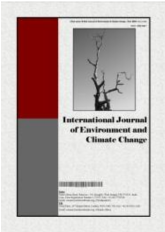

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# Triangulating Indigenous Place Names and Meteorological Data for a Better Understanding of Climate Change in Same District, Tanzania

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author SNL designed the study, managed literature review, prepared the tools, guided field work, conducted data analysis and wrote the first draft. Author AAM involved in designing the study, managed literature review, wrote the study protocol, involved in data collection, involved in writing the first draft. Both authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The study sought to triangulate climate-related place names and quantitative evidence of climate change from meteorological data from 1960 to 2021 so as to establish the extent of climate change in Same District. Triangulating the two was important in ascertaining the strategies developed to adapt to climate change.

**Study Design:** The study deployed a mixed research design which allows for the triangulation of qualitative and quantitative methods to gain a better understanding of the studied topic. This was important, as the study needed both qualitative and quantitative data.

**Methodology:** Four villages with climate-related names were purposefully selected. In-depth interviews, structured interviews and direct observations were used in collecting primary data from 152 respondents. Meteorological data were collected from the Tanzania Meteorological Authority (TMA).

**Results:** Seven place names associated with wet conditions were found in the villages. The climatic conditions that led to the invention of the names have changed such that if the villages were to be named today, their names would reflect the dry condition found in the villages. These

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findings were supported by meteorological data, which indicated a significant decrease in rainfall (b = -1.1 and R = 0.1) and increase in maximum and minimum temperature (b = 0.02) and R = 0.4 and 0.5, respectively). Besides, the intensity and frequency of drought has been increasing over time such that currently (1991 to 2021) the area experiences intensive drought every three years, but did so every ten years, from 1960 to 1990. Farmers' adaptation strategies included growing early maturing crops (EMCs), changing planting dates, growing drought-tolerant crops (DTCs), reducing the number of meals, and migration. However, most of the strategies are ineffective due to rapid climate change.

**Conclusion:** Farmers' adoption of strategies which can be effective in adapting to the current rapid climate change is important in having sustainable livelihoods. The strategies may include beekeeping and the cultivation of drought-tolerant crops.

*Keywords: Climate change; place names; meteorological data; beekeeping and drought-tolerant crops.*

## 1. INTRODUCTION

There is plenty of knowledge of changes in the earth's climate systems [1,2]. However, the knowledge is, to a large extent, pegged on an analysis of meteorological data. Studying local evidence of climate change provides knowledge of the extent of change and sheds light on the effects and adaptation strategies appropriate in certain local conditions. This is important because climate change and adaptation to its effects vary spatially [1]. Place names are among the local and social things, which provide useful historical, cultural, and environmental information on the areas to which they belong. Essentially, names that are spontaneously given to places reflect the interplay between man and the natural environment [3].

There has been climate change since time immemorial due to variations in the atmospheric energy balance [4,5]. This has resulted in various extreme climatic events, namely, *inter alia*, droughts, floods, hurricanes, and heat waves [6,2,5]. These extreme climatic events have shaped the history of places in myriad ways due to their spatial and temporal variations such that some places bear names that were given due to such climatic events or conditions. Indeed, studies show that some place names originate from environmental factors [3]. Some place names emerged due to climate-related events. Such names were given to the places because the attendant climatic events were so pleasant or unpleasant, desirable or undesirable to property, production, and lives such that they could not be easily forgotten.

It should be noted, however, that some of the names reflect climatic conditions that differ substantially from the current ones. This suggests different climatic conditions at the time when they were named. Although some climate-related names reflect climatic conditions different from the current ones, only a few studies have evaluated climate change through such names and this study is a milestone in that regard. The study contributes some knowledge of the importance of comparing meteorological data with various pieces of local evidence to enhance our understanding of climate change and its effects in local contexts. In Same District there are places which bear names that are related to climatic conditions or events. Studying those climate-related names as well as meteorological data provides detailed knowledge of climate change. This approach broadens our understanding of climate change and enables us to act locally where the effects are actually felt. By studying place names and meteorological data, this paper contributes some knowledge of the extent of change in the earth's climate systems, its effects, and strategies to adapt to the effects. The study was guided by the following research questions: What are the climate-related place names found in Same? What are the meanings or implications of the climatic-related place names? What is the relationship between such meanings and the current climatic conditions? What is the quantitative extent of climate change in the area from 1960 to 2021?

