



# Competences of Agricultural Extension Agents in Dissemination of Climate Change Adaptation Strategies in Misungwi District, Tanzania

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

This paper assessed the awareness and competencies of extension agents regarding climate change in Tanzania, utilizing questionnaires from 64 agents and analysing data through descriptive statistics. Results indicated a high knowledge level, with an overall mean score of 6.36; 70.3% identified drought and extreme weather as significant climate change effects, and 82.8% recognized soil conservation as vital for adaptation. However, knowledge gaps were noted in crop diversification (53.1%) and climate-resilient crop varieties (46.9%). Skills assessment yielded a mean score of 6.8, with 70.3% competent in recommending mulching and drip irrigation, and 75.0% guiding farmers in organic farming. Attitudes towards climate adaptation were generally positive,

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with a mean score of 3.97; 73.5% valued continuous learning. Yet, practice inconsistencies emerged, as only 23.4% frequently recommended climate-resilient practices and 37.5% regularly implemented innovative solutions. Institutional support was inadequate, with the highest support observed in policy availability (54.7%), while the lowest was in digital tool provision, as none of the extension agents (100%) had access to such resources. The findings suggest that enhanced training, improved communication, and better resource allocation are essential for strengthening extension agents' roles in aiding farmers' climate change adaptation in Tanzania.

*Keywords: Institutional support; climate-smart agriculture; agricultural extension; climate resilience.*

## 1. INTRODUCTION

Climate change is becoming a more severe threat to world agricultural systems, especially in developing countries where agriculture as an economic activity and a source of food is mainly practised by the majority of people (Wiebe et al., 2019). An increase in temperature, fluctuation in rainfall and increased incidences of hydro meteorological disasters have compounded challenges to agricultural productivity, hence, reducing food security and leading to income volatility among smallholder farmers (Aboul, 2024). However, the climate-induced changes are more dramatic in sub-Saharan Africa, where rain-fed agricultural production is predominant. Groups of people depending on farmer incomes and food production remain vulnerable to crop losses, pest invasion and poor soil health: climate change mitigation is thus necessary for income and food security in such region (Tesfay, 2023).

In Tanzania, where agriculture is the source of income for Tanzanians that accounts for about seventy per cent of the people and contributes to 30 per cent of the national gross domestic product, the effects of climate change are felt the most by farming populations. (Mpogole et al., 2020). Despite the importance of agriculture to people's livelihood, national economy and food security in Tanzania, agricultural activities (farming and livestock production) are severely affected by inadequate rainfall, protracted dry spells and rising temperatures thereby compromising the income of farmers in rural households (Rupia, 2020). To overcome these challenges, Climate Smart Agriculture (CSA) practises have been recognised to improve resilience and sustainable agriculture production. The CSA adopts practices that reduce greenhouse gas emissions, and enhance the resilience of farmers to climate change stressors to enable them to adapt (Matteoli et al., 2020).

Therefore, the extension agents are instrumental in encouraging farmers to adopt CSA practices

by delivering research information to farmers and linking them with researchers. Furthermore, extension agents convey new knowledge and skills on farming techniques as well as methods of developing new crops to farmers as a way of handling climate change (Thottadi & Singh, 2024; Osuafor et al., 2023). Despite the importance of extension services, the delivery of extension services in Tanzania is compromised by inadequate resources, inadequate training, and little or a lack of knowledge on climate-smart practices. Such constraints have reduced the capacity of extension agents to respond appropriately to the needs of farmers (Tilumanywa, 2021). As is the case with other parts of Tanzania, these challenges are also pronounced and even so in Misungwi District where smallholder farmers are the majority, and where the agricultural community is highly vulnerable to climate change due to heavy reliance on rain-fed agriculture. The advice of extension agents is highly valued.

While extension agents are one of the key actors in enhancing climate resilience, few studies such as Olorunfemi et al., (2020) have established the competencies necessary for extension agents to facilitate CSA practices in vulnerable farming communities such as Misungwi. To the best of the authors' knowledge, systematic comparative assessments of extension agents' knowledge, skills, attitudes, practical competencies and the ability to provide adequate support to farmers on farmers' adaptation to climate change are limited (Tamsah & Yusriadi, 2022; Olorunfemi et al., 2020; Tilumanywa, 2021). In Misungwi District, the agricultural community relies heavily on the guidance provided by extension agents to overcome the challenges of susceptibility to climate variability. Despite the critical role of extension agents in building climate resilience, limited research exists on the specific competencies possessed for their effectiveness in promoting CSA practices where by specific competencies required are known, particularly in vulnerable areas such as Misungwi. Few studies

(Tamsah & Yusriadi, 2022; Olorunfemi et al., 2020) have comprehensively evaluated the knowledge, skills, attitudes, and practical as required competencies of extension agents in guiding farmers towards climate adaptation. This current study therefore sought to fill this gap by establishing the competencies of extension agents in the Misungwi District and determining their preparedness in promoting the use of CSA practices among farmers. Therefore, by filling the gaps cited in the foregoing, this study makes a small but significant contribution to the efforts of enhancing climate resilience among the Tanzanian agricultural communities.

