneficiaries of the Pradhan Mantri Krishi Sinchayee Yojana (PKMSY). In turn, it is highly urgent to increase the overall adoption of the MI system through simplifying its usability as this has significant importance. Theoretically, the present study adds to the technology acceptance model, making it applicable to precision irrigation technologies in a large-scale, policy-based agricultural context. The evidence narrows down TAM by demonstrating empirically that the perceived ease of use and perceived usefulness do not directly rely into adoption decisions but affect behavioural intention and attitude in the first place. This underscores how intention mediates between technology adoption in agriculture, which is a key process, and implies that the TAM channels in resource-limited farming settings are different than those that are recorded in the consumer-oriented or information-technology field.

The implications of this research on the use of MI technology to motivate farmers to use it are many: first, work on the intention of farmers. Since the intention is a mediator between the adoption of MI by a farmer, there must be attempts to focus on the strategies that influence the intention. Some of the possible interventions are demonstrating the benefits of using MI by providing demonstrations, holding workshops to emphasize its effectiveness, and providing testimonials of successful adopters. As the perceived utility and attitude towards MI have an indirect influence on adoption through the intention, these aspects must be paid attention to. The campaigns need to shed light on the benefits of MI technology in increasing crop production, streamlining the use of water and even increasing the revenues. Although indirectly affecting adoption by the intention factor, perceived ease of use does not directly affect the decision-making, and an over-emphasis on ease of use is not the most effective approach. Still, explicit instructions and easily available facilitation can have a beneficial impact on the worries about complexity and create acceptance and usage of technology. Besides its theoretical applicability, the research contributes to the irrigation policy literature by providing behavioural data on the reaction of farmers to the mass public intervention like PMKSY. This research, unlike other previous studies that mostly look at economic or agronomic results, illustrates that the effectiveness of a programme depends on how the design factors influence how farmers perceive, intend to act or not. By isolating the micro-irrigation adoption to behavioural mechanisms, the study provides policy-relevant information, which complements the existing assessment of PMKSY and other similar irrigation projects.

Future studies can continue to develop these results by expanding the analytical model to clearly include institutional and situational variables including the intensity of extension, the quality of training, the availability of credit, and the effectiveness of governance. The longitudinal research would be of great use in investigating the changes in the perceptions and intentions of farmers throughout the time and how the long-term impact of micro-irrigations on the productivity, water conservation, and income stability would be. Interstate/inter-irrigation programme comparisons might also be useful in confirming the generalizability of the streamlined TAM pathways reported herein and reinforcing evidence-based policymaking on irrigation in different agroecological settings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

PM: Investigation, Conceptualization, Funding acquisition, Formal analysis, Project administration, Supervision, Methodology, Writing – review & editing. PS: Investigation, Funding acquisition, Writing – review & editing, Project administration. MM: Supervision, Methodology, Validation, Conceptualization, Writing – review & editing, Investigation, Funding acquisition, Project administration, Visualization. MA: Project administration, Investigation, Visualization, Writing – review & editing. AN: Supervision, Investigation, Writing – review & editing, Project administration, Funding acquisition, Validation, Visualization. AI: Formal analysis, Methodology, Writing – original draft, Visualization, Software, Writing – review & editing. MK: Writing – review & editing, Visualization, Supervision, Data curation. PV: Resources, Data curation, Writing – review & editing, Investigation. KA: Resources, Investigation, Data curation, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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References

Abdullah, F., Ward, R., and Ahmed, E. (2016). Investigating the influence of the most commonly used external variables of TAM on students' perceived ease of use (PEOU) and perceived usefulness (PU) of e-portfolios. *Comput. Hum. Behav.* 63, 75–90. doi: 10.1016/j.chb.2016.05.014

Abhilash,, Rani, A., Kumari, A., Kumar, J., and Ravindra Reddy, B. (2020) *Water resource and use efficiency under changing climate.* (Singapore: Springer), 519–576. doi: 10.1007/978-981-15-6953-1_15

Adhikari, B., Prasad, S. V., Praveena, P. L. R. J., Sagar, G. K., and Ravindra Reddy, B. (2021). Socio-personal and communication characteristics of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) beneficiary farmers in Uttarakhand. *Asian J. Agric. Extension Econ Sociology* 39, 11–19. doi: 10.9734/ajaees/2021/v39i1130715

