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From Climate information to Climate Smart Agriculture, Evaluating Extension Delivery Models for Climate Information and Their Influence on Climate-Smart Agriculture Adoption in Zambia: Evidence from Kasenengwa and Monze Districts

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Abstract: Climate change is one of the significant threats to agricultural productivity and food security in sub-Saharan Africa, whereby smallholder farmers that depend entirely on rain-fed agriculture are more susceptible to climate change than other farming communities. In Zambia, increasing climate variability increases the need for relevant and appropriate climate information to inform decisions related to agriculture. Agricultural extension plays a critical role in facilitating the use of climate information in making appropriate decisions that increase the adaptive capacity of farmers and promote Climate-Smart Agriculture (CSA). Although a lot of resources have been devoted to providing climate information services, little research has been done to compare the effectiveness of different models of extension in providing climate information. The present study seeks to evaluate the effectiveness of different extension delivery models in disseminating climate information and how they influence CSA adoption by smallholder farmers in Kasenengwa and Monze districts in Zambia. The research adopts a convergent mixed methods research approach whereby a combination of quantitative household surveys, key informant interviews, and focus group discussions was conducted. Findings reveal that participatory models of extension, such as Farmer Field Schools, PICSA, and lead farmer models, perform better compared to traditional non-participatory approaches in the promotion of CSA adoption. However, institutional constraints, including inadequacy in extension staffing, poor coordination among institutions, inadequate transportation network, and lack of ICT connectivity, limit the efficacy of extension service delivery.

Keywords: *Climate-Smart Agriculture, Agricultural Extension, Climate Information Services, Climate Adaptation, Smallholder Farmers, Zambia.*

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I. INTRODUCTION

Agriculture forms the backbone of the Zambian economy and is a major source of employment and food security for the nation. Over half of the population earns either directly or indirectly from agriculture and the majority of households rely almost solely on rainfed farming systems (Food and Agriculture Organization [FAO], 2022). Hence, changes in the climate system pose risks not only to the productivity of farms but also to the overall economic development and prosperity.

Zambia has experienced significant climatic variability within the last few decades, including irregular rainfall, droughts, floods, high temperatures, and changing seasons. Such changes in the climate have resulted in low crop yield, increased number of livestock deaths, increase in pest and disease incidence, and increased food insecurity amongst vulnerable farming communities (Intergovernmental Panel

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on Climate Change [IPCC], 2022). The adverse effects are especially felt by small-scale farmers because of poor financial standing, lack of irrigation facilities, inability to purchase inputs, and limited adaptive capacity.

To address these issues, Climate-Smart Agriculture (CSA) has been proposed as a global strategy towards achieving sustainable agricultural development despite changes in climate systems. According to the Food and Agriculture Organization (FAO) (2019), Climate-Smart Agriculture attempts to improve the agricultural productivity while increasing resilience to the impacts of climate change and mitigating greenhouse gas emissions wherever possible. Some of the most common practices of CSA include conservation agriculture, crop rotation, agroforestry, integrated soil fertility management, growing of drought-resistant crops, improved water management, and farm planning according to climate conditions.

The current research is designed to investigate the efficiency of extension delivery models of dissemination of climate information and their effects on adoption of Climate-Smart Agriculture (CSA) by smallholder farmers in Kasenengwa and Monze districts. For smallholders to successfully adopt CSA, there is a need for their ability to access and utilize accurate climate information. Seasonal forecasts, weather advisories, drought alerts, and early warning systems help in making timely decisions about sowing dates, type of crops planted, fertilization, irrigation, and harvesting. However, climate information is useful to farmers only if its delivery and application is efficient and turns into agricultural advice (Hansen et al., 2019).

Extension services can be seen as the important link between scientific institutions and the farm sector. In the traditional practice, extension services were focused on transfer of agricultural technologies developed by scientific institutions to farmers. In terms of climate change, the role of extensions has been significantly expanded. Nowadays, it is necessary to engage extension services in knowledge exchange, adaptive decision-making support, learning among farmers, community building, and dissemination of climate information (Faure et al., 2020).

