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# Enabling Climate Resilience Through Effective Communication: Field-Based Lessons from Smallholder Farmers in selected Semi-arid Regions of Tanzania

By

Gerald. A. Sumari
Department of Co-operative Development and Management, Moshi Co-operative University (MoCU), Tanzania

Correspondence Email: gerald.sumari@mocu.ac.tz

**Abstract**
This study examined the influence of communication factors on the uptake and utilization of climate change adaptation strategies among 300 smallholder farmers in the semi-arid regions of Tanzania, specifically in Singida, Dodoma, and Shinyanga. A cross-sectional research design was employed, and data were collected using structured questionnaires and key informant interviews. Stratified random sampling was used to select respondents from selected villages, ensuring representativeness across the study sites. Quantitative data were analysed using the Statistical Package for Social Sciences (SPSS), where a binary logistic regression model was applied to assess the significance and strength of communication-related variables influencing adaptation uptake. The results revealed that lack of training, low literacy levels, lack of practical orientation, limited group membership, and inadequate access to extension officers following the introduction of new technologies were significant barriers to adoption. These findings underscore the need for inclusive and practical training, enhanced extension service delivery, and active promotion of farmer group participation. The study concludes that addressing communication-related constraints is critical for enhancing climate resilience and supporting sustainable agricultural livelihoods in Tanzania's semi-arid zones.

**Keywords**: Climate change adaptation, Communication, Extension services, Training, Smallholder farmers, Semi-arid regions and Tanzania

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**Enabling Climate Resilience Through Effective Communication: Field-Based Lessons from Smallholder Farmers in selected Semi-arid Regions of Tanzania**

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## 1.Introduction

Climate change presents a growing threat to agricultural productivity, rural livelihoods, and overall socio-economic development, especially in sub-Saharan Africa (Zadawa & Omran, 2020; Rathoure & Patel, 2020). In the semi-arid zones of Tanzania, smallholder farmers face increasing vulnerability due to their dependence on rainfed agriculture, limited access to financial resources, and weak institutional support. Shifts in temperature and rainfall patterns have disrupted traditional farming calendars, shortened cropping seasons, and led to declining yields (Barnett, 2020; Sylvester, 2020). These changes have deepened rural food insecurity, increased market volatility, and escalated reliance on external food assistance (Ekpa et al., 2018; Ahmed, 2020).

Adaptation to climate change is critical to building resilience in these vulnerable farming systems. A key enabler of adaptive capacity is access to timely, accurate, and context-relevant climate information. Effective communication can enhance farmers' awareness of climate risks, strengthen their ability to make informed decisions, and support the timely adoption of adaptation practices (Ajuang et al., 2016; Odikor et al., 2023). However, climate information must be delivered through credible, accessible, and culturally appropriate channels. The use of indigenous knowledge systems such as traditional weather forecasting, community seed selection, and customary land practices can complement scientific data and foster greater trust and engagement among farming communities.

Despite increasing availability of climate information services, low uptake of adaptation strategies remains a persistent challenge. Factors such as low literacy levels, gender disparities, inadequate training, and limited access to agricultural extension services constrain the effectiveness of communication efforts (Chaplin, 2017; Tall et al., 2014). Women farmers, in particular, face systemic barriers to information access due to unequal resource ownership, limited participation in farmer groups, and cultural norms that restrict mobility and decision-making (Eastin, 2018; Huyer & Partey, 2020). These gendered dimensions of vulnerability underscore the importance of inclusive communication strategies that recognize and respond to the differentiated needs of men and women in agriculture.

The study investigates how communication influences the uptake and utilization of climate change adaptation strategies among smallholder farmers in the semi-arid zones of Tanzania. It examines the communication channels used to access climate information and explores the enabling and constraining factors that shape the adoption of adaptation practices. The study places particular emphasis on gender inclusion, indigenous knowledge integration, and the alignment of local communication practices with national climate policy frameworks. By addressing a critical gap in the literature on farmer-centered communication, the study provides actionable insights for extension agents, policymakers, and development practitioners seeking to promote climate resilience in Tanzania's semi-arid agricultural systems.

