Original Research Article

Triangulating Indigenous Place Names and Meteorological Data for Better Understanding of Climate Change in Tanzania

ABSTRACT

Aims: The study aimed at triangulating climate related place names and quantitative evidences from meteorological data from 1960 to 2021 so as to establish the extent of climate change in Same district. This was important to ascertain the sustainable climate change adaptation strategies.

Study design: The study deployed mixed research design which allows for triangulation of methods for better understanding of the studied phenomena. This was useful as the study required both qualitative and quantitative data.

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

Results: Seven place names associated with wet conditions were found in the studied villages. The climatic conditions that created these names have changed such that if they were to be named today, the assigned names would represent dry conditions. These findings were further evidenced by meteorological data which indicated a significant decrease in rainfall (b = -1.1 and R = 0.1) and increase in maximum and minimum temperatures (b = 0.02) and R = 0.4 and 0.5 respectively). Besides, the intensity and frequency of droughts have been increasing over time such that currently (1991 to 2021) the area experiences an average of one intensive drought in every three years compared to one such events in every ten years from 1960 to 1990. Adaptation strategies used by farmers included; growing early maturing crops (EMCs), changing planting dates, growing drought tolerant crop (DTCs), reducing number of meals and migration. However, most of the strategies fail due to rapid changing climates.

Conclusion: Farmer's adoption of strategies which can withstand current rapid climate change is important for sustainable livelihoods. Such strategies may include beekeeping and drought tolerant crops.

Keywords: Climate change, place names, meteorological data, beekeeping and drought tolerant crops

1. INTRODUCTION

There is plenty of knowledge regarding changes in the earth's climate systems [1,2]. However, to a large extent, such knowledge is pegged on analysis of meteorological data. Studying local evidences of climate change provides robust knowledge regarding the extent of change and shed light on the impacts and adaptation strategies that suit local conditions. This is important because climate change and adaptation to its impacts vary spatially [1]. Place-names is one of the local and social aspect which provide useful historical, cultural and environmental information regarding the areas to which they belong. Essentially, names that were spontaneously given to places reflect the interplay between man and the natural environment [3].

Climate change has been taking place since time immemorial due to variations over time in the atmospheric energy balance [4,5]. This has resulted into various extreme climatic events, namely, *inter alia*, droughts, floods, hurricanes and heat waves [6,2,5]. These events have shaped history of places in myriad ways due to their spatial and temporal variations, such that some places bear names that were given due to those climate related events or conditions. Indeed, studies indicate that some place names arise due to environmental factors [3]. Worldwide, there are a number of place names that have 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 properties, production and lives such that they could not be easily forgotten.

It is of great concern, however, that some of the names reflect climatic conditions that differ substantially from current ones. This suggests that such areas had different climatic conditions during the times they were named. In Same district there are places which bear names that are related to climatic conditions or events. Studying those climatic related names together with meteorological data provide a detailed knowledge on climate change from local context. This approach broadens our understanding of climate change and enable us act locally where the impacts are actually felt. By triangulating place names and meteorological data, this paper expands knowledge on the extent of change in the earth's climate systems, the impacts and sustainable strategies to adapt to the impacts. The study was guided by the following research questions: What are the climate related place names in the study area? What are the meanings or implications of those climatic related place names? What is the relationships between such meanings and current climatic conditions of the places to which they represent? What is the quantitative extent of climate change from 1960 to 2021 in the study area?

2. MATERIAL AND METHODS

2.1 Study Area

This study was conducted in Same district of Kilimanjaro region in the North-eastern zone of Tanzania. The district lies on 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 for this study owing to presence of evidences of wet conditions in the past compared to current conditions, including, many dry valleys and place-names. These evidences suggest that previously the district used to receive relatively high amount of rainfall. Conversely, the district is currently a semi-arid with low amount of rainfall which is highly variable [7, 8]. As such, this was found to be the suitable location to examine the meanings and implications of climate related place-names and evaluating current climatic conditions of the areas to which those names belong.

2.2 Study Approaches and Design

This study was organised under the mixed research design which allows for triangulation of methods for much better understanding of the studied phenomena. This was useful because the study required both qualitative and quantitative data. Qualitative data included meanings and historical realities of climate related place names that were collected through in-depth interviews with purposefully selected elder residents. Quantitative data included data on climate change impacts and adaptation to such impacts. Besides, mixed research design allowed for corroboration of findings from primary data with meteorological data on rainfall and temperatures.

