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Research Article

Analyzing Effects Of Climate Variability In The Nexus Of Informal Microfinance Institutions: A Case Study Of Tharaka South Subcounty, Kenya

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Abstract: Climate variability is variation of climate elements from the longterm mean state on all spatiotemporal scales. Climate variability affects microfinance institutions directly and indirectly through physical and transition risks. However, no studies have analyzed the effects of climate variability in relation to informal microfinance institutions. The study, therefore, analyzed the effects of climate variability in relation to informal microfinance institutions. It used a descriptive study design and multi-stage sampling design. Data was analyzed using thematic analysis, descriptive analysis, and Kendall's tau-b correlation analysis. The study found a positive trend in climate variability ($\tau_b = 0.174$, $\alpha > 0.05$). Local people are highly vulnerable to climate variability as confirmed by 98.7% of the respondents who observed that climate variability affects their livelihoods. This vulnerability stems from the effect of climate variability on access to capital assets and livelihood strategies. Vulnerability to climate variability has a significant negative effect on loan repayment performance, loan access and sustainability, and hence on informal microfinance performance ($\tau_b = -0.109**, P < 0.01$). Nevertheless, climate variability increases participation in informal microfinance institutions as shown by the positive relationship with the number of people who joined informal microfinance institutions ($\tau_b = 0.239**, P < 0.01$) and the number formed per year ($\tau_b = 0.137, P < 0.01$) from 1981 to 2018. This is because informal microfinance institutions help vulnerable households in building resilience to climate variability as observed by 80.8% of the respondents. The characteristics of informal microfinance institutions have positive or negative relationships with vulnerability to climate variability. These relationships are and could be further leveraged upon to address effects of climate variability on informal microfinance institutions. Detailed contextual analysis of informal microfinance institutions in the nexus of climate variability is thus imperative to inform actions aimed at cushioning the groups and their members against the impacts.

Keywords: capital asset; climate variability; informal microfinance institution; informal microfinance performance; livelihood strategy; vulnerability

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1. Introduction

Climate variability is the variation of climate elements from the longterm mean state on all spatial and temporal scales [1,2]. Climate variability in Kenya has been observed to exhibit a generally positive trend in Kenya [3,4] with its effects being associated with the deteriorating livelihoods in rural areas [5]. Just like other economic sectors, microfinance institutions are affected by climate variability [6] with those in low income countries being more vulnerable [7]. The impact of climate variability on microfinance institutions is aggravated by the high vulnerability of their clients who mainly earn low incomes, inhabit marginal areas and largely depend on climate sensitive economic activities [8,9]. In a study on the dynamics of microfinance and financial vulnerability in Tamil Nadu in India, [10] observed that most microfinance institutions member's households were vulnerable with more than half (57.6%) living below the poverty line per capita and a third (29.5%) living slightly above the poverty line.

The climatic risks facing financial institutions include physical risks and transition risks [11]. Climate events and the underlying socioeconomic trends have the potential to undermine asset values, employment opportunities, crop production, livestock production, business activities and investment returns of microfinance institutions and their clients hence impairing their loan repayment performance, portfolio quality and profitability to a point of insolvency [8,9,12–16]. Climate variability therefore affects the economic performance of microfinance institutions clients leading to poor loan repayment performance [13,17] and hence hindering their social and financial performance [18]. Moreover, poor loan repayment performance reduces the creditworthiness of microfinance institutions and their members compromising their ability to receive credit as well as stiffening of lending conditions by lenders in the future [19]. Further, the negative effects of climate risks on assets of clients of microfinance institutions reduces their credit worthiness and capacity to access loans [20,21].

Microfinance institutions are, however, an important tool for addressing vulnerability to impacts climate variability [6,22–24]. Microfinance institutions provide financial services through loans, savings and insurance services to the poor enabling them to undertake productive activities, accumulate assets, stabilize their consumption, manage disasters, and cushion themselves against risk [3,25–28]. Microfinance institutions enable households to diversify their income sources [29], access inputs of crop and livestock production [22], and access education and healthcare services [30]. This is especially true among the poor who are more vulnerable to climate risks and are attracted by microfinance institutions as vehicles for facilitating adaptation due to the more favorable nature of their core structures [31].

Given the important role of microfinance institutions, there is thus need to put in place measures aimed at cushioning them against the impacts of climate change and variability The financial sector thus addresses climate risks in various ways including integrating the risks into lending decision making processes, capacity building, focus on low risk investments and leveraging on mitigation and adaptation products and services [14,16,32]. Microfinance institutions could also make their loan repayments more flexible during extreme climate events to ease the client's repayment burdens without increasing the risk of default [26,33,34].

Nonetheless, very few studies have analyzed the impacts of climate variability on microfinance institutions [8,17]. The risks and opportunities posed by impacts of climate variability on microfinance institutions are not clearly understood and integration of the existing knowledge into their decision making processes is minimal [8,12,16,35]. Besides, the response measures which microfinance institutions could employ in adapting to impacts of climate variability have not been analyzed properly [26]. Microfinance institutions are thus not able to clearly identify nor manage climate risks [8].

Furthermore, no studies have specifically analyzed the impacts of climate variability on informal microfinance institutions. Therefore, the risks and opportunities posed by climate variability on informal microfinance institutions are also not well understood. No studies have also analyzed the response measures that informal microfinance institutions could employ in responding to impacts of climate variability. Additionally, no past studies analyzed how the characteristics of informal microfinance institutions affect vulnerability to climate variability. Understanding the relationship between characteristics of informal microfinance institutions and vulnerability to climate variability is critical to enable leveraging on their structures and activities to cushion the groups and members against the impacts.