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## 2. Methodology

### 2.1 Study Area Description

The study was conducted in selected districts within three semi-arid regions of Tanzania: Singida (Singida and Manyoni), Dodoma (Kongwa, Kondoa, and Bahi), and Shinyanga (Shinyanga, Kishapu, and Kahama). These areas experience a semi-arid climate characterized by low and erratic rainfall ranging from 400 mm to 800 mm annually, with a unimodal rainfall pattern occurring between November and April. Mean annual temperatures range from 21°C to 29°C, often exceeding 35°C during the dry season. The regions face high evapotranspiration rates and limited water availability, making agriculture highly vulnerable to climate variability. Soils vary from sandy loams and ferralsols to clayey vertisols, with generally low organic content and poor water retention capacity, particularly in Singida and Manyoni. Agriculture is predominantly rainfed and practiced on a small scale, with sorghum, millet, maize, groundnuts, and beans serving as staple food crops, while sunflower, cotton, and tobacco are key cash crops depending on local conditions. Livestock keeping, particularly of cattle and goats, is an important complementary activity, especially in Dodoma and Shinyanga where agro pastoralism is common. Although these regions have been sites for climate-smart agriculture and land management interventions, the uptake of adaptation strategies remains inconsistent, highlighting the need to better understand the communication dynamics influencing smallholder resilience

### 2.2 Research Design

The study adopted a cross-sectional research design, selected for its cost-effectiveness and suitability in analysing multiple variables at a single point in time. This design enabled the simultaneous examination of various communication factors influencing farmers' uptake of climate adaptation strategies. Primary data were collected through structured household surveys and key informant interviews, allowing for both quantitative and qualitative insights into the communication dynamics within the study regions.

### 2.3 Sampling Procedures and Sample Size

The study regions, Singida, Dodoma and Shinyanga were purposively selected due to their semi-arid climate nature and the predominance of small-scale farming among residents. Within each region, stratified random sampling was used to cluster the study population by village, ensuring geographic and agroecological representativeness. Simple random sampling was then applied within each stratum to select households for participation in the research study survey.

The sample size for the household survey was determined using the Cochran (1977) formula for sample size estimation for proportions in large populations Based on this calculation, a total of 300 smallholder farmers were selected and interviewed using structured questionnaires. To complement the quantitative data, 30 Key Informant Interviews (KIIs) were conducted with agricultural extension officers, government officials, village leaders, NGOs and climate information service providers. These respondents were selected purposively for their expert knowledge and roles in the local agricultural and communication.

### 2.4 Data Analysis

The collected data were carefully reviewed for completeness and consistency before being organized for analysis. Quantitative data were analyzed using the Statistical Package for

Social Sciences (SPSS). To examine the influence of communication related factors on the uptake and utilization of climate change adaptation strategies, respondents were asked to rate various indicators on a five-point Likert scale, with the categories: strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1).

The Likert scores were used to compute communication factor scores for each respondent, which served as predictors in a binary logistic regression analysis. This analytical approach was selected because the dependent variable uptake and utilization of adaptation strategies is binary, with values coded as 1= uptake and utilization, and 0 = no uptake and utilization.

The regression model estimated the probability of uptake using the following logistic function:

$$y = \beta 0X0 + \beta 1X1 + \beta 2X2 + \ldots + \beta nXn + \varepsilon$$

Where:
y is the probability of uptake and utilization of adaptation strategies
β0 is the intercept
β1, β2, ..., βn are the parameter estimates
X1, X2, ..., Xn are the independent communication variables
ε is the error term

The independent variables included: access to agricultural extension officers, attitude toward extension agents, access to training, membership in farmer groups, literacy level, complexity of information, practical orientation, repetition of information, availability of supporting literature, access to extension services following the introduction of new technologies, access to up-to-date information, and challenges in engaging with broadcasted climate programs.

To test the model's validity, several statistical diagnostics were conducted. The Hosmer and Lemeshow Test for goodness-of-fit yielded a Chi-square value of 6.31 (df = 8) with a significance level of 0.61. Since the p-value exceeded the 0.05 threshold, the model fit was considered satisfactory, indicating no significant difference between observed and expected values. Additionally, the Nagelkerke $R^2$ was 0.197, suggesting that approximately 19.7% of the variability in the dependent variable is explained by the model.

