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Smallholder Farmers' Perception Toward Use of Indigenous Knowledge for Climate Change Adaptation in Morogoro-Tanzania

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Abstract

Rationale of Study- Indigenous knowledge plays a key role in climate change and weather forecast prediction among smallholder farmers. However, effective and efficient use of indigenous knowledge for climate change adaptation requires a positive perception towards it. This study aimed to assess smallholder farmers' perceptions toward the use of indigenous knowledge for climate change adaptation and mitigation in Morogoro, Tanzania.

Methodology - The study was conducted in the Kilosa District, Morogoro Region, Tanzania. The study employed a cross-sectional research design and included 240 randomly selected respondents. The study employed both qualitative and quantitative methods, collecting data from both sources. SPSS version 25 was used to analyse quantitative data to determine frequency percentages and correlations, while content analysis was used to analyse qualitative data.

Findings - The study found that the majority (216, 90.4%) of respondents reported being affected by drought. Similarly, others (216, 90.4%) were affected by animal and crop diseases, and (203, 84.9%) were affected by floods. Additionally, 166 (69%) of respondents acquired indigenous knowledge from fellow farmers, (155, 65.1%) from family members, and (148, 62.2%) from their parents. Moreover, the study found that (145, 60.4%) of respondents perceived indigenous knowledge to be useful in controlling pests. The study found that gender, income, and farming experience have a significant influence on the perception of using indigenous knowledge for climate change adaptation among smallholder farmers ($p < 0.05$).

Implications - The study suggests that indigenous knowledge is a community resource acquired from fellow farmers, friends, and family members. This highlights the significance of family and community members in sharing indigenous knowledge for climate change adaptation. The findings also suggest that farmers perceive indigenous knowledge as a valuable resource for climate change adaptation. This indicates farmers' positive perception and trust towards indigenous knowledge.

Originality - This is an original study conducted in three wards of Kilosa District in Morogoro, Tanzania

Keywords

Indigenous knowledge, climate change adaptation, smallholder farmers, Tanzania

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1 Introduction

Knowledge management plays a key role in climate change adaptation efforts. The knowledge management process involves the creation, acquisition, dissemination, and preservation of knowledge, which can be used to adapt to and mitigate the impacts of climate change. Knowledge can be indigenous or scientific. It is indigenous if indigenous people create, acquire, disseminate, and preserve it. On the other hand, scientific knowledge involves scientific procedures in its creation, acquisition, dissemination, and preservation (David et al., 2020). Indigenous knowledge has been developed through direct observation of changes in the sky and the behaviour of animals and plants at various times of the year. Smallholder farmers acquire this knowledge through experience and direct observation of their environment (Zvobgo et al., 2022).

Climate change is a real and serious disaster facing humanity at both local and global levels, characterised by unprecedented temperature increases, poor agricultural productivity, storms, and crop and animal diseases that significantly impact people's lives on a large scale (Sugerman et al., 2021). Smallholder farmers residing in resource-constrained local communities are exposed to double jeopardy from local and global environmental changes owing to limited access to financial, scientific, and government support (Boillat et al., 2013). The perception of climate change risk has a significant influence on efforts to adapt to and mitigate its impacts in both resource-rich and resource-constrained environments. Those who perceive climate change as posing a serious risk take appropriate action to ensure the sustainable use of resources and make adjustments to the changing environment, which enhances their adaptation efforts and the measures they take (Nyinondi & Sospeter, 2023). In efforts to mitigate climate change, Smallholder farmers have developed an indigenous knowledge system, which has been used to adapt to and mitigate the effects of climate change (Kaganzi et al., 2021). Indigenous knowledge is created, acquired, used, shared and preserved through interaction between local people and their environment. Moreover, observation of changes in animal behaviour as a response to climate change results in the accumulation of knowledge, which can be passed down from one generation to another (Fundisha, 2020). It predicts climate change events, such as floods, the onset of rainfall, droughts, outbreaks of animal and crop diseases, and temperature increases (Kihila, 2017).

Indigenous knowledge has been key for climate change and weather forecast prediction among smallholder farmers (Nkuba et al., 2021). Despite this fact, there has been a significant increase in the frequency of climate change impacts, including floods, droughts, and the unpredictability of weather events, which pose a serious risk to their agricultural activities due to an increase in crop diseases and poor yields (Nkuba et al., 2019). Due to over-dependence on rain-fed agriculture, while the is the universal promotion of technology and innovations for climate change adaptation, indigenous knowledge, which is embedded in people's interaction with their environment, cultural values, spiritual practices, communally owned resources, remains a critical resource for smallholder farmers still use traditional ways of predicting climate change and use indigenous adaptive practices. However, there is limited empirical evidence on how smallholder farmers perceive indigenous knowledge of climate change adaptation.