This study addressed the following objectives: What level of knowledge do extension agents possess regarding climate-smart agricultural practices? What practical skills are essential for extension agents to effectively promote climate adaptation strategies? What are the primary constraints extension agents encounter when supporting farmers in adopting climate-resilient practices? What are the attitudes of extension agents toward climate adaptation and their motivation for assisting farmers? Additionally, what level of institutional support, including resources, training, and collaboration opportunities, is provided to extension agents to engage in climate adaptation efforts in Misungwi District? By addressing these objectives, the research envisaged providing insights into the competencies needed for extension agents to enhance climate resilience among farmers, helping them meet the challenges posed by climate change and contribute to sustainable agricultural development in Misungwi District.

## 2. METHODOLOGY

The research was conducted in Misungwi District, Mwanza Region, Tanzania, located along the shores of Lake Victoria at longitude 33.0817144 and latitude -2.8429633. The district receives an average of 930 mm of rainfall annually, with short rains occurring from October to December and long rains from March to May. Misungwi District was selected due to its significant agricultural activities and a relatively large number of extension agents (71) working in climate change adaptation. The district is accessible via the paved trunk road T8, which connects its four divisions, 27 wards, and 114 villages, making it easier to reach extension agents for the study.

A cross-sectional research design was used to collect data from extension agents at a single

point in time to assess their competencies in climate change adaptation. The study targeted all 71 agricultural extension agents in the district. Since the research required insights from those actively engaged in climate adaptation, purposive sampling was used to select respondents. This method ensured that only those with relevant experience and knowledge participated. A total of 64 extension agents responded to the survey, representing 90% of the total population, making the sample highly representative.

Data was collected using structured questionnaires administered through the Kobo Toolbox platform. The questionnaire captured demographic information, knowledge, skills, attitudes, practices, and institutional support related to climate change adaptation. The online approach was chosen for its efficiency in reaching extension agents across different locations and ensuring a high response rate.

Data analysis involved descriptive statistics, including mean scores and percentages, to measure the extension agents' competencies. Knowledge and skills assessments were scored by assigning 10 points for correct answers and 0 points for incorrect ones. The mean score was calculated across all responses to determine overall competency levels. Percentages were used to show the proportion of extension agents who correctly responded to specific questions, while the mean score provided an overall measure of performance within each category. For example, a higher percentage of correct responses in a particular area resulted in a higher mean score, indicating better competency. A Likert scale was used to assess attitudes and practices, measuring agreement levels and practice frequency. The overall mean score for each category (knowledge, skills, attitudes, and practices) was determined by averaging the individual scores. This approach provided a clear and structured assessment of extension agents' abilities in supporting climate change adaptation.

## 3. RESULTS AND DISCUSSION

### 3.1 Knowledge of Extension Agents on Climate Change Adaptation

The result in Table 1 shows that 70.3% of the extension agents had good knowledge of the increased incidence of drought and extreme weather as one of the impacts of climate change. This means that a significant number of extension agents had good knowledge of the

severe climate impacts affecting agriculture. This knowledge places them in a good position to help farmers in dealing with the realities of climate change.

Moreover, most (82.8%) of the extension agents had a good understanding of the part played by soil conservation and soil management in responding to the effects of climate change. This is a fundamental area of knowledge for extension agents because effective conservation practices are fundamental to the future climate resilience in agriculture.

