Farmer’s adaptation behavior and strategies under the climatic change’s impacts.

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Abstract. Serengeti district in Tanzania, a climate-vulnerable region, faces increasing risks to farmers' livelihoods and food security due to climate change. This study examines farmers’ adaptive behaviors using the Adaptive Capacity Framework (ACF), which analyzes five key dimensions: assets, flexibility, learning, social organization, and agency. Through participatory methods, the research assesses both strengths and capacity gaps in local adaptation. One analytical tool was employed, Importance-Performance Analysis (IPA). IPA revealed significant gaps between the perceived importance and actual performance of critical services such as agricultural extension, access to credit, and timely weather information. These results highlight the need for climate adaptation approaches that align with community priorities and realities. The study concludes that enhancing farmers’ adaptive capacity requires inclusive, multi-dimensional strategies supported by improved institutional frameworks and access to key resources. The proposed framework serves as both a diagnostic tool and a practical guide for community-centered climate resilience and planning.

1. Introduction

Agriculture is vital for livelihoods, economies, and sustainable development but faces growing threats from climate change such as drought, erratic rainfall, and extreme weather events that reduce food security and rural incomes [1], [2]. Developing countries remain highly vulnerable due to limited adaptive capacity and dependence on climate-sensitive resources [3],[14]. In Tanzania, over 80% of people rely on rain-fed farming, leaving the sector highly exposed to shocks, particularly in Serengeti District [4], [5]. Understanding farmers’ perceptions and responses is crucial for resilience and food security [6]. Adaptation, pursued individually or through policies, is the most practical pathway [7]. This study applies the Adaptive Capacity Framework (ACF) covering assets, flexibility, learning, social organization, and agency alongside Importance-Performance Analysis (IPA) to examine perceptions, adaptation strategies, and willingness to engage in resilience initiatives [3]. By assessing awareness, practices, and constraints, it identifies priority areas for strengthening adaptive capacity [8],[6]. The findings contribute to climate resilience discourse while supporting Tanzania’s agricultural agenda and global adaptation frameworks emphasizing local knowledge [9], [12].

2. Conceptual framework

2.1 Application of adaptive capacity and policy gaps in climate change response among farmers in Serengeti district

Shown in Figure 1, Climate change threatens farmers in Serengeti District, Tanzania, where rain-fed agriculture faces droughts, extreme temperatures, and erratic rainfall [5]. Historically home to Ikoma, Natta, Kurya, and Maasai agro-pastoralists, farming evolved from indigenous sorghum, millet, and cassava systems with livestock to market-oriented production shaped by colonial cash crops, Ujamaa policies, and climate-smart initiatives [10], [6], [1]. Between 1990 and 2025, farmers adopted drought-tolerant crops, altered planting calendars, integrated crop-livestock systems, and off-farm diversification with support from extension services, NGOs, and local networks [11], [5]. Yet adaptation is limited by land degradation, population growth, human wildlife conflict, insecure tenure, and poor access to credit and climate information. Although national frameworks such as the Tanzania National Environmental Policy (1997) and Tanzania National Climate Change Strategy (2012, revised 2021) aim to build resilience, implementation in fragile areas remains weak, leaving women and youth highly vulnerable. To address these gaps, this study employed a structured questionnaire capturing socio-demographics, perceptions, adaptation strategies, and institutional support [12],[7] pre-tested for reliability and administered via face-to-face interviews in Kiswahili and local dialects [11], using stratified random sampling to ensure representation across wards, systems, and gender for robust analysis within the IPA framework.