Therefore, this study was conducted to assess smallholder farmers' perceptions of the use of indigenous knowledge for climate change adaptation and mitigation in Morogoro, Tanzania. Specifically, to:

i. To identify the sources used to acquire indigenous knowledge among smallholder farmers
ii. To determine the smallholder farmers' perception of the use of indigenous knowledge
iii. To ascertain the perceived usefulness of indigenous knowledge for climate change adaptation among smallholder farmers
iv. To determine the demographic factors influencing smallholder farmers' perception towards the use of Indigenous knowledge for climate change adaptation.

2 Literature review

Indigenous knowledge is the key component in smallholder farmers' efforts to mitigate and adapt to climate change. Their use of indigenous knowledge is determined by their perception towards its usefulness in providing skills for adaptation and mitigation of climate change impacts. This section examines the sources of indigenous knowledge for climate adaptation, the climate change events affecting smallholder farmers, and their perceptions of using indigenous knowledge for climate change adaptation.

2.1 Sources of indigenous knowledge on climate change adaptation and mitigation

Indigenous knowledge for adaptation and mitigation impacts of climate change can be acquired from multiple sources. The major sources are personal direct observations, traditional beliefs, the performance of cultural rituals and traditional storytelling (David et al., 2020).

The study conducted in Uganda among pastoralist communities found that the male members of the community were the custodians and the major sources of indigenous knowledge in society; specifically, male elders, traditional and clan leaders were the major sources of indigenous knowledge and were responsible for passing indigenous knowledge to the youth (Filho et al., 2023). A study assessing the sources of indigenous knowledge among smallholder farmers in Bukoba, Tanzania, found that personal experience and community members were the major sources of indigenous knowledge (Theodory, 2021).

The 2018 UNESCO report reveals that traditional elders and communities play a crucial role in preserving indigenous knowledge. The young generation acquires this knowledge through storytelling and the sharing of experiences; this practice is key to the preservation of indigenous knowledge across generations. In addition, among pastoralist societies, such as the Maasai communities, males were the primary custodians and major sources of indigenous knowledge. This knowledge is an integral part of agricultural practices, being passed down through the agricultural system, which gives them an advantage in adapting to climate change (Oladele & Amara, 2024).

2.2 Climate change events affecting smallholder farmers

Indigenous communities are not insulated from climate change events; they are even more vulnerable to climate change impacts due to their limited capacity and resources to adapt to the changing environments. Indigenous knowledge is a key factor in recognising and adapting to the climate change impacts that smallholder farmers face, including temperature increases, decreases in rainfall, drought, and crop diseases, which have led to poor agricultural productivity. Since smallholder farmers depend much on rain-fed agriculture (Kaganzi et al., 2021). According to Mussa & Mjemah (2015), smallholder farmers who use indigenous knowledge have noted an increase in the frequency of floods, droughts, and animal and crop diseases, which are significantly impacting people's lives.

The study conducted by Tweheyo et al. (2024) revealed that based on indigenous knowledge, smallholder farmers identified the following events: sunshine, unexpected heavy rainfall full of storms, prolonged drought seasons, armyworms invasion and destroy crops, crop diseases, poor agricultural yields, floods and landslides are the impact of climate change which is significantly affecting their economic activities. Smallholder farmers are affected by drought, which causes a loss of crops and poor agricultural productivity due to a shortage of rainfall. As a result, they are unable to produce enough yield from their farms (Theodory, 2020).

Based on indigenous knowledge, Smallholder farmers have observed that climate change has affected soil. Resulting in soil degradation, poor soil fertility, and hindered soil development due to prolonged drought. Farmers demonstrated knowledge of the impacts of climate change on their agricultural activities (Tumwesigye et al., 2023).

2.3 Perceived usefulness of indigenous knowledge for climate change adaptation among smallholder farmers

Farmers' perceptions play a crucial role in the application of indigenous knowledge for climate change adaptation and mitigation. The community owns indigenous knowledge, which is learned through informal means, including cultural rituals, spiritual practices, prayers, and traditions. Indigenous knowledge is a valuable and essential resource in weather forecasting, prediction, and response to climate change events, including floods, droughts, crop diseases, and animal diseases (Radney et al., 2019). Smallholder farmers' interaction with their environment has helped them understand and utilise available indicators, which enable them to adapt to a changing environment characterised by unpredictable rainfall and drought. Using indigenous knowledge, farmers can respond to the challenges presented by Nkuba et al. (2021).