## 2. MATERIALS AND METHODS

### 2.1 Study Area

This study was conducted in Same District, Kilimanjaro Region. The region is located in the north-eastern Tanzania. The district is at latitude $3^0$ 47' and $4^0$ 36' south of the Equator and longitude $37^0$ 29' and $38^0$ 24' east of the

Greenwich meridian. Same District was selected because of the presence of pieces of evidence of wet conditions in the area in the past, including, many dry valleys and place names. Such pieces of evidence suggest that the district used to receive relatively high rainfall. Conversely, the district is currently a semi-arid area with low rainfall, which is highly variable [7,8]. As such, the district was found to be a suitable place in which to examine the meanings and implications of climate-related place names and evaluate the current climatic conditions of the areas to which the names belong.

## 2.2 Study Approaches and Design

This study used a mixed research design, which allows for the triangulation of methods for a better understanding of climate change in the study area. This research design was adopted because the study needed both qualitative and quantitative data. Qualitative data included the meanings and historical realities of the climate-related place names that were collected through in-depth interviews with purposefully selected elderly respondents. Quantitative data included data on the effects of climate change and adaptation to them, as well as meteorological data on rainfall and temperature. Thus, the mixed research design was helpful in realizing the objectives of this study.

## 2.3 Sample Size and Sampling Procedures

A pilot study was conducted to identify the villages whose names are associated with climatic conditions. The villages with such names are Kidaru, Idaru, Hedaru, and Njoro. Thus, these villages were purposefully selected for this study. Twenty-one elderly respondents with distinctive knowledge of climate-related place names and their meanings and history were purposefully selected from each village. In-depth interviews were held with them and went on until a saturation point was reached.

The size of the sample with which structured interviews were held was determined on the basis of a 95% confidence level and the precision level of 5% or 0.05. The equation for determining the size of the sample from the finite population was used [9]. The equation is given below.

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2\,(N-1) + z^2 \cdot p \cdot q}$$

Where:

$n$ = sample size
$z$ = a standard variate at a given confidence level (which is 1.96 at 95% confidence level based on table of area under normal curve)
$p$ = sample proportion
$q = 1 - p$
$N$ = size of the population (number of households)
$e$ = acceptable error (precision)

Data for calculating the sample size were:

$z$ = 1.96
$p$ = 0.1 (The population was homogeneous with regard to the variables studied.)
$q$ = 0.9
$N$ = 2,584
$e$ = 5% (0.05)

Inserting data into the equation:

$$n = ((1.96)^2 (0.1)(0.9)(2{,}584)) / ((0.05)^2 (2{,}584) + (1.96)^2 (0.1)(0.9)) = 131$$

Thus, 131 respondents were interviewed during the structured interviews. The respondents were systematically selected from the sampling frame, which comprised all the heads of households.

## 2.4 Data Types and Data Collection Methods

Qualitative data on climate-related place names, their meanings, and the current climatic conditions of the places to which the names refer, as well as perceptions of the sustainability of the adaptation strategies were collected through in-depth interviews. In-depth interviews enabled the researchers to interact with the respondents who possess distinguishing knowledge of the themes covered in this study. This study used an interview guide so that the same questions could be asked to each respondent to ensure that a saturation point was reached and content validity was attained [10].

Quantitative data, particularly, those on the adaptation strategies used in the area where the study was conducted were collected using structured interviews. The interviews contained closed and open-ended questions. The researchers administered the questionnaire to the respondents and recorded their responses. Further, the data on the mean annual rainfall and the data on maximum and minimum temperature for a period of 62 years, from 1960 to 2021, were collected from the Tanzania Meteorological Agency (TMA).

## 2.5 Data Analysis Techniques

A content analysis of the qualitative data collected using in-depth interviews was done. The analysis involved doing three things, *viz*. description, classification and connection [11]. A descriptive statistical analysis of the quantitative data was done with the aid of IBM SPSS Statistics version 23 and Microsoft excel version 2016. The procedure involved checking the data for consistency, preparation of a coded template in IBM SPSS, data entry, and analysis of descriptive statistics.