According to the sustainable livelihoods framework the effect of the vulnerability context on access to capital assets influences the effectiveness of structures and processes in undertaking livelihood strategies and hence the resultant livelihood outcomes [36]. On the other hand, structures and processes have direct positive or negative feedback on the vulnerability context by either enhancing or restricting access to capital assets [36–39]. Besides, [40] notes that institutions influence how individuals, households or communities perceive, are affected, and respond to climate variability.

The research for study, therefore, analyzed the effects of climate variability in the nexus of informal microfinance institutions in Tharaka South Subcounty in Kenya. This involved analysis of the effects of climate variability on informal microfinance institutions. It also analyzed the relationship between the characteristics of informal microfinance institutions and vulnerability to climate variability and how the relationship could be leveraged on in addressing effects on the groups and members. The study informs actions for cushioning informal microfinance institutions and their members against the effects of climate variability.

2. Materials and Methods

2.1. Study Area

Tharaka South Subcounty is part of Tharaka Nithi County and covers a surface area of 637 km^2 [41] (Figure 1). The subcounty has a total population of 75,250 people living in 18,466 households. The population density is 118 people per km^2 [41]. The subcounty has three main livelihood zones namely the mixed farming zone, marginal mixed farming zone, and the rainfed farming zone [42]. The people are largely agropastoralists with farming and animal husbandry accounting for over 70% of their income [43].

Tharaka South Subcounty lies in a semiarid area characterized by a bimodal rainfall pattern and a temperature range of 24° to 37° Celsius, at times rising to 40° Celsius [44–46]. The subcounty falls in the dry/savannah climatic zone in the Köopen-Geiger climate classification [47]. The main agroecological zone is intermediate lowland 5 with the main vegetation type being the Northern acacia-commiphora bushland and thicket. Proximity of the area to Mount Kenya means that the local climate is influenced by the El Niño/Southern oscillation, intertropical convergence zone, latitude and altitude, and sea surface temperatures among other factors [48] Climate patterns in the area are also influenced by the Indian Ocean Dipole which is responsible for driving climate variability in East Africa [49,50].

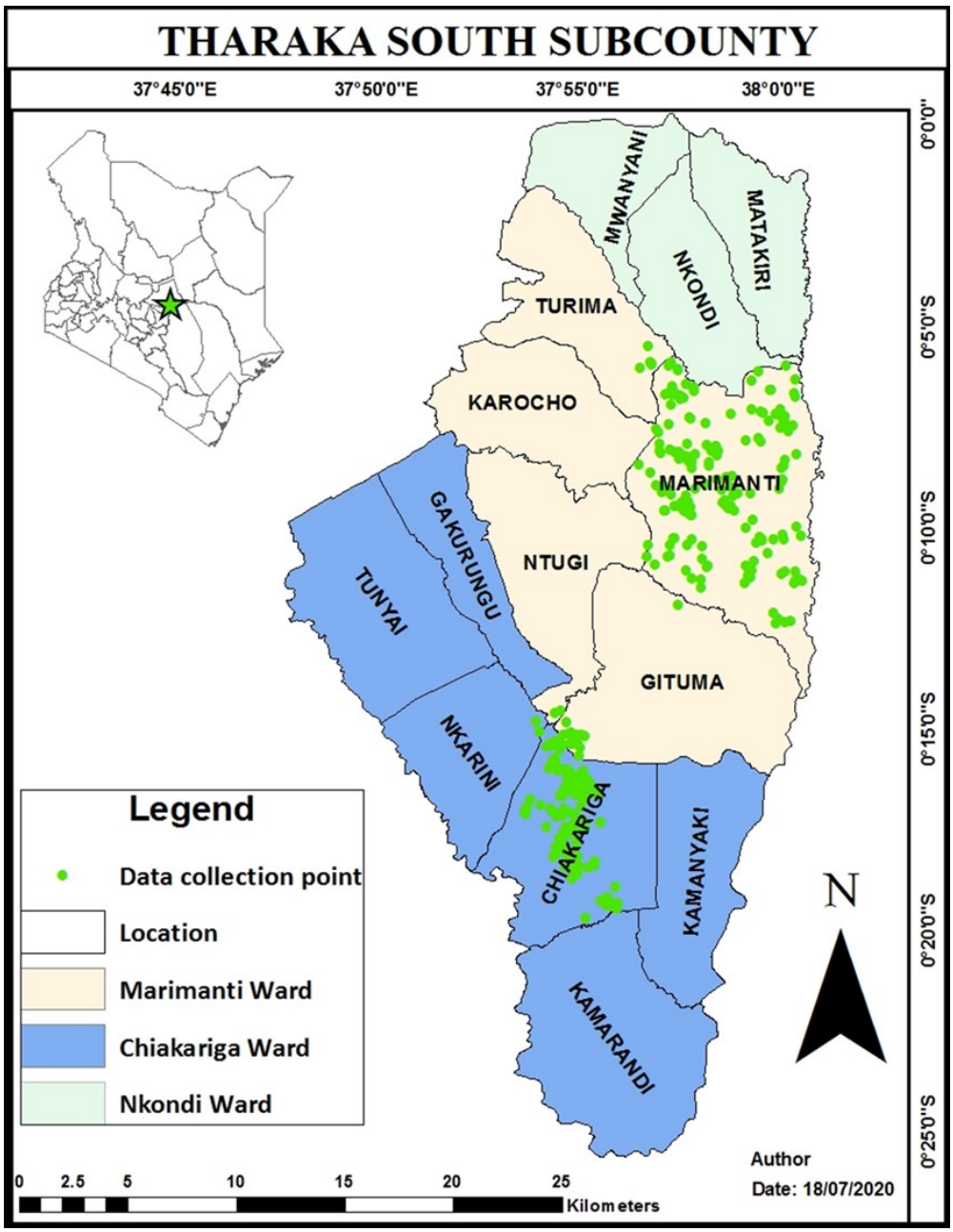

Figure 1. The study area in Tharaka South Sub County.