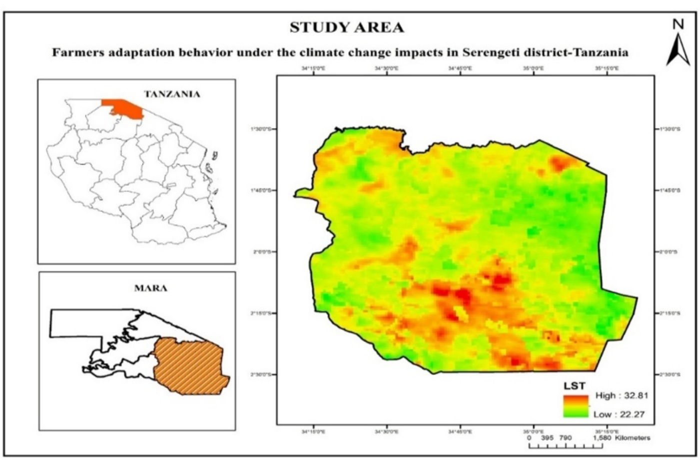

Fig. 1. Study area Serengeti district

2.2 Questionnaire design and data collection

Primary data were collected using a structured questionnaire administered to farming households in Serengeti district. The instrument was designed in English, translated into Kiswahili, and pre-tested with 50 farmers to ensure clarity. It contained sections on socio-demographics, climate-change perceptions, adaptation behaviors, and adaptive capacity based on the ACF. Most questions used a 5-point Likert scale to measure perceptions, importance, and performance, with some binary and multiple-response items capturing specific adaptation strategies. For the IPA, each adaptive-capacity attribute was rated twice-once for importance and once for performance-and then grouped under the five ACF dimensions (assets, flexibility, learning, social organization, and agency). Reliability testing showed good internal consistency (Cronbach's α = 0.82). The target population was 11,870 households, and the sample size was determined using Israel's (2012) formula with a 5% margin of error:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where:

- n= required sample size
- t.p= total population size (11,870 households)
- M.e = margin of error (0.05)

Applying the formula:

$$n = \frac{11{,}870}{1+11{,}870(0.05)^2} = 386.96 \quad (2)$$

Thus, the calculated sample size is approximately 387, which was rounded up to 400 respondents to ensure robustness and accommodate potential non-responses or incomplete surveys, shown in Table 1.

Table 1. Indicators of adaptive capacity in farming over climate change impacts.

Dimension	Abv	References
Assets that people can rely on during the climate changes impacts mitigation over agricultural activities. -Promoting full access to agricultural resources -Ensuring access to funding opportunities.	PAAR FO	-J.E. Cinner, et al., (2018) -D. Dawid, B. Boka (2025)
Flexibility, to adapt their approach when dealing with climate changes impacts management over farming activities. -Collaboration with the private sector. -Forming agricultural community societies.	CPS FACS	-B. Smit, J. Wandel (2006). -R. Beazley, V.D. Boogaard. (2023)
Social Organization, to come together and collaborate in response to agricultural activities.	SFOC KSC	-I.W.K. Suryawan, C.-H. Lee. (2023). -B. Gwambene, J. Saria (2024)

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Dimension	Abv	References
-Strengthening farmers organization and cooperative -Knowledge sharing and collaboration.		
Learning, to identify and react to changes caused by climatic changes in the farming. -Farmer-to-farmer training -Training centers.	FT TC	- P.K. Mogomotsi, A. Sekeleman, et al. (2020). Y.-C. Wang, S.-W. Lin, C.-H. Lee. (2020)
The agency to decide whether or not to adapt in response to the climate changes impacts over agricultural sector. -Access of farming information -Agricultural community agency	AFI ACA	-B. Smit, J. Wandel. (2006) Nguyen, V. V., Phan, T. T. T., & Lee, C. H. (2022).

3. Results

3.1 IPA grid

The IPA Grid Figure 2 is based on ten adaptive-capacity items, PAAR, FO, CPS, FACS, SFOC, KSC, FT, TC, AFI, and ACA. Farmers rated each item on a 5-point Likert scale for importance (how essential it is for adaptation) and performance (how well it currently functions). Quadrants were created using the overall mean scores of importance and performance as the thresholds. The results show that FO, PAAR, and ACA fall in the Concentrate Here quadrant, indicating high importance but weak performance. KSC and AFI appear in Keep Up the Good Work, reflecting strong performance in information access and knowledge sharing. FT and FACS fall under Possible Overkill, while TC and SFOS sit in Low Priority with low ratings on both dimensions. Overall, the IPA highlights financial access, resource provision, and institutional support as the most urgent areas for strengthening farmers' adaptive capacity.

