American Journal of Agricultural Science, Engineering, and Technology (AJASET)

ISSN: 2158-8104 (ONLINE), 2164-0920 (PRINT)

VOLUME 10 ISSUE 2 (2026)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Agricultural Science, Engineering, and Technology (AJASET)

Volume 10 Issue 2, Year 2026
ISSN: 2158-8104 (Online), 2164-0920 (Print)
DOI: https://doi.org/10.54536/ajaset.v10i2.7960
https://journals.e-palli.com/home/index.php/ajaset

The Impact of Extension Services on The Adoption of New Irrigation Technologies in Tanzania: A Case Study of Mufindi District, Iringa Region

Happymark Josephat Pangani[1*], Thorne Haverford[2], Alexander Clarke[2], Princewell Inyang[2]

Article Information

Received: March 30, 2026

Accepted: June 07, 2026

Published: July 20, 2026

Keywords

Extension Services, Irrigation Technologies, Mufindi District, Smallholder Farmers, Tanzania, Technology Acceptance Model, Technology Adoption

ABSTRACT

Agricultural extension services are crucial in the development of new farming technology and cutting-edge systems for farmers. Modern irrigation technologies play a key role in increasing agricultural productivity, developing resilience to climate extremes and anticipating food security, especially in semi-arid areas. This study intended to assess the impact of extension services on the adoption of new irrigation technologies among smallholder farmers in Mufindi District, Tanzania, while examining the mediating and moderating factors that explain variations in adoption. The study employed Technology Acceptance Model (TAM) focusing on Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as parameters for adoption and utilization. The study utilized quantitative and qualitative methods involving 200 farmers in questionnaire surveys while 4 extension officers and one District Agricultural, Livestock and Fisheries Officer (DALFO) participated in interviews in Mufindi District, Iringa. Convergent Parallel Design was used. Quantitative data analysis took place using SPSS and Partial Least Squares Structural Equation Modelling (PLS-SEM). Findings indicated that most farmers in Mufindi were highly aware of furrow irrigation technology (67%), implying that furrow irrigation was the main technology transferred to them by professional extension officers. Sprinkle irrigation (17%), drip irrigation (13%), subsurface irrigation systems (3%), solar power irrigation (0%), and center pivot irrigation (0%) were not widely known among farmers. Extension services reached 93% of farmers. Adoption rate was 44%, with 21% planning to adopt and 35% not adopting. Economic constraints (lack of capital 30%, high cost of technology 29.5%) were the dominant barriers, followed by limited knowledge/skills (22.9%) and inadequate water supply (17.6%). Perceived usefulness of extension services was reported by 68.5% of farmers. The study concludes that farmers adopted irrigation technology which they perceived as useful and easy to use, but adoption was hampered by low earnings. Agricultural policy and other sectoral policies must support good allocation of resources, sufficient staffing, and performance monitoring of extension activities to enhance efficiency and effectiveness.

INTRODUCTION

Background

Modern irrigation technologies play a key role in increasing agricultural productivity, developing resilience to climate extremes, and anticipating food security, especially in semi-arid areas (Fawzy & Shedeed, 2020). Over 70 percent of freshwater withdrawals are consumed by agriculture globally, but efficiency is low, particularly among smallholder farmers who are dependent on rain-fed agriculture (Teferi *et al.,* 2025). Extension services are critical in helping to close the knowledge gap between technological innovations and practical application by advising farmers on how to utilize new tools and irrigation methods (Prajapati *et al.,* 2025). Nevertheless, smallholder farmers have been experiencing yield losses and poor resilience to climate shocks, which underscores the ongoing issue of technology adoption (Kuhl, 2020).

In the past, agricultural extension services were designed as top-down and government-centered models but have developed into participatory and farmer-centered models (Mujeyi & Mutodi, 2021). In Tanzania, new projects combine digital advisory services with Farmer Field Schools to expand the area and efficacy of extension provision (Ortiz-Crespo *et al.,* 2021). This development highlights the importance of contextual, ongoing, and dynamic transfer of knowledge to encourage technology adoption by smallholders.