Extension services in Zambia have become a pluralistic system that includes public extension officers, non-governmental organizations, research institutions, farmer groups, community radios, digital advisory platforms, and private companies. Different organizations use different models to deliver climate information to the farming community. However, it is unclear what delivery models are the most efficient in terms of promoting CSA adoption.

The districts of Kasenengwa and Monze present an adequate environment to conduct such research because they differ in their agro-ecological characteristics but both experience increasing climate variability. It is necessary to know how different delivery models work in such environment to increase agricultural resilience and to inform policy on national level. Therefore, this research will assess the effectiveness of extension delivery models of climate information dissemination and their impact on CSA adoption by smallholder farmers in Kasenengwa and Monze districts.

II. LITERATURE REVIEW

Agricultural extension has seen a lot of changes in the past five decades. The earlier extension systems had centralized and top-down communication whereby the extension officers communicated the technical advice provided by the research institutions. Though the earlier extension systems helped to increase agricultural production, they had some limitations such as little involvement of farmers, lack of contextualization of the recommendations and sustainability (Davis, 2020).

The present-day agricultural extension involves participatory learning, knowledge exchange and innovation. The farmers are now viewed as partners in the process as opposed to being mere receivers of technology. This is especially the case for the adaptation to climate change as the farmers need to be able to understand climate information in the context of the environment, economy, and culture.

The Climate Information Services (CIS) are important elements of the agricultural extension system. As stated by the World Meteorological Organization (2021), climate services include the production, interpretation, communication, and use of climate information to improve decisions in climate-sensitive areas. The climate services include the seasonal forecasts, weather information, drought monitoring, flood alerts and pest surveillance systems.

Studies show that climate information has been found to be very useful in improving the adaptive decisions among farmers (Hansen et al., 2019). The farmers are able to change planting calendars, diversification of crops, growing drought-resistant crop varieties and other adaptive decisions.

Among extension delivery models, Farmer Field Schools (FFS) have received considerable international recognition. These schools encourage experiential learning through demonstrations, field experimentation, observation, and collective problem-solving. Studies consistently report that FFS improve farmers' technical knowledge, confidence, and adoption of agricultural innovations because learning occurs under local farming conditions.

Similarly, Participatory Integrated Climate Services for Agriculture (PICSA) enables farmers to combine historical climate records with seasonal forecasts and livelihood analysis to make informed production decisions. Rather than prescribing uniform recommendations, PICSA encourages farmers to evaluate risks and opportunities within their own farming systems, thereby strengthening ownership of adaptation decisions.

Farmer-to-farmer extension also plays an increasingly important role where government extension services face

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resource constraints. Lead farmers disseminate knowledge through demonstration plots, mentoring, and informal social networks. Because recommendations originate from trusted community members operating under similar environmental conditions, adoption rates frequently improve. Nevertheless, technical supervision remains essential to maintain information quality.

Digital technologies have further transformed extension delivery. Mobile phones, SMS services, smart phone applications, community radio, and internet-based advisory platforms enable rapid dissemination of weather forecasts and agronomic advice. However, unequal access to electricity, internet connectivity, digital literacy, and affordable devices continues to limit their effectiveness among many rural households.

The present study is informed principally by Rogers' (2003) Diffusion of Innovations Theory, which explains how innovations spread through communication channels over time. The theory suggests that adoption depends upon perceived relative advantage, compatibility, complexity, trialability, and observability. Participatory extension approaches strengthen each of these characteristics by enabling farmers to observe, test, discuss, and evaluate innovations before adoption.

The Sustainable Livelihoods Framework further explains that adaptation decisions depend not only on information but also on farmers' access to human, financial, social, natural, and physical capital (Scoones, 2021). Consequently, extension effectiveness must be understood within the broader socio-economic environment influencing farmers' adaptive capacity.

