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Spatiotemporal Variability of Temperature, Relative Humidity and Rainfall in Different Altitudes of Lower Lake Victoria Basin, Kenya

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Abstract

Purpose: Global Climate Variability and Change are among environmental challenges with adverse consequences in the world. Their impacts include heightened temperatures, heightened or lowered rainfall and Relative Humidity. Those impacts depend on a place or how sensitive the people are. Examples of variations at the global scale which do influence local climate elements include: North Atlantic Oscillation (NOA), El Niño Southern Oscillation (ENSO), and Madden-Julian Oscillation. Lower Lake Victoria Basin (LLVB), Kenya was suspected to experience such variations differently due to varied altitudes. This study sought to investigate variability of selected climate elements in different altitudes of the LLVB, Kenya.

Methodology: Meteorological data were obtained per county i.e. Migori - South Nyanza (SONY) Central Meteorological Station, Kisumu - Kisumu Airport Meteorological Station and Kakamega -Mumias Sugar Company (MSC) Meteorological Station. Data for the three selected climate parameters were collected for twenty years except Relative Humidity from Kisumu Airport which was available for only 12 years (2009-2020). ANOVA, Shapiro Wilk W test, Tukeys Honest Significance Difference (HSD) test, Time Series and Pearson's Correlation Coefficient were used for analysis.

Findings: The findings showed that the elements significantly varied: Temperature F = 120.87, P = 0.0001; rainfall (F = 24.56, P = 0.000 and Relative Humidity (RH) F = 30.37, P = 0.0001. Temperature means correlated with altitudes revealed a negative correlation (r = - 0.896). Extreme events were observed in rainfall.

Unique Contribution to Theory, Policy and Practices: Extreme events of rainfall, increasing trends of selected climate parameters were observed in the study area. These were evidence that climate change has already become an aspect of concern in the study area. Impacts of such extreme events should be investigated to help construct mitigative and adaptive strategies which should be implemented early enough to prevent unwanted outcomes, otherwise similar investigations should be conducted to establish situations elsewhere at different altitudes.

Keywords: *Climate Variability, Temperature, Relative Humidity and Rainfall, Different Altitudes*

I. INTRODUCTION

Consequences of Global Climate Variability and Change are some of the biggest environmental threats and challenges the world is currently facing. Impacts include heightened temperatures which are proposed to increase by 3^0C by the year 2100 [11], rainfall and increased frequency of extreme weather events. These impacts vary or are determined by where a person lives and how sensitive the people are to the resulting impacts [18].

Africa is the most vulnerable due to her high dependence on natural environmental resources and one of the issues most associated with Climate Change in Africa is malaria [11]. Health effects of climate variability and change in the Sub – Saharan Africa mainly occur due to consequences of rising temperature and increase in extreme occurrence of other weather events [14].

Knowledge about how human health and wellbeing are affected, the range of policies and measures that need to be implemented to protect health range from local to global dimensions [14]. From that point, despite a lot of articles having been written about the LLVB, Kenya, information about the area is still limited and prediction methods from the available information is still wanting [5]. [5] also described the basin as being characterized by climate systems that are difficult to simulate because of the undulating terrain and the influence from mega world oscillations. Among the many factors influencing heterogeneity in the climatology of Eastern Africa is topography [13]. This leads to spatiotemporal variation in seasonality and recorded amounts of elements over short distances. Following unprecedented speed and magnitude at which climate is changing in mountains including the rapidity of changing conditions, it was concluded that crucial adaptation be developed and implemented [1]. This would only be possible if prevailing climatic conditions at specific areas are identified through local research. Local research should have the capacity to determine the heterogeneity of local factors that may define varying climatic conditions.

Current adaptation efforts are not sufficient to address the ongoing and future risks in the mountain and lowland regions. Knowledge on climate variability and change adaptation should be increased so as to cater for different altitudes [1]. Application of such knowledge on climate variability and change in solving problems at different altitudes in the study area (LLVB), Kenya was found to be imperative.

Based on the foregoing, the study sought to investigate spatiotemporal variability of temperature, relative humidity (RH) and rainfall in different altitudes of lower Lake Victoria basin (LLVB), Kenya between the years 2001 to 2020.

II.METHODOLOGY

a) Study Area

The study was carried out in the Lower Lake Victoria Basin (LLVB), Kenya covering eight counties of Migori, Homabay, Kisumu, Vihiga, Siaya, Kakamega, Bungoma and Busia. From the eight, three (Migori, Kisumu and Kakamega) were sampled for the study (Figure 1). The LLVB counties are located between latitudes 1.15^{0}N and 1.75^{0}S, and longitudes 33.95^{0}E and 35.05^{0}E [4]. The Basin covers an area of about 17,723km^2 [4] and [8]. The land covering this area slopes from an altitude of 1550m in Migori County down to 1100m at its lowest in Siaya County, and then rises again to 1535m in Kakamega County and 1559m in Vihiga County [8] and [12].

The climate of the area is Equatorial modified by the presence of the Lake and the surrounding Highlands. Rainfall ranges from 1100mm in Homabay County to 1971mm in Kakamega County, an average of 1556.5mm annually [2]. Temperatures ranged from 20.0^{0}C in Vihiga County to 22.5^{0}C in Homabay County, an average of 21^{o}C [2] and [15]. There are two rainfall regimes with no real dry season (Figure 1).