The data on rainfall and temperature from the TMA were analyzed to establish the timelines of climate change in the area. Microsoft excel was used to analyze the data and the nature of the trend line for each data was evaluated. The slope of the regression equation (b) (in $y = bx + a$) was used for each climate element to determine whether the rate of change (R) was that of increase or decrease, where a positive sign (+) indicated an increase and a negative sign (-) indicated a decrease.

Besides, the intensity and frequency of drought (the main extreme climatic events in the area) were examined using the Percent of Normal Precipitation Index (PNPI). The PNPI was used to measure rainfall deviations from normal rainfall in the area. This index provides the percent deviations of actual rainfall for a particular year, from the long-term mean (normal rainfall), using the following equation from Kumar et al. (2009:383).

$$\text{PNPI} = \frac{\text{Actual Rainfall} - \text{Normal Rainfall}}{\text{Normal Rainfall}} \text{ x } 100$$

With PNPI, rainfall deviations ranging from +20% to -20% are considered normal and below -20% is drought [12]. Accordingly, drought is announced by many countries when the rainfall deviation is below -25%. Thus, this study considered years with rainfall deviations above 20.0% as years when rainfall was above normal, 20.0 to -20.0% as years when rainfall was normal, -20.1 to -24.9% as years when drought was moderate, and -25.0% and below as years when drought was intensive (severe) (Table 1).

The PNPI was used in analyzing drought in this study because it is very effective in comparing the intensity of drought in single locations over different periods of time. Besides, the index is transparent and appropriate for communicating results [13,14].

**Table 1. Values of the PNPI**

| S/N | Classification | Index Value |
|---|---|---|
| 1 | Above normal rainfall | > 20.0% |
| 2 | Normal rainfall | 20.0% to -20.0% |
| 3 | Moderate drought | -20.1% to -24.9% |
| 4 | Intensive (severe) drought | ≤ -25.0% |

## 3. RESULTS AND DISCUSSION

### 3.1 Climate-Related Place Names

Results of the in-depth interviews held with the respondents contained seven climate-related place names. Four were village names, whereas three referred to certain places within the villages. The former were Njoro, Hedaru, Idaru, and Kidaru, and the later were Mto Washi, Kitivo, and Kadaraja. The meanings of these names are given in Table 2.

**Table 2. Climate-related place names and their meanings**

| S/N | Name | Meaning of the Name |
|---|---|---|
| 1 | Njoro | Water Source |
| 2 | Hedaru | Wetland |
| 3 | Idaru | Wetland |
| 4 | Kidaru | Wetland |
| 5 | Mto Washi | Wash River |
| 6 | Kitivo | A wetland where rice is grown |
| 7 | Kadaraja | A bridge |

*Source: Field Data*

Njoro is the name of one of the villages; it means a water source. This village is located in the lowland area of Same District. According to one respondent, the name was given to the village before independence when there were several water sources in the village. Talking about the water condition during that time, the respondent said, "*We used to fetch water for domestic use from within our village, but now water is obtained from Ishinde*" ((Ishinde is a neighboring village)).

Hedaru, Idaru, and Kidaru are names of three different villages. Hedaru is located in the lowland ecological zone, while the other two are located in the highland ecological zone. All three names mean wetland in the Pare language (Pare is the major and original ethnic group in Same

District). Talking about Hedaru, one respondent said, "*Hedaru is not the original name of this place. Originally, this place was known as Idaru, which means a wetland. The name Hedaru was the result of Germans' inability to pronounce Idaru*." The respondents from Idaru village had the same position with regard to the meaning of the name of their village. Kidaru was found to have the same meaning as Idaru, although the two names differed slightly in pronunciation. This suggests that Idaru and Kidaru are closely related names in the Pare language; they mean a wetland in which one can grow water-intensive crops like yams.