The Wald test was used to assess the statistical significance of individual predictors. Variables with p-values less than 0.05 or 0.1 were deemed significant contributors to the model. According to Norusis (2008), the B-coefficients in the null model represent log-odds, while Exp(B) (the odds ratio) offers a more interpretable measure of effect size.

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**Table 1: Description of Communication Factors Influencing Uptake and Utilization of Climate Information**

| Variable | Measurement Scale |
|---|---|
| Uptake and utilization of adaptation strategies | Binary (0 = No uptake, 1 = Uptake) |
| Inability to access agricultural extension officers | Ordinal (1–5) |
| Poor attitude toward extension agents | Ordinal (1–5) |
| Lack of training | Ordinal (1–5) |
| Lack of membership in farmer groups | Ordinal (1–5) |
| Low literacy levels | Ordinal (1–5) |
| Information complexity | Ordinal (1–5) |
| Lack of practical orientation | Ordinal (1–5) |
| Repetition of information | Ordinal (1–5) |
| Inadequate literature material | Ordinal (1–5) |
| Limited access to extension agents' post-technology introduction | Ordinal (1–5) |
| Inability to access up-to-date information | Ordinal (1–5) |
| Challenges in engaging with broadcasted programs | Ordinal (1–5) |

**Source: Field Data 2025**

## 3. Results And Discussion

### 3.1 Socioeconomic and Demographic Attributes of Respondents

The study assessed the socioeconomic characteristics of 300 smallholder farmers across Singida, Dodoma, and Shinyanga regions. Among the respondents, 53.3% (n = 160) were male-headed households, while 46.7% (n = 140) were female-headed as shown in Table 2. This gender distribution reflects the continued male dominance in household agricultural decision-making, often attributed to cultural norms and unequal access to land and productive resources. Similar patterns have been reported in related studies (Mihiretu et al., 2020; Huyer & Partey, 2020).

With regard to age, the majority of respondents were older than 35 years. Specifically, 6.6% (n = 20) were under 25 years, 22.9% (n = 69) were aged 26–35, 45.8% (n = 137) were between 36–50, and 24.7% (n = 74) were over 50 years. This distribution indicates an aging farming population, with younger individuals increasingly migrating to urban centers in search of alternative livelihoods (Weldemariam et al., 2022). This trend raises concerns over labor availability and long-term agricultural sustainability in rural areas (Rozelle et al., 1999).

In terms of educational attainment, 10.1% (n = 30) had no formal education, 26.9% (n = 81) had primary education, 44.1% (n = 132) had completed secondary school, 12.8% (n = 38) had attended college, and 6.17% (n = 19) had university education. These findings suggest that a significant portion of the sample (over 61%) had education beyond primary school, enhancing their potential to access, comprehend, and act upon climate-related information (Funk et al., 2020; Hirpha et al., 2020).

Regarding land ownership, 63.9% (n = 192) of respondents farmed on plots smaller than 2 acres, 33.5% (n = 101) on 3–5 acres, and 2.6% (n = 7) on 6–10 acres. These small landholdings are consistent with patterns of land fragmentation and increasing population pressure in semi-arid regions (Milu & Jayne, 2014).

Farmers' experience was relatively high, with 12.3% (n = 37) reporting less than 6 years of farming, 24.7% (n = 74) between 7–12 years, 30.8% (n = 92) between 13–18 years, and 33.9% (n = 97) having more than 19 years of experience. This indicates that a large segment of the population possesses long-term engagement in agriculture, which may influence their adaptive knowledge and behavioral responses.

Institutional participation was modest: 45.4% (n = 136) of the farmers were members of agricultural groups, whereas 56.6% (n = 164) were not. Access to financial services was limited, with 43.2% (n = 130) having accessed agricultural loans, compared to 56.8% (n = 170) who had not. These figures highlight the need for expanded financial inclusion and group-based support mechanisms to enable better climate adaptation planning.

In terms of extension and capacity building services, 49.4% (n = 148) reported having received climate-related training, while 50.6% (n = 152) had not. Access to agricultural extension services was reported by 54.2% (n = 163) of respondents, while 45.8% (n = 137) indicated no access. These findings reinforce the importance of strengthening farmer-centered communication, training, and extension systems to enhance resilience to climate change in Tanzania's semi-arid farming communities.