2.3 Sample and Sampling Procedures

Pilot study was conducted to establish the villages whose names are associated with climatic condition. The villages with such names are Kidaru, Idaru, Hedaru and Njoro. Thus, these villages were purposefully selected for this study. Elder respondents with distinctive knowledge on climate related place names together with their meanings and history were purposefully selected from each village for in-depth interviews. In-depth interviews continued until saturation point was reached. Saturation is a point in qualitative studies where no new themes are obtained by additional sources of data [9]. Basing on saturation point, twenty-one (21) elder respondents were selected and interviewed during in-depth interviews.

Sample size for structured interviews was determined basing on 95% confidence level and the precision level of 5% or 0.05. Equation for determination of sample size for finite population was used [10]. The equation is given as:

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

Where: n = Sample size
z = Standard variate at a given confidence level (which is 1.96 at 95% confidence level; basing on table of area under normal curve)
p = Sample proportion
$q = 1 - p$
N = Size of population (Number of households)
e = Acceptable error (the precision)

Data for calculation of sample size were:
z = 1.96
p = 0.1 (The population was homogeneous regarding the variables under study)
q = 0.9
N = 2,584
e = 5% (0.05)

Inserting data into the equation:

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

As such, 131 respondents were interviewed during structured interviews. These respondents were systematically selected from the sampling frame which comprised the list of all heads of households.

2.4 Data Types and Methods of Collection

Qualitative data on climate related place names, their meanings and current climatic conditions of the places to which the names refer together with perceptions of the sustainability of the adaptations strategies were collected through in-depth interviews. In-depth interviews allowed interaction between the researcher and respondents who possess distinguishing knowledge on important themes of this study. This study used interview guide to allow the same set of questions to be asked to each respondent to ensure that saturation point is reached and content validity is attained [9].

Quantitative data, particularly, those on adaptation strategies used in the study area were collected through structured interviews. Structured interviews deployed a structured questionnaire with closed and open ended questions. The researchers administered the questionnaire items and recorded respondents' responses to allow for probing and increase returning rates. Further, mean annual rainfall together with maximum and minimum temperature data for a period of 62 years from 1960 to 2021 were collected from the Tanzania Meteorological Agency (TMA).

2.5 Data Analysis Techniques

Qualitative data collected through in-depth interviews were analysed through content analysis. The technique was undertaken in three levels, *viz*. description, classification and connection [11]. On the other hand, quantitative data from structured interviews were analysed through descriptive statistics by the aid of IBM SPSS Statistics version 23 together with 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.

Rainfall and temperature data from TMA were analyzed to establish the timelines of climate change in the study area. Microsoft excel was used to analyse these data in which 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 indicate whether the rate of change (R) was that of increase or decrease, whereby, positive sign (+) indicated increase and negative sign (-) indicated decrease.

Besides, the intensity and frequency of droughts (the main extreme climatic events in the study area) were examined using the Percent of Normal Precipitation Index (PNPI). The PNPI was used to measure rainfall deviations from normal rainfall in Same district. 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).

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

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

Table 1: Limit 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%

The PNPI was selected for analysis of droughts in this study because it is very effective in comparing intensity of drought events on single location for different periods of time. Besides, the index is transparent and favorable in communicating results [13,14].

3. RESULTS AND DISCUSSION

3.1 Climate Related Place Names

Results of in-depth interviews with elder respondents indicated seven (7) climate related place names in the studied villages. Four of them were the village names whereas three names referred to some places within the villages. The former included Njoro, Hedaru, Idaru and Kidaru whereas the later included Mto Washi, Kitivo and Kadaraja. Meanings of these names are depicted in Table 2.

Table 2: Climate Related Place Names and their Meanings

S/N	**Name**	**Meaning of the Names**
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 (way to cross the river)

Njoro is the name of one of the studied villages whose meaning is water source. This village is located in the lowland areas of Same district. According to one elder respondent, this name was given to this village even before independence where the place used to have water sources in various areas. Explaining about water condition during those years, the respondent said, *"we used to fetch water for domestic purposes in our own village, but now, you see, water has to be obtained from Ishinde"* ((Ishinde is a nearby village)).