However, the use of modern irrigation technologies in Tanzania remains low despite active policy support and national programs such as the Agricultural Sector Development Programme (ASDP II) (Rweyemamu *et al.,* 2024). In some areas like Kilimanjaro, extension visits are not common and training material is not usually technical in nature, causing farmers to lose confidence in using new irrigation methods (Jha *et al.,* 2020). These gaps necessitate exploring the direct impact of extension service elements on the adoption of modern irrigation technologies in the Tanzanian smallholder environment.

Statement of the problem

Despite many initiatives to modernize agriculture, there remains low penetration of modern irrigation methods among smallholder farmers in Tanzania, limiting

[1] Foxford University, CISR and Cereals and Other Produce Regulatory Authority COPRA, Tanzania
[2] Foxford University, Faculty of Science, Tanzania
[*] Corresponding author's email: dr_pangani@yahoo.com

agricultural productivity and food security. Smallholder farmers are very much exposed to rain-fed farming, which exposes them to unpredictable rainfall and frequent droughts (Borona, 2021). Extension services are supposed to fill this gap in areas like Mufindi District, Iringa Region, by providing training, technical advice, and advisory services. Nevertheless, evidence suggests these services are not always effective in influencing the actual adoption of modern irrigation systems.

The critical issue is not only that extension programs exist but also how the particulars of such programs—frequency of visits, delivery schemes, topicality of material, and competence of agents—influence farmers' decisions to implement irrigation technologies (Norton & Alwang, 2020). This study addresses these gaps by specifically targeting smallholder farmers in Mufindi District.

Research Objectives

General Objective

To assess the impact of extension services on the adoption of new irrigation technologies among smallholder farmers in Mufindi District, Tanzania, while examining the mediating and moderating factors that explain variations in adoption.

Specific Objectives

i. To measure the relationship between extension service characteristics (frequency of visits, delivery methods, content quality, and agent competence) and the level of adoption of new irrigation technologies among farmers in Mufindi District.

ii. To examine whether farmers' perceptions (perceived usefulness and perceived ease of use) of irrigation technologies mediate the relationship between extension services and technology adoption.

iii. To identify contextual moderators (access to credit, availability of inputs, farm size, and socio-demographic characteristics) that influence the strength of the extension-adoption relationship.

iv. To propose practical recommendations and an analytical model for strengthening extension services to increase the adoption of irrigation technologies among smallholder farmers in Mufindi District.

Research Hypotheses

H_1: Extension service characteristics have a significant positive effect on adoption of new irrigation technologies among farmers in Mufindi District.

H_2: Farmers' perceived usefulness mediates the relationship between extension services and adoption.

H_3: Farmers' perceived ease of use mediates the relationship between extension services and adoption.

H_4: One or more contextual factors (access to credit, input availability, farm size, socio-demographics) significantly moderate the relationship between extension services and adoption.

Theoretical Framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), is a popular model for studying factors that influence technology adoption and usage. According to TAM, an individual's attitude towards adopting new technology is influenced by two major constructs Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) that then impact behavioral intention and actual adoption. Perceived usefulness is the perceived level of an individual's belief that utilizing technology will positively affect performance, productivity, or results. Perceived ease of use is the perceived level of ability to learn and use technology without putting in a lot of effort (Caffaro *et al.,* 2020). The applicability of TAM to this research is especially high. The model provides a systematic approach to study the relationship between extension service features (visit frequency, delivery method, content quality, and agent competence) and adoption of irrigation technologies via the mediating perceptions of usefulness and ease of use. Figure 1 presents the conceptual framework.