The LLVB, Kenya was preferred for this study because from the literature review, most of the studies carried out in this area hardly paid attention to the influence of the existing altitude variations on climate variability, vector distribution, and hence malaria transmission. It was claimed that despite a lot of articles having been written about the LLVB, Kenya, information about the area is still limited and prediction methods from the available information is still wanting [5]. This study therefore sought to analyze climate variability scenario in different altitudes of lower Lake Victoria Basin, Kenya.

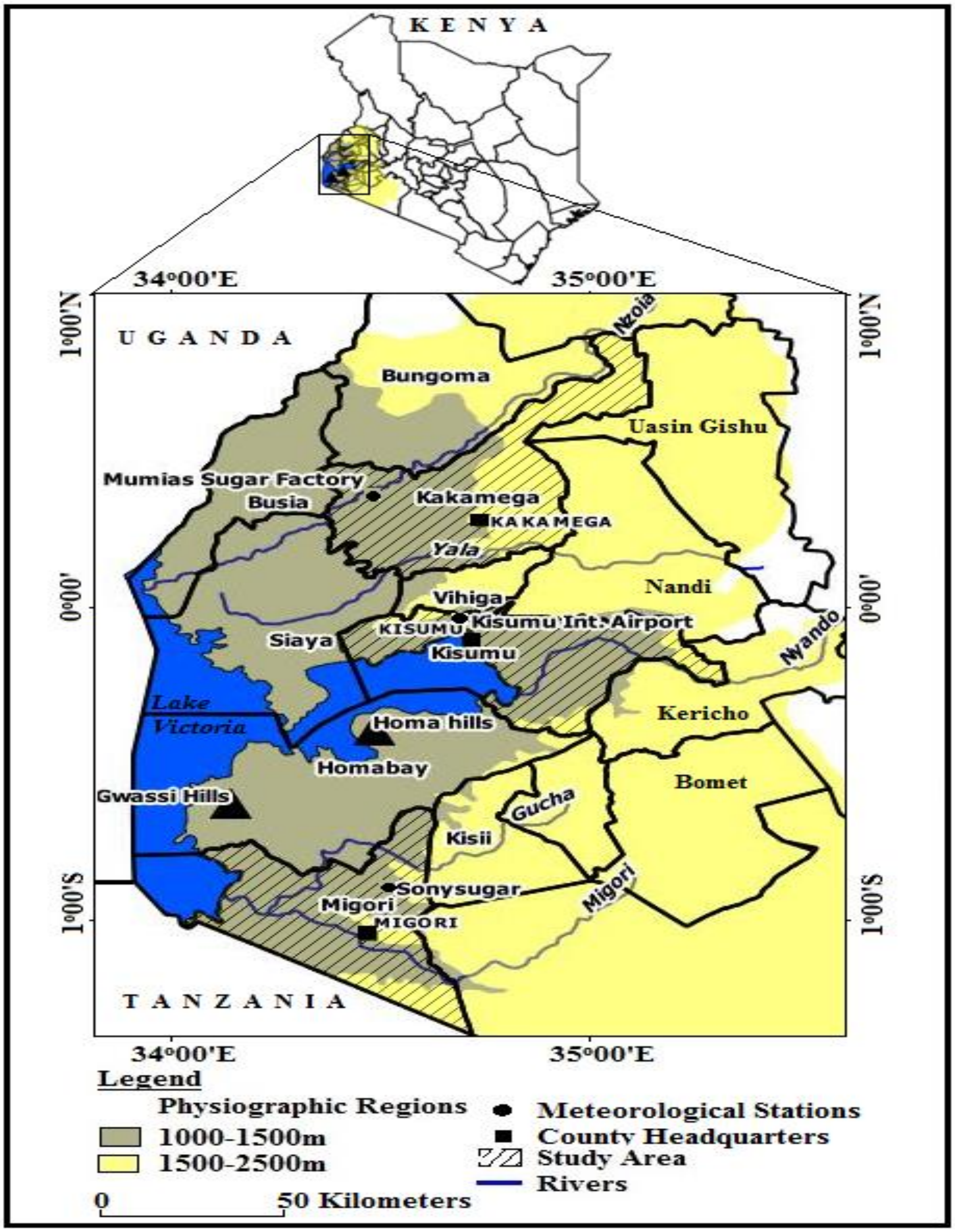

Figure 1: Map of the study area

Source: Modified from [9].

b) Data Collection and Data Characteristics

The study relied on secondary data from Meteorological stations within the sampled study areas. South Nyanza (SONY) Central Meteorological Station (Code 9034145) represented Migori County, Kisumu Airport Meteorological Station (Code 637080-9999) represented Kisumu County and Mumias Sugar Company (MSC) Meteorological Station (Code 8934-133) represented Kakamega County. Data were collected for twenty years (2001 – 2020) except Kisumu Airport Relative Humidity which was only available for 12 years (2009-2020).

c) Data Analysis

All data collected were harmonized before being used. Shapiro Wilk W test for normality was used to examine how the sample data fitted to normal distribution at P value ≥ 0.05. To establish the variations, Analysis of Variance (ANOVA) was used. Tukeys Honest Significance Difference (HSD) test was used to determine the strength of the significance of the relationships. Time series analysis was used to determine the trends during the study period.