The last three names, *Mto Washi*, *Kitivo*, and *Kadaraja*, are the names of certain places in Hedaru village. *Mto Washi* means the Washi River, *Kitivo* means a wetland, where rice is grown, and *Kadaraja* means a bridge. Responses indicate that, before the early 1970s, Hedaru village used to have water in many areas. Talking about the dry valley in the village, one elder respondent said, "*This valley is known as Mto Washi (the Washi River). From the 1950s to 1980s water used to flow in this valley throughout the year. The water from the valley was used in irrigating various crops, including rice".* The respondent also said that the water drawn from the Washi River was used to cool the engine of a train which used to pass through the village from Dar es Salaam and Tanga to Moshi. The responses also indicated that the Washi River was the source of the name Kadaraja because there was a small bridge on the north-eastern part of the village whereby the people crossed the river. This study realized that there was a mismatch between the dry valley and the name *Mto Washi* (the Washi River).

There was mismatch between the names and the current climatic conditions with regard to all the place names studied. The respondents were asked to write or say the names in the Pare language that best reflected the current climatic conditions of the areas. Their responses are given in Table 3.

The information in Table 3 suggests that the names associated with dry conditions would be given to the areas if the areas were to be named today.

### 3.2 Results of the Analysis of Meteorological Data

The findings on rainfall and temperature data for 62 years, from 1960 to 2021, agree with the findings on the indigenous place names. The meteorological data indicate that substantial changes have occurred in the climate of Same District (Figs. 1 and 2).

The trend seen in Fig. 1 indicates that in Same District rainfall has been decreasing. This is also shown by the values of the regression equation, where the slope (b) = -1.1 at the rate (R) of 0.1 ($R^2$ = 0.01). The decrease in rainfall could also be seen by comparing the long-term means or normal rainfall [12,15]. In this study, two periods of 31 years each were compared. The periods are categorized as the previous period (1960 to 1990) and the current period (1991 to 2021). The calculated long-term mean for the previous period is 602.2mm, whereas the long-term mean for the current period is 528.0mm. Thus, the current average rainfall is less by 74.2mm compared to average rainfall for the period between 1960 and 1990. It is worth noting that the shift in the mean climate increases the intensity, frequency, duration and spatial coverage of some extreme weather and climatic events [16,11,17].

**Table 3. Names that best reflect the current climatic conditions**

| S/N | Name | Meaning | Name for Current Situation/Conditions | Meaning |
|---|---|---|---|---|
| 1 | Njoro | Water Source | Nyika | Dry land with short trees and shrubs |
| 2 | Hedaru | Wetland | Nyika | Dry land with short trees and shrubs |
| 3 | Idaru | Wetland | Heomie | Dry land |
| 4 | Kidaru | Wetland | Heomie | Dry land |
| 5 | Mto Washi | Wash River | Ikorongo | Dry valley |
| 6 | Kitivo | Rice growing area | Nyika | Dry land with short trees and shrubs |
| 7 | Kadaraja | A bridge | - | - |