2.2. Data Collection

The study used a descriptive study design and employed the multistage sampling design. This first involved random selection of two locations, Marimanti and Chiakariga, in Tharaka South Sub County for the study. Then 177 informal microfinance institutions in the two locations were identified based on data at the department of social development and listed to form a sampling frame. The number of informal microfinance institutions in the study were distributed proportionately per study location and selected systematically by picking every fifth group from the list. A total of 36 informal microfinance institutions, 18 from each location, were chosen for the study. The study's' sample size was determined using Cochran's Equation 1 [51] equating to a sample size of 385 respondents.

The total number of respondents was then divided by the number of groups selected for the study, 36, to determine the number of respondents to interview per group and a figure of eleven arrived at. The eleven respondents were then systematically chosen from each of the selected informal microfinance institutions using the group's member's lists as sampling frames. Respondents were chosen from the member's lists systematically. The sampling interval was determined by dividing the total number of members by 11 for each informal microfinance institution selected for the study.

The study used both primary and secondary data. Primary data was collected through observation, questionnaire surveys, 2 focused group discussions, and 17 key informant interviews. Data collection was done with the assistance of a mobile-based georeferenced data collection system called kMACHO. This is an application system that allows a user to collect geographical location specific information. In doing this the data collection tools were first coded and uploaded into Android based mobile phones which were used to collect data. The data was then sent to an online data base and accessed through the kMACHO web portal. Methodological triangulation was used to validate and harmonize data from different data collection methods. This helped increase the credibility and validity of the results. Pilot testing of the data collection instruments was done to check for weaknesses in design and instrumentation. The instruments were tested for reliability using the Cronbach Alpha method to test the degree of internal consistency between items. Cronbach's alpha is a measure used to assess the reliability, or internal consistency of a scale or test, expressed as a number between 0 and 1 with a higher score indicating greater reliability [52] and 0.7 indicating an acceptable reliability [53]. A Cronbach alpha of 0.784 was arrived at indicating good reliability. The instruments were evaluated for validity through expert consultation.

2.3. Calculation of Variables

2.3.1. Calculation of climate variability

Climate variability was measured using the coefficient of variation. This was based on the annual rainfall of the last 38 years, i.e. from 1981 to 2018. Rainfall data was sourced from Climate Hazards InfraRed Precipitation with Station data (CHIRPS). CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and drought monitoring. The calculation of coefficient of variation used the formula.

$$CV = \frac{SD}{\bar{X}}$$

Where:
CV = Coefficient of variation
SD = Standard Deviation
$\bar{X}$ = Mean

Climate variability was also analyzed based on local people's perceptions.

2.3.2. Calculation of informal microfinance performance index

A composite index was calculated to measure informal microfinance performance and called informal microfinance performance index. The composite index was calculated using savings, loan access, and loan repayment performance (measured using the number of loan delayments in loan repayment) in the past one year as indicators.

In calculating the informal microfinance performance index, the negative oriented values were first adjusted for directionality using a multiplicative inverse adjustment to ensure higher values always indicate higher loan repayment performance, i.e.

$$x_i = \frac{1}{x_u}$$

Where:
x_i = Adjusted value of *x*
x_u = Unadjusted value of *x*.

The variables were then normalized to ensure the comparability of indicators bearing different measurement units and scales. This was done using the Min-Max normalization to yield standard index values with relative positions in the range of zero to one for each indicator, i.e.

$$z_i = x_i - \frac{min(x)}{max(x) - min(x)}$$

Where:
z_i = Normalized value of x_i
min(x) = Minimum value of *x*
max(x) = Maximum value of *x*.

These indicators were then weighted to avoid the uncertainty of equal weights given their diversity. This entailed weighing the variables using the pairwise ranking matrix. This allocated weights according to the number of times a variable was chosen as being more important than the other variables.

$$CI = \sum \frac{w_i z_i}{n}$$

Where:
CI = Composite index
w_i = Weight of variable
z_i = Variable index value
n = Number of variables.

The member's informal microfinance performance composite index was tested for accuracy and robustness using uncertainty and sensitivity analysis. Uncertainty analysis was done using the propagation of the standard errors approach i.e. based on uncertainties of index components. This involved adding their standard errors as a weighted sum in quadrature (squared, weighted, added and then square rooted) as in [54], i.e.

$$U = \sqrt{\sum (w_i S_i)^2}$$

Where:
U = Uncertainty
w_i = Variable weight
S_i = Standard error of variable's index value.

Sensitivity analysis was done using multiple regression analysis to determine how components constituting the composite index influence it as in [55]. In doing this the coefficient of determination (R^2) indicated the amount of variation in the composite index which can be explained by the model's components.

2.3.3. Calculation of perception based climate variability vulnerability index

A composite index was calculated to measure the impact of climate variability and called perception-based climate variability vulnerability index. The composite index was calculated based on the perception of the effect of climate variability on household's access to education, health, crop production, and livestock production as indicators.