III.RESULTS

3.1 Spatiotemporal Variability of Temperature in Different Altitudes of Lower Lake Victoria Basin, Kenya

Temperature variability in the period, 2001 – 2020 in Kisumu, Migori and Kakamega Counties were compared using Analysis of Variance (ANOVA) at 95% confidence interval (CI). The findings showed that there was significantly higher temperature mean in Kisumu County (23.77^{0}C) during the period compared to Kakamega County (22.61^{0}C) and Migori County (22.52^{0}C) (F = 120.87, P = 0.0001). The means were separated by Tukeys Honest Significance Difference (HSD) at P ≤ 0.05. When correlated with the altitudes of these areas, the result was negative (r -0.896). Kisumu County which is at the lowest altitude registered the highest temperature followed by Kakamega County then Migori County in that order. Kakamega and Migori Counties temperatures however did not significantly differ (Table 1).

Table 1: Average temperatures in Kakamega, Kisumu and Migori Counties during the period 2001-2020

Region	Mean ± SE	Minimum	Maximum
Kisumu County	23.77 ± 0.05b	22.25	26.25
Kakamega County	22.61 ± 0.062a	20.75	25.65
Migori County	22.52 ± 0.08a	20.1	26.65
F –value	**120.87**		
P –value	**0.0001**		

Mean values in the same column denoted by similar letters are not significantly different. Mean separated using Tukey's Honest Significance Difference (HSD) at P ≤ 0.05.

Mean temperature variability in the three regions was tested using Shapiro Wilk W test of Normality. The findings showed that, average temperatures in Kakamega, Kisumu and Migori Counties significantly varied over the period (2001 – 2020) with Shapiro Wilk W values of 0.97682, 0.96972 and 0.97550 respectively, meaning the data used were normally distributed (Prob> z of 0.00058, 0.00005 and 0.00036 respectively), (Table 2).

Table 2: Normality test result of the mean temperature in the three areas over the period 2001 – 2020

Variable	Obs	W	V	Z	Prob> z
Kakamega County	240	0.97550	4.286	3.379	0.00036
Kisumu County	240	0.97682	4.056	3.251	0.00058
Migori County	240	0.96972	5.299	3.872	0.00005

3.1.1Annual Temperature Trends over the Study Period (2001 – 2020)

Temperature trends during the study period revealed that mean annual temperature was highest in Kakamega County (23.58^{0}C) in the year 2004 and lowest in the year 2020 (21.69^{0}C). It was highest in Migori County in the year 2020 (24.12^{0}C) and lowest in 2001 (21.04^{0}C). In Kisumu County, mean annual temperature was highest in the year 2015 at 24.63^{0}C and lowest in 2001 (23.21^{0}C). The trend during the study period further revealed that temperature decreased in Kakamega County while it increased in Kisumu and Migori Counties. In Kakamega County, the decrease was Y = -0.0602x. (Where Y = temperature in degrees Celsius and x = years). In Kisumu County, the increase was Y = 0.0616x while in Migori County it was Y = 0.1146x (Figure 2). It should also be observed that the highest and lowest events occurred at different times in different areas and this confirmed spatiotemporal variations of the three climate parameters in the study area during the study period.

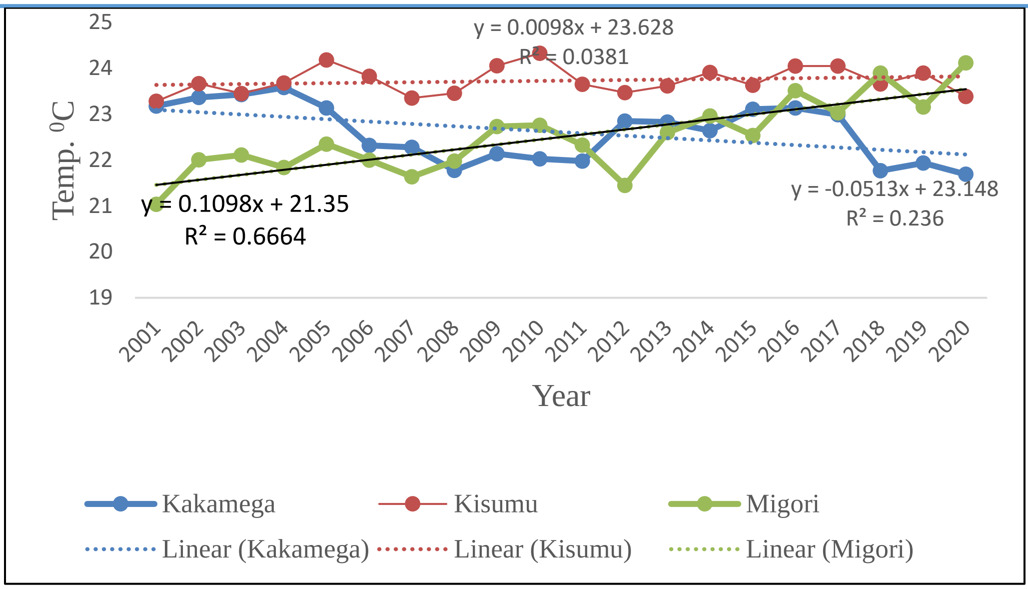

Figure 2: Annual Temperature Trends in Kakamega, Kisumu and Migori Counties (2001 – 2020)

3.1.2 Monthly Temperature Trends over the Study Period (2001 – 2020)

During the period of the study (2001 – 2020) the highest monthly mean temperature in Kisumu County was recorded in the month of February (24.81^{0}C) and lowest in June (22.08^{0}C). In Kakamega County, the temperature was highest in March (23.31^{0}C) and lowest in July (21.83^{0}C). Temperature in Migori County was highest in March (23.38^{0}C) and lowest in June (21.78^{0}C) otherwise in all the cases, temperatures were highest between February and March, lowest between June and August then rose again to December. In all the cases, temperature tended to divide a year into three "temperature seasons" by being "High – Low – High" (Figure 3). Temperature generally indicated decreasing trends from the beginning of the year towards the end in the sampled counties i.e. in Kisumu, the decrease was Y = - 0.056x + 24.05, R^2 = 8.4%, Migori, Y = - 0.051x + 22.85, R^2 = 16.0% and Kakamega, Y = 0.087x + 22.95 R^2 = 42.9%. The fact that the R^2 values were very low means that the increases over time were not great.