Indigenous knowledge has been a vital part of smallholder farmers' lives and a fundamental resource for climate change predictions, adaptation, and mitigation due to their familiarity with local environments, the ability to comprehend signs and indicators, and the reliability of the results (CTA, 2017). The study conducted by Radeny et al. (2019) revealed that the majority of smallholder farmers (56%) believed that using indigenous knowledge to forecast climate and weather change yielded more reliable results compared to 22% for scientific knowledge forecasting. This suggests that indigenous knowledge is more beneficial to smallholder farmers, which is why they rely on it.

The study conducted by Filho et al. (2023) revealed that the majority 64.4% of smallholder farmers relied on indigenous knowledge in their farming practice and reduce the risk posed by drought because of limited accessibility of scientific knowledge and culture of using indigenous knowledge, which is embedded in their society increase their level of usage indigenous knowledge. There is a significant contextual knowledge gap on the sources used to acquire indigenous knowledge in Morogoro, Tanzania, for little has been done to assess the sources used to acquire indigenous knowledge, the perception of smallholder farmers on climate change, and the perceived usefulness of indigenous knowledge for climate change adaptation in Kilosa district.

3 Theoretical Framework

The study adopted the Indigenous Knowledge System (IKS) theory, which recognises indigenous knowledge as community-owned resources and elders as the knowledge custodians. This knowledge system influences communities' perceptions and interpretations of their world; the knowledge is transferred from one generation to the next. The perception of smallholder farmers regarding climate change is influenced by their indigenous knowledge system, which is closely tied to their life experiences, spiritual practices, and cultural heritage. Indigenous knowledge is acquired through social interaction between community members, where elders share the knowledge with young generations (Hoppers, 2002). Additionally, people have varying perceptions of the knowledge system and its effectiveness in addressing challenges such as climate change.

Furthermore, Hoppers (2002) explains the indigenous knowledge system as an independent knowledge system which indigenous people use in their daily activities to solve different challenges. Furthermore, Smith (1999), in Her book titled "*Decolonizing Methodologies: Research and Indigenous Peoples*", claims that the indigenous knowledge system has been marginalised and devalued by the Western scientific knowledge system while critically emphasises that the indigenous knowledge system is valid and independent epistemology system, which has been useful for sustainable development among indigenous communities over a long period. This knowledge has been useful in addressing environmental changes, technological development and adaptation to climate change. In addition, Sillitoe (2007) emphasises that indigenous knowledge is a critical part of community culture and offers context-based solutions to contemporary problems, such as climate change. This suggests that indigenous knowledge offers an alternative solution with the potential to address context-specific challenges, such as climate change.

4 Methodology

The study was conducted in the Kilosa District of the Morogoro Region. The district was selected because it has been a frequent victim of extreme climate events, including floods, crop diseases, and droughts, for more than 30 years (Mang'enya, 2021). In addition, its unique physical geographic units, namely mountains, uplands, plateaus, and floodplains, make it highly vulnerable to climate change compared to other districts in the Morogoro region (Zakayo, 2015).

According to the 2022 census, Kilosa district has a total population of 617,032, with 165789 households. The district is found between latitude 5'55" and 7'53" south and Longitude 36'30" and 37'30" East. It borders the Mvomero District to the east, the Kilombero District and Iringa Region to the South, the Gairo District to the North, and the Mpwapwa District to the West (URT, 2022). The district is characterised by two seasons of rainfall per year. It has a tropical climate with a temperature range of 25 °C to 30 °C (Kilosa District Council, 2017).

The study adopted a cross-section research design. The design was adopted because it allows the researcher to collect data once at a time. The study used simple random sampling to select three wards and one village from each ward. The three wards selected were Kitete, Magole, and Kimamba A. Furthermore, villages selected were Madudu, Magole, and Kimamba A respectively.

The Israel (2003) model was used to determine the sample size for this study. The model considers sample sizes for precision levels of ±3%, ±5%, ±7%, and ±10%, with a 95% confidence level and a significance level of 0.5. According to the model, if a precision of ±7 is chosen when the population size is 33,006. This justifies the sample used in this study, which is 240.