III. METHODOLOGY

For this research study, a convergent mixed-methods research approach was adopted, whereby quantitative and qualitative data approaches were used in order to come up with an integrated analysis of the different extension delivery systems. Quantitative data was obtained on patterns of access to climate information as well as adoption of Climate Smart Agriculture practices, while qualitative data was collected on experiences of the farmers and institutions in extension service delivery (Creswell & Creswell, 2018).

The research was conducted in Kasenengwa District and Monze District owing to differences in the agro-ecology and vulnerability to climate change. The study targeted small-scale farmers, agricultural extension workers, weather experts and other people from institutions providing climate information services.

A total sample of 120 respondents was selected using stratified random sampling for the farmers and purposive sampling for the extension workers. Data were collected using questionnaires, key informants interviews and focus group discussion. Statistical analysis was done using both descriptive statistics and binary logistic regression, while thematic analysis was applied to analyze qualitative data.

IV. RESULTS AND DISCUSSION

➢ *Access to Climate Information*

The study established that access to climate information among smallholder farmers in Kasenengwa and Monze districts has improved considerably over the past decade. Most respondents indicated that they received climate information through multiple channels, including agricultural extension officers, community radio, mobile phones, television broadcasts, farmer organisations, and fellow farmers.

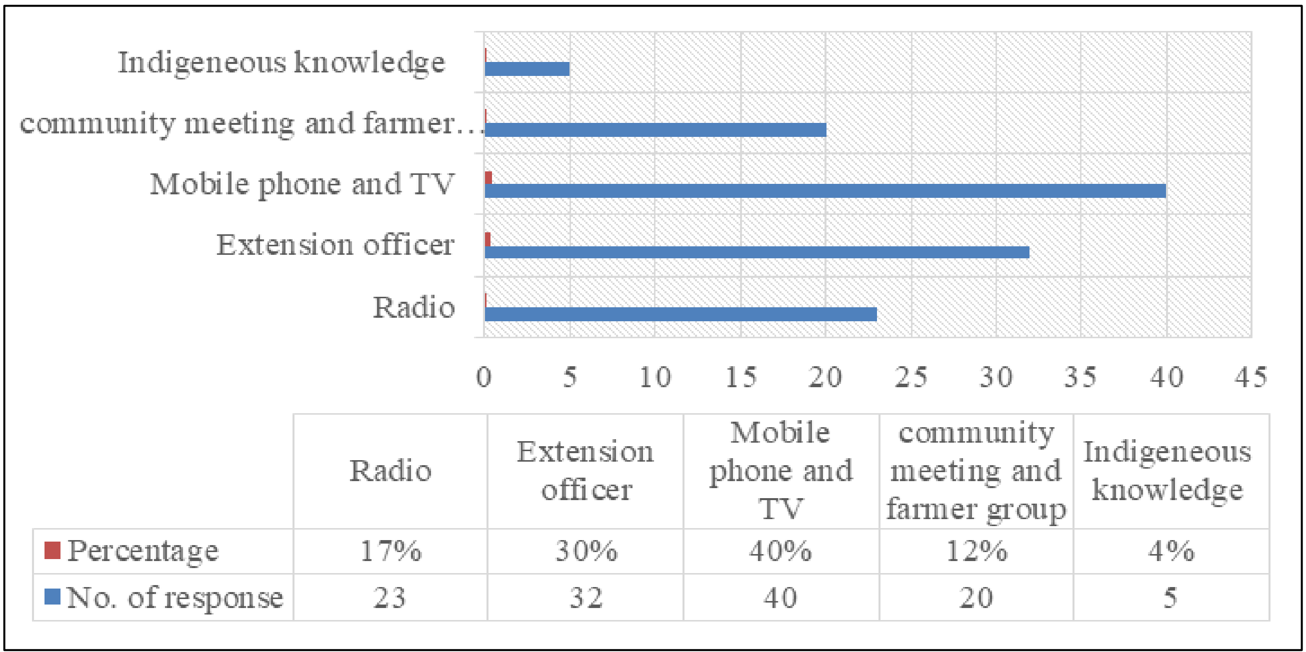

Fig 1 Access to Climate Information

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The increasing diversity of communication channels reflects the gradual transition from conventional public extension systems towards more pluralistic agricultural advisory services involving government institutions, civil society organisations, research institutions, meteorological agencies, and digital service providers.