*Source: Field Data*

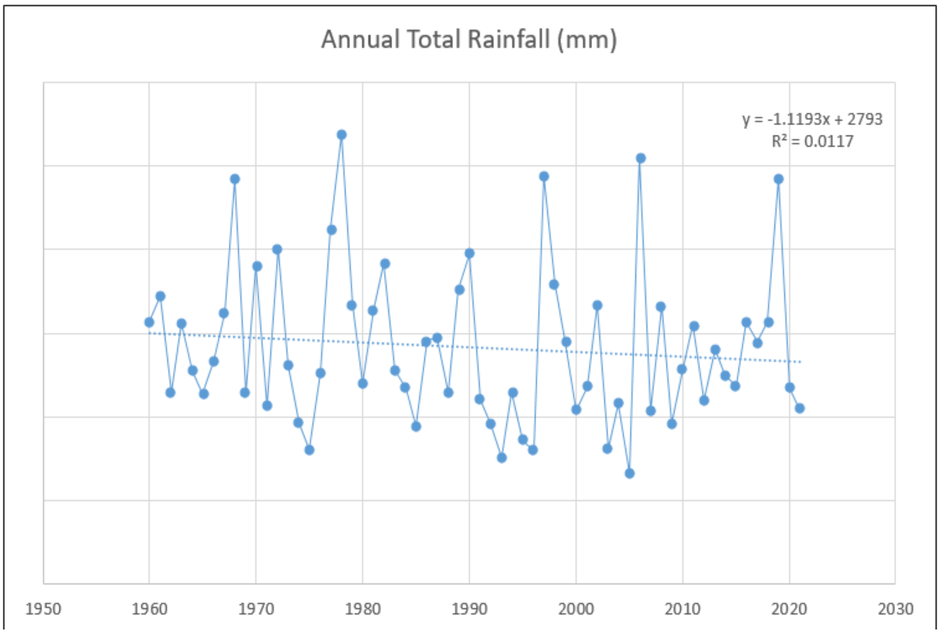


**Fig. 1. Rainfall pattern for same District from 1960 to 2021**

There was an increase in the intensity and frequency of drought. Results of the analysis of meteorological data on drought from 1960 to 2021 using the PNPI are given in Table 4.

According to Table 4, there were 13 years with intensive (severe) drought (an average of one intensive drought in every five years). The years with intensive drought were 1974, 1975, 1985, 1992, 1993, 1995, 1996, 2000, 2003, 2005, 2007, 2009, and 2021. Thus, there was an increase in the intensity of drought over time. It was established that there was no drought with a magnitude which was below -25% in the 1960s, and only two such droughts occurred in the 1970s. However, in the 1990s and 2000s 'drought events' of such magnitude were four and five, respectively.

The frequency of drought events has also been increasing in the area. Table 4 shows that there was severe drought in only three years in 31 years from 1960 to 1990, namely, 1974, 1975, and 1985. However, such years tripled in the next 31 years, from 1991 to 2021, in which there was severe drought in 1992, 1993, 1995, 1996, 2000, 2003, 2005, 2007, 2009, and 2021. Thus, on average, one severe drought occurred every three years from 1991 to 2021, compared to one such event every 10 years from 1960 to 1990.

An increase in drought goes hand in hand with a decrease in the number of years when there was above normal rainfall. The calculated values of the PNPI (Table 4) show that there were 13 years when there was above normal rainfall, of which only four (1997, 1998, 2006 and 2019) were from 1991 to 2021 (current period), while whereas nine were in the previous period, that is, from 1960 to 1990. The findings on the decrease in rainfall agree with the findings of other researchers, who reported for long and more frequent drought since the mid-1980s in Same District [8].

Temperature is another climatic element that has changed substantially in the area. Fig. 2 shows maximum and minimum temperatures in the area for a period of 62 years from 1960 to 2021. The figure shows that temperature increased, as shown by a slope (b) of about 0.02 for both maximum and minimum temperatures at the rate (R) of about 0.4 and 0.5, respectively.

A substantial decrease in rainfall and an increase in temperature cause an increase in drought in the area. The findings are in agreement with the findings of other scholars, who reported a decrease in rainfall and high temperature to be among the variables for meteorological droughts which are the mother of other types of droughts (agricultural drought and hydrological drought) [4]. Although droughts have been occurring throughout the earth's history, their current trends especially since 1990s have been so alarming due to current rapid and unprecedented climate change [6,17].