Table 1: Israel Sample Size Determination Table

Sample size for ±3%, ±5%, ±7% and ±10% Precision Levels Where Confidence Level is 95% and P=.5.				
Size of Population	**Sample Size (n) for Precision (e) of:**			
	±3%	±5%	±7%	±10%
10,000	1,000	385	200	100
15,000	1,034	390	201	100
20,000	1,053	392	204	100
25,000	1,064	394	204	100
50,000	**1,087**	**394**	**204**	**100**
100,000	1,099	398	204	100

Source: Israel 2003

Table 2: Sampling frame for respondents in wards, total population (33,006) of three wards based on a census of 2022 (URT, 2022).

Ward Name	**Total population**	**Sample size for questionnaire**	**Sample size for FGD**
Kitete	13,229	95	9
Magole	11752	83	9
Kimamba A	8025	62	10
Total	33006	240	28

Respondents were selected using simple random sampling, which involved the use of an Excel randomisation program. The researcher used a list of smallholder farmers' names from the ward executive office and entered it into MS Excel. A randomisation process then took place to create the list of respondents.

The study involved both qualitative and quantitative methods. Quantitative methods are used for collecting numerical data. Additionally, qualitative methods are employed to collect non-numerical data. Quantitative data were collected using a semi-structured questionnaire, while qualitative data were collected through a focus group discussion guide. Quantitative data were analysed using IBM SPSS version 25, where descriptive statistics, such as frequency and percentages, were examined. In contrast, inferential statistics, including chi-square tests, were also performed to test for associations between the variables. Qualitative information collected from the focus group discussions (FGDs) was conceptualised, summarised, and analysed using content analysis.

5 Results

This section presents the demographic characteristics, major crops grown in the place, sources of indigenous knowledge among smallholder farmers, climate change impacts facing Kilosa, usage of indigenous knowledge to predict climate change impacts, smallholder farmers' usage of indigenous knowledge in adaption of climate change impacts, perceived usefulness of indigenous knowledge for climate change adaptation, and demographic factors influencing smallholders' usage of indigenous knowledge in climate change impacts adaptation.

5.1 Demographic characteristics

Table 3 presents the demographic characteristics of respondents. The findings indicate that 126 (52.5%) of the respondents were female and 114 (47.5%) were male. Moreover, most of the respondents were between 36 and 55 years of age. The respondents were asked to indicate their education level. Findings revealed that the majority (157, 65.4%) had primary education, followed by 54 (22.5%) who had secondary education.

The farmers were asked to indicate their average annual income. Findings indicate that the majority of the farmers had an annual income ranging from 500,000 to 1,500,000 Tanzanian shillings. Likewise, respondents were asked about their farming experience. Results reveal that 79 (32.9%) of the respondents had experience of 1-10 years in farming, followed by 77 (32.1%) with experience of 11-20 years. Moreover, respondents were asked to indicate their family size. It was found that 122 (50.8%) respondents had families with five to eight members, followed by 100(41.7%) with one to four people.

Table 3: Demographic characteristics

Variable		Frequency	Percentage
Ward	Kimamba A	62	25.8%
	Kitete	95	39.6%
	Magole	83	34.6%
Age	18-26	18	7.5%
	27-35	46	19.2%
	36-45	75	31.2%
	46-55	53	22.1%
	56-65	30	12.5%
	66+	18	7.5%
Sex	Female	126	52.5%
	Male	114	47.5%

Variable		Frequency	Percentage
Education level	Non-formal education	29	12.1%
	Primary education	157	65.4%
	Secondary education	54	22.5%
	Certificate	0	0.0%
	Diploma	0	0.0%
	Bachelor	0	0.0%
	Postgraduate	0	0.0%
Average annual income	below 500000	35	14.6%
	500001-1000000	74	31.%
	1000001-1500000	66	27.6%
	1500001-2000000	32	13.4%
	2000001-2500000	5	2.1%
	25000001-3000000	13	5.4%
	3000001+	14	5.9%
Farming experience	1-10	79	32.9%
	11-20	77	32.1%
	21-30	49	20.4%
	31-40	28	11.7%
	41-50	3	1.2%
	51-60	3	1.2%
	61+	1	0.4%
Family size	1-4	100	41.7%
	5-8	122	50.8%
	9-12	17	7.1%
	13+	1	0.4%

Source: Field survey, 2024

5.2 Major crops grown in the place

The respondents were asked to indicate the crops they grew. The study found that the majority (223, 93.2%) of the smallholder farmers grew maise, followed by 196(82.4%) who grew rice, 69(29%) grew leguminous crops and 43(14%) who grew horticultural crops.