The perception-based climate variability vulnerability index was calculated using the procedure used in calculating the informal microfinance performance index.

2.4. Data Analysis

Qualitative data was analyzed using thematic analysis whereas quantitative data was analyzed using descriptive analysis and Kendall's tau-b.

3. Results

3.1. Analysis of Climate Variability based on Rainfall Variability

The inter-annual rainfall variability for 1981–2018 is 0.25, i.e. 25% from the mean. This depicts a high inter-annual rainfall variability. The minimum intra-annual rainfall variability is observed in 1993 i.e. 1.009 and the highest in 2016 i.e. 1.655. The area has a positive increasing non-significant trend for intra annual rainfall variability ($\tau_b = 0.174, \alpha > 0.05$). This means climatic patterns are becoming more variable over the years (Table 1 and Figure 2).

This trend is confirmed by local people's perceptions of climate variability. Local people have perceived climate variability as witnessed by the fact that 86.5% of the respondents said local climatic patterns have changed to a high extent while 13.5% said climatic patterns have changed to a low extent. The changes observed include a decrease in rainfall amounts (55.6%) and erratic rainfall patterns (38.7%). Based on Kendall's tau-b statistical analysis, annual rainfall amounts depict a decreasing negative non-significant trend ($\tau_b = -0.107, \alpha > 0.05$) meaning that rainfall amounts are decreasing over time with the rainfall pattern being nonlinear and unpredictable. A negative relationship was observed between intra-annual rainfall variability and total annual rainfall amount ($\tau_b = -0.014, \alpha > 0.05$) meaning climate variability leads to a decrease in rainfall amounts.

Local people have also observed an increase in the severity, frequency, and length of droughts. Based on Kendall's tau-b statistical analysis, a non-significant negative trend ($\tau_b = -0.107, \alpha > 0.05$) was observed for the percentage of normal precipitation along the years indicating increasing severity of droughts Further, a negative relationship between intra-annual rainfall variability and annual Percentage of normal precipitation which was not statistically significant ($\tau_b = -0.014, \alpha > 0.05$) was observed meaning climate variability causes an increase in drought severity. Local people have also perceived higher temperatures and erratic temperature regimes (5.2%), an increase in evapotranspiration rates and a decrease in streamflow. Furthermore, a negative relationship was observed between intra-annual rainfall variability and average annual NDVI ($\tau b = -0.95, \alpha > 0.05$) meaning climate variability leads to a decrease in the condition of the vegetation. This is confirmed by 71.9% of the respondents who observed that climate variability is caused by environmental degradation especially deforestation.

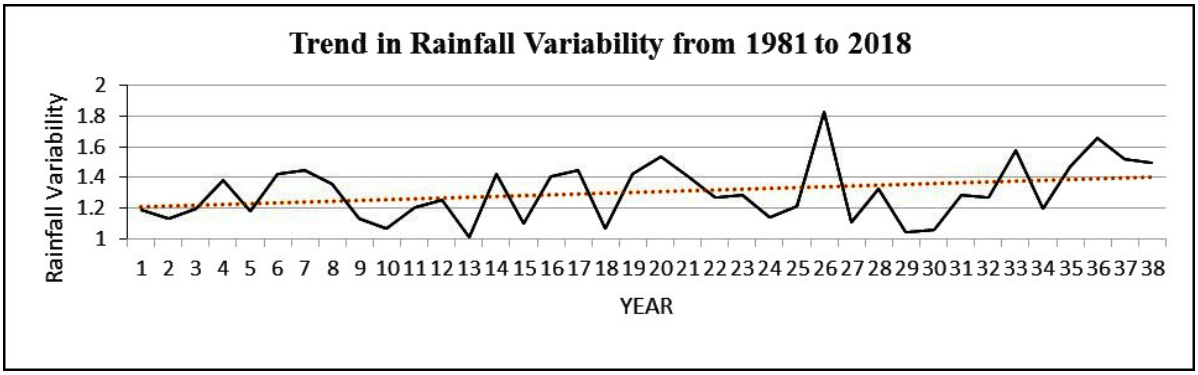

Figure 2. Trend in rainfall variability from 1981 to 2018.

Table 1. Analysis of annual rainfall variability for 1981 to 2018.

Variable	Value (Year 1981–2018)
Interannual rainfall variability	0.243
Minimum intra-annual rainfall variability	1.009
Maximum intra-annual rainfall variability	1.831
Trends in intra-annual rainfall variability (τ_b)	0.174

3.2. Calculation of Perception based Climate Variability Vulnerability Index

The household's perception based climate variability vulnerability index was calculated based on the perception of the effect of climate variability on household's access to education, health, crop production, and livestock production as indicators as presented in (Table 2).

The index was then tested for accuracy and robustness using uncertainty analysis and uncertainty of 0.059 arrived at indicating very high certainty (Table 3).

Further, the index was analyzed for sensitivity using multiple regression analysis and a coefficient of determination (R^2) of 0.979 arrived at giving an indication of very high sensitivity (Table 4).

The mean household's perception based climate variability vulnerability index arrived at was 2.256. The median was 2.500 while the mode was 2.500. The household's perception based climate variability vulnerability index ranged between 0.000 and 2.500 while the standard deviation is 0.498 and the skewness is - 2.164. Local households are thus marked by high vulnerability to climate variability.

3.3. Calculation of Informal Microfinance Performance Index

Secondly, the informal microfinance performance index was calculated based on savings, loan access, and loan repayment performance in the past year as presented in (Table 5).