Hedaru, Idaru and Kidaru are names for three different villages. Hedaru is located in the lowland ecological zone while the rest are located at the highland ecological zone. All of the three names means wetland in Pare vernacular (*Pare* is the main and original ethnic group in Same district). Talking about Hedaru, one elder 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 came as a result of failure of Germans to pronounce Idaru".* Respondents at Idaru village held the same position with regard to the meaning of the name of their village. Regarding the name Kidaru, it was found to have the same meaning as Idaru with slight differences in pronunciation. This suggests that Idaru and Kidaru are closely related words/names in Pare language meaning wetlands where one can grow high water demanding crops like yams.

The last three names, *Mto Washi*, *Kitivo* and *Kadaraja*, are the names of some places in Hedaru village. *Mto Washi* means Washi River, *Kitivo* implies a wetland where rice is grown and *Kadaraja* means a bridge. Responses indicate that before early 1970s Hedaru village used to have water in many areas. Talking about the observed dry valley in the village, one elder respondent said, "*This valley is known as Mto Washi* ((Washi River))*. In 1950s to 1980s water used to flow in* *this valley throughout the year. Water from this valley was used for irrigation of various crops including rice that used to be grown down there"* ((pointing to the area known as Kitivo)). This respondent explained as well that water from Washi River was used to cool engine of the train used to pass through this village from Tanga and Dar es Salaam to Moshi. Accordingly, the train normally stopped for a while in this village to take water for cooling purposes. Responses indicated also that Washi River was the reason for the name Kadaraja because there were a small bridge on the North-eastern part of the village that was used by people to cross the River. This study realized that there is a mismatch between the observed dry valley and the name *Mto Washi* (Washi River).

Mismatch between the names and current climatic conditions were realized for all of the studied place names. Respondents were asked to indicate the names/words in Pare language that would best describe the current climatic conditions of these areas and their responses are indicated in Table 3.

Table 3: Names that would Describe 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	-	-

Table 3 indicates that names associated with dry conditions would be given to these areas if they were to be named today. This suggests changes in the climatic conditions that formed these place names.

3.2 Results from the Analysed Meteorological Data

Findings from the analysed rainfall and temperature data for sixty-two (62) years from 1960 to 2021 agree with findings from indigenous place names. These meteorological data indicate substantial change in the climate of Same district (Figure 1 and 2).