Table 4: Crops grown in Kilosa

Crops grown	Frequency	Percentage %
Maise	223	93.7%
Rice	196	82.4%
Cassava	34	14.3%
Potato	10	4.2%
Sunflower	26	10.9%
Leguminous crop varieties	69	29.0%
Horticulture crops	34	14.3%

Source: Field survey, 2024

5.3 Sources of indigenous knowledge among smallholder farmers

The respondents were asked to indicate the sources from which they acquired indigenous knowledge. Findings indicate that 166 (69%) of respondents acquired indigenous knowledge from their fellow farmers, 155 (65.1%) from family members, and 148 (62.2%) from parents (Table 5). During focus group discussion, smallholder farmers revealed that indigenous knowledge is acquired mostly from community members, especially elders. It is passed down from generation to generation.

Table 5: Sources used to acquire indigenous knowledge

Source	Frequency	Percentage
Friends	135	56.7%
Family member	155	65.1%
Parents	148	62.2%
Community members	145	60.9%
Fellow farmers	166	69.7%
Elders	98	41.2%
Extension officer	30	12.6%

Source: Field survey, 2024

5.4 Climate change impacts facing Kilosa

The respondents were asked to indicate the climate impacts faced by their villages. Findings indicate that the majority (216, 90.4%) of respondents reported being affected by drought, 216 (90.4%) by animal and crop diseases, while others, 203 (84.9%), were affected by floods (Table 6).

Table 6: Climate change impacts facing Kilosa

Climate events	Frequency	Percentage
Drought	216	90.4%
Strong wind	150	62.8%
Crop and animal diseases	216	90.4%
Floods	203	84.9%
Increase in temperature	94	39.3%
decrease in temperature	15	6.3%
Soil degradation	37	15.5%

Source: Field survey, 2024

5.5 Usage of indigenous knowledge to predict climate change impacts

The study aimed to investigate how smallholder farmers utilised indigenous knowledge to perceive the impacts of climate change. The study found that 173 (72.1%) respondents agreed that, based on their indigenous knowledge, they had observed an increase in recent years. Others, 184 (76.7%) respondents observed an increase in the number of extreme weather events in recent years. Findings indicate that 165 (68.8%) respondents observed that climate change has led to poor agricultural production, while 174 (72.5%) noted unpredictability in weather and climatic events.

During FGDs, it was revealed that smallholder farmers perceived indigenous knowledge played a key role in predicting the impacts of climate change. It was also helping smallholder farmers to set strategies for combating the expected impacts. Reliable, and things were happening as predicted. They believe that combining both scientific and indigenous knowledge is more effective in addressing climate change adaptation and mitigation. They said:

> *"We would prefer to use both kinds of knowledge, meaning scientific and indigenous knowledge, because you know when you use indigenous knowledge. You cannot be certain 100% that what it is forecasting or predicting will happen as it is because climate and weather changes have become even more unpredictable in recent years. However, when combining both scientific and indigenous knowledge, we get better results. However, the fundamental cause for being overly dependent on indigenous knowledge is limited access to scientific knowledge".*

Table 7: Farmers' perception of climate change based on their Indigenous knowledge

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I have observed that temperature have increased in recent years	55(22.9%)	173(72.1%)	9(3.8%)	3(1.2%)	0(0%)
I have observed that the amount of rainfall has decreased in recent years	43(17.9%)	150(62.5%)	20(8.3%)	24(10.0%)	3(1.2%)
I have observed that the number of extreme weather events has increased in recent years	35(14.6%)	184(76.7%)	19(7.9%)	2(0.8%)	0(0%)
The length of rainy seasons has decreased in recent years	55(22.9%)	170(70.8%)	7(2.9%)	6(2.5%)	2(0.8%)
I have observed unpredictability in weather and climatic events	47(19.6%)	174(72.5%)	9(3.8%)	8(3.3%)	2(0.8%)
Climate change has resulted into poor agricultural production	64(26.7%)	165(68.8%)	4(1.7%)	6(2.5%)	1(0.4%)
Climate change has caused floods	57(23.8%)	158(65.8%)	15(6.2%)	8(3.3%)	2(0.8%)
Climate change has caused drought	59(24.6%)	170(70.8%)	3(1.2%)	7(2.9%)	1(0.4%)

Source: Field survey, 2024

5.6 Smallholder farmers' usage of indigenous knowledge in adaption of climate change impacts

The study aimed to investigate the utilisation of indigenous knowledge by smallholder farmers in adapting to the impacts of climate change. Findings indicate that 145 (60.4%) respondents used indigenous knowledge to control pests, and 148 (61.7%) respondents reported that the use of indigenous crop varieties had some impact on crop productivity. In comparison, 153 (63.8%) respondents mentioned that sufficient gaps between crops were important for managing soil fertility. During the focus group discussion, it was revealed that smallholder farmers perceived indigenous knowledge as part of their culture and tradition. Results from focus group discussions quoted a statement from respondents:

"I use indigenous knowledge because it is our traditions and culture. I personally use indigenous knowledge because I find scientific knowledge difficult to acquire, understand and use it".