**Table 2: Socioeconomic Characteristics of Respondents**

| Category | Number of Respondents | Percentage (%) |
|---|---|---|
| Gender: Male | 160 | 53.3 |
| Gender: Female | 140 | 46.7 |
| Age: <25 | 20 | 6.6 |
| Age: 26–35 | 69 | 22.9 |
| Age: 36–50 | 137 | 45.8 |
| Age: >50 | 74 | 24.7 |
| Education: No Formal Education | 30 | 10.1 |
| Education: Primary | 81 | 26.9 |
| Education: Secondary | 132 | 44.1 |
| Education: College | 38 | 12.8 |
| Education: University | 19 | 6.2 |
| Farm Size: <2 acres | 192 | 63.9 |
| Farm Size: 3–5 acres | 101 | 33.5 |
| Farm Size: 6–10 acres | 7 | 2.6 |
| Farming Experience: <6 years | 37 | 12.3 |
| Farming Experience: 7–12 years | 74 | 24.7 |
| Farming Experience: 13–18 years | 92 | 30.8 |
| Farming Experience: >19 years | 97 | 33.9 |
| Group Membership: Yes | 136 | 45.4 |
| Group Membership: No | 164 | 54.6 |
| Loan Access: Yes | 130 | 43.2 |
| Loan Access: No | 170 | 56.8 |
| Climate Training: Yes | 148 | 49.4 |
| Climate Training: No | 152 | 50.6 |
| Extension Access: Yes | 163 | 54.2 |
| Extension Access: No | 137 | 45.8 |

**Source: Field Data 205**

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### 3.2 Communication Channels Used by Farmers for Climate Change Adaptation Information

The study assessed the communication channels used by smallholder farmers in the semi-arid regions of Tanzania for accessing climate change adaptation information. The most commonly reported source was broadcasting media, with 76.2% (n = 173) of respondents indicating its usage. This was followed closely by peer-to-peer communication, with 74.9% (n = 170) relying on fellow farmers. Other significant sources included agricultural officers (34.8%, n = 86), printed media (33.0%, n = 75), shows and exhibitions (33.9%, n = 77), and farmers' training and workshops (22.0%, n = 50). Respondents were allowed to indicate more than one source, highlighting the diverse communication channels used.

This pattern aligns with findings from other studies. Muema et al. (2018) and Gitonga et al. (2020) found that radio remained the most accessible and trusted medium, used by 83% and 69.7% of farmers respectively. Odawa et al. (2024) identified radio (95%), television (28%), and extension officers (80%) as key sources in Somalia. Ngigi and Muange (2022) reported radio (75%), extension officers (31.41%), and print media (2.89%) as primary sources in South Africa. While broadcasting ensures mass reach, it lacks interactivity, a limitation noted by Mittal and Mehar (2016) and Popoola et al. (2020). Additionally, Al-Rumaili (2016) emphasized the value of agricultural exhibitions in disseminating innovations through practical demonstrations and technical materials.

**Table 3: Communication Channels Used by Farmers for Climate Change Adaptation Information**

| Information Source | Frequency (n) | Percentage (%) |
|---|---|---|
| Broadcasting | 173 | 76.2 |
| Other farmers | 170 | 74.9 |
| Agricultural officers | 86 | 34.8 |
| Print media | 75 | 33.0 |
| Shows and exhibitions | 77 | 33.9 |
| Farmers' training and workshops | 50 | 22.0 |

Note: Multiple responses were allowed per respondent.
**Source: Field Data 2025**

### 3.3 Factors Hindering the Uptake and Utilization of Adaptation Strategies

The revealed as shown in Table 5 that several communication related factors negatively influenced the uptake and utilization of climate change adaptation strategies. Specifically, lack of training (p = 0.01), lack of group membership (p = 0.01), limited access to agricultural extension officers following the introduction of new technologies (p = 0.00), low literacy levels (p = 0.01), and lack of practical orientation (p = 0.08) were significantly associated with reduced adoption. These findings underscore the importance of structured support systems, farmer education, and institutional engagement in enhancing adaptive capacity.