Despite these improvements, considerable disparities in access remained evident. Farmers residing in remote communities reported receiving extension visits less frequently than those located near agricultural camps and district centres. Poor road infrastructure, inadequate transport for extension officers, unreliable mobile network coverage, and shortages of extension personnel were identified as major barriers to effective climate information dissemination. Similar observations have been reported by the World Meteorological Organization (2021), which emphasises that climate information services cannot achieve their intended impact unless farmers can access timely, understandable, and location-specific information.

Respondents further indicated that although seasonal climate forecasts were increasingly available, many farmers lacked the technical capacity to interpret meteorological information independently. Agricultural extension officers therefore remained essential intermediaries responsible for translating scientific forecasts into practical recommendations regarding planting dates, crop selection, fertiliser application, pest management, and water conservation. This finding reinforces the argument by Hansen et al. (2019) that the usefulness of climate information depends not only on scientific accuracy but also on its communication and practical interpretation.

- *Effectiveness of Extension Delivery Models*

One of the principal objectives of this study was to compare the effectiveness of different extension delivery models in promoting Climate-Smart Agriculture (CSA). The findings demonstrate that participatory extension approaches consistently outperformed conventional top-down communication methods. Out of 120 respondents, it was established that 23 (17.2%) mentioned government visits; 30 (27.3%) mentioned farmer field schools and radio programmes; 17 (10.2%) respondents mentioned mobile alerts and NGO trainings; 35 (38.2%) respondents mentioned community meetings and lead farmer approach; and 15 (7.1%) respondents mentioned agro-dealer and private sector advice. Hereinbelow is a diagrammatic representation.