Table 8: Smallholder farmers' perception of the use of indigenous knowledge

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Practicing crop rotation improves soil texture	47(19.6%)	156(65.0%)	20(8.3%)	12(5.0%)	5(2.1%)
Practicing bush fallowing to improved soil fertility	65(27.1%)	144(60.0%)	11(4.6%)	16(6.7%)	4(1.7%)
Bush fallowing causes soil erosion	29(12.1%)	47(19.6%)	37(15.4%)	78(32.5%)	49(20.4%)
Manuring improves water conservation	44(18.3%)	69(28.8%)	92(38.3%)	21(8.8%)	14(5.8%)
The burning of green manure is of no use	60(25.0%)	154(64.2%)	15(6.2%)	7(2.9%)	4(1.7%)
Sufficient gaps between crops maintain the soil fertile	68(28.3%)	153(63.8%)	13(5.4%)	4(1.7%)	2(0.8%)
Use of Indigenous knowledge in production help to control pests	16(6.7%)	145(60.4%)	44(18.3%)	26(10.8%)	9(3.8%)
Intercropping of Indigenous crops increases productivity	38(15.8%)	148(61.7%)	18(7.5%)	21(8.8%)	15(6.2%)
Drying crop seeds for one month before storing is effective	47(19.6%)	145(60.4%)	35(14.6%)	10(4.2%)	3(1.2%)

Source: Field survey, 2024

5.7 Perceived usefulness of indigenous knowledge for climate change adaptation

The study was set to determine the usefulness of indigenous knowledge for climate change adaptation among smallholder farmers. It also aimed to determine its usefulness in efforts to adapt to and mitigate climate-related risks. The study found that 173 (72.1%) respondents agreed that the use of indigenous knowledge is beneficial based on the environment in which they live, and 112 (46.7%) trust indigenous knowledge more than scientific knowledge. 153 (63.8%) respondents stated that indigenous knowledge of climate is reliable and provides accurate predictions of climate change (Table 7).

Table 7: Perceived usefulness of indigenous knowledge for climate change adaptation

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I find the use of indigenous knowledge good for climate adaptation in our environment	45(18.8%)	173(72.1%)	12(5.0%)	5(2.1%)	5(2.1%)
I easily understand climate change based on my IK	43(17.9%)	158(65.8%)	30(12.5%)	5(2.1%)	4(1.7%)
I trust indigenous knowledge over scientific knowledge	36(15.0%)	112(46.7%)	35(14.6%)	34(14.2%)	23(9.6%)
Indigenous knowledge is good because it was developed based on climate changes happening around our environment	51(21.2%)	158(65.8%)	17(7.1%)	11(4.6%)	3(1.2%)
I use indigenous knowledge because it is the only one I have access to	42(17.5%)	135(56.2%)	35(14.6%)	24(10.0%)	4(1.7%)
Climate Indigenous knowledge is reliable and provide reliable climate change predictions	44(18.3%)	153(63.8%)	29(12.1%)	8(3.3%)	6(2.5%)

Source: Field survey, 2024

5.8 Demographic Factors influencing smallholders' usage of indigenous knowledge in climate change impacts adaptation

The study aimed to identify factors influencing the use of indigenous knowledge for adapting to climate change impacts. The study found that farming experience has a significant influence at 0.033 ($p<0.05$). This implies that the more experienced the farmer is in farming, the more they find indigenous knowledge useful in adapting to the impacts of climate change.

Table 8: Cross tabulation between smallholder farmers' perception on the use of Indigenous knowledge and demographic factors

Indigenous coping strategy against climate change	Age	Sex	Education level	Farming experience	Income
Practicing crop rotation improves soil texture	0.397	0.515	0.450	0.029*	0.058
Practicing bush fallowing improves soil fertility	0.358	0.299	0.457	0.336	0.251
Bush following causes soil erosion	0.437	0.007*	0.697	0.017*	0.008*
Manuring improves water conservation	0.222	0.267	0.222	0.362	0.043*
I use the remains of crops as mulching materials	0.371	0.120	0.362	0.917	0.190
Sufficient gaps between crops maintain the soil fertility	0.846	0.297	0.170	0.802	0.044*
Use of Indigenous knowledge in production help to control pests	0.543	0.051	0.892	0.398	0.130
Intercropping of Indigenous crops increases productivity	0.739	0.002*	0.884	0.027*	0.007*
Drying crop seeds for one month before storing is effective for storage	0.318	0.104	0.228	0.264	0.094
* Indicates there is association between variables at ($p<0.05$)					

6 Discussion

This section discusses the findings using the key themes of the study. These are sources used to acquire indigenous knowledge among smallholder farmers; smallholder farmers' perception of the use of indigenous knowledge; perceived usefulness of indigenous knowledge for climate change adaptation among smallholder farmers; and demographic factors influencing the use of indigenous knowledge in climate change adaptation.