**Table 4. Values of the percentage of the normal precipitation index 1960-2021 (62 Years)**

| S/N | Year | Total Rainfall (mm) | Normal Rainfall for 62 Yrs | PNPI (%) | Classification | S/N | Year | Total Rainfall (mm) | Normal Rainfall for 62 Yrs | PNPI (%) | Classification |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1960 | 625.7 | 565.1 | 10.7 | Normal Rainfall | 32 | 1991 | 441.1 | 565.1 | -22 | Moderate Drought |
| 2 | 1961 | 690.5 | 565.1 | 22.2 | Above Normal Rainfall | 33 | 1992 | 383 | 565.1 | -32 | Severe Drought |
| 3 | 1962 | 458.7 | 565.1 | -19 | Normal Rainfall | 34 | 1993 | 302.4 | 565.1 | -47 | Severe Drought |
| 4 | 1963 | 623.3 | 565.1 | 10.3 | Normal Rainfall | 35 | 1994 | 458.7 | 565.1 | -19 | Normal Rainfall |
| 5 | 1964 | 508.4 | 565.1 | -10 | Normal Rainfall | 36 | 1995 | 344.5 | 565.1 | -39 | Severe Drought |
| 6 | 1965 | 454 | 565.1 | -20 | Normal Rainfall | 37 | 1996 | 318.3 | 565.1 | -44 | Severe Drought |
| 7 | 1966 | 532.2 | 565.1 | -5.8 | Normal Rainfall | 38 | 1997 | 975.2 | 565.1 | 72.6 | Above Normal Rainfall |
| 8 | 1967 | 649.8 | 565.1 | 15 | Normal Rainfall | 39 | 1998 | 716.8 | 565.1 | 26.8 | Above Normal Rainfall |
| 9 | 1968 | 967.5 | 565.1 | 71.2 | Above Normal Rainfall | 40 | 1999 | 582.1 | 565.1 | 3 | Normal Rainfall |
| 10 | 1969 | 459.1 | 565.1 | -19 | Normal Rainfall | 41 | 2000 | 415.6 | 565.1 | -27 | Severe Drought |
| 11 | 1970 | 760.3 | 565.1 | 34.5 | Above Normal Rainfall | 42 | 2001 | 471.8 | 565.1 | -17 | Normal Rainfall |
| 12 | 1971 | 427.2 | 565.1 | -24 | Moderate Drought | 43 | 2002 | 668 | 565.1 | 18.2 | Normal Rainfall |
| 13 | 1972 | 799.8 | 565.1 | 41.5 | Above Normal Rainfall | 44 | 2003 | 324.1 | 565.1 | -43 | Severe Drought |
| 14 | 1973 | 523.2 | 565.1 | -7.4 | Normal Rainfall | 45 | 2004 | 430.8 | 565.1 | -24 | Moderate Drought |
| 15 | 1974 | 385 | 565.1 | -32 | Severe Drought | 46 | 2005 | 265.3 | 565.1 | -53 | Severe Drought |
| 16 | 1975 | 320.1 | 565.1 | -43 | Severe Drought | 47 | 2006 | 1019.2 | 565.1 | 80.4 | Above Normal Rainfall |
| 17 | 1976 | 506.4 | 565.1 | -10 | Normal Rainfall | 48 | 2007 | 414.3 | 565.1 | -27 | Severe Drought |
| 18 | 1977 | 847.8 | 565.1 | 50 | Above Normal Rainfall | 49 | 2008 | 662.8 | 565.1 | 17.3 | Normal Rainfall |
| 19 | 1978 | 1074 | 565.1 | 90.1 | Above Normal Rainfall | 50 | 2009 | 382.7 | 565.1 | -32 | Severe Drought |
| 20 | 1979 | 667.1 | 565.1 | 18 | Normal Rainfall | 51 | 2010 | 512.9 | 565.1 | -9.2 | Normal Rainfall |
| 21 | 1980 | 480.8 | 565.1 | -15 | Normal Rainfall | 52 | 2011 | 619.7 | 565.1 | 9.7 | Normal Rainfall |
| 22 | 1981 | 656.7 | 565.1 | 16.2 | Normal Rainfall | 53 | 2012 | 438.9 | 565.1 | -22 | Moderate Drought |
| 23 | 1982 | 768.1 | 565.1 | 35.9 | Above Normal Rainfall | 54 | 2013 | 560.7 | 565.1 | -0.8 | Normal Rainfall |
| 24 | 1983 | 511.6 | 565.1 | -9.5 | Normal Rainfall | 55 | 2014 | 498.2 | 565.1 | -12 | Normal Rainfall |
| 25 | 1984 | 468.9 | 565.1 | -17 | Normal Rainfall | 56 | 2015 | 473.1 | 565.1 | -16 | Normal Rainfall |
| 26 | 1985 | 376.5 | 565.1 | -33 | Severe Drought | 57 | 2016 | 626.7 | 565.1 | 10.9 | Normal Rainfall |
| 27 | 1986 | 581.9 | 565.1 | 3 | Normal Rainfall | 58 | 2017 | 578.7 | 565.1 | 2.4 | Normal Rainfall |
| 28 | 1987 | 589.8 | 565.1 | 4.4 | Normal Rainfall | 59 | 2018 | 626.1 | 565.1 | 10.8 | Normal Rainfall |
| 29 | 1988 | 458.4 | 565.1 | -19 | Normal Rainfall | 60 | 2019 | 969.7 | 565.1 | 71.6 | Above Normal Rainfall |
| 30 | 1989 | 705.6 | 565.1 | 24.9 | Above Normal Rainfall | 61 | 2020 | 469.1 | 565.1 | -17 | Normal Rainfall |
| 31 | 1990 | 789.2 | 565.1 | 39.7 | Above Normal Rainfall | 62 | 2021 | 418.6 | 565.1 | -26 | Severe Drought |

