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RESEARCH ARTICLE

Barriers on Adoption of Micro Irrigation by farmers in Tamil Nadu

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ABSTRACT

Irrigation becomes crucial in modern agriculture, particularly in water-scarce regions like Tamil Nadu, India. Pradhan Mantri Krishi Sinchai Yojana micro-irrigation scheme operated in Tamil Nadu from 2015–2016 to date in Tamil Nadu. The list of beneficiaries from all the districts was collected from the Micro Irrigation (MI) Management Information System. From each district, 60 farmers were randomly chosen and data collected from 2,220 respondents across 37 districts and were analyzed using the problem confrontation index to identify the constraints. The constraints were categorized into technical, infrastructural, financial, knowledge-based, and climate/geographical issues. The most critical technical challenge identified was the clogging of drippers, followed by frequent maintenance and lack of skilled technical expertise to solve technical issues. Poor post-sale services and unavailability of spare parts rank highest among infrastructural constraints, impacting the sustainability of the systems. Financial burdens, such as high maintenance costs and expensive water-soluble fertilizers, also significantly affect farmers, making it challenging for small-scale farmers to adopt and maintain these systems. Lack of training and knowledge about system operation was a significant knowledge barrier, highlighting the need for more hands on demonstrations and expert consultations. Furthermore, environmental factors such as unsuitable soils in saline areas and high temperatures contribute to the reduced durability of the MI systems. Topographical challenges also made it difficult to install MI effectively in uneven terrains. Addressing these challenges requires a multifaceted approach, including targeted technical support, improved post sales services, affordable financial assistance, and climate adapted system designs. Expanding training programs and providing better access to spare parts and technical expertise will enhance the adoption and long-term success of MI in Tamil Nadu.

Key words: Adoption, Challenges, Micro irrigation, Pradhan Mantri Krishi Sinchai Yojana, Problem confrontation index

INTRODUCTION

Water scarcity and inefficient irrigation practices are major challenges in Indian agriculture, particularly in states like Tamil Nadu, where dependence on traditional irrigation methods has led to declining water tables and reduced agricultural productivity. Micro irrigation (MI), which includes drip and sprinkler systems, has emerged as a viable solution to enhance water efficiency and improve crop yields. Despite the proven benefits and government efforts to promote MI through subsidies and awareness programs, its adoption in Tamil Nadu remains relatively low. This review explores the key barriers to MI adoption, categorizing them into technical,

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infrastructural, financial, knowledge-based, and climate/geographical issues.

MI is pivotal in modern agriculture, significantly improving water use efficiency (WUE), enhancing crop yields, and reducing environmental impacts. This method involves the controlled application of water on the soil above, or below the soil in the form of drips, tiny streams, or miniature sprays using systems such as bubblers, micro-sprinklers, subsurface drip, and surface drip irrigation. India's average annual water availability is 2,200 cubic meters (Statista, 2023). Tamil Nadu has only 750 cubic meters per capita. Of Tamil Nadu's 60.74 lakh hectares of gross cropped area, 80% or 35 lakh hectares are suitable for irrigated agriculture, while the remaining 20% is used for non-food crops. The WUE in India is the lowest at the global level, with agricultural WUE ranging between 30 and 40%, improving the irrigation WUE is essential for increasing the area under irrigation and overall agricultural productivity (Manjunatha *et al*., 2011). This can be achieved by adopting modern irrigation techniques such as MI alongside other improved management practices. MI systems include drip, sprinkler, micro-sprinkler, and mini-sprinkler technologies. Tamil Nadu, one of the most water-stressed states, has only 3% of India's total water resources and has a greater pressure on available irrigation water. MI plays a crucial role in delivering water and nutrients directly to the plant's root zone, minimizing water loss through evaporation and runoff. It also allows for precise irrigation control, optimizing water usage and reducing the risks of water stress or overwatering. This paper highlighted the challenges faced by farmers and extension officials in implementing MI schemes. These constraints are categorized into five main areas: Technical, infrastructural, financial, knowledge-based, and climate/geographical challenges.

REVIEW OF LITERATURE

Around the world, MI, or MI, has become an essential part of sustainable agriculture, especially in arid and semi-arid areas such as Israel, Australia, and the southwestern United States. Crop yields and WUE have been greatly increased in these areas by combining MI with precision agriculture (Archibald and Marshall, 2018). This success story, however, stands in stark contrast to the circumstances in many developing nations, where farmers' lack of awareness, insufficient technical assistance, and financial constraints impede the adoption of MI (Friedlander *et al*., 2013).