The index was then tested for accuracy and robustness using uncertainty analysis and uncertainty of 0.028 arrived at indicating very high certainty (Table 6).

Further, the index was analyzed for sensitivity using multiple regression analysis and a coefficient of determination (R^2) of 1.00 arrived at indicating very high sensitivity (Table 7).

Table 2. Calculation of perception based climate variability vulnerability index.

Variable	Percentage of households affected	Median impact score	Average variable index value	Variable weight	Average weighted variable index value
Effect on health	88.3%	2	0.888	4	3.553
Effect on access to education	86.8%	2	0.868	3	2.604
Effect on crop production	96.9%	2	0.969	2	1.938
Effect on livestock production	93.0%	2	0.932	1	0.932
Average composite index value					2.256

Table 3. Calculation of accuracy using uncertainty analysis.

Variable	w_i	S_i	w_iS_i	$(w_iS_i)^2$
Effect on health	4	0.01607389	0.06429556	0.0003145557639184
Effect on access to education	3	0.01729944	0.05189832	0.0026934356188224
Effect on crop production	2	0.00886786	0.01773572	0.0003145557639184
Effect on livestock production	1	0.01280582	0.01280582	0.0001639890258724
$\sum(w_iS_i)^2$				0
$\sqrt{\sum(w_iS_i)^2}$				0.05904689807

Table 4. Calculation of sensitivity using multiple regression analysis.

Model Summary				
Model	**R**	**R square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.989	0.979	0.979	0.07182

Table 5. Calculation of informal microfinance performance index.

Variable	**Total**	**Average**	**Average variable index value**	**Variable weight**	**Average weighted variable index value**
Amount of savings	642,879	1,670	0.675	2	1.35
Loan access	10,4339,00	27,101	0.075	1	0.075
Loan repayment performance	178	0.5	0.908	3	2.724
Average composite index value					0.976

Table 6. Calculation of accuracy using uncertainty analysis.

Variable	w_i	S_i	$w_i S_i$	$(w_i S_i)^2$
Loan repayment performance	3	0.0083	0.0249	0.00062001
Savings	2	0.0056174	0.0112348	0.00012622073104
Loan access	1	0.0055541	0.0055541	0.00003084802681
$\sum(w_i S_i)^2$				0.0007770787
$\sqrt{\sum(w_i S_i)^2}$				0.02787613136

Table 7. Calculation of sensitivity using multiple regression analysis.

Model Summary				
Model	**R**	**R square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	1.000	1.000	1.000	0.002103415

The average informal microfinance performance index was arrived at was 0.976. The median is 1.021 and the mode is 1.021. The informal microfinance performance index ranges between 1.713 to 0.099 while the standard deviation is 0.189 and the skewness is - 0.951. The informal microfinance institutions are therefore mainly marked by high levels of informal microfinance performance.

3.4. Effect of Climate Variability on Performance in Informal Microfinance Institutions

To determine the effect of climate variability on informal microfinance performance. Kendall's tau-b correlation analysis was used to calculate the relationship between perceptions based climate variability vulnerability index and informal

microfinance performance index. A significant negative correlation ($\tau b = -0.109 * *, P < 0.01$) was found indicating that an increase in climate vulnerability leads to a decrease in performance in informal microfinance institutions.

Climate variability has a negative effect on member's loan repayment performance in informal microfinance institutions. This is illustrated by the negative correlation found between perception-based climate variability vulnerability index and loan repayment performance ($\tau b = -0.169 * *, P < 0.01$) Climate variability negatively affects loan access in informal microfinance institutions as depicted by the negative correlation between perception-based climate variability vulnerability index and loan access ($\tau b = -0.021, P > 0.05$).

Climate variability leads to a decrease in the sustainability of informal microfinance institutions. This is as shown by the positive relationship between perception-based climate variability vulnerability index and the ability of the informal microfinance institutions to fully meet their financial needs ($\tau b = 0.012, P > 0.05$) when if informal microfinance institutions can fully meet their financial needs is coded as 1 = Yes, 2 = No. Moreover, 75% of the members said that lack of adequate funds to undertake activities is one of the challenges that informal microfinance institutions face. Additionally, 61.1% of the informal microfinance institutions said they have problems in fully meeting their financial requirements.

Informal microfinance institutions and their members mainly invest in climate-sensitive activities which aggravates vulnerability to effects of climate variability. This is as portrayed by the fact that 67.5% of the groups that engage in joint investment activities invest in climate-sensitive activities including crop and livestock production, agribusiness and tree seedlings production. Further, 11.1% of the members said that the effect of harsh climate conditions on investments is one of the challenges faced by informal microfinance institutions in their activities. Problems facing informal microfinance institutions in their activities are associated with climate risks including fluctuations in the market and prices of products (2.8%), lack of raw materials for activities such as basketry (2.8%), and lack of adequate infrastructure (5.6%).

Effects of climate variability on activities undertaken by informal microfinance institutions and their member's leads to low returns on investments which causes loan delinquency and loan default. Lack of money to repay loans was identified as the cause of loan delinquency by 97.5% of those who delayed in repaying their loans while 80% of those who defaulted in repaying their loans attributed it to lack of money to repay the loan.