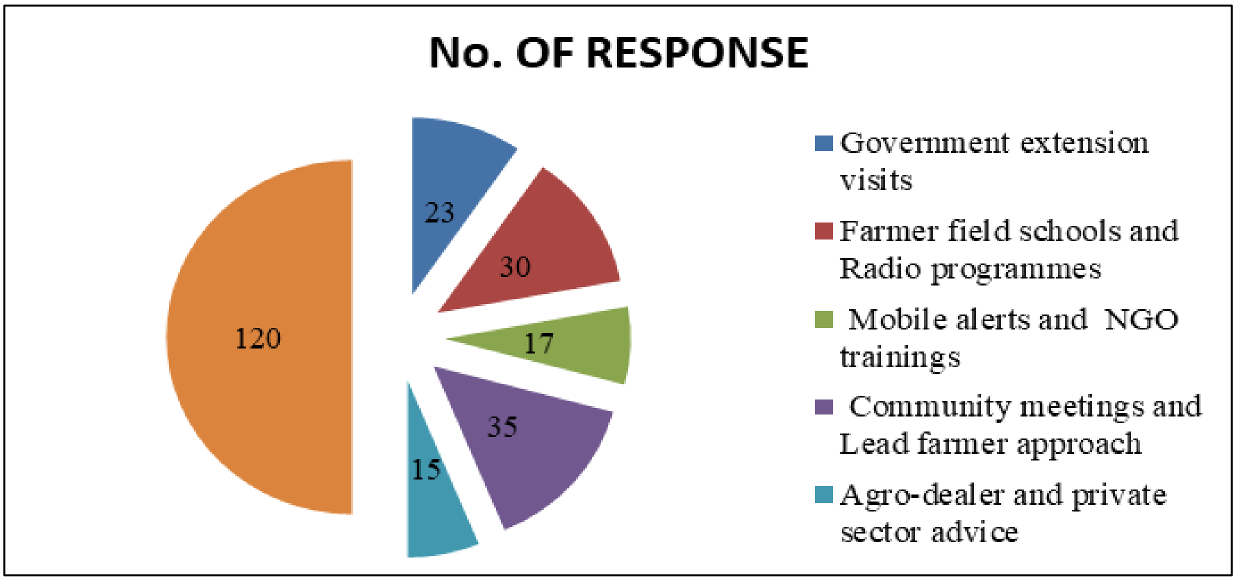

Fig 2 Effectiveness of Extension Delivery Models

Farmer Field Schools (FFS), Participatory Integrated Climate Services for Agriculture (PICSA), demonstration plots, community meetings, and lead farmer systems were associated with higher levels of farmer participation, improved understanding of climate risks, and greater adoption of climate-smart agricultural practices. Farmers participating in these programmes reported increased confidence in applying seasonal forecasts to farm planning because learning was supported by practical demonstrations, peer interaction, and continuous feedback throughout the agricultural season.

The findings support previous research demonstrating that participatory extension enhances farmers' adaptive capacity by promoting experiential learning and collaborative problem-solving (Dinku et al., 2021). Unlike conventional extension approaches, which often rely on one-way communication, participatory approaches encourage farmers to analyse risks, evaluate alternative strategies, and adapt recommendations to local conditions. Such interaction strengthens ownership of adaptation decisions and increases the likelihood of sustained adoption.

Conversely, respondents perceived conventional extension approaches as less effective because interactions were often infrequent, brief, and constrained by limited operational resources. Many extension officers reported being responsible for large geographical areas with

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insufficient transport and inadequate funding, reducing opportunities for regular farmer engagement.

➢ *Climate-Smart Agriculture Adoption*

The study found encouraging levels of Climate-Smart Agriculture adoption among participating farmers. Frequently adopted practices included conservation agriculture, crop diversification, agroforestry, integrated soil fertility management, drought-tolerant crop varieties, and water harvesting technologies. Farmers adopting multiple CSA practices consistently reported greater resilience to drought, improved soil fertility, and relatively stable crop production despite increasing climatic variability.