6.1 Sources used to acquire indigenous knowledge among smallholder farmers

The study found that the major sources of indigenous knowledge for smallholder farmers were fellow farmers, family members, elders and parents. This finding is consistent with a study conducted in Uganda, which revealed that fellow farmers were the primary source of indigenous knowledge (Nkuba et al., 2021). The study conducted in Nigeria by Olawuyi et al. (2024) found that the major sources of indigenous knowledge among smallholder farmers were farmers' groups and extension services. This highlights the importance of community interaction in knowledge sharing, which is essential for farmers to acquire knowledge. The UNESCO report on indigenous knowledge and climate change revealed that community elders protected indigenous knowledge. A study conducted by Nyadzi et al. (2021) revealed that indigenous knowledge is owned by local people, making it best suited to solve local or contextual problems. This increases the need for recognition of indigenous knowledge in the specific context to help smallholder farmers with policies that favour the use of indigenous knowledge, thereby boosting their adaptation capacity (UNESCO, 2018). The study revealed that the major consequences of climate change facing smallholder farmers in the Kilos district are drought, floods, animal and crop diseases, and strong wind. This finding aligns with the study by Zvobgo et al. (2022), which revealed that climate change has had significant consequences in Uganda, including soil erosion, floods, drought, a decrease in agricultural production, crop and animal diseases, and an increase in heat. A study conducted in the Mvomero district (Mussa & Mjemah, 2015) found a decrease in rainfall and an increase in drought events, which was attributed to the disappearance of water-loving plant species, including the Fig mulberry tree (Mkuyu). The review conducted by Filho et al. (2023) revealed that climate change has had significant consequences in East Africa, including soil erosion, floods, drought, a decrease in agricultural production, crop losses, and animal diseases, as well as an increase in heat.

6.2 Smallholder farmers' perception of the use of Indigenous knowledge

Smallholder farmers have a long history of interaction with the environment, which has enabled them to develop indigenous knowledge systems that have been useful in adapting to and mitigating climate change. The results indicate that smallholder farmers perceived the use of indigenous knowledge for climate change adaptation positively. They utilise indigenous knowledge in production to help control pests, and the intercropping of indigenous crops increases productivity. The extreme events of climate change make life very difficult for smallholder farmers, requiring countermeasures that are effective in the local context. The study found that the smallholder farmers perceived the climate to have changed, and the use of Indigenous knowledge was perceived positively. Farmers utilised indigenous knowledge in production to help control pests, intercrop indigenous crops to increase productivity, create sufficient gaps between crops, and maintain fertile soil. A study conducted in Uganda revealed that smallholder farmers use indigenous techniques to adapt to climate change, such as planting certain species of local trees, like "*omumba*," to protect the soil from erosion and land degradation.

Additionally, organic manure is used to maintain soil fertility and crop rotation is practised (Tweheyo et al., 2024). The chi-square results indicate that smallholder farmers have a positive perception of climate change and the use of indigenous knowledge for climate change adaptation. The major predictors for smallholders' perception of climate change and the use of indigenous knowledge were income, education, level, and farming experience ($p < 0.05$). The more a farmer experienced farming, the more they recognised the danger of climate change. Additionally, more farmers perceived indigenous knowledge as useful in combating climate change within their local context.

6.3 Perceived usefulness of indigenous knowledge for climate change adaptation among smallholder farmers

The study found that respondents that the use of indigenous knowledge is perfect in the local context to solve the climate change problem. Additionally, they prioritise indigenous knowledge over scientific knowledge, indicating that they are more likely to utilise indigenous knowledge when addressing climate change. This indicates that indigenous knowledge is a valuable tool for climate change adaptation among smallholder farmers, as the study revealed that indigenous knowledge is more reliable among smallholder farmers than scientific knowledge. A study conducted by Filho et al. (2023) revealed that the majority, 64.4% of smallholder farmers, relied on indigenous knowledge in their farming practices to reduce the risk posed by drought. A study conducted by Mahoo et al. (2015) in Tanga revealed that smallholder farmers perceived indigenous knowledge as highly reliable and provided accurate predictions of climate events comparable to those made using scientific knowledge.