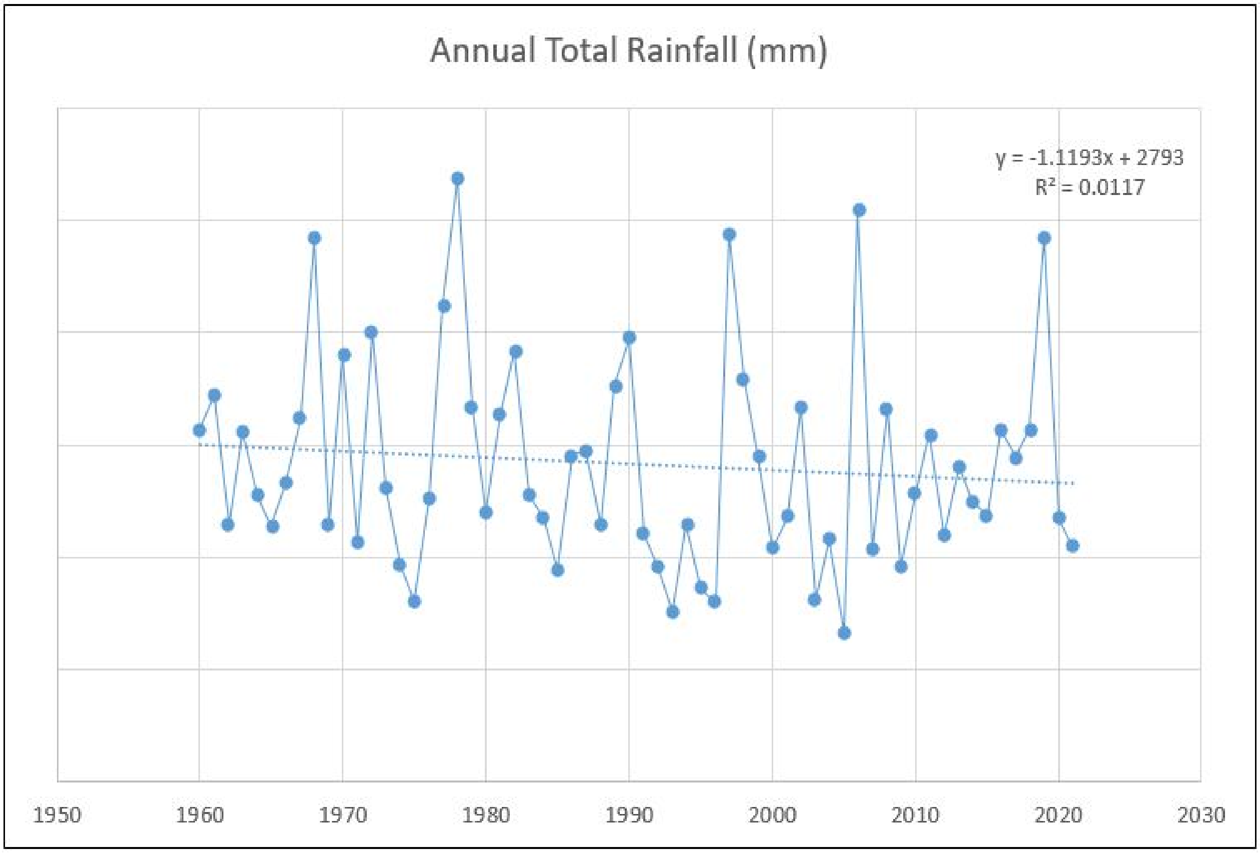

Figure 1: Rainfall Pattern for Same District Since 1960 to 2021

The trend line in Figure 1 indicates that rainfall in Same district has been decreasing. This is also depicted by values of the regression equation where the slope (b) = -1.1 at a rate (R) of 0.1 (R^2 = 0.01). Decrease of rainfall can also be observed by making comparison of 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 previous (1960 to 1990) and current (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, currently average rainfall is less by 74.2mm compared to average rainfall for the period between 1960 and 1990. It is worth noting that shift in mean climate increases the intensity, frequency, duration and spatial coverage of some extreme weather and climate events [16,11,17].

Increase in intensity and frequency of droughts, for instance, has been observed in this study. Results of the analysis of meteorological drought from 1960 to 2021 using the PNPI is depicted in Table 4.

Table 4: Calculated Values of the Percent of 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

According to Table 4, there were 13 years with intensive (severe) droughts in 62 years from 1960 to 2021 (an average of 1 intensive drought event in every 5 years). The years with intensive droughts were 1974, 1975, 1985, 1992, 1993, 1995, 1996, 2000, 2003, 2005, 2007, 2009 and 2021. Thus, there is increase in intensity of droughts over time. It can be observed that, there was no drought with magnitude below -25% in 1960s and only two such droughts occurred in 1970s. However, in 1990s and 2000s drought events with such magnitude were four (4) and five (5) respectively.

Frequency of drought events has also been increasing in the study area. Table 4 depicts that years with severe droughts were three only for 31 years from 1960 to 1990, namely, 1974, 1975 and 1985. However, such years tripled for the next 31 years from 1991 to 2021 in which 1992, 1993, 1995, 1996, 2000, 2003, 2005, 2007, 2009 and 2021 were the severe drought years. Thus, on average, one severe drought occurred in every 3 years since 1991 to 2021 compared to one such events in every 10 years from 1960 to 1990. Increase in droughts goes hand in hand with decrease in years with above normal rainfall. The calculated values of the PNPI (Table 4) shows that years with above normal rainfall since 1960 to 2021 were 13, of which only four (1997, 1998, 2006 and 2019) were from 1991 to 2021 (current period) whereas nine are from the previous period between 1960 and 1990. Findings with regard to decrease in rainfall concur with other researchers who reported for long and more frequent droughts since the mid-eighties in Same District [8].