Through the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) and other state-level subsidy programs, the Indian government has actively promoted MI. Due to socioeconomic differences and infrastructure obstacles, adoption is still uneven despite these efforts (Rasul, 2014). Tamil Nadu still faces significant obstacles in implementing MI, whereas Gujarat and Maharashtra have made significant strides. According to Kumar *et al*. (2017), these include problems with small and dispersed landholdings, declining water quality, and a lack of institutional support.

The slow adoption of MI is further exacerbated by the conservative mindset of many farmers. Farmers are deterred from abandoning traditional irrigation methods by concerns about technological failure and uncertain returns (Perez *et al*., 2015). One of the biggest obstacles to adoption is still the high initial investment costs, particularly for small and marginal farmers with limited funding (Mohan *et al*., 2024). This is made worse by restricted access to official credit, which prevents many people from using even subsidized systems (Ayaz *et al*., 2019). The design and implementation of effective MI systems are made more difficult by the small, irregular land parcels that define Tamil Nadu's agrarian landscape (Narotzky and Besnier, 2014). Furthermore, long-term investments in irrigation infrastructure are frequently discouraged by informal land leasing and tenancy agreements (Lambin *et al*., 2001).

Farmers' lack of technical expertise is yet another significant barrier to MI's widespread adoption. Many people are discouraged from considering MI as a feasible alternative due to the intricacy of system installation, operation, and maintenance (Teferi *et al*., 2024). Furthermore, the transition from traditional flood irrigation to MI is challenging from a technical and cultural standpoint due to Tamil Nadu's dominant agricultural pattern, which emphasizes water-intensive crops like paddy (Mohan *et al*., 2024). Frequent clogging of drip irrigation systems due to poor water quality or improper maintenance further discourages adoption (Arunachalam and Venkatesan, 2020). Farmers often lack access to adequate support services for timely repairs and maintenance, leading to system failures and dissatisfaction. Although the Tamil Nadu government provides subsidies for MI adoption, bureaucratic delays and procedural complexities in availing subsidies create frustrations among farmers (Prabha and Arunachalam, 2017). It is impossible to overestimate the contribution that agricultural extension services make to MI promotion. These services, however, frequently lack adequate outreach and resources in Tamil Nadu. According to Maiangwa *et al*. (2011), many extension agents lack the practical training and field demonstrations necessary to encourage farmers to adopt new technologies. Farmers' exposure to MI's long-term advantages is further restricted by this communication gap.

METHODOLOGY

The study adopted an Ex post facto research design to explore the challenges faced by farmers under the PMKSY micro-irrigation scheme in Tamil Nadu. A random sampling method was employed, targeting 37 districts across the seven Agro-Climatic Zones of Tamil Nadu, ensuring a diverse representation of geographical and agro-climatic conditions. In each district, one block was selected based on the highest number of beneficiaries from the PMKSY scheme, and within these blocks, three villages with maximum number of beneficiaries were chosen. In each district, 60 beneficiaries are chosen randomly, and the total sample size is 2,220 MI beneficiaries. To assess the challenges faced by these farmers, the problem confrontation index (PCI) was used. A four-point rating scale with the responses of "Not at all," "Low," "Medium," and "High," with the corresponding scores of 0, 1, 2, and 3 is given. The PCI was calculated using the formula

$$PCI = Ph \times 3 + Pm \times 2 + Pl \times 1 + Pn \times 0,$$

Where,
PCI = Problem confrontation index
Ph = Number of beneficiaries having high problem
Pm = Number of beneficiaries having medium problem
Pl = Number of beneficiaries having low problem
Pn = Number of beneficiaries having no problem

RESULTS AND DISCUSSION

The barriers to MI adoption in Tamil Nadu present a multifaceted challenge that requires a deeper analysis of technical, infrastructural, financial, knowledge-based, and climate/geographical constraints. While existing literature provides valuable insights into these factors, empirical evidence from field studies can offer a clearer understanding of how these barriers manifest at the grassroots level. The following section presents the results and discussion based on data collected from farmers to assess the real-world implications of these challenges.