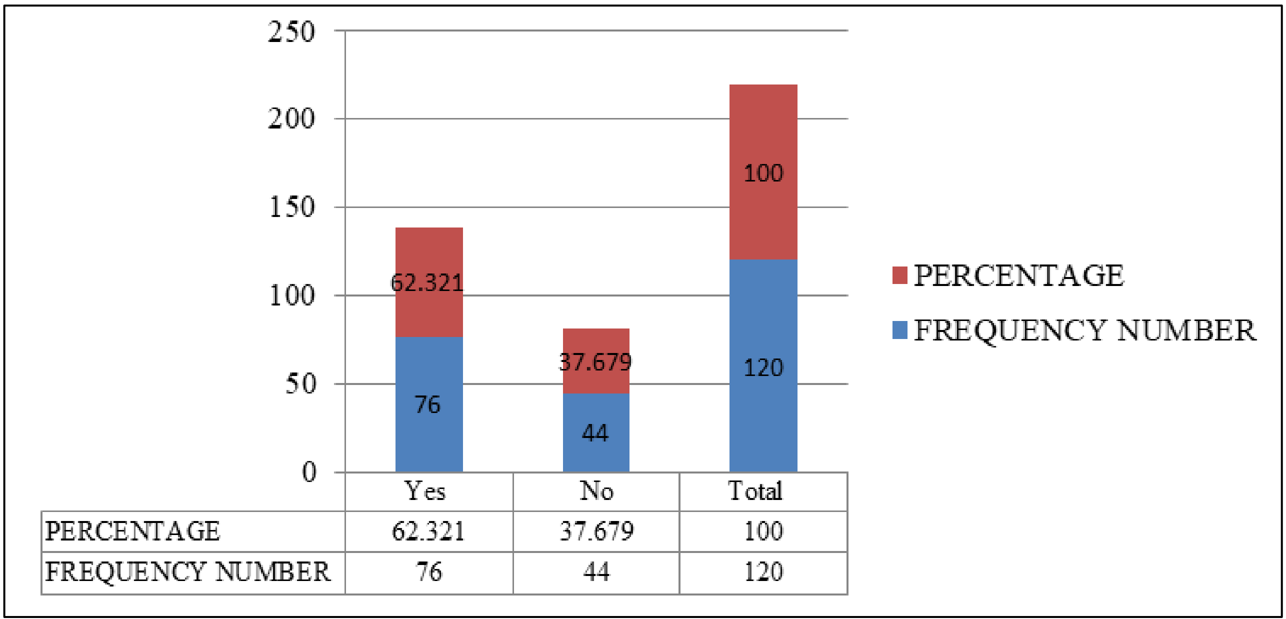

Fig 3 Climate-Smart Agriculture Adoption

Statistical analysis indicated that effective access to climate information significantly increased the probability of CSA adoption. Farmers receiving regular advisory support through Farmer Field Schools, PICSA, or lead farmer networks demonstrated substantially higher adoption rates than those relying solely on occasional extension visits. These findings are consistent with the meta-analysis by Kpadonou (2020), which identified agricultural extension as one of the strongest determinants of Climate-Smart Agriculture adoption across sub-Saharan Africa.

However, the study also established that access to climate information alone was insufficient to ensure adoption. Household income, educational attainment, farm size, membership in farmer organisations, farming experience, and access to agricultural credit also significantly influenced farmers' willingness and ability to implement recommended practices. This finding supports the Sustainable Livelihoods Framework, which argues that innovation adoption depends upon the interaction between knowledge, institutional support, and access to livelihood assets (Scoones, 2021).

➢ *Institutional Challenges*

Although extension services contributed positively to climate adaptation, respondents identified several institutional constraints limiting their effectiveness. The shortage of agricultural extension officers emerged as one of the most significant challenges. Extension personnel frequently served large farming populations scattered across extensive geographical areas, making regular advisory visits difficult. Limited operational budgets, inadequate transport facilities, and insufficient training in climate services further reduced the quality and frequency of extension delivery.

Weak coordination among agricultural extension services, meteorological institutions, research organisations, and development partners also limited effective dissemination of climate information. Several respondents indicated that climate forecasts occasionally reached farming communities too late to influence critical agricultural decisions such as land preparation and planting.

Furthermore, digital advisory services remained constrained by limited internet connectivity, unreliable electricity supply, high communication costs, and low digital literacy, particularly among elderly farmers. These findings suggest that digital technologies should complement rather than replace conventional extension systems.

➢ *Discussion*

The findings demonstrate that effective agricultural extension extends beyond information dissemination to encompass farmer learning, participation, trust-building, and institutional coordination. Participatory extension models consistently produced better outcomes because they promoted dialogue, practical experimentation, and continuous interaction between extension officers and farming communities.

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The results strongly support Rogers' (2003) Diffusion of Innovations Theory, which emphasises that innovations are more readily adopted when potential users can observe their benefits, test them under local conditions, and discuss them with trusted peers. Farmer Field Schools, PICSA, and demonstration plots create precisely these opportunities by enabling farmers to evaluate innovations before adoption.

Similarly, the Sustainable Livelihoods Framework explains why climate information alone cannot guarantee behavioural change. Farmers may understand recommended adaptation measures but remain unable to implement them because of financial constraints, labour shortages, insecure land tenure, inadequate agricultural inputs, or weak institutional support (Scoones, 2021). Consequently, successful climate adaptation requires integrated interventions addressing informational, institutional, economic, and social constraints simultaneously.

All in all, the study demonstrates that pluralistic extension systems integrating public extension services, digital technologies, community-based learning, and farmer organisations offer greater potential for strengthening agricultural resilience than reliance upon any single extension model**.**

V. POLICY IMPLICATIONS

It is important to stress that increased investment in agricultural extension on the part of the government is needed. More extension officers, improved transport, and continuous professional development would certainly increase access to climate information among farming communities in remote areas.