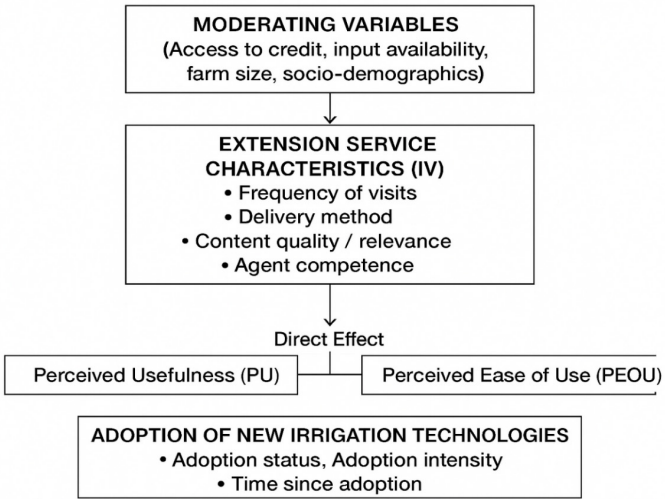

Figure 1: Conceptual Framework for Adoption of Irrigation Technology

Independent Variable

• Extension service characteristics (frequency, delivery method, content quality/relevance, agent competence)

Mediating Variables

• Perceived Usefulness (PU) - farmers' belief that irrigation technology improves yield/income or reduces risk

• Perceived Ease of Use (PEOU) - farmers' belief that technology is easy to learn and apply

Moderating Variables

• Access to credit

• Input availability (pumps, pipes, spare parts)

• Farm size

• Socio-demographics (farmer education, age, gender, household labour availability)

Dependent Variable

• Adoption of new irrigation technologies (adoption status, adoption intensity, time since adoption)

MATERIALS AND METHODS

Research Philosophy and Design

This paper employed pragmatism philosophy, enabling quantitative and qualitative methodologies to be integrated (James, 2020). The research design was a Convergent Parallel Design, presupposing simultaneous gathering of both quantitative and qualitative data, independent analysis, and subsequent combination (Shahab *et al.,* 2021).

Study Area and Population

Mufindi District of Iringa Region, Tanzania, was identified as the study area due to its agricultural importance, dominance of crop production, and continued irrigation programs. The target population was smallholder farmers belonging to irrigation schemes using furrow irrigation systems, involved in crop production including cereals, root and tuber crops, legumes and pulses, vegetables and horticultural crops, temperate fruits, perennial and cash crops, and industrial and fodder crops.

Sampling and Sample Size

Quantitative participants were sampled using multistage sampling. Wards were purposively chosen based on irrigation interventions, villages randomly sampled, and smallholder farmers randomly selected. Qualitative participants (extension officers, farmers, ward agricultural officers) were purposefully sampled. Sample size (n=200) was calculated using the Yamane formula:

$n = N / (1 + N(e)^2)$

Data Collection and Analysis

Quantitative data were collected through closed-ended questionnaires measuring extension service attributes, perceived usefulness, perceived ease of use, adoption indicators, and contextual moderators on 5-point Likert scales. Qualitative data were gathered through key informant interviews, focus group discussions, and non-participant observation. Quantitative analysis used SPSS and PLS-SEM to test direct, mediating, and moderating effects. Thematic analysis was used for qualitative data.

Ethical Considerations

Institutional review board approval was obtained. Participants were informed of the study's purpose, voluntary participation, and confidentiality. Written consent was obtained, and identifiers were anonymized.

RESULTS AND DISCUSSION

Demographic Characteristics

The sample comprised 200 farmers from four wards (Ihalimba, Makungu, Sadani, Ikweha; 25% each). Age distribution: 53% aged 31-40 years, 28.5% aged 41-60 years, 17.5% aged 18-30 years, and 1% above 60 years. Gender: 55% male, 45% female. Education: 75.5% completed Standard 7, 17% Form 4, 4% Form 6, and 3.5% had certificate/diploma/degree. Farm size: 46% farmed 0.25-1 acre, 45.5% farmed 1.5-2 acres, and 8.5% farmed above 2.5 acres.