Technical Constraints (n = 2220)

As seen Figure 1, the Clogging of drippers due to suspended materials, with the highest PCI score of 5658, is the most critical technical issue in MI systems. Clogging hinders the uniform distribution of water to crops, as debris, sediment, or organic matter can block drippers and requires frequent maintenance to ensure optimal water flow. The need for regular maintenance, with a PCI score of 5632, is another major concern, as systems need consistent inspection and maintenance to improve efficiency and prevent downtime. The lack of technical expertise, with a PCI score of 5570, poses challenges in system installation and management, highlighting

S. No.	Technical constraints	Level of expression					
		Not at all	Low	Medium	High	PCI	Rank
	Score	0	1	2	3		
1.	Clogging of drippers by suspended materials	0	334	668	4656	5658	I
2.	Lack of technical know-how	0	259	1144	4167	5570	III
3.	Inadequate pressure to discharge water	0	70	1904	3594	5568	IV
4.	Require frequent maintenance	0	280	936	4416	5632	II
5.	Water leakage	0	239	1384	3867	5490	V

the need for proper training for both farmers and technicians. Inadequate water pressure (PCI score of 5568) leads to uneven water distribution, negatively impacting crop health, while water leakage, with a PCI score of 5490, results in water wastage and potential infrastructure damage. Addressing these issues through proper system design, supply of quality materials, and regular inspection is essential for maximizing system performance and reliability.

Infrastructural Constraints (*n* = 2220)

Post-sales support is critical in the adoption and long-term performance of MI systems, with poor services ranking as the highest constraint, indicated by a PCI score of 5875. Timely assistance, warranty coverage, and maintenance are essential for customer satisfaction. The unavailability of field technicians, ranked second with a PCI score of 5660, highlights the importance of technical staff for installation and troubleshooting.

Damage caused by squirrels and rats (PCI score of 5643) underscores the need for rodent-resistant materials to prevent system disruption. The difficulty in accessing spare parts, ranked fourth with a PCI score of 5569, stresses the importance of easy access to components for timely repairs. Which is clearly depicted in Figure 2. Limited water availability (PCI score of 5560) is a crucial issue, especially in water-scarce regions. Poor-quality pipes and micro-tubes (PCI score of 5501) result in leaks and system inefficiency, emphasizing the need for durable materials. Finally, inadequate electricity supply (PCI score of 5245) hampers irrigation systems reliant on electrical power, leading to reduced crop yields and lower farm productivity.

Financial Constraints (*n* = 2220)

The Figure 3 shows that the high maintenance cost of MI systems, with the highest PCI score of 5940, is a significant burden on farmers, as regular upkeep is essential to prevent downtime and ensure system efficiency. The financial strain affects their ability to sustain these systems. In addition, the cost of water-soluble fertilizers, with a PCI score of 5869, is a medium-level constraint but still impacts profitability, as these fertilizers are crucial for precise nutrient management. High repair and replacement costs (PCI score of 5691) further strain farmers' budgets, discouraging them from investing in necessary system maintenance. The initial installation costs (PCI score of 480) are a major barrier, especially for small-scale farmers who may struggle with the upfront investment. Finally, inadequate access to credit (PCI score of 608) exacerbates these challenges, as farmers need financial support to adopt and maintain MI systems,

S. No.	Infrastructural constraints	Level of expression					
		Not at all	Low	Medium	High	PCI	Rank
	Score	0	1	2	3		
1.	Inadequate supply of electricity for irrigating the fields	140	65	1730	3450	5245	VII
2.	Non-availability of technical field staff	0	230	3100	4350	5660	II
3.	Poor services by companies after sales	0	135	1030	4710	5875	I
4.	Difficulty in access to spare parts	0	261	1138	4170	5569	IV
5.	Low-quality pipe and micro-tubes	0	236	1374	3891	5501	VI
6.	Limited water sources availability	0	225	1300	4035	5560	V
7.	Damage of microtube/laterals by squirrels and rats	0	286	890	4467	5643	III

S.No	Financial constraints	Level of expression					
		Not at all	Low	Medium	High	PCI	Rank
	Score	0	1	2	3		
1.	Initial installation cost is very high	1894	172	308	0	480	IV
2.	High maintenance cost	0	89	1084	4167	5940	I
3.	Higher cost of water-soluble fertilizers	0	236	638	4995	5869	II
4.	High repair and replacement cost	0	221	1054	4416	5691	III
5.	Inadequate credit facilities for the farmers	1892	102	344	162	604	V

limiting their capacity to implement water-saving practices and boost agricultural productivity.