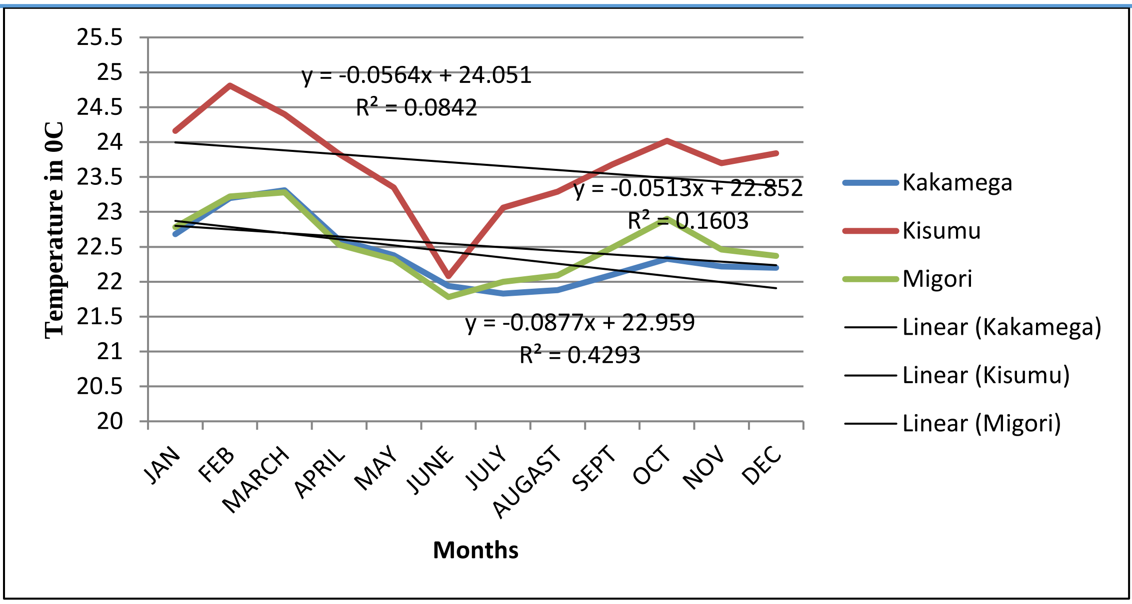

Figure 3: Monthly Temperatures in Kakamega, Kisumu and Migori Counties (2001 – 2020)

3.2 Spatiotemporal Rainfall Variability in Different Altitudes of Lower Lake Victoria Basin

Mean annual rainfall in the three areas during the study period (Kisumu, Migori and Kakamega Counties) was compared using One-way ANOVA. The means were separated by Tukeys HSD at $P \leq 0.05$. The mean annual rainfall recorded were significantly different ($F = 24.56$, $P = 0.0001$). Mean annual rainfall in Kisumu County (121.3 mm) was significantly lower compared to Migori County (157.2 mm) and Kakamega County (182.7 mm) (Table 3).

Table 3: Mean annual rainfall in Mumias, Kisumu and SONY during the study period

Region	Mean ± SE	Minimum	Maximum
Kisumu County	121.3±5.22a	0.0	398.20
Kakamega County	182.7± 6.81c	0.0	545.6
Migori County	157.2± **6.53**b	5.5	590.6
F -value		24.56	
P -value		0.0001	

Mean values in the same column denoted by similar letters are not significantly different. Mean separated using Tukey's Honest Significance Difference (HSD) at $P \leq 0.05$.

3.2.1Annual Rainfall Trends over the Study Period (2001 – 2020)

Mean annual rainfall trends in the three regions increased during the study period as shown in Figure 4.3 below i.e. Kisumu Y = 1.044x + 110.28, Kakamega Y = 1.627x +140.06 and Migori, Y = 1.2926x + 169.15 .Extreme events of rainfall were observed i.e. extremely high rainfall in the year 2006 for all the stations, the year 2010 for Kakamega, and the year 2020 for all the stations. Rainfall was extremely low for all the stations in the year 2016 proceeding to 2017 for Kakamega and Migori Counties. Kisumu County registered the lowest (981mm) in the year 2016 (Figure 4).