Response actions to impacts of climate variability such as migration also undermine loan repayment performance as shown by 2.5% of the delinquent members who attributed this to having traveled from the area when they were supposed to repay. In addition, response actions to impacts climate variability including health issues, food insecurity, and unfavorable conditions for crop productions cause members to divert the use of borrowed loans. Those who had diverted the use of loans to other purposes said they had used the money to address health issues (52.6%), to buy food (11.3%), to respond to emergencies (7.5%) and due to occurrence of unfavorable climatic conditions that couldn't allow the success of agricultural activities they had planned to invest the loans in (4.5%). Diversion of borrowed loans leads to a decrease in loan repayment performance as confirmed by Kendall's statistical test ($\tau_b = -0.040, P > 0.05$).

3.5. Effect of Climate Variability on Participation in Informal Microfinance Institutions

Further, the effect of climate variability on participation in informal microfinance institutions was determined by using Kendall's tau-b correlation analysis to calculate the relationship between intra-annual climate variability and the number of informal microfinance institutions formed per year from 1981 to 2018. The results of the analysis indicated there is a positive correlation ($\tau_b = 0.137, P > 0.05$) between intra-annual climate variability and the number of informal microfinance institutions formed per year.

Additionally, Kendall's tau-b correlation analysis was used to determine the relationship between intra-annual climate variability and the number of people who joined informal microfinance per year from 1981 to 2018. A positive significant correlation ($\tau_b = 0.239*, P < 0.05$) was found between intra-annual climate variability and the number of people who joined informal microfinance institutions per year.

A positive relationship was found between perception-based climate variability vulnerability index and the number of informal microfinance institutions belonged to as confirmed by Kendall's statistical test ($\tau_b = 0.002, P > 0.05$). Participation in informal microfinance institutions helps in responding to climate variability as observed by 80.8% of the respondents. Climate variability is thus associated with greater participation in informal microfinance institutions.

3.6. Relationship between characteristics of informal microfinance institutions and member's vulnerability to climate variability.

The informal microfinance institutions were characterized based on their structures and activities (Table 8).

Table 8. Characteristics of the informal microfinance institutions.

#	Variable	Classes	Value
1	Number of groups a member belongs to	Average	2
		Standard deviation	1.03
		Minimum	1
		Maximum	6
2	Member's years of group membership	Average	11
		Standard deviation	8.86
		Minimum	1
		Maximum	41
3	Age of group in years	Average	12
		Standard deviation	10.25
		Minimum	1
		Maximum	37
4	Number of members in the group	Average	21
		Standard deviation	6.63
		Minimum	12
		Maximum	42
5	Group composition by gender	1 = Female and male members	66.7%
		2 = Female members only	33.3%
6	Number of group officials	Average	6
		Standard deviation	1.71
		Minimum	3
		Maximum	9
7	Length of term of office in years	Average	1.7
		Standard deviation	1.09
		Minimum	0.5
		Maximum	6
8	If the group gives allowances to officials	1 = Yes	27.8%
		2 = No	72.2%
9	Number of group meetings per month	Average	2
		Standard deviation	1.46
		Minimum	1
		Maximum	4
10	Number of training attended by officials	Average	1
		Standard deviation	1.27
		Minimum	1
		Maximum	5
11	Number of training attended by members	Average	0.27
		Standard deviation	0.86
		Minimum	0
		Maximum	6
12	If group gets external support	1 = Yes	27.8%
		2 = No	72.2%
13	Belonging of group to an umbrella support organization	1 = Yes	16.7%
		2 = No	83.3%

Table 8. *(Continuation).*

#	Variable	Classes	Value
14	Ability of the group to fully meet its financial needs	1 = Yes	39.5%
		2 = No	60.5%
15	Length of savings contribution cycle in months in month's	Average	1
		Standard deviation	0.24
		Minimum	0.25
		Maximum	5
16	Length of full cycle in months i.e. period between start of cycle to the auction audit date	Average	13.42
		Standard deviation	7.32
		Minimum	1
		Maximum	36
17	Minimum savings contribution per cycle (KShs)	Average	573.12
		Standard deviation	599.05
		Minimum	50
		Maximum	2000
18	Maximum loan amount lendable per time (KShs)	Average	19125
		Standard deviation	24045.15
		Minimum	1000
		Maximum	90000
19	Loan interest rates (%)	Average	10
		Standard deviation	3.42
		Minimum	1
		Maximum	20
20	Length of the grace period in days	Average	19
		Standard deviation	16.21
		Minimum	7
		Maximum	60
21	Loan repayment period in months	Average	7
		Standard deviation	5.25
		Minimum	0.5
		Maximum	12
22	Follows up of loan borrowers	1 = Yes	44.4%
		2 = No	55.6%
23	Group engagement in other activities other than just savings and lending	1 = Yes	80.6%
		2 = No	19.4%
24	Group members engagement in joint investment	1 = Yes	22.2%
		2 = No	77.8%
25	Group use of mobile money services	1 = Yes	27.8%
		2 = No	72.2%

The relationship between the characteristics of informal microfinance institutions and vulnerability to climate variability was then analyzed. In doing this, Kendall's tau-b correlation analysis was used to determine the relationship between characteristics of informal microfinance institutions and perception based climate variability vulnerability index (9).

Participation in more informal microfinance institutions is associated with higher vulnerability to impacts of climate vulnerability. Informal microfinance institutions that have more members have greater vulnerability to impacts of climate variability. Participation in informal microfinance institutions for more years is associated with greater vulnerability to

climate variability. Similarly, older informal microfinance institutions are less vulnerable to impacts of climate variability. Women only informal microfinance institutions are also marked with higher vulnerability to climate variability.