6.4 Demographic factors influencing the use of indigenous knowledge in climate change adaptation

The study found that demographic factors influenced several indigenous climate change coping strategies, including the practice of crop rotation to improve soil texture. Intercropping of indigenous crops increases productivity and is significantly influenced by farming experience, as indicated by $p < 0.05$. The intercropping of indigenous crops increased productivity and was significantly influenced by gender, income, and farming experience. The causes of soil erosion following the Bush were significantly influenced by gender, income, and farming experience. This suggests that the majority of social demographic factors influence the perception of smallholder farmers towards the use of indigenous knowledge for climate change adaptation. This finding is similar to that of Mudekhere et al. (2023), who found a significant relationship between socio-demographic factors — namely, income, education level, household size, land ownership size, and age — and climate change adaptation strategies. This indicates that demographic factors influence the perception of indigenous knowledge among smallholder farmers, which in turn affects their understanding of climate change risks and adaptation strategies (Basiru et al., 2022). Furthermore, the study conducted by Sherpa (2023) revealed that social demographic factors, such as age, farming experience, farm size, and livelihood source, had a significant relationship with farmers' perception of the efficacy of indigenous knowledge in climate change adaptation. This highlights the importance of indigenous knowledge in climate change adaptation among smallholder farmers and underscores the need to incorporate indigenous knowledge into climate change adaptation strategies.

7 Conclusion

Indigenous knowledge has been beneficial to smallholder farmers in the Kilosa district as they adapt to and mitigate the impacts of climate change, including floods, drought, crop diseases, animal diseases, and rising temperatures. This knowledge is a community resource acquired from parents, fellow farmers, community members, and personal experience. The study emphasises the importance of knowledge sharing among community members to enhance the ability of smallholder farmers to adapt to and mitigate climate change impacts, as indigenous knowledge empowers farmers to adapt and mitigate the effects of climate change.

Smallholder farmers have a positive perception of the use of indigenous knowledge for climate change adaptation, as evidenced by their greater trust in indigenous knowledge over scientific knowledge, their familiarity with the environment and their ability to understand signs and predict climate change.

Additionally, the adoption of crop rotation, traditional medicine, or the use of indigenous knowledge to control pests and diseases. In addition, the importance of farmer-to-farmer knowledge sharing is evident, as farmers are the primary source of indigenous knowledge. Farming experience is important for recognising the importance of indigenous knowledge and the dangers posed by climate change.

8 Recommendation

The study recommends documenting indigenous knowledge used for climate change adaptation in the Kilosa district and creating a knowledge-sharing platform to facilitate the transfer of knowledge from one farmer to another.

Also, the study recommends the provision of training on how to use scientific knowledge to empower farmers with more knowledge to use in the efforts to adapt against climate change impacts, as they have indicated that indigenous knowledge alone is not enough to solve the challenge of climate change.

In addition, the study recommends further studies on indigenous knowledge for climate change adaptation and mitigation in other districts of Tanzania.

9 Implications of the study

The study suggests that indigenous knowledge is a key resource for climate change adaptation and mitigation among smallholder farmers, and they have confidence in their knowledge system. Factors such as income, age, farming experience, education level, and gender influence their perception. However, farmers need training and access to reliable scientific information on climate change. They have stated that climate change has become more unpredictable, indicating that indigenous knowledge alone is insufficient to address the impacts of climate change. The study enriches the literature by highlighting how knowledge systems influence social and cultural dimensions, as well as the perceptions of smallholder farmers regarding the impact of climate change adaptation efforts. In addition, the study suggests that integrating both indigenous and scientific knowledge could yield more desirable results, thereby enhancing climate change adaptation among smallholder farmers. This aligns with the study by Filho et al. (2023), which suggests that indigenous and scientific knowledge should be integrated into climate change adaptation strategies by responsible agencies to enhance climate change adaptation among smallholder farmers.

Additionally, the study suggests that indigenous knowledge is a valuable resource for climate change adaptation among smallholder farmers. This indicates that there is a need for wide recognition, documentation and protection of indigenous knowledge by the communities and government agencies to ensure sustainable use of indigenous knowledge for climate change adaptation among local communities, as the study by (Nyadzi et al., 2021) highlighted on the disappearance of indigenous knowledge due to modernisation and contemporary changes in the global landscape, migration and shifting in beliefs in Africa.

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