Study results indicate however that extension agents were less knowledgeable on other areas of climate-smart practices, such as crop diversification, which received a mean score of 5.31, and the benefits of climate resilient crop varieties, which received a mean score of 4.69. For example, 53.1% of the respondents reported knowing that crop diversification is a part of climate-smart agriculture; however, fewer extension agents appeared to understand the full potential of using drought-resistant crop varieties, as only 46.9 % responded correctly. This might mean that while extension agents have some level of knowledge of climate change adaptation practices, more still needs to be done to train them on other more refined techniques. A similar observation is reported in other related studies. For example, according to Naik et al. (2024) such factors as age, education level, and the number of years in farming affect the level of knowledge farmers or extension agents have on climate-resilient farming practices. A cross-sectional survey on the knowledge and practices of Agricultural Extension Officers in Ghana

conducted by Antwi-Agyei and Stringer (2021) revealed a relatively low awareness of climate change among agricultural extension workers due to the lack of formal training on climate change adaptation measures such as crop and land-use diversification and water-saving irrigation technologies. The researchers also reported that most of the Extension Officers may have some level of understanding on these climate resilient measures but they rarely possessed the technical knowledge nor the tools to explain and show how these measures can be applied at the community level (Eta et al., 2023). This limitation prevents them from advising farmers on how to apply these techniques most effectively to mitigate climate vulnerability. Similar findings are reported in the current study, which reveals that extension agents have a satisfactory level of knowledge about general climate change issues but require comprehensive training on particular practices to improve their performance in helping farmers.

### 3.2 Skills of Extension Agents on Climate Change Adaptation

The ability to recommend mulching and drip irrigation as water conservation methods during extended dry periods was high among the extension agents with 70.3 % (Table 2). This shows that their capacity in determining suitability and effectiveness of climate smart methods in water conservation for agricultural production especially in water scarce regions is above satisfactory level. The correct identification of this practice calls for proper management of water in the fight against climate change.

**Table 1. Knowledge of extension agents on climate change adaptation**

Climate change knowledge statements	Percentage	Mean score
A key effect of climate change on agriculture is Increased incidence of drought and extreme weather events	70.3	7.03
Crop diversification to improve resilience is a practice that is part of climate-smart agriculture	53.1	5.31
Higher tolerance to drought and temperature fluctuations is the main benefit of using climate-resilient crop varieties	46.9	4.69
Water management practices that is effective for climate change adaptation is drip irrigation	48.4	4.84
Role of soil conservation in climate change adaptation is prevention of erosion and maintenance of soil health	82.8	8.28
One major impact of climate change on pest populations is altered distribution and emergence patterns	57.8	5.78
Farmer education and training is one of the factors that can significantly influence the success of agricultural adaptation to climate change	85.9	8.59
Overall	63.6	6.36

**Table 2. Skills of extension agents on climate change adaptation**

<b>Statement</b>	<b>Percentage</b>	<b>Mean Score</b>
Recommending mulching and drip irrigation for water conservation during prolonged drought	70.3	7.0
Suggesting crop rotation and organic composting to improve soil health resilience	62.5	6.3
Describing crop diversification as growing multiple crop types to mitigate climate variability	70.3	7.0
Advising natural pest predators or intercropping to address pest problems sustainably	68.8	6.9
Proposing rainwater harvesting and storage for effective water management during erratic rainfall	64.1	6.4
Conducting soil and climate analysis to identify suitable crop types for a specific area	67.2	6.7
Providing resources on organic farming practices for transitioning to organic farming	75.0	7.5
Overall	68.0	6.8

Further, 62.5% of the extension agents demonstrated high competence in advising framers on crop rotation and the application of organic compost to enhance soil productivity. All these practices are crucial as far as soil fertility and its abilities to withstand the climatic shocks such as drought and temperature variations are concerned. It is crucial that extension agents understand the best practices that maintain sustainability of soils for long term crop production and resilience to climate change.

However, although most of the extension agents demonstrated relatively high ability in advising farmers on water conservation and soil health, their skills and confidence on other conservation measures such as pest control and crop rotation was average. For example, there is 68.8 per cent of the extension agents agreed that the following need to be done to counter pests as a result of climate change, namely, the introduction of pests' natural enemies or inter cropping with a mean score of 6.9. This amounts to the application of integrated pest management practices that seek to minimise reliance on chemical pesticides. However, the level of skills was slightly lower in advising farmers on crop diversification, 70.3 per cent of the extension agents were considered to have good skills in advising farmers on growing different crops to avoid the effects of climate variability Furthermore, 64.1% of the extension agents were assessed on their ability to recommend rainwater harvesting and storage as an effective practise in managing low rainfall well, This was affirmed from their expertise in pin pointing water management interventions that are mandatory in

regions affected by climate change causing erratic rainfall.

In the second competency area, more specifically on the analysis of soil and climate in the target area and on identification of the most appropriate crop species, 67.2 per cent of the respondents obtained a high score while the overall mean score was 6.7. This implies that extension agents are well endowed with the right skills of advising farmers on the choice of crops that can perform well in different climatic conditions of their regions, which is very important for crop resiliency.