## 3.3 Adaptation to the Effects of Climate Change

The findings show that drought is the major climatic event which occurs in Same District and agriculture is the hardest hit sector. As such, this section examines farmers' adaptation to the effects of drought. Farmers have reported a decrease in crop production and the attendant food insecurity and poor livelihoods. The adaptation strategies adopted by households are given in Table 5.

**Table 5. Strategies used to adapt to drought effects**

| S/N | Adaptation Strategy | Frequency | Percentage |
|---|---|---|---|
| 1 | Changing planting dates | 32 | 24.4 |
| 2 | Rainwater harvesting (RWH) | 3 | 2.3 |
| 3 | Growing at least one DTC | 26 | 19.8 |
| 4 | Growing early maturing crops (EMCs) | 38 | 29 |
| 5 | Terracing | 3 | 2.3 |
| 6 | Irrigation | 7 | 5.3 |
| 7 | Reducing the number of meals | 11 | 8.4 |
| 8 | Emigration | 4 | 3.1 |
| 9 | Providing casual labor | 3 | 2.3 |
| 10 | Doing petty businesses | 4 | 3.1 |
| **Total** | | **131** | **100** |

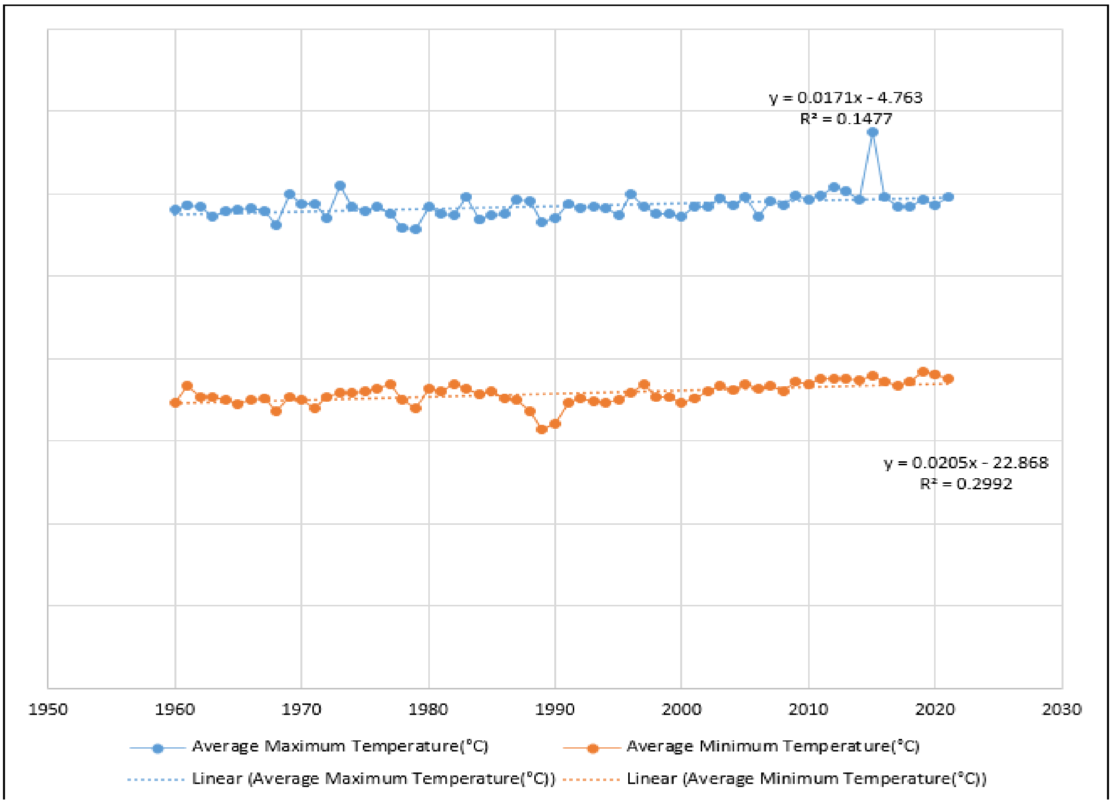


**Fig. 2. Maximum and minimum temperatures for same District from 1960 to 2021**

The strategies in Table 5 can be categorized into on-farm and off-farm adaptation strategies. The on-farm adaptation strategies are growing early maturing crops (EMCs), changing planting dates, adopting irrigation, rainwater harvesting (RWH), and terracing and growing drought-tolerant crops (DTCs). The off-farm adaptation strategies are reducing the number of meals, doing petty businesses, providing casual labor to others, and emigration.

The findings show that most of the on-farm adaptation strategies fail due to the rapid climate change and the attendant intensive and frequent drought. They also show that most off-farm adaptation strategies have certain negative social and health-related effects. For instance, despite planting early maturing varieties of maize, poor maize production is very frequent due to a decrease in the amount of rainfall and the length of the rain seasons. Talking about this, one respondent in Hedaru village said, "Early maturing varieties of maize used to help us, but currently you may grow them but harvest nothing. Rains end before the crops mature. For instance, the rain season is normally starts in March and ends in May. But sometimes it ends in April, leading to poor harvests or no harvests at all." Likewise, changing planting dates, terracing the land, and irrigation fail due to the severity of drought. The common alternative strategies, such as reducing the number of meals, migration, and casual labour, have certain negative health and social effects. These findings are in tune with the findings of other studies which show that many adaptation strategies will fail due to the increase in climate change [18].

The majority of those who participated in the in-depth interviews were of the opinion that growing drought-tolerant crops is a good strategy for adapting to the effects of climate change in general and to drought in particular. It is crops like millet, sweet potatoes, cassava, sunflower, legumes, and the hyacinth bean that are grown in Same. These crops give relatively high yields even during droughts. These findings agree with previous findings that show that drought-tolerant crops have anatomical and physiological characteristics that enable them to tolerate drought [19,20,21].