Lack of training reduced the odds of adaptation uptake by 26.8%, with trained farmers being 0.732 times more likely to adopt adaptive strategies. Similar findings were observed by Ndiwa et al. (2024) in Kenya, reinforcing that farmer training improves awareness and implementation of adaptive practices. Lack of group membership reduced the adoption probability by 25.7% (0.743 odds ratio), consistent with studies by Jabbar et al. (2023) and Makate (2019), who found that agricultural groups play a key role in sharing adaptation knowledge. Low literacy was linked to a 34% decline in adoption likelihood, emphasizing the crucial role of education in comprehension and application of climate information, as also reported by Sahoo and Moharaj (2022).

Lack of practical orientation caused a 22.1% decrease in uptake probability. Practical methods, such as demonstration plots, were emphasized by Singh et al. (2018) and Bossink (2015) for their impact on behavioral change and learning. Limited access to extension officers' post-technology introduction had the most substantial effect, reducing adoption odds by 47.9% (0.521 times), illustrating the central role of timely, continued support from extension services. These results support assertions by Afsar & Idrees (2019) and Prokopy et al. (2015) that extension officers' communication ability and guidance are essential for effective adaptation implementation in smallholder systems.

**Table 5: Communication Factors Hindering the Uptake and Utilization of Adaptation Strategies**

| Parameter | Estimate | Std. Error | z value | Pr(>\|z\|) | Sig |
|---|---|---|---|---|---|
| Constant | 3.59 | 1.62 | 2.21 | 0.03 | ** |
| Inability to access extension officers | 0.04 | 0.11 | 0.38 | 0.70 | |
| Poor attitude toward extension agents | -0.04 | 0.14 | -0.28 | 0.78 | |
| Lack of training | -0.31 | 0.11 | -2.70 | 0.01 | ** |
| Lack of membership in farmer groups | -0.30 | 0.12 | -2.60 | 0.01 | ** |
| Low literacy levels | -0.30 | 0.11 | -2.66 | 0.01 | ** |
| Lack of practical orientation | -0.20 | 0.11 | -1.75 | 0.08 | * |
| Repetition of information | -0.13 | 0.11 | -1.21 | 0.23 | |
| Inadequate literature material | 0.13 | 0.11 | 1.11 | 0.27 | |
| Information complexity | -0.06 | 0.11 | -2.93 | 0.60 | |
| Inability to access up-to-date information | 0.06 | 0.11 | 0.55 | 0.59 | |
| Farmers' challenges in engaging with broadcasts | 0.01 | 0.11 | 0.12 | 0.91 | |
| Limited access to extension officers' post-technology | -0.65 | 0.22 | -0.52 | 0.00 | * |

Note: **Significant at 0.05 level; * significant at 0.1 level. Model fit statistics: Hosmer and Lemeshow Test Chi-square = 6.31; df = 8; Sig. = 0.612; Nagelkerke $R^2$ = 0.197.

**Source: Field Data 2025**

## 4.Conclusion and Recommendations

### 4.1 Conclusion

The study results demonstrate that lack of training, limited group membership, low literacy levels, insufficient practical orientation, and restricted access to agricultural extension officers' post-technology introduction are significant barriers to the adoption of adaptation measures. These factors collectively constrain farmers' ability to make informed decisions and engage meaningfully in climate-resilient agricultural practices.

The study confirms that improving communication pathways and capacity building initiatives is crucial for enhancing climate adaptation at the grassroots level. Furthermore, enabling environments that support learning, information sharing, and farmer-to-farmer collaboration are instrumental in strengthening the resilience of smallholder agricultural systems.

### 4.2 Recommendations

Based on research findings, the study recommends several actions to enhance the uptake and utilization of climate change adaptation strategies among smallholder farmers. There is a critical need to strengthen farmers' knowledge through regular and inclusive training programs tailored to their literacy levels. These should be complemented by improved access to agricultural extension officers, particularly following the introduction of new technologies. Incorporating practical orientation and demonstration-based approaches during training and extension visits can significantly increase farmers' likelihood of adopting adaptation measures. Additionally, farmers should be encouraged to join agricultural groups to benefit from peer learning and shared experiences. Communication strategies must be designed to be inclusive and locally relevant, ensuring that even those with low literacy levels can access and act on climate-related information. These measures are essential for building resilient farming systems and enhancing farmers' adaptive capacity in the face of increasing climate variability

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