Table 1: Awareness of Irrigation Technologies

Technology	No. of farmers aware (n)	Percentage (%)
Furrow irrigation	134	67
Sprinkle Irrigation	34	17
Drip Irrigation	26	13
Subsurface Irrigation Systems	6	3
Solar power Irrigation	0	0
Center Pivot Irrigation	0	0

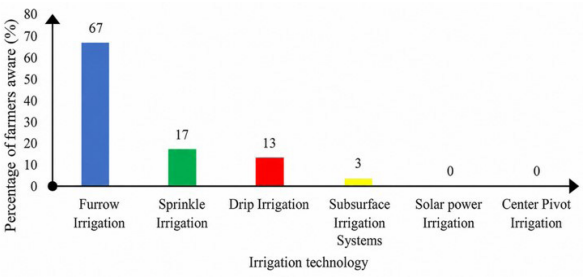

Figure 2: Bar chart showing awareness of irrigation technologies among farmers

Reach and Frequency of Extension Support

An overwhelming majority (93%, n=186) confirmed receiving training or advice on new irrigation technologies. Visit frequency: 40.5% received 2-3 visits per year, 22% received one visit, 20.5% received more than three visits, and 17% received no visits.

Table 2: Perceived Usefulness of Extension Services

Response	Frequency (n)	Percentage (%)
Yes	137	68.5
No	63	31.5
Not Sure	0	0
Total	200	100

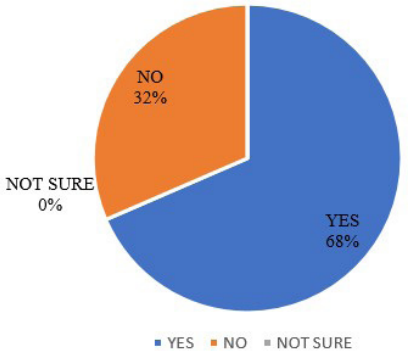

Figure 3: Pie chart showing the distribution of responses (Yes/No/Not sure) for perceived usefulness

Table 3: Technology Adoption Status

Adoption status	Frequency (n)	Percentage (%)
Yes	88	44
No	70	35
Planning To	42	21
Total	200	100

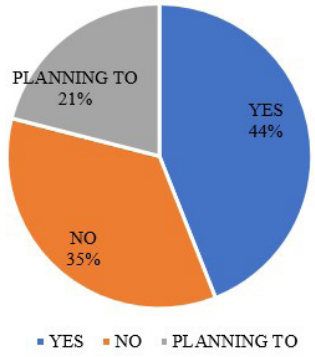

Figure 4: Pie chart showing technology adoption status

Table 4: Challenges to Adoption

Challenge	Number of farmers reporting (n)	Percentage of farmers reporting (%)
Lack of Capital	199	29.97
High Cost of Technology	196	29.52
Limited Knowledge/ Skills	152	22.89
Inadequate Water Supply	117	17.62
Other	0	0
Total Responses	664	100

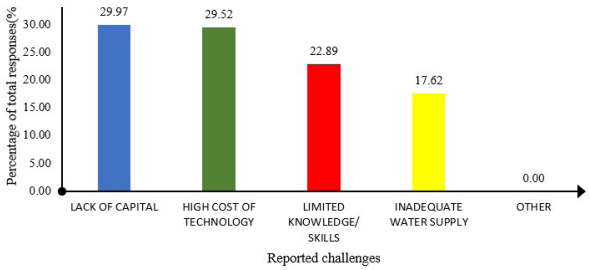

Figure 5: Bar chart showing challenges to adoption of modern irrigation technologies

Extension Service Characteristics and Adoption

Findings indicated dramatic variation between irrigation systems. Furrow irrigation was known to 67% of farmers, implying it is the main technology demonstrated and discussed by extension officers. This finding aligns with Justine *et al.* (2025), who demonstrated inadequate knowledge of irrigation technologies constrained adoption, and Madureira *et al.* (2022), who discovered that frequent farmer-extension interaction and personalized technical guidance had major impacts on adoption rates.