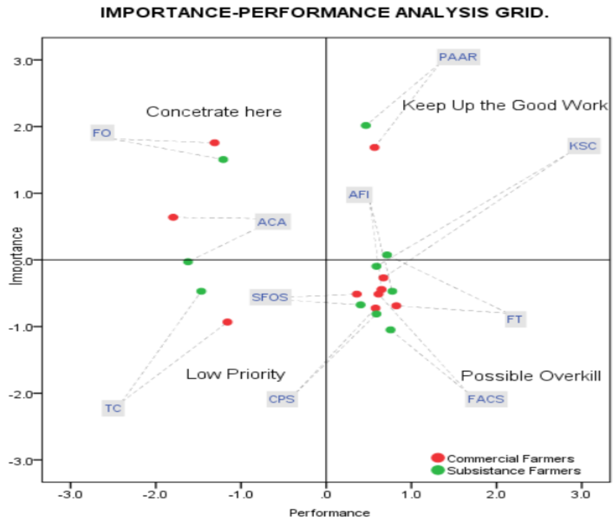

Fig. 2. Importance- performance quadrants gragh.

3.2 Estimation of result of local perception, of farmers adaptation behavior over climate changes impact, on probit and logit model

The Probit and Logit models identify perception of climate change, machinery use, and financial support as the most significant factors influencing local views on adaptation strategies. Farmers aware of climate change, using machinery, or receiving financial support were more likely to value adaptation measures. By contrast, gender, age, and education showed no significant effect. Model performance was moderate, with McFadden Pseudo R^2 values of 0.25-0.34. AIC results favored Models I and III, while Hosmer-Lemeshow tests confirmed Model I as the best fit and Model IV the weakest, shown in Table 2. Overall, strengthening awareness, improving access to machinery, and expanding financial support could enhance farmers' adoption of adaptation strategies.

Table 2. Estimation of Result of Local perception, of Farmers adaptation behavior over climate changes impact, on Probit and Logit model.

		Probit Model				Logit Model		
Variable names	Model I		Model II		Model III		Model IV	
	Coeff.	Std.error	Coeff.	Std.error	Coeff.	Std.error	Coeff.	Std.error
Constant	-4.56808***	.76644	-1.97945***	.49223	-8.03673***	1.41261	-3.40282***	.87442
Gender female represent 0, otherwise is 1)	.11961	.21621	-.26572	.20241	.18045	.40375	-.45577	.37393
Age (21-40 Early	.27482	.23147	.15376	.22033	.44993	.43042	.15916	.39546

		Probit Model				Logit Model		
Variable names	Model I		Model II		Model III		Model IV	
	Coeff.	Std.error	Coeff.	Std.error	Coeff.	Std.error	Coeff.	Std.error
adulthood represent 0, otherwise 1)								
Edu basic education represent 0, otherwise is 1)	-.14692	.22144	-.31523	.21604	-.19663	.40093	-.54536	.39304
Perception (no represent 0 otherwise is 1)	.80012**	.31796	1.27512***	.29364	1.42700**	.56072	2.18002***	.49685
Use of machinery (1 represent yes, otherwise 0)	.61383***	.20784	.50012**	.19550	1.09000***	.38611	.84204**	.36318
Financial support (no represent 0, otherwise 1)	.59686***	.20455	.46356**	.19806	1.09894***	.37844	.87145**	.36659
Overall mean importance.	.98294***	.15954			1.71211***	.29091		
Mean performance			.63453	.15398			1.10503***	.28333
McFadden Pseudo R2	.3400918		.2547184		.3341314		.2498175	
-2Log likelihood	-167.33918		-167.33918		-167.33918		-167.33918	
AIC	236.9		265.4		238.9		267.1	
AIC/N	.592		.664		.597		.668	
p-value	.00076		.00635		.04723		.20923	
(Hosmer-Lemeshow test) Chi square value.	21.13938		17.95360		11.21780		9.65094	

Note: ***, **, * are significant at 1%, 5% and 10%, respectively.