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behav. Hum. Decision Processes* 50, 179–211. doi: 10.1016/0749-5978(91)90020-T

Caffaro, F., Cremasco, M. M., Roccato, M., and Cavallo, E.. (2020). Drivers of farmers' intention to adopt technological innovations in Italy: The role of information sources, perceived usefulness, and perceived ease of use. *J. Rural Stud.* 76, 264–271. doi: 10.1016/j.jrurstud.2020.04.028

Chen, L., and Aklikokou, A. K. (2019). Determinants of e-government adoption: Testing the mediating effects of perceived usefulness and perceived ease of use. *Int. J. Public Administration* 00, 1–16. doi: 10.1080/01900692.2019.1660989

Cho, M., Bonn, M. A., and Li, J. (2019). Differences in perceptions about food delivery apps between single-person and multi-person households. *Int. J. Hospitality Manage.* 77, 108–116. doi: 10.1016/j.ijhm.2018.06.019

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (Routledge). doi: 10.4324/9780203771587 (Accessed November 20, 2025).

Davis, (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. *Management Information Systems Research Center*. 13, 319–340. doi: 10.5962/bhl.title.33621

Doss, D. A., Asokhan, M., Balasubramaniam, P., and Kumaresan, P.. (2024). Perception and adoption of drip irrigation technology among beneficiaries of the Tamil Nadu Irrigated Agriculture Modernization Project: A structural equation modelling approach. *Plant Sci. Today* 11 (sp4), 1–9. doi: 10.14719/pst.5795

Fornell, C., and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *J. Marketing Res.* 18, 39–50. doi: 10.1177/002224378101800104

Hair, J. F.Jr, Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., and Ray, S. (2021). *Partial least squares structural equation modeling (PLS-SEM) using R: A workbook* (Springer Nature), 197.

Hair, J. F., Ringle, C. M., and Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *J. Marketing Theory Pract.* 19, 139–152. doi: 10.2753/MTP1069-6679190202

Hair, J. F., Risher, J. J., Sarstedt, M., and Ringle, C. M. (2019). When to Use and How to Report the Results of PLS-SEM. *Eur. Bus. Rev.* 31, 2–24. doi: 10.1108/EBR-11-2018-0203

Hansen, T., Jensen, J. M., and Solgaard, H. S. (2004). Predicting online grocery buying intention: A comparison of the theory of reasoned action and the theory of planned behaviour. *Int. J. Inf. Manage.* 24, 539–550. doi: 10.1016/j.ijinfomgt.2004.08.004

Henseler, J., Hubona, G., and Ray, P. A. (2016). Using PLS path modeling in new technology research: Updated guidelines. *Ind. Manage. Data Syst.* 116, 2–20. doi: 10.1108/IMDS-09-2015-0382

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *J. Acad. Marketing Sci.* 43, 115–135. doi: 10.1007/s11747-014-0403-8

Hu, L. T., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct. Equation Modeling* 6, 1–55. doi: 10.1080/10705519909540118

Ibnu, M., and Hutabarat, B. (2016). Predicting technology adoption in paddy (rice) cultivation at Sukoharjo and Wonokarto village of Sekampung subdistrict in East District of Lampung Province, Indonesia. *J. Agric. Educ.* 30, 59–79. doi: 10.21082/JAE.V30N1.2012.59-79

Jayasankar, R., Sneha, V., and Muthukumar, R.. (2020). Technological and cultivational knowledge of the PMKSY beneficiaries about grape cultivation with drip irrigation in Tamil Nadu. *Plant Arch.* 20(Suppl. 1), 1589–1592. Available online at: https://www.plantarchives.org/SPECIAL%20ISSUE%2020-1/1589-1592%20(552).pdf.