The complete lack of awareness about solar power and center pivot irrigation is critical—farmers cannot desire or adopt technology they have never heard of. As Yang *et al.* (2021) showed in China, a mixture of regular extension checks, online guidance, and participatory demonstration has a tremendous positive effect on drip and sprinkler irrigation adoption.

The high penetration rate (93%) demonstrates agricultural extension has managed to reach the vast majority of farmers across the four wards. This finding differs from Masanja, Lukenku, and Kalungwizi (2023) in Kigoma, who revealed only 18.3% of farmers had access to extension services.

Perceptions as Mediators

The data portrayed a positive view on training effectiveness, with 68.5% of farmers unanimous that extension services effectively communicated advantages of new irrigation technologies. However, 31.5% reported services did not help them. The complete absence of "Not Sure" responses suggests farmers had definite opinions.

These findings support TAM assumptions that perceived usefulness and perceived ease of use mediate the influence of external interventions on actual adoption (Ibrahim & Shiring, 2022). Playan *et al.* (2024) identified that farmers who rated technologies as complex or time-consuming were less likely to adopt advanced irrigation systems. Similarly, in Zanzibar, Vuai (2023) demonstrated that perceived usefulness had a significant positive association with smallholder farmers' willingness to adopt drip irrigation.

Contextual Factors as Moderators

Economic constraints accounted for almost 60% of all mentioned challenges—lack of capital (30%) and high cost of technology (29.5%). This aligns with Jesse

(2023), who established that while farmers were aware of merits of modern irrigation, they encountered difficulties including limited capital. Sanchis-Ibor *et al.* (2021) discovered in Spain that microfinance and subsidies played a significant moderating role in adoption of water-saving irrigation technologies.

Limited knowledge/skills (22.9%) indicate a shortage of experiential, practical training. Vecchio *et al.* (2020) in Italy revealed that bigger farms with more available labour tended to adopt precision irrigation systems, while small farms remained limited despite training.

CONCLUSION

This study concludes that professional agricultural extension services play a significant role in influencing farmers' acquisition and utilization of irrigation technologies in Mufindi District. Farmers who maintained regular contact with extension officers demonstrated greater awareness, improved technical knowledge, and more favorable attitudes toward irrigation innovations than those with limited access to extension support. Nevertheless, the effectiveness of extension services remains constrained by inadequate staffing, limited follow-up visits, and insufficient practical support, which reduce farmers' ability to effectively adapt and sustain irrigation technologies. The study further established that adoption is influenced not only by extension services but also by factors such as education level, access to credit, availability of water resources, and farm size.

To enhance irrigation technology adoption, policymakers should prioritize the revitalization and adequate financing of extension services through increased staffing, continuous training, and improved infrastructure. Stronger linkages between extension services, credit providers, irrigation equipment suppliers, and other agricultural support systems are also necessary. Extension approaches should become more practical through demonstrations and farmer field schools while remaining inclusive of women and youth. Future research should examine the long-term sustainability of adopted irrigation technologies, compare the effectiveness of public and private extension systems, and explore gender and socio-economic dimensions affecting access to irrigation technologies and extension services.

REFERENCES

Arowosegbe, O. B., Alomaja, O. A., & Tiamiyu, B. B. (2024). The role of agricultural extension workers in transforming agricultural supply chains. *World Journal of Advanced Research and Reviews, 23*(3), 2585–2602.

Caffaro, F., Cremasco, M. M., Roccato, M., & Cavallo, E. (2020). Drivers of farmers' intention to adopt technological innovations in Italy. *Journal of Rural Studies, 76,* 264–271. https://doi.org/10.1016/j.jrurstud.2020.04.003

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340. https://doi.org/10.2307/249008

Fawzy, Z. F., & Shedeed, S. I. (2020). Climate smart agriculture and intelligent irrigation systems. In M. Negm & A. Abuhashim (Eds.), *Water, flood management and water security* (pp. 361–370). Springer. https://doi.org/10.1007/978-3-030-35586-9_16