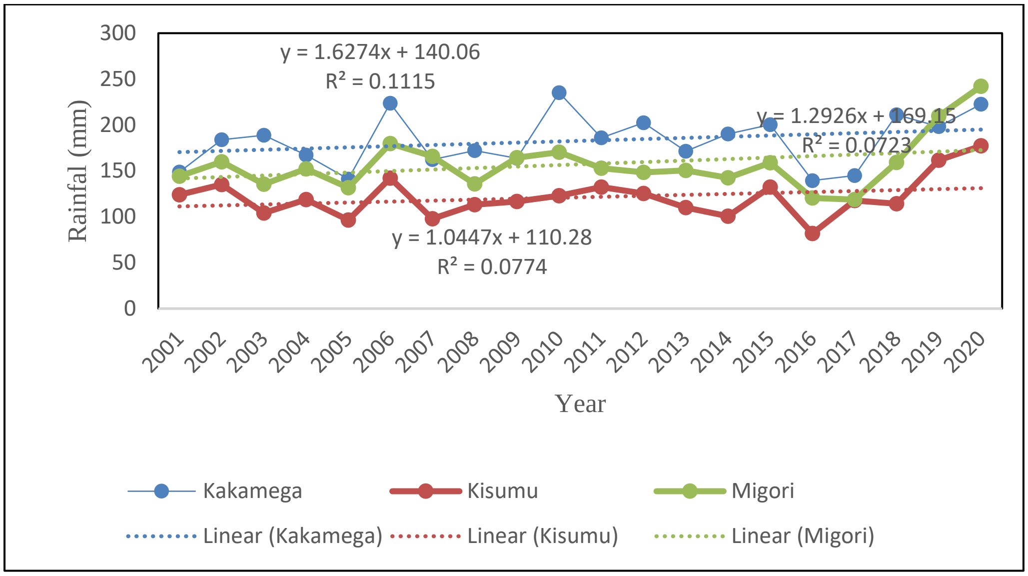

Figure 4: Mean annual rainfall trends during the study period in the three regions

3.2.2 Monthly Rainfall Trends over the Study Period (2001 – 2020)

In the study period (2001 – 2020) the mean monthly rainfall generally revealed increasing trends i.e. in Kisumu County, the increase was Y =1.345x+112.5, Migori County, Y =3.724x+132.9 and Kakamega County, Y = 1.297x+170.2 (Figure 5). Rainfall was high in Kakamega, Kisumu and Migori Counties in the month of April. Lower rainfall levels were recorded in the months of February and July in the three stations. The months of January and February were drier than the rest of the year. Rainfall gradually increased from February to a peak in April before descending to its lowest in July then rising again to double maxima in September and November for SONY (Migori). For Kakamega (Mumias), the rainfall peaked between September and October. As had been observed earlier, rainfall quantity varied but did not obey the altitudinal differences. It was highest in Kakamega County most of the times being followed by Migori and Kisumu Counties in that order.

Another major observation made was that despite high rainfall in all the stations in the months of March-May and September–December, and low rains in the months of June and July (double maxima regime), a characteristic that had been observed by LVBC (2018-2023) in the study of the LLVB, East Africa, wet periods were longer while dry periods were shorter than had been observed in the study of LLVB, East Africa. Of particular concern was the fact that quantities both temporally and spatially varied. It is only in the Months of December and January that all the stations registered almost similarly low quantities of rainfall. The areas were wet throughout the year with literally no real dry month and fairly two well defined seasons separated by two low rainy periods occurring in the months of January – February and June – July (Figure 5).

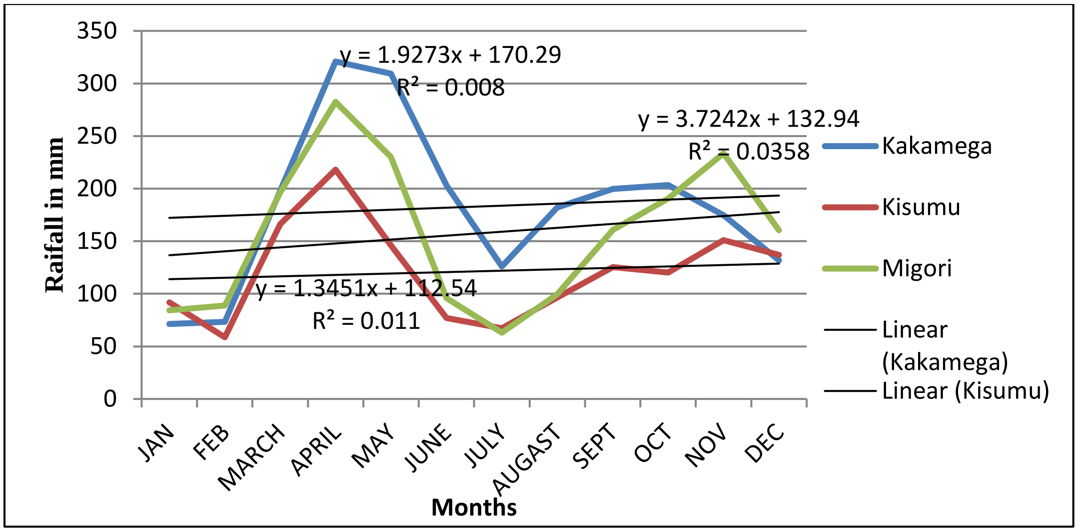

Figure 5: Monthly rainfall in Kakamega, Kisumu and Migori Counties (2001 – 2020)

3.2.3 Total Annual Rainfall Variability in Kakamega, Kisumu and Migori Counties

Migori County recorded the highest (2906.2 mm) annual rainfall in 2020 and the lowest (1424.3mm) in 2017 during the study period. In Kakamega County, the highest rainfall was recorded in the year 2010 (2823.7 mm) and lowest (1674.4mm) in the year 2016. Kisumu had the highest (2125.9 mm) occurring in 2020 and the lowest (981.0mm) in 2016. On average, Kakamega County (mean 2192.6 mm), had a significantly higher annual rainfall during the study period compared to Migori County (1885.8 mm) and Kisumu County (1455.3 mm), F = 26.79. This indicated that performance of rainfall significantly differed per region in terms of quantity (P = 0.0001) (Table 4).