Jinger, D., Kaushal, R., Kumar, R., Paramesh, V., Verma, A., Shukla, M., et al. (2023). Degraded land rehabilitation through agroforestry in India: Achievements, current understanding, and future prospectives. *Front. Ecol. Evol.* 11. doi: 10.3389/fevo.2023.1088796

Shah, M., and Vijayshankar, P. S.. (2022). Symbiosis of Water and Agricultural Transformation in India. In: R. Chand, P. Joshi and S. Khadka, editors. *Indian Agriculture Towards 2030*. Singapore: Springer. 109–152. (India Studies in Business and Economics). doi: 10.1007/978-981-19-0763-0_5

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *Int. J. E-Collaboration* 11, 1–10. doi: 10.4018/ijec.2015100101

Kumar, S., Yadav, A., Kumar, A., Hasanain, M., Shankar, K., Karan, S., et al. (2023). Climate Smart Irrigation Practices for Improving Water Productivity in India: A Comprehensive Review. *Int. J. Environ. Climate Change* 13 (12), 333–348. doi: 10.9734/ijecc/2023/v13i123689

Kumari, V., Chander, S., Malik, K., and Kaur, B. (2022). Assessment of knowledge and adoption of drip irrigation in cotton crop among farmers of Haryana. *Indian J. Extension Educ.* 58, 149–154. doi: 10.48165/ijee.2022.58430

Lewis, K., and Devi, G. (2025). Adoption of agri-tech and precision farming among entrepreneurs in Dakshina Kannada: An extended TAM approach. *Asian Rev. Soc. Sci.* 14, 38–46. doi: 10.70112/arss-2025.14.1.4307

Ma, S., Meng, Y., Han, Q., and Ma, S. C. (2023). Drip fertilization improve water and nitrogen use efficiency by optimizing root and shoot traits of winter wheat. *Front. Plant Sci.* 14. doi: 10.3389/fpls.2023.1201966

Nejadrezaei, N., Allahyari, M. S., Sadeghzadeh, M., Michailidis, A., and El Bilali, H. (2018). Factors affecting adoption of pressurized irrigation technology among olive farmers in Northern Iran. *Appl. Water Sci.* 8, 190. doi: 10.1007/S13201-018-0819-2

Park, S., Nishikoji, H., Takahashi, S., Fawibe, O. O., Wang, P., and Isoda, A. (2021). Rice cultivation under drip irrigation with plastic film mulch in the Kanto area of Japan. *Universal J. Agric. Res.* 9, 101–110. doi: 10.13189/UJAR.2021.090401

Pickering, B., Bartholomew, R., Janian, M. N., López Moreno, B., and Surridge, M. (2020). *Ask me no questions: Increasing empirical evidence for a qualitative approach to technology acceptance* (Cham: Springer), 125–136. doi: 10.1007/978-3-030-49059-1_9

Rajaguru, S., Kalidasan, T., and Tamilselvi, G. (2023). Constraints faced by the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) beneficiaries in adoption of drip irrigation system in Tamil Nadu. *Indian J. Sci. And Technol.* 16, 82–88. doi: 10.17485/ijst/v16i2.2328

Reddy, P. V. R. M., Kona, S., Reddy, R. V. S. K., Reddy, B. J., Ramana, R. V., Rekha, D. V. S. R. L., et al. (2022). Impact of watershed management on bio-physical, hydrological and agricultural indicators in the Lakkonda Watershed Project of East Godavari District, Andhra Pradesh, India. *Int. J. Plant Soil Sci.* 34, 1112–1125. doi: 10.9734/ijpss/2022/v34i242742

Shankar, G., Sharma, G., and Mazhar, S. H.. (2023). Personal Characteristics and Knowledge of Beneficiary Farmers towards Pradhan Mantri Krishi Sinchai Yojana in Amber Block of Jaipur, India. *Asian J. Agric. Ext. Econ. Soc.* 41(7), 140–145. doi: 10.9734/ajaees/2023/v41i71956

Sharma, N. (2020). Awareness and performance of agricultural development schemes in context of farmers' welfare in Haryana. *Economic Affairs* 65, 167–172. doi: 10.46852/0424-2513.2.2020.5

Shehrawat, A., Sharma, N., Shehrawat, P., and Bhakar, S. (2020). Awareness and performance of agricultural development schemes in context of farmers' welfare in Haryana. *Economic Affairs (New Delhi)* 65, 167–172. doi: 10.46852/0424-2513.2.2020.5