Lastly, 75.0 per cent of the extension agents showed high competence in helping farmers adopt organic farming as a climate change mitigation practice with a mean score of 7.5. This attests that extension agents had enlightened self-interest resulting from appreciating the need to adopt organic farming in preparing for the impacts of climate change while at the same time minimising the use of synthetic products. These outcomes results are consistent with results from other comparable works such as Willson (2021), which indicated the significance of technical competencies in assisting farmers to transition to climate resilience with a mean score of 6.7. This implies that extension agents are equipped with the necessary skills in guiding farmers in selecting crops based on specific climatic conditions of their areas, which is vital for ensuring crop resilience.

Finally, 75.0 per cent of extension agents displayed excellent skills in assisting farmers with transitioning to organic farming as a climate

adaptation strategy, with a mean score of 7.5. This shows a strong understanding of the importance of organic farming for building resilience to climate change by reducing dependency on synthetic inputs.

These results are in line with results in similar studies such as that of Willson (2021), which highlighted the importance of practical skills in helping farmers adapt to climate change. Willson (2021) and Ojo et al., (2023) also noted that the level of practical knowledge of Agricultural Extension Agents has some influence on the advice they provided to farmers on sustainable farming practices. Furthermore, a study by Waaswa et al. (2022), indicated that Kenyan Extension Agents had a high level of success in the dissemination of climate-smart practises, including rainwater harvesting and organic farming, as they demonstrated adequate theoretical knowledge and practical skills. This finding calls for the need for extension agents to be trained to update their knowledge and skills to enable them assist farmers to cope with climate conditions.

### **3.3 Attitude of Extension Agents on Climate Change Adaptation**

The extension agents' attitude scores about climate change adaptation, presented in Table 3 were above the mid-point of the scale. In response to the statement, climate change adaptation is important, 39.1 per cent agreed and 34.4 per cent 'strongly agreed with a mean of 3.86. This has been evident from the preceding sections especially in noting the importance of climate change adaptation for sustainable agriculture. Likewise, 39.1 per cent indicated willingness to support the farmers, which yielded a mean score of 3.88. Similar results are reported by Olorunfemi et al. (2020) who established that motivation of extension agents plays a central role in the adoption of climate smart practices.

On further training, extension agents strongly agreed that additional training is important with a mean score of 3.85. Perhaps most importantly, both groups reported a desire to gain new knowledge and develop competencies on climate change mitigation. Also, the level of confidence of extension agents in the strategies that they recommend was also high with a mean score of 3.69; thus, implying that extension agents are competent in helping farmers as pointed out by Olorunfemi et al. (2020) and Mustapha (2024)

On the reception farmers provided to the advice offered with a mean score of 3.80. This has implications on the flow of information between extension agents and farmers. Lastly, participants strongly agreed with the statement that continuous learning was needed, with a mean score of 3.97.

Therefore, according to the data obtained in related studies, extension agents had positive attitudes, confidence in the measures taken and willingness to expand knowledge towards climate adaptation.

### **3.4 Practices of Extension Agents on Climate Change Adaptation**

Findings in Table 4 indicate that extension agents often participate in climate-resilient agriculture practices. On encouraging the use of climate-resilient practices, 44 per cent sometimes, 24 per cent often, and 11 per cent always recommended such practices, with a mean score of 3.3. This implies a moderate level of implementation of climate-resilient practises, which is in line with a study by Norton and Alwang's (2020) who observed that the implementation of climate-resilient practises among extension agents was mixed.

Findings indicate further that 28.1 per cent occasionally and 21.9 per cent frequently followed up with farmers, with a mean of 3.31. This is quite encouraging in an attempt of ensuring that climate-resilient practices are accorded an optimal implementation. The options include often indicated by 34.4 per cent and always indicated by 21.9 per cent making a mean score of 3.50 for the level of seeking new information. This implies that extension agents go out in search of more information with the objective of enhancing their advisory services, an observation which is also made by Kansime et al. (2019) who noted that there is need for agents to embrace continuing learning.

The use of feedback from farmers was also another area that received moderate practice that includes sometimes indicated by 29.7 per cent and often by 26.6 per cent with a mean score of 3.38, This suggests that extension agents appreciate feedback to improve their strategies. Regarding the use of adaptation measures, 31.3 per cent of the respondents said sometimes and 21.9 per cent said they always incorporated adaptation measures as part of their practices, with a mean score of 3.55. This is a proactive response to climate change impacts,

which is in line with similar practices as reported in other studies across other regions (Norton & Alwang, 2020).