Table 4: Total annual rainfall in (in mm) Mumias, Kisumu and SONY during the study period

Region	Mean ± SE	Minimum	Maximum
Kakamega County	**2192.6 ± 76.3c**	1674.4	2823.7
Migori County	**1885.8 ± 77.4b**	1424.3	2906.2

kisumu County	**1455.3 ± 59.6a**	981.0	2125.9
F -value		26.79	
P -value		0.0001	

Mean values in the same column denoted by similar letters are not significantly different. Mean separated using Tukey's Honest Significance Difference (HSD) at $P \leq 0.05$.

Annual rainfall variability data in the three areas was tested using Normality test (Shapiro Wilk W test). The result showed that, annual rainfall in Migori County varied significantly over the period under this study (W value of 0.87455, Prob> z of 0.001414). Rainfall in Kakamega and in Kisumu Counties did not significantly vary over the period of this study (Prob> z greater than 0.05). This showed that rainfall in Kakamega and Kisumu Counties was normally distributed (Table 5).

Table 5: Normality test result of the annual rainfall in the three regions over the period 2001 – 2020

Variable	Obs	W	V	Z	Prob>z
Kakamega County	20	0.96533	0.821	-0.398	0.65474
Kisumu County	20	0.95398	1.089	0.172	0.43162
Migori County	20	0.87455	2.970	2.193	0.01414

3.3 Spatiotemporal Variability of Relative Humidity in different altitudes of Lower Lake Victoria Basin

Relative humidity (RH) variability for Kakamega, Kisumu and Migori Counties (2001 – 2020) were compared using ANOVA at 95% confidence interval (CI). The findings showed that there was a significant difference in the three areas. Lowest relative humidity was recorded in Kisumu County (mean 58.77%) during the period as compared to Kakamega (67.74%) and Migori Counties (66.88%) (F =30.37, P = 0.0001). The means were separated using Tukeys HSD at $P \leq 0.0$. (Table 6).

Table 6: Average RH in % in Kakamega, Kisumu and Migori Counties in the study period 2001-2020

Region	Mean ± SE	Minimum	Maximum
Kisumu County	58.77± 0.58a	35.0	74.0
Kakamega County	67.74± 0.471b	41.0	79.5
Migori County	66.876± 0.907b	51.5	82.5
F -value		30.37	
P -value		0.0001	

Mean values in the same column denoted by similar letters are not significantly different. Mean separated using Tukeys HSD at $P \leq 0.0$

Mean relative humidity variability data in the three areas was tested using Shapiro Wilk W test of Normality. The result showed that, relative humidity in the three areas significantly varied over the period with a Shapiro wilk W value of, 0.93527 0.94819, and 0.86703 in Kakamega, Kisumu and Migori Counties respectively, Prob> z of less than 0.05. This indicated that in the three areas, RH significantly differed during the study period (Table 7).

Table 7: Normality test result of the mean RH in the three areas over the period 2001 – 2020

Variable	Obs	W	V	Z	Prob>z
Kakamega County	20	0.93527	1.532	0.860	0.19495
Kisumu County	12	0.94097	0.986	-0.027	0.51071
Migori County	20	0.86703	3.147	2.311	0.01042

3.3.1 Annual Variability of Relative Humidity (RH) trends in Kakamega, Kisumu and Migori Counties during the Study Period (2001-2020)

In the three areas, relative humidity generally increased over the period as depicted in Kakamega County (Y = 0.016x + 65.91), Kisumu County (Y = 0.155x + 56.52) and Migori County (Y = 0.608x + 60.48). However, it also fluctuated a lot during the same period. The highest case in Kakamega County occurred in 2019 (68.96%) and the lowest in 2005 (62.42%). Between 2009 and 2020, Kisumu County RH was highest in the year 2020 (62.96%) and lowest in the year

2009 (56.33%). In Migori County RH was highest in the year 2018 and lowest in the year 2002. Generally, all the trends were observed to vary during the study period (Figure 6).