Ibrahim, A., & Shiring, E. (2022). The relationship between educators' attitudes, perceived usefulness, and perceived ease of use. *International Journal of Technology in Education, 5*(4), 535–551. https://doi.org/10.46328/ijte.314

James, W. (2020). What pragmatism means. In D. B. Audretsch & A. Link (Eds.), *Shaping entrepreneurship research* (pp. 521–533). Routledge. (Original work published 1907)

Jha, S., Kächele, H., Lana, M., Amjath-Babu, T. S., & Sieber, S. (2020). Exploring farmers' perceptions of agricultural technologies: A case study from Tanzania. *Sustainability, 12*(3), 998. https://doi.org/10.3390/su12030998

Justine, P., Csorba, A., Ocansey, C. M., *et al.* (2025). Awareness and adoption strategies for improved agricultural practices (IAPs) in Tanzania. *Discover Sustainability, 6,* 198.

Kuhl, L. (2020). Technology transfer and adoption for smallholder climate change adaptation. *Climate and Development, 12*(4), 353–368. https://doi.org/10.1080/17565529.2019.1630340

Madureira, L., Labarthe, P., Marques, C. S., & Santos, G. (2022). Exploring microAKIS: Farmer-centric evidence on the role of advice. *The Journal of Agricultural Education and Extension, 28*(5), 549–575. https://doi.org/10.1080/1389224X.2021.1984958

Mujeyi, K., & Mutodi, K. (2021). *Policy research report.* Zimbabwe Farmers Union.

Norton, G. W., & Alwang, J. (2020). Changes in agricultural extension and implications for farmer adoption. *Applied Economic Perspectives and Policy, 42*(1), 8–20. https://doi.org/10.1002/aepp.13008

Ortiz-Crespo, B., Steinke, J., Quiros, C. F., *et al.* (2021). User-centred design of a digital advisory service in Tanzania. *International Journal of Agricultural Sustainability, 19*(5–6), 566–582. https://doi.org/10.1080/14735903.2021.1898693

Playán, E., Gimeno, Y., Lorenzo-González, M. A., *et al.* (2024). Irrigation modernization in the Ebro-Aragón region of Spain. *Agricultural Water Management, 302,* 108975. https://doi.org/10.1016/j.agwat.2024.108975

Prajapati, C. S., Priya, N. K., Bishnoi, S., *et al.* (2025). The role of participatory approaches in modern agricultural extension. *Journal of Experimental Agriculture International, 47*(2), 204–222.

Rweyemamu, M. R., Muma, T., & Nkanyani, S. (2024). *Tanzania agricultural policy profile.* CGIAR.

Sanchis-Ibor, C., Ortega-Reig, M., Guillem-García, A., *et al.* (2021). Irrigation post-modernization in the region of Valencia (Spain). *Agriculture, 11*(4), 317. https://

doi.org/10.3390/agriculture11040317

Shahab, H., Zahur, H., Akhtar, N., & Rashid, S. (2021). Characteristics of ethical leadership through convergent parallel mixed method design. *Frontiers in Psychology, 12,* 787796. https://doi.org/10.3389/fpsyg.2021.787796

Teferi, E., Kassawmar, T., Bewket, W., *et al.* (2025). Rainfed agriculture in Ethiopia: Green water management pathways. *Frontiers in Agronomy, 7,* 1418024. https://doi.org/10.3389/fagro.2025.1418024

Vecchio, Y., Agnusdei, G. P., Miglietta, P. P., & Capitanio, F. (2020). Adoption of precision farming tools: The case of Italian farmers. *International Journal of Environmental Research and Public Health, 17*(3), 869. https://doi.org/10.3390/ijerph17030869

Vuai, A. U. (2023). *Factors affecting the adoption of drip irrigation technology in Zanzibar* (Master's thesis, Open University of Tanzania).

Yang, Q., Zhu, Y., & Wang, F. (2021). Exploring mediating factors between agricultural training and farmers' adoption of drip fertigation in China. *Water, 13*(10), 1364. https://doi.org/10.3390/w13101364.