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

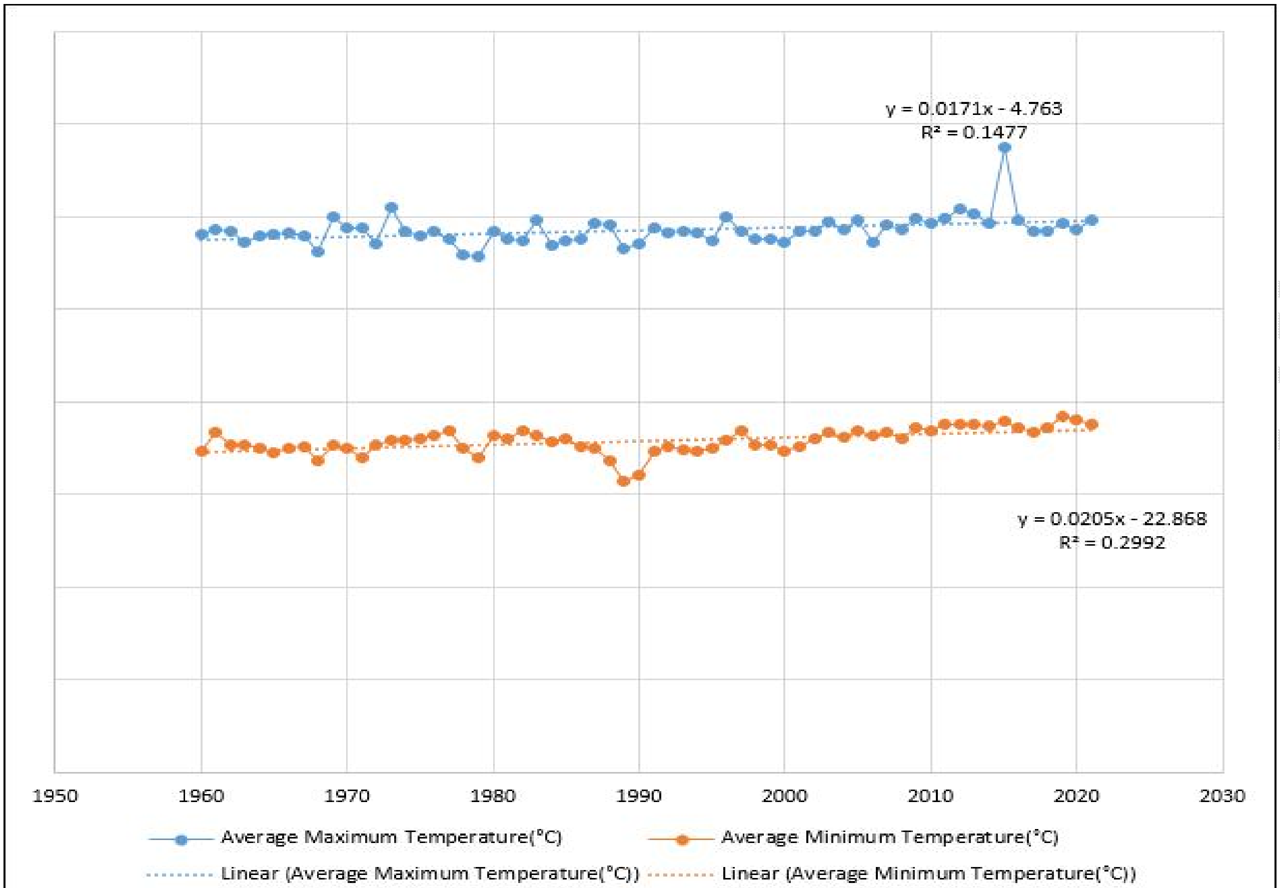

Figure 2: Maximum and Minimum Temperatures for Same District Since 1960 to 2021

Substantial decrease in rainfall and increase in temperature cause increase in drought conditions in the study area. These findings are in agreement with other scholars who reported for 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]

3.3 Adaptation to Climate Change Effects

Findings indicate that drought is the major climatic event occurring in Same district and agriculture is the main affected sector. As such this part is confined to farmers' adaptation to drought effects. Farmers have reported decrease in crop production and the attendant food insecurity and poor livelihoods in general. With regard to adaptation strategies, responses on the main drought adaptation strategy at the household level are as indicated in Table 5.