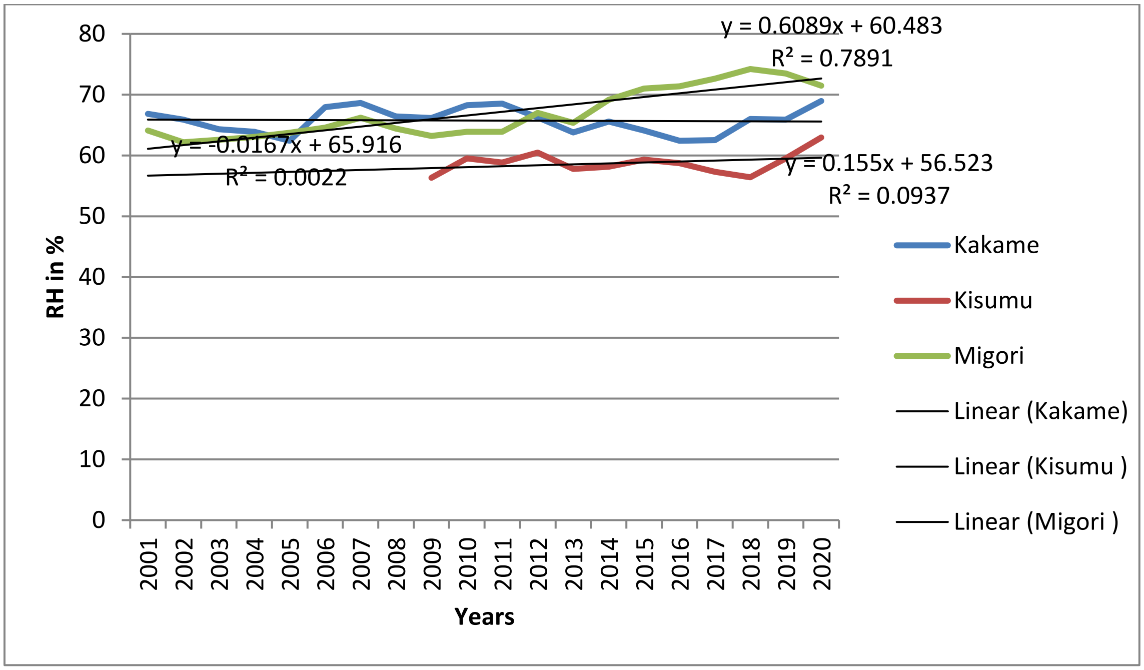

Figure 6: Annual % Relative humidity in Kakamega, Kisumu and Migori Counties

3.3.2 Monthly Relative Humidity Trends over the Study Period (2001 – 2020)

Monthly, RH in Kakamega County was found to be relatively low (57.51%) and (56.59%) in January and February respectively. It begun to rise in March and stabilized between April and July then fell from August to December. In Kisumu County, RH was observed from the year 2009 to 2020 and the lowest case occurred in February after which it rose sharply to the month of April. There was some stability between April and June. From June, RH slightly ascended from a mean of 62.42% to a mean of 63.46% in July, again fairly stabilizing between July and December. At Migori County, RH was lowest in the month of June (63.98%) and august (63.85%). It was highest in October (68.98%) then descended to December (66.85%). Humidity in Migori County thus divided a year into two seasons of March – April and September – October. There were relatively no extreme cases observed during a mean study year. In the three areas, relative humidity generally increased during a mean study year over the study period as is shown in the figure 7 below such that, in Kakamega County, the increase was Y = 0.585x + 62.141, Kisumu County, Y = 0.385x + 56.263 and Migori County, Y = 0.0226x + 66.529 (Figure 7).

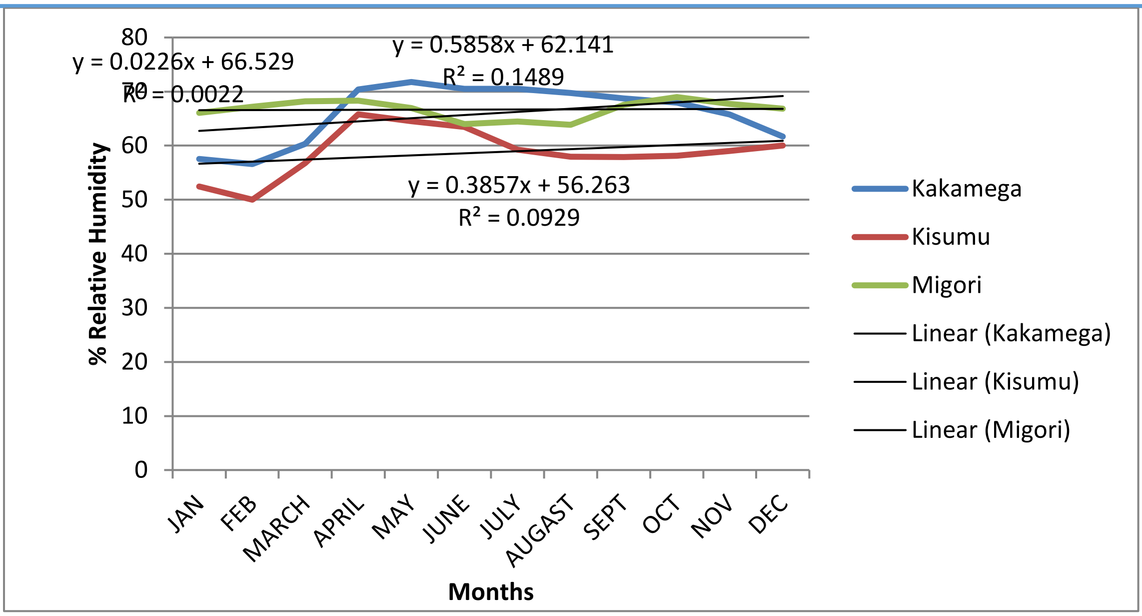

Figure 7: Monthly % Relative humidity in Mumias, Kisumu and SONY

From the foregoing, the researcher rejected the hypothesis, "There is no significant spatiotemporal variation in the means of temperature, relative humidity, and rainfall in lower Lake Victoria Basin, Kenya".