Participatory methods of extension need to be adopted by the national agricultural extension system. Increased funding and technical assistance should be provided to the farmer field schools, PICSA, demonstration farms, and farmer-to-farmer extension initiatives as they ensure more participation of farmers and use of climate smart agriculture.

Furthermore, coordination and cooperation between the Ministry of Agriculture, the Zambia Meteorological Department, universities, research institutions, NGOs and farmer organizations would increase the production, interpretation, and dissemination of climate information.

Increasing access to digital agricultural advisories is needed through investments in rural internet connection and telecommunications infrastructure, digital literacy and affordability of mobile devices. However, digital advisories should not be used as a substitute for the traditional one because personal communication is important in interpreting climate information.

Lastly, agricultural policies should deal with the socio-economic obstacles to the implementation of climate-smart agriculture. Improved access to agricultural credit, high-quality seeds, irrigation facilities, insurance services, input and output markets is crucial for successful adaptation.

VI. CONCLUSION

Climate change continues to pose potential threats to agricultural production, food security, and rural development in Zambia. With the increased incidence of climate variability, agricultural extension services have come to play an important role in helping farmers adapt through improved communication of climate information and promotion of Climate-Smart Agriculture practices. The current study shows that participatory approaches to agricultural extension – such as the Farmer Field School approach, the Participatory Integrated Climate Services for Agriculture approach, the lead farmer approach, and community demonstrations – are much more effective than traditional forms of agricultural extension services in encouraging farmers in Kasenengwa and Monze Districts to adopt Climate-Smart Agriculture. The reasons for higher effectiveness of participatory approaches lie in promoting experiential learning, peer interactions, building trust, and locally-relevant climate information interpretation.

However, the effect of agricultural extension is limited due to the institutional weaknesses in the form of understaffing, lack of adequate resources, poor cooperation between agencies, weak digital infrastructure, and other socio-economic factors that undermine farmers' adaptive capacity. Overcoming the above-mentioned limitations requires a policy intervention aimed at strengthening agricultural extension and improving farmers' access to productive assets and infrastructure.

REFERENCES

[1]. Braun, V., & Clarke, V. (2021). Thematic analysis: A practical guide. SAGE Publications.
[2]. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.
[3]. Davis, K. (2020). Agricultural extension in transition: Challenges and opportunities for developing countries. Journal of Agricultural Education and Extension, 26(2), 105–120.
[4]. Dinku, T., Clarkson, G., & Hansen, J. W. (2021). Climate services for resilient agriculture in Africa. Frontiers in Climate, 3, 657914.
[5]. Food and Agriculture Organization. (2019). Climate-smart agriculture sourcebook (2nd ed.). FAO.
[6]. Food and Agriculture Organization. (2022). The State of Food and Agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems. FAO.
[7]. Faure, G., Desjeux, Y., & Gasselin, P. (2020). New challenges in agricultural advisory services from a research perspective. The Journal of Agricultural Education and Extension, 26(2), 179–190.
[8]. Hansen, J. W., Vaughan, C., & Dinku, T. (2019). Climate services can support African farmers' adaptation to climate change. Nature Climate Change, 9(5), 337–339.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul1166

[9]. Intergovernmental Panel on Climate Change. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Cambridge University Press.
[10]. Kpadonou, R. (2020). Determinants of Climate-Smart Agriculture adoption in sub-Saharan Africa: A review of empirical evidence.
[11]. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
[12]. Scoones, I. (2021). Sustainable livelihoods and rural development. Practical Action Publishing.
[13]. Vaughan, C., & Dessai, S. (2014). Climate services for society: Origins, institutional arrangements, and design elements for an evaluation framework. Wiley Interdisciplinary Reviews: Climate Change, 5(5), 587–603.
[14]. World Meteorological Organization. (2021). State of climate services 2021. World Meteorological Organization.