Having more officials and a longer term of office in an informal microfinance institutions leads to greater vulnerability to climate variability. On the other hand, giving allowances to officials is associated with less vulnerable to impacts of climate variability. Training of officials and training of members is also associated with lower vulnerability to impacts of climate vulnerability. However, informal microfinance institutions that hold more meetings have greater vulnerability to impacts of climate vulnerability.

Informal microfinance institutions that receive external support and belong to umbrella organizations have less vulnerability to impacts of climate vulnerability. Likewise, the ability of an informal microfinance institutions to fully meet its financial needs and thus sustainability is associated with less vulnerability. Informal microfinance institutions that have a longer savings contribution cycle and a shorter full cycle are marked by higher vulnerability to climate variability. A higher minimum contribution per cycle is however associated with lower vulnerability to climate variability.

Table 9. Relationship between informal microfinance institutions characteristics and perception based climate variability vulnerability index.

#	Variable	Coefficient (τ_b)	Sig *(p)*
1	Number of groups a member belongs to	+ 0.044	0.336
2	Member's years of group membership	- 0.027	0.502
3	Age of the group in years	- 0.050	0.225
4	Number of members in the group	+ 0.024	0.557
5	Group composition by gender	- 0.014	0.779
6	Number of group officials	+ 0.022	0.619
7	Length of term of office in years	+ 0.017	0.715
8	If the group gives allowances to officials	+ 0.060	0.219
9	Number of group meetings per month	+ 0.073	0.115
10	Number of training attended by officials	- 0.072	0.114
11	Number of training attended by members	- 0.066	0.166
12	If group gets external support	+ 0.013	0.794
13	Belonging of group to an umbrella support organization	+ 0.045	0.354
14	Ability of the group to fully meet its financial needs	+ 0.012	0.808
15	Length of savings contribution cycle	+ 0.001	0.979
16	Length of full-cycle	- 0.048	0.311
17	Minimum savings contribution per cycle	- 0.062	0.141
18	Maximum loan amount lendable per time	- 0.033	0.423
19	Loan interest rate	+ 0.059	0.206
20	Length of loan grace period	- 0.004	0.931
21	Loan repayment period	+ 0.005	0.905
22	Follow up of loan borrowers	+ 0.119**	0.014
23	Group engagement in other activities other than just savings and lending	+ 0.060	0.218
24	Group members engagement in joint investment	+ 0.100*	0.040
25	Group use mobile money services	+ 0.063	0.198

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Informal microfinance institutions that give larger loans per lending are less vulnerable to impacts of climate variability while higher loan interest rates are associated with higher vulnerability. A longer grace period leads to less vulnerability to impacts of climate variability whereas a longer loan repayment period is associated with higher vulnerability. Follow up of borrowers in an informal microfinance institutions leads to lower vulnerability to impacts of climate variability.

lending have less vulnerability to climate variability. Likewise, informal microfinance institutions whose members invest jointly as a group are associated with less vulnerability to climate variability. Also, informal microfinance institutions that use mobile money services in their financial activities have less vulnerability to impacts of climate variability.

These relationships are a reflection of how informal microfinance institutions address impacts of climate variability. This includes reducing their financial burden in the contribution of savings by reducing the minimum amount of savings contributed per cycle, suspending savings contributions until conditions improve, and increasing the length of the contribution cycle. Further, informal microfinance institutions use available savings to survive through harsh periods.

Informal microfinance institutions increase the loan repayment period, allow members to make repayments in kind and some allow borrowers a grace period. They analyze loan requests based on set criteria, follow up on borrowers, and employ various enforcement measures to enhance loan repayment. Informal microfinance institutions also recover loans from member's savings, defer loan repayment to the next installment, suspend loan repayments until conditions improve, and announce an early auction audit date to start a new cycle at an optimal time. Some use mobile money transfer services enabling members to make payments even when they migrate in response to impacts of climate variability.

Besides, members support each other to repay loans during hardships or borrow loans from other groups to repay. To address lack of financial capital, informal microfinance institutions seek support from external agencies, conduct fundraising events, and engage in income-generating activities to diversify their income sources. They also facilitate access to training to enhance member's management and adaptive capacity.

4. Discussion

The study aimed to analyze the effects of climate variability in the nexus of informal microfinance institutions in Tharaka South Subcounty. The analysis shows that climatic variability in the study area has a nonlinear positive trend which means climatic patterns are becoming increasingly erratic and unpredictable. Climate variability manifests through a decrease in rainfall amounts; and more severe, frequent, and longer droughts. This concurs with [56] who in a case study of Laikipia, Kenya found that local farmers had perceived an increase in the variation of climatic conditions through decrease in rainfall amounts and increase in tem-

perature levels. Besides, [22] in a study on climate-related risks and opportunities for agricultural adaptation and mitigation in semi-arid Eastern Kenya who observed that the frequency and intensity of droughts have increased to almost being an annual phenomenon. According to the [57], the climate projection for Kenya includes longer and more frequent dry spells interspersed with intense but unpredictable rainfall episodes.

The decrease in rainfall amounts coupled with an increase in the frequency of above-normal temperatures events have led to an increase in evapotranspiration rates and reduction in streamflow levels. The area is thus not only experiencing an increase in meteorological drought but also an increase in agricultural and hydrological drought. This is confirmed by [58,59] who observe that climate variability leads to water insecurity and could further worsen its scarcity through higher evaporation and altered rainfall patterns. Additionally, an analysis of the impact of climate change on food production in the Nile Basin of Ethiopia by [60] deduced that farmers in African countries have already perceived an increase in temperatures. Climate variability in the area leads to a decline in the condition of the vegetation. This finding is in agreement with [3] who in a study of thirteen arid and semi-arid divisions in Kenya found that 96% of the farmers attributed lack of pastures to climate variability. According to the [61], climate change will have an impact on forests and trees of which are depended upon directly by more than one billion of the 1.2 billion extremely poor people making them even more vulnerable.