Knowledge Constraints (*n* = 2220)

According to Figure 4, Less exposure to training about MI system (Rank I) with the highest level of expression and the highest PCI score of 5993 underscores the significance of training. Comprehensive training programs are essential for equipping farmers with the knowledge and skills needed to effectively implement and manage MI systems. Training sessions should cover system operation, maintenance, troubleshooting, water management practices, and sustainable agriculture principles. A significant constraint faced by farmers was the lack of knowledge regarding the operation of micro irrigation systems, which ranked second (Rank II) with a high Problem Confrontation Index (PCI) score of 5806. This highlights a critical gap in technical understanding that can hinder the effective utilization and long-term sustainability of the system., the lack of knowledge about operating micro irrigation systems is a significant constraint. Proper operation of micro irrigation systems is crucial for achieving water efficiency and maximizing crop yield. Farmers need adequate training and guidance on system operation, maintenance, and troubleshooting to ensure optimal performance and resource utilization. The limited number of demonstrations conducted before the installation of micro irrigation systems was identified as a moderate-level constraint (Rank III) with a PCI score of 5518, indicating that farmers did not receive enough practical exposure to understand the system thoroughly before implementation. On-site demonstrations provide farmers with practical insights into system functionality, installation techniques, and performance expectations. Increasing the number of demonstrations can enhance farmers' confidence, promote adoption, and facilitate successful implementation of micro irrigation technologies. Limited knowledge on Micro irrigation system calibration with a PCI score 5443 was ranked fourth, this constraint indicates a high level of expression, highlighting the importance of calibration. Proper calibration ensures accurate water application rates and uniform distribution across the field. Farmers require training and guidance on calibration techniques to optimize system performance, minimize water wastage, and maximize crop productivity. Less contact with expertise persons (Rank V), despite being a medium-level constraint, limited contact with expertise persons is critical, with a PCI score of 5252. Access to knowledgeable individuals, such as agricultural extension workers or technical experts, is essential for addressing technical queries and obtaining assistance with MI systems. Establishing networks and platforms for knowledge sharing and collaboration can facilitate learning and innovation in MI practices.

S. No.	Knowledge constraints	Level of expression					
		Not at all	Low	Medium	High	PCI	Rank
	Score	0	1	2	3		
1	Lack of knowledge about operating of micro irrigation system	0	189	952	4665	5806	II
2	Less contact with technical experts	0	446	1032	3774	5252	V
3	Limited knowledge of micro irrigation system calibration	0	356	1010	4077	5443	IV
4	Less exposure to training about micro irrigation system	0	104	918	4971	5993	I
5	Inadequate number of demonstrations before the installation of micro irrigation system	0	318	1012	4188	5518	III

S. No.	Climate and geographical constraints	Level of expression					
		Not at all	Low	Medium	High	PCI	Rank
	Score	0	1	2	3		
1	Topography challenges	504	508	504	2868	3880	II
2	Unsuitable for highly saline areas	0	125	698	5238	6061	I
3	Durability of micro irrigation systems has been reduced due to high temperature	456	654	740	2220	3614	III