Singh, G., and Gandhi, V.. (2023). Enhancing the Adoption of Water Saving Technologies in India's Agriculture: The Determinants Across Four States of India. SSRN. Available online at: https://ssrn.com/abstract=4604984 (Accessed March 14, 2026). doi: 10.2139/ssrn.4604984

Sishodia, R. P., Shukla, S., Graham, W. D., Wani, S. P., and Garg, K. K. (2016). Bi-decadal groundwater level trends in a semi-arid south Indian region: Declines, causes and management. *J. Hydrology: Regional Stud.* 8, 43–58. doi: 10.1016/j.ejrh.2016.09.005

Sudaryati, E., and Agustia, D. (2017). The Influence of Perceived Usefulness, Perceived Ease of Use, Attitude, Subjective Norm, and Perceived Behavioral Control to Actual Usage PSAK 45 Revision on 2011 with Intention as Intervening Variable in Unair Financial Department. In: *2017 International Conference on Organizational Innovation (ICOI 2017)*. Amsterdam: Atlantis Press. 174–180. doi: 10.2991/ICOI-17.2017.30

Sugandini, D., Purwoko, A., Pambudi, A., Resmi, S., Reniati, R., Muafi, M., et al. (2018). The Role of Uncertainty, Perceived Ease of use, and Perceived usefulness towards the Technology Adoption. *Int. J. Civil Eng. Technol.* 9(4), 660–669. Available online at: http://iaeme.com/Home/issue/IJCIET?Volume=9&Issue=4 (Accessed March 14, 2026).

Susanti, E., and Astuti, F. D.. (2019). Technology acceptance model for digital marketing analysis. In: *Proceedings of the International Conferences on Information System and Technology (CONRIST)*. Setúbal, Portugal: SCITEPRESS – Science and Technology Publications, Lda.. 85–91.

Taufik, M., and Ruzardi, (2021). Literature study of irrigation management of irrigation modernization based to support the productivity of paddy. *Universal J. Agric. Res.* 9, 184–190. doi: 10.13189/ujar.2021.090505

Tripathy, M., Mishra, B., Satapathy, G. P., and Das, S. (2023). Analysis of constraints affecting beneficiaries under Pradhan Mantri Krishi Sinchayee Yojana in Odisha. *Indian J. Extension Educ.* 59, 153–155. doi: 10.48165/IJEE.2023.59330.

Troise, C., O'Driscoll, A., Tani, M., and Prisco, A. (2021). Online food delivery services and behavioural intention – a test of an integrated TAM and TPB framework. *Br. Food J.* 123, 664–683. doi: 10.1108/BFJ-05-2020-0418

Valizadeh, N., Rezaei-Moghaddam, K., and Hayati, D. (2020). Analyzing Iranian farmers' behavioural intention towards acceptance of drip irrigation using extended technology acceptance model. *J. Agric. Sci. Technol.* 22, 1177–1190. Available online at: https://jast.modares.ac.ir/article-23-32523-en.html.

Verma, B., and Tandon, U.. (2024). Modelling barriers to wearable technologies in Indian context: validating the moderating role of technology literacy. *Global Knowl. Mem. Commun.* 73(6/7), 984–1004. doi: 10.1108/GKMC-08-2022-0209

Wani, S. P., Anantha, K. H., Garg, K. K., Joshi, P. K., Sohani, G., Mishra, P. K., and Palanisami, K.. (2016). Pradhan Mantri Krishi Sinchai Yojana: Enhancing the Impact through Demand Driven Innovations. (Research Report IDC-7). Patancheru, Telangana, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 52 pp. Available online at: http://oar.icrisat.org/9758/ (Accessed March 14, 2026).

Xie, C. (2025). The role of modern agricultural technologies in improving agricultural productivity and land use efficiency. *Front. Plant Sci.* 16. doi: 10.3389/fpls.2025.1675657

Xing, Y., and Wang, X. (2024). Precise application of water and fertilizer to crops: Challenges and opportunities. *Front. Plant Sci.* 15. doi: 10.3389/fpls.2024.1444560

Zhang, Q., Han, Y., Qi, M., Jing, H., Nie, X., Yu, G., et al. (2025). Optimizing irrigation and nitrogen rate can enhance the grain yield in both main and ratoon rice crop. *Front. Plant Sci.* 16. doi: 10.3389/fpls.2025.1646424