IV.DISCUSSION

From the overall outlook, this study observed that all the selected climate elements significantly varied in space and time during the study period. The findings showed significantly higher temperature in Kisumu County (23.77^{0}C) compared to Kakamega County (22.61^{0}C) and Migori County (22.52^{0}C), (F = 120.87, P = 0.0001). The means correlated with altitudes, revealed a negative correlation (r = - 0.896) indicating a positive laps rate in different altitudes of the study area. Temperature was proposed to increase by 3^{0}C by the year 2100[11]. If this proposal is something to go by, then Kisumu County mean temperature by the year 2100 will be 26.77^{0}C, Kakamega, 25.61^{0}C and Migori, 25.52^{0}C. Such changes will be observed differently all over LLVB, Kenya depending on altitude which varies between 1069m in Siaya County and 2248m in Migori County. The changes are predicted to have very significant implications on the entire social and physical environments of the study area. Of particular concern will be human vulnerability especially to diseases and food production. Monthly temperature trends in all the sampled areas cyclically divided a year into three seasons by peaking in February and March, low in June and July then peak again in October.

Highest and lowest temperature events occurred at different times in different areas. Trends indicated increase in Kisumu and Migori Counties during the study period. In Kakamega, it was found to be decreasing. This reduction undermines the argument by [11] and though climate change is real, such micro occurrences should not be ignored in the debate.

The mean annual rainfall recorded significantly differed (F = 24.56, P = 0.000). The mean annual rainfall in Kisumu County(121.3mm) was significantly lower compared to Migori (157.2mm) and Kakamega(182.7mm) Counties. The fact that rainfall in Kisumu was lowest should be typical of her given her proximity to the lake as was observed by [5] that regions bordering the lake normally experience low rainfall. The findings further confirmed, as had been observed by [5] that rainfall in East Africa spatio - temporally fluctuates.

This study again revealed that rainfall was highest in Kakamega County, a lower altitude than Migori County and lowest in Kisumu County. Rainfall variability was thus inconsistent with increase in altitude. It was therefore difficult to pre-empt what happens in areas where rainfall occurrence had not been investigated. Annual rainfall trends indicated increase in all the sampled counties.

Despite high rainfall in all the stations in the months of March-May and September–December, and low rains in the months of "January – February", and "June – July" (double maxima or double minima regime), the findings conformed to those of [11] where wet periods were longer than dry periods. It was also important to note that the study area had no real dry month [5]. Rainfall revealed four cyclic seasons in the study area of, "Dry – Wet – Dry – Wet" in a year.

Mean Relative Humidity (RH) revealed significant differences i.e. in Kisumu County the mean was 58.77%, Kakamega County 67.74% and Migori County 66.88% (F = 30.37, P = 0.0001) Like in the case of rainfall, RH was highest in Kakamega County followed by Migori and lastly Kisumu hence not consistent with altitude. There were no extreme events but annual trends were increasing. The observed variations confirm the findings made by[17] that the global variations occurring naturally affect local micro – climates differently.

[3] Postulated that climate variation brings extreme events influencing micro – occurrences and as [11] had proposed, extreme events were noticed mainly in the annual rainfall totals. In Kisumu County for example, very low rainfall was recorded in the year 2016 (981mm) while the year 2020 was highest (2126mm) compared to the other years during the study period. Kisumu mean rainfall for the study period was 1456mm, meaning the observed lows and highs were rather extreme. Equally interesting were the cases of Kakamega (2673mm from an annual mean of 2193mm) and Migori (2906mm from an annual mean of 1886mm). The occurrence of extreme rainfall events confirmed the postulations made by [11]characterizing LVB with frequent episodes of either deficient or excessive rainfall events in the study area. This study further revealed some of the extreme episodes occurring at different altitudes during the same years (2006, 2016 and 2020). This must have been an influence of one of the external forces as was observed by [3] that global climate variations bring extreme events influencing micro – occurrences. [13] Recognized extreme events as evidence of climate change responsible for negative health and food production issues hence an argent need for mitigation and adaptation strategies.

Deviations in temperature and relative humidity were not that serious i.e. the lowest temperature in Kisumu was 23.28^0C and the highest 24.33^0C from a mean of 23.77^0C, Kakamega lowest was 21.69^0C and the highest 23.58^0C from a mean of 22.61^0C while Migori lowest was 21.04^0C and highest 24.12^0C from a mean of22.52^0C. Highest and lowest events of Relative Humidity occurred at different times during the study period and there were no extreme cases.

Another very important observation was that all the selected climate parameters had annually increasing trends over the 20 - year period. Though the changes were not significant, when combined with variability and the observed rainfall extremes, they are indicators that climate change is with us and will make humans become vulnerable to sufferings [7].

V.CONCLUSION

In the overall observation, the three selected climate parameters each varied in space and time. Temperature for example decreased with increase in altitude. Rainfall and RH on the other hand were not consistent with either decrease or increase in altitude but they varied in space and time. Extreme events though not many, were witnessed in rainfall especially in the years 2006, 2016 and 2020. Wet periods were confirmed to be longer than the dry periods. The extreme events of rainfall, increasing trends of selected climate parameters and the observed variability were evidence that climate change is already becoming an aspect of concern in the study area. The occurrence may however not be uniform even at micro - scale.

The three climate elements were confirmed to vary in space and time. They each tended to divide a year into two seasons. Their annual increasing trends and the observed extreme rainfall events were elements of climate change in the study area.

VI.RECOMMENDATION

Since rainfall and RH were inconsistent and did not have clear relationship with altitude; there is need to establish their occurrences elsewhere. Temperature indicated normal laps rate and can be inferred to other places with different altitudes. With evidence of climate change in the study area, impacts of the observed extreme events should be investigated to help in timely formulation and implementation of the necessary mitigation and adaptation strategies in order to prevent any possible negative consequences on the vulnerable human population.

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