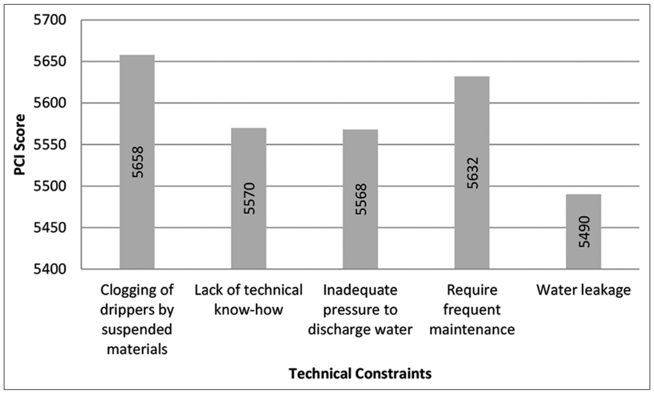

Figure 1: Technical constraints

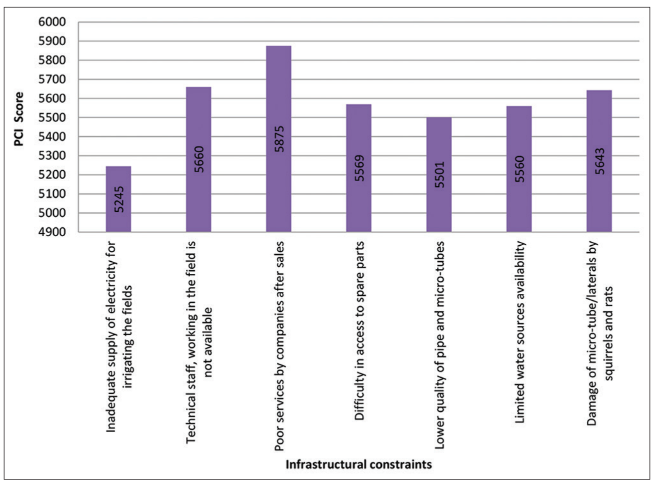

Figure 2: Infrastructural constraints

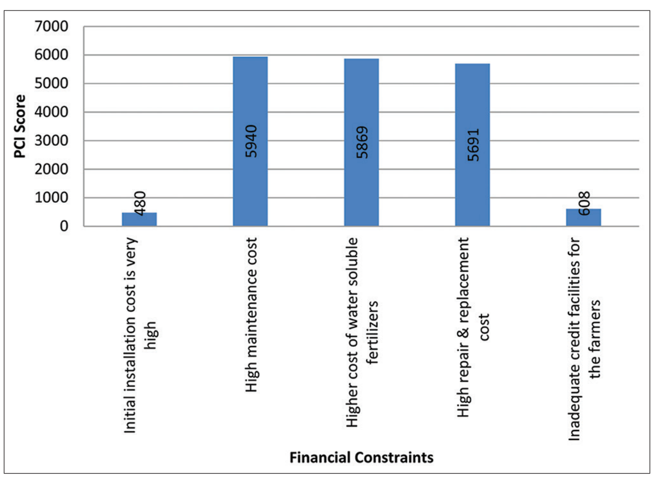

Figure 3: Financial constraints

Climate and Geographical Constraints ($n = 2220$)

Unsuitable for highly saline areas (Rank I) with the highest level of expression and the highest PCI score of 6061 underscores the significance of soil salinity as shown in Figure 5. Highly saline soils can adversely affect crop growth and compromise