4. Discussion

This study shows that Serengeti farmers are already adapting to climate change, but the effectiveness of these strategies varies across the ACF dimensions [13],[8]. Farmers with stronger assets, greater flexibility in labor and income, better learning opportunities, stronger social networks, and higher agency demonstrated more successful adaptation. The IPA results highlighted key adaptive-capacity gaps especially limited access to climate information, credit, and affordable technologies revealing areas where performance is low despite high importance [10], [11]. These findings are consistent with studies from Tanzania, Ethiopia, and Kenya, which similarly report that financial constraints, weak institutions, and poor information systems undermine farmers' adaptive responses [15],[2]. Critical strategies such as access to agricultural resources (PAAR), funding opportunities (FO), and agricultural community agencies (ACA) ranked highly in importance but underperformed in practice, highlighting a clear policy-practice disconnect. Conversely, knowledge sharing and collaboration (KSC) performed relatively well and fell into Quadrant I (Sustain Performance), demonstrating areas of resilience that can be built upon. These results align with the study's objectives by confirming that farmers are aware of climate risks and have clear preferences for support mechanisms [13],[7],[4] yet systemic barriers limit effective adoption. The study's main contribution is the integration of IPA into the ACF, providing a practical tool for identifying priority interventions. Access to climate-smart resources, affordable technologies, micro-insurance, and strengthened extension services should be expanded. Participatory training and communication platforms can enhance capacity, while multi-level coordination among government, NGOs, researchers, and farmer groups ensures coherence Strengthening extension services, climate information delivery, and inclusive support for women and youth remains critical for sustaining adaptive capacity in the Serengeti.

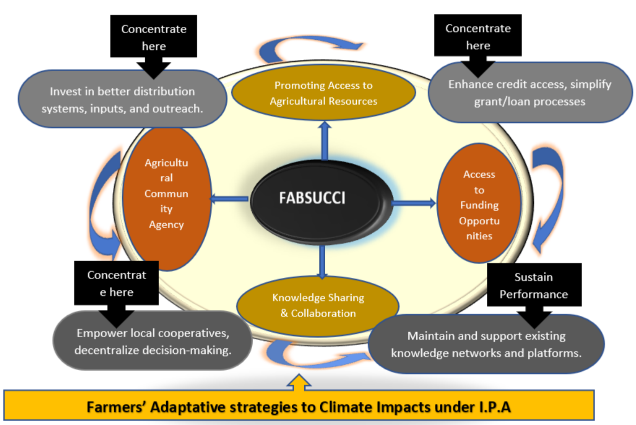

Fig. 3. Adaptation Behaviors in Response to farmers over Climatic change Impacts Insight from IPA.

These results collectively call for a more strategic realignment of priorities intensifying support where needs are most pressing, sustaining excellence where performance is strong, and reconsidering investment in areas that may not yield substantial returns in resilience outcomes. A well-balanced, context-driven approach is vital for enhancing the overall effectiveness of climate change adaptation strategies in the agricultural sector at Serengeti district.

4.1 Policy implications, community-based and participatory adaptation approaches.

The study shows that farmers' adaptation choices are shaped by risk perceptions and attitudes, so outreach must reflect their realities [7]. Key priorities include improved seeds, irrigation, and agroforestry, while underperforming practices need better support through quality inputs, infrastructure, and credit [12]. Integrated climate-smart packages, such as drought-tolerant seeds with water harvesting, can magnify benefits [9],[4]. Barriers like weak extension, poor access to climate information, and limited education must be addressed with training, local forecasts, and tailored credit [3],[14]. Community participation through cooperatives, demo plots, and farmer field schools is vital for practical uptake [4], [12]. Overall, aligning support with farmers' needs ensures resilience and food security in Serengeti [11].

5. Conclusion and recommendation

This study found that Serengeti farmers are already adapting to climate change through strategies such as adjusting planting times, using drought-resistant crops, diversifying income, and practicing soil and water conservation, but effectiveness is limited by socio-economic constraints, weak institutions, and poor access to information and finance. Households with financial assets, flexible labor arrangements, strong social networks, and active learning demonstrated higher resilience, while personal agency motivated proactive adaptation. Policy recommendations include farmer-centered, flexible, and inclusive interventions that integrate local knowledge and behavioral insights. Access to climate-smart resources, affordable technologies, micro-insurance, and strengthened extension services should be expanded. Participatory training and communication platforms can enhance capacity, while multi-level coordination among government, NGOs, researchers, and farmer groups ensures coherence. Gender-sensitive and youth-inclusive approaches are essential to support vulnerable populations and sustain adaptive capacity.

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