The analyses also show that climate variability has a negative effect on informal microfinance performance due to the negative effect of loan repayment performance and sustainability. Besides, negative effect on informal microfinance performance is brought about by negative effects on assets, and production and entrepreneurship activities of groups and members which is aggravated by high dependence on climate-sensitive economic activities. It could also be due to adoption of response actions that negatively affect the assets, and production and entrepreneurship activities of groups and members.

This finding concurs with [9] who observed that climate variability impacts microfinance institutions directly through effects on their operations and indirectly through impacts on the client's loan repayment capacity. Further, [8] found that the vulnerability of microfinance institutions to climate risks mainly emanates from the exposure, sensitivity, and low adaptive capacity of their client's livelihoods. Moreover, [17] gathered that climate change affects the loan portfolio of microfinance institutions indirectly by increasing disease incidences which affects the health and hence economic productivity of clients. According to [11], climate risks affect financial institutions through physical risks which entail damage on their resources and infrastructure and transition risks which manifest in terms of reevaluation of assets, destabilization of markets, and stiffer financial conditions. Additionally, [14] notes that the need to address climate risks could increase the cost of doing business hence reducing competitiveness and loan repayment capacity.

In addition, the analysis found that climate variability has a negative effect on informal microfinance performance due to negative effects on loan access. Member's access to loans is affected by poor loan repayment performance which impairs their creditworthiness and increases their financial burdens thus affecting future access to credit. Negative effects of climate variability on member's capital assets endowment also affect their capacity to access loans. Climate variability has a negative effect on the sustainability of informal microfinance institutions which could have a negative effect on their capacity to lend loans to members. Negative effects of climate variability could thus reduce their capacity to provide financial capital thus affecting member's ability to undertake production and entrepreneurship activities and accumulate assets. A study by [19] observed that loan default reduces a debtor's credit score and subjection to high interest rates during future borrowing thus their ability to access loans in the future. An evaluation of individual and group lending in Kenya by [62] found that loan default is the single biggest threat to microfinance profitability and sustainability.

Further, the calculations show that vulnerability to climate vulnerability is positively associated with participation in informal microfinance institutions. This could be because vulnerable people, who mainly constitute low-income earners participate more in informal microfinance institutions as a strategy to cushion themselves against future risks and due to marginalization by formal financial institutions. People thus join and form informal microfinance institutions in response to climate variability. Besides, [63] observed that economically vulnerable people are more likely to participate in informal microfinance institutions since they tend to be more involved in insurance tools and saving solutions. A study of resilience in vulnerable households in Niger by [64] gathered that informal microfinance institutions cushion members against shocks and stresses through consumption smoothing and risk pooling during hardship periods.

The analysis found that the characteristics of informal microfinance institutions affect the groups and member's vulnerability to the effects of climate variability. This is by creating conditions that either enhance or constrain their social and financial performance and thus capacity to address effects of climate variability. Unfavorable savings and lending conditions and governance structures in informal microfinance institutions could increase member's vulnerability to climate variability through influence on informal microfinance performance. The characteristics of informal microfinance institutions could also influence member's access to capital assets and thus outcomes of livelihood strategies. The process of accessing assets and converting them into livelihood outcomes through livelihood strategies is mediated by structures of which include organizations such as member groups [38,39,65]. According to [66], access to livelihood support institutions and credit facilities reduces vulnerability to climate variability. Institutional arrangements that promote participation are likely to strengthen adaptive

capacity among those involved [67]. Nevertheless, [68], note that microfinance schemes can be a risk to participants if their terms and conditions are very rigid especially in the backdrop of higher climate risks since this may impede the participant's ability to repay loans forcing them to sell off productive assets to repay and into a downward spiral of poverty.

The results from the analysis revealed that informal microfinance institutions address vulnerability to climate variability by leveraging on their characteristics. This involves integrating climate risks in financial decision making by setting savings and lending terms and conditions that ease the financial burden of vulnerable members in loan repayment and contribution of savings. This finding is confirmed by [35] who deduced that there is need for microfinance institutions to climate-proof their activities by adjusting their loan conditions, introducing flexibility in savings products, developing disaster management strategies, participating in climate policy-making processes, and leveraging on investment opportunities offered by response activities.

5. Conclusion

Climate variability in Tharaka South Subcounty has a positive trend and manifests through erratic climatic patterns and increasing severity and frequency of extreme weather events. Climate variability has direct or indirect negative effects on performance in informal microfinance institutions. This involves negative effects on access to capital assets and livelihood strategies which in turn negatively affects loan repayment performance, sustainability, and loan access in informal microfinance institutions. Climate variability, however, has a positive association with participation in informal microfinance institutions. This is because informal microfinance institutions are the major source of financial services among vulnerable households and help in building resilience to climate risks. Vulnerability to effects of climate variability is affected by the characteristics of informal microfinance institutions which create conditions that enhance or constrain their social and financial performance and member's access to capital assets and outcomes of livelihood strategies. The informal microfinance institutions thus leverage on their characteristics to address challenges associated with vulnerability to the effects of climate variability. Detailed contextual analysis of the effects of climate variability in the nexus of informal microfinance institutions is thus imperative to inform actions aimed at cushioning the groups and their members against the impacts.

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