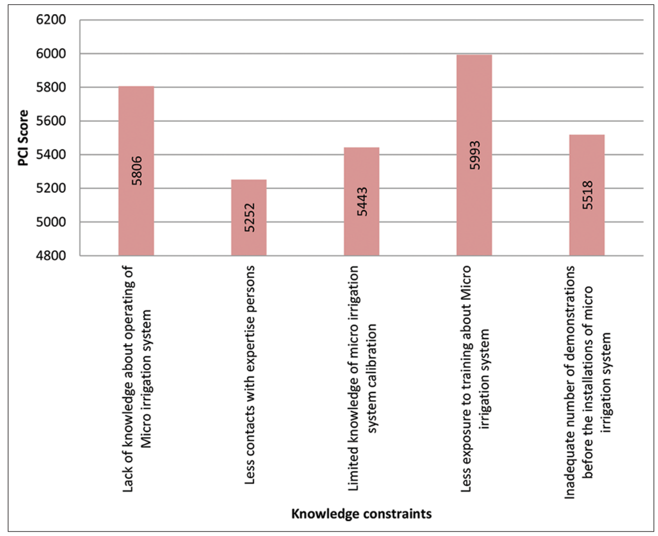

Figure 4: Knowledge constraints

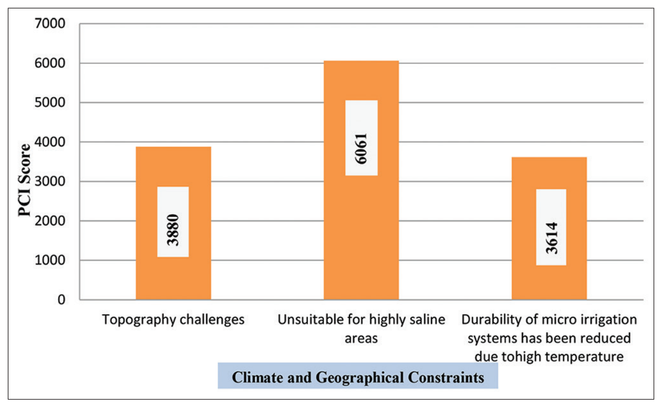

Figure 5: Climate and geographical constraints

the effectiveness of MI systems. Soil management practices such as leaching, drainage, and soil amendments may be necessary to mitigate salinity issues and optimize crop performance in affected areas. Topography challenges (Rank II) with a high level of PCI score 3880 ranked second in Climate and Geographical constraints, topography challenges represent a significant constraint. Irregular terrain, slopes, and elevation variations can pose challenges in the layout and installation of MI systems. Adaptations such as terracing, contour farming, and customized design solutions are often required to address topographical constraints and ensure efficient water distribution. Durability of the MI system has been reduced due to high temperature (PCI Rank III) with a PCI score of 3614, and this constraint indicates a high level of expression, highlighting the impact of high temperatures on system durability. Exposure to prolonged heat and sunlight can degrade materials, reduce system lifespan, and increase maintenance requirements. Implementing measures such as selecting UV-resistant materials, shading, and insulation can help mitigate the effects of high temperatures and prolong system durability.

CONCLUSION

The study highlights several key constraints in the adoption and performance of MI systems, categorized into technical, infrastructural, financial, knowledge-based, and climate/geographical challenges. The most critical issues include the clogging of drippers, poor post-sales services, and high maintenance costs, all of which directly affect system efficiency and sustainability. Other significant constraints such as inadequate technical know-how, access to spare parts, and financial limitations such as high installation costs and inadequate credit facilities further hinder adoption, particularly among small-scale farmers. In addition, environmental factors such as soil salinity, topographical challenges, and high temperatures compromise system durability. Addressing these barriers requires targeted interventions, including improved training programs, better access to technical support, and financial assistance, as well as customized solutions to suit specific climate and geographical conditions, to enhance the effectiveness and widespread adoption of MI technology.

REFERENCES

1. Lambin EF, Turner B, Geist HJ, Agbola SB, Angelsen A, Bruce JW, *et al*. The causes of land-use and land-cover change: Moving beyond the myths. Glob Environ Change 2001;11:261-9.
2. Friedlander L, Tal A, Lazarovitch N. Technical considerations affecting adoption of drip irrigation in sub-Saharan Africa. Agric Water Manag 2013;126:125-32.
3. Archibald TW, Marshall SE. Review of mathematical programming applications in water resource management under uncertainty. Environ Model Assess 2018;23:753-77.
4. Rasul G. Food, water, and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region. Environ Sci Policy 2014;39:35-48.
5. Kumar R, Mishra V, Buzan J, Kumar R, Shindell D, Huber M. Dominant control of agriculture and irrigation on urban heat Island in India. Sci Rep 2017;7:14054.
6. Perez C, Jones E, Kristjanson P, Cramer L, Thornton P, Förch W, *et al*. How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective. Glob Environ Change 2015;34:95-107.
7. Mohan G, Perarapu LN, Chapagain SK, Reddy AA, Melts I, Mishra R, *et al*. Assessing determinants, challenges and perceptions to adopting water-saving technologies among agricultural households in semi-arid states of India. Curr Res Environ Sustain 2024;7:100255.
8. Ayaz M, Ammad-Uddin M, Sharif Z, Mansour A, Aggoune EM. Internet-of-things (IoT)-based smart agriculture: Toward making the fields talk. IEEE Access 2019;7:129551-83.
9. Bryan E, Ringler C, Okoba B, Roncoli C, Silvestri S, Herrero M. Adapting agriculture to climate change in Kenya: Household strategies and determinants. J Environ Manage 2012;114:26-35.
10. Narotzky S, Besnier N. Crisis, value, and hope: Rethinking the economy. Curr Anthropol 2014;55:S4-16.
11. Teferi ET, Assefa TT, Tilahun SA, Wassie SB, Minh TT, Béné C. Bridging the gap: Analysis of systemic barriers to irrigation technology supply businesses in Ethiopia. Agric Water Manage. 2024;303:109004.
12. Prabha D, Arunachalam R. Farmers' preferences for mobile agro advisory services. J Ext Educ 2017;29:5811.
13. Maiangwa M, Omolehin R, Adeniji O, Mohammed U. Food insecurity: Challenges of agricultural extension in developing countries. J Agric Ext 2011;14(2). doi: 10.4314/jae.v14i2.64126
14. Manjunatha A, Speelman S, Chandrakanth M, Van Huylenbroeck G. Impact of groundwater markets in India on water use efficiency: A data envelopment analysis approach. J Environ Manage 2011;92:2924-29.