Table 5: Drought Adaptation Strategies

S/N	Adaptation Strategies	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	Reduce number of meals	11	8.4
8	Out migration	4	3.1
9	Casual labour	3	2.3
10	Petty business	4	3.1
	Total	**131**	**100**

The strategies in Table 5 can be categorized into on-farm and off-farm adaptation strategies. The on-farm adaptation strategies included growing early maturing crops (EMCs), changing planting dates, irrigation, rainwater harvesting (RWH), terracing and growing drought tolerant crop (DTCs). The off-farm adaptation strategies, on the other hand, included, reducing number of meals, petty business, casual labour and migration.

Findings indicated that most of the on-farm adaptation strategies fail due to rapid changing climate and the attendant intensive and frequent droughts whereas most off-farm adaptation strategies cause some negative social and health impacts. For instance, despite planting early maturing maize varieties, poor maize production occurs so frequently due to decrease in amount of rainfall and length of rain seasons. Talking about this, one respondent in Hedaru village said during in-depth interview, *"early maturing maize varieties used to help us, but currently, you may grow them but harvest nothing. Rains ends early before the crops are mature. For instance, rain season is normally between March and May. But sometimes it ends in April, leading to poor or nor harvests".* Likewise, changing planting dates, terracing and irrigation fail due to severity of current drought events. The common alternative strategies like reducing number of meals, migration and casual labour pose negative health and social impacts. These findings are in line with those from other studies which assert that many adaptation strategies will face challenges due to increasing climate change hence advocated for adoption of strategies beyond what people/systems are experienced to [18].

Majority of the respondents during in-depth were of the opinion that growing drought tolerant crops is sustainable strategy to adapt to the impacts of climate change and drought in particular. Responses indicated that crops such as millet, sweet potatoes, cassava, sunflower, legumes and hyacinth bean are the DTCs grown in the study area. These crops ensure relatively high production even during droughts. These findings agree with the available scientific knowledge that drought tolerant crops have anatomical and physiological characteristics to enable drought toleration [19,20,21].

Another sustainable drought adaptation strategy found in the study area is beekeeping. In this study, only few respondents of in-depth interview reported to practice beekeeping and none of the respondents of structured interview reported to practice one. Despite its low adoption, findings show that beekeeping is a sustainable drought adaptation strategy. Responses from in-depth interviews indicated that bee products can be harvested even during drought conditions. In fact, one respondent insisted, *"heavy rainfall lower quality and quantity of honey"*. This suggests that some degree of dry conditions is useful for beekeeping. These findings concur with other researchers who reported that beekeeping can help farmers to sustainably adapt to climate change impacts [22]. Moreover, beekeeping is encouraged in the country's policy framework because it encourages forest management thus improving biodiversity conservation and ecosystem services [23].

4. CONCLUSION

This study was conducted to ascertain the extent of climate change in Same district in the North-eastern zone of Tanzania. Through triangulation of climate related place names and meteorological data, the study found the significant change in the climate parameters. 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 they represent. The analysed rainfall and temperatures data suggest that the climate of Same district have changed since 1960 to current (2021) by indicating decrease in rainfall and increase in maximum and minimum temperatures. The percent of normal precipitation index (PNPI) indicated increase in intensity and frequency of drought events over time. Currently (from 1991 to 2021), one (1) severe drought occurs in every three (3) years compared to one (1) such events in every ten (10) years for the previous period between 1960 and 1990.

Findings of this study provide information pertaining to linkages between changes in climatic elements and local evidence of climate change. This provides broader understanding of climate change at local context and could be used as inputs in evaluating and innovating sustainable adaptation strategies that can suit local conditions. The commonly used adaptation strategies in Same district, including growing early maturing crops (EMCs), changing planting dates, irrigation, rainwater harvesting (RWH) and terracing fail due to increasing climate change and the associated climatic events like droughts. In this paper we contend that beekeeping and growing DTCs are sustainable drought adaptation strategies. These activities can result into high production even with drought conditions. Besides, beekeeping is environmental friendly activity which encourages afforestation and reforestation to improve ecosystem health and increase carbon sequestration. Therefore, beekeeping is useful climate change mitigation and adaption strategy.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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