Another adaptation strategy used in Same is beekeeping. In this study, only a few respondents said they practiced beekeeping. Despite its low adoption, the findings show that beekeeping is a sustainable drought adaptation strategy. The findings indicated that bee products could be harvested even during drought conditions. In fact, one respondent said, "Heavy rainfall lower the quality and quantity of honey." This suggests that some degree of dry condition is useful for beekeeping. These findings concur with the findings of other researchers, who say that beekeeping can help farmers to sustainably adapt to the effects of climate change [22]. Moreover, beekeeping is encouraged in Tanzania's policy framework because it encourages forest management, thus improving biodiversity conservation and ecosystem services [23].

## 4. CONCLUSION

This study was conducted to determine the extent of climate change in Same District, Tanzania. Through the triangulation of climate-related place names and meteorological data, the study found a significant climate change in the area. The climate-related place names included Njoro, Hedaru, Idaru, Kidaru, Mto Washi, Kitivo and Kadaraja. Currently, these names do not resemble the dry conditions of the places to which they refer. The analysed data on rainfall and temperatures suggest that the climate of Same District has changed since 1960: there has been a decrease in rainfall and an increase in maximum and minimum temperature. The percent of normal precipitation index (PNPI) indicated an increase in the intensity and frequency of drought over time. Currently, (from 1991 to 2021), one severe drought occurs in every three years compared to one such event in every ten years for the previous period from 1960 to 1990.

The findings of this study provide information on the linkages between local evidences of climate changes and findings of the meteorological data. This provides a broader understanding of climate change in local context and could be used in evaluating and devising sustainable adaptation strategies. The commonly used adaptation strategies in Same District, including the growing early maturing crops (EMCs), changing planting dates, irrigation, rainwater harvesting (RWH) and the terracing of land. These strategies fail due to an increase in climate change and related climatic events like droughts. In this paper, we argue that there is a need to adopt strategies that can withstand the increase in climate change. Beekeeping and growing DTCs are among such strategies. These strategies can result into high production even with drought conditions. Besides, beekeeping is an environment-friendly activity, which encourages afforestation and reforestation to improve the quality of the ecosystem and increase carbon sequestration.

## CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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