Lastly, regarding the degree of innovation implementation, 37.5 per cent said sometimes, and 23.4 per cent said they often introduced new

methods, with a mean score of 3.56. This indicates that although there is evidence of innovation, it is not yet culturally embedded in the organisations. In general, extension agents exhibit moderate levels of climate adaptation practices with the potential for a more consistent and creative approach.

**Table 3. Results for attitude statements**

Attitude statements	Mean Score
Climate change adaptation is important.	3.86
I am motivated to assist farmers in adapting to climate change.	3.88
I am willing to pursue further training on adaptation strategies.	3.85
I am confident in the effectiveness of adaptation strategies I provide.	3.69
Farmers are receptive to the advice I provide.	3.80
Continuous learning is essential for effective adaptation.	3.97

**Table 4. Results for climate adaptation practices**

Variable	Mean Score
Frequency of recommending climate-resilient practices	3.20
Frequency of follow-ups	3.31
Seeking new information	3.50
Incorporating feedback	3.38
Percentage of practices with adaptation strategies	3.55
Implementing innovative solutions	3.56

**Table 5. Results for institutional support on climate change adaptation**

Question	Category	Frequency (n)	Percent
Does your institution provide resources (e.g., materials, training) specifically for advising on climate change adaptation?	Yes	18	28.1
	No	46	71.9
How frequently does your institution offer training on new climate adaptation techniques or climate-smart agriculture practices?	Monthly	10	15.6
	Quarterly	6	9.4
	Annually	12	18.8
	Rarely	14	21.9
	Never	22	34.4
Do you feel supported by your institution in carrying out your role in climate change adaptation?	Yes	22	34.4
	No	23	35.9
	Somewhat	19	29.7
How often does your institution communicate updates on climate change research and best practices to extension agents?	Daily	0	0.0
	Weekly	3	4.7
	Monthly	7	10.9
	Rarely	26	40.6
	Never	28	43.8
Does your institution encourage collaboration with other organizations to enhance climate adaptation efforts?	Yes	8	12.5
	No	56	87.5
Are you provided with digital tools (e.g., mobile apps, software) to assist in delivering climate adaptation advice to farmers?	Yes	0	0.0
	No	64	100.0
Does your institution have a clear policy or guidelines specifically focused on climate change adaptation?	Yes	35	54.7
	No	29	45.3

### 3.5 Institutional Support for Extension Agents on Climate Change Adaptation

Table 5 indicates that institutional support for extension agents on climate change adaptation is not well supported. Specific resources such as training were said to be provided to agents by only 28.1 per cent; whereas 71.9 per cent per cent said they did not receive any of such support. This finding corresponds with the findings in a study by Antwi-Agyei and Stringer (2021) who noted that there is a need for enhanced institutional support.

When asked about training, 34.4% of the agents said their institution never provides training on climate-smart agriculture while 21.9% said it only does so occasionally. As for frequencies, 18.8 per cent said they underwent training annually, and 15.6 per cent said they had training sessions every month. This calls for more frequent professional development, as observed by Nkambwe et al. (2016) as well.

Regarding supporting the role of extension agents, 35.9 per cent of the respondents reported not being supported, 29.7 per cent said they were somewhat supported, and 34.4 per cent were fully supported. The finding also demonstrated conflicting views regarding institutional support. Further, 40.6 per cent said that climate research updates are a rarity and 43.8 per cent reported never to have received them, an indication of poor communication.

Furthermore, 87.5 per cent of the respondents said that their institution does not promote cooperation with other organisations on climate adaptation to facilitate exchange of knowledge. In terms of digital support, specifically tools that help in climate adaptation advice, all participants reported that their institution has no tools. Nevertheless, exactly half of the respondents said that their institution has a clear climate adaptation policy in place upon which to base their support. In general, there are some institutional provisions and practices, but there are shortcomings in training, information sharing, cooperation, and information technologies that limit the role of extension agents in climate change adaptation.

### 4. CONCLUSION AND RECOMMENDATIONS

The study showed that extension agents possessed good knowledge and favourable

attitudes towards climate-resilient practices but their application of these practices was not consistent. This study established that institutional support including resources, training and communication was inadequate, which hampered the ability of the agents to help farmers adapt to climate change.

To increase efficiency of extension agents, it is important to provide them with training constantly and periodically in climate-smart agriculture. There is a need for institutions to provide information technology in order to support the delivery of climate advice. Enhancing institutional communication as well as increasing cooperation between organisations will enhance support for climate adaptation. Secondly, there is a need to develop sound policies and or guidelines in the area of climate change adaptation to enhance the extension agents' tasks.

### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that the generative AI technology, ChatGPT, was used during the revision of this manuscript to enhance its clarity and coherence.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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