# RAINFALL AND TEMPERATURE VARIATIONS OVERTIME (1986-2015) IN SIAYA COUNTY, KENYA

Beatrice Atieno Abura (Corresponding Author)
School of Spatial Planning and Natural Resources Management (SPNRM),
Jaramogi Oginga Odinga University of Science and Technology (JOOUST),
P. O. Box 210-40601, Bondo- Kenya.
E-mail: janeafline@gmail.com Telephone Number: +254 713 744 199

Patrick Odhiambo Hayombe
School of Spatial Planning and Natural Resources Management (SPNRM),
Jaramogi Oginga Odinga University of Science and Technology (JOOUST),
P. O. Box 210-40601, Bondo- Kenya.
E-mail: rapospat@yahoo.com Telephone Number: +254 721 516 325

Warkach Kipkorir Tonui
School of Humanities and Social Sciences
Jaramogi Oginga Odinga University of Science and Technology (JOOUST),
P. O. Box 210-40601, Bondo- Kenya.
E-mail: kwtonui@yahoo.com Telephone Number: +254 725 473 275

**Abstract**
This study was carried out in Siaya County. The purpose of the study was to analyze the variations on temperature and rainfall overtime (1986-2015) in Siaya County. The secondary data used for the Mann-Kendall test was attained from the metrological department of Siaya County. The Mann-Kendall results from mean annual average temperature, and mean annual rainfall indicated that Siaya County had no significant trends on rainfall and temperature over time (1986-2015) but it had variation on the same as consecutive years varied on the temperatures and rainfall levels. The metrological department of Siaya County should find a way of ensuring that rainfall and temperature variations County data is made available to community members as it can help in developing resilience strategies to climate change and knowing how best they can manage their livelihoods even with the continuation of the variations.

**Key Words:** Rainfall, Temperature, Variation, Siaya, County, Kenya.

## 1.0 Introduction

According to the International Panel on Climate Change (2013) report, the present-day warming and the increased variability of precipitation are likely to be exacerbated in future climate with large regional variations and different degrees of confidence. However, mean precipitation shows substantial uncertainties as the Coupled Models Inter-comparison Project Phase 5 (CMIP5; Taylor, Stouffer & Meehl, 2012). The climate of Africa is warmer than it was 100 years ago and model-based predictions of future Green House Gases (GHGs) induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate (Christensen et al. 2007).

Observational records show that during the 20th century the continent of Africa has been warming at a rate of about 0.05°C per decade with slightly larger warming in the June–November seasons than in December-May (Hulme, Doherty, Ngara, & New, 2001). By 2000, the five warmest years in Africa had all occurred since 1988, with 1988 and 1995 being the two warmest years. This rate of warming is not dissimilar to that experienced globally, and the periods of most rapid warming-the 1910s to 1930s and the post-1970s-occur simultaneously in Africa and the rest of the world (Intergovernmental Panel on Climate Change, 2001).

As a matter of fact, Intergovernmental Panel on Climate Change (2013) reports a drying trend over West Africa in a longer time series ranging from 1951 to 2012. Recently, a more extensive study by Ibrahim, Karambiri, Polcher, Yacouba & Ribstein (2014) reveals that in the last two decades, not only have the annual precipitation totals increased, but also the rainy days have been more frequent, leading to the partial recovery of precipitation amount. This recent precipitation recovery in the Sahel is due, to a great extent, to the direct influence of higher levels of anthropogenic greenhouse gases in the atmosphere, along with changes in anthropogenic aerosol precursor emissions (Haarsma, Selten, Weber & Kliphuis, 2005; Biasutti 2013; Dong & Sutton, 2015), although natural variability might have played an important role (Mohino, Janicot & Bader, 2011). In addition to the wetter precipitation trend, the prevalence of a higher inter-annual variability, a delayed onset and an early retreat of the monsoon season in recent years over West Africa have been reported (Biasutti & Sobel 2009; Sylla, Gaye, Jenklins, Pal & Giorgi, 2010a; Diallo, Sylla, Camara & Gaye, 2013; Seth et al. 2013; Hartmann et al. 2013).

Studies show that the Eastern African region has been experiencing rise in seasonal mean temperature and at the same time there is high confidence that the extreme temperatures will increase (Funk, Eilerts, Davenport & Michaelson, 2010; Moyo et al., 2012; Wagesho, Goel & Jain, 2013; Opiyo, Nyangito, Wasonga & Omondi, 2014). Research conducted in 2010 revealed that many parts of Kenya would experience more dry seasons and decline of more than 100 millimeters in rainfall by the year 2025 (Funk, Eilerts, Davenport & Michaelson, 2010). The report also showed that the experienced decline in rainfall is matched with increases in air temperature. Overall, the study revealed that the frequency of dry seasons would increase in Kenya. Other studies have also revealed significant warming in East Africa (Christensen et al., 2007; Nyong & Niang-Diop, 2006; Williams & Funk, 2010).

The evidence of climate change in Kenya is unmistakable. Temperatures have risen throughout the country. Rainfalls have become irregular and unpredictable, and when it rains, downpour is more intense making extreme and harsh weather to be now a norm in Kenya (Government of Kenya, 2010). More specifically, since the early 1960s, both minimum (night time) and maximum (day time) temperatures have been on an increasing (warming) trend. The minimum temperature has risen generally by 0.7 – 2.0$^{o}$C and the maximum by 0.2 – 1.3$^{o}$C, depending on the season and the region. In areas near large water bodies like Lake Victoria, the maximum temperatures has risen much like in other areas but the minimum temperatures have either not changed or become slightly lower (ibid.). This study was to help analyze rainfall and temperature variations overtime (1986-2015) in Siaya County, Kenya. This is because analysis of rainfall and temperature variation, trend and projection is an important exercise because it is significant in the designing of climate change adaptation strategies and giving information on the options that are available for uptake.

## 2.0 Materials and Methods

Materials and methods constitutes the study area; types of data; data analysis and presentation.

### 2.1 Study Area

This study was carried out in Siaya County. Siaya County is one of the six counties in the Nyanza region. It has a land surface area of 2,530 $km^2$ with a water surface area of 1,005 $km^2$. It is bordered by Busia County to the North West, Vihiga and Kakamega counties to the North East, Kisumu County to the South East and Homa Bay County across the Winam Gulf to the South (Figure 1). The water surface area forms part of Lake Victoria. It approximately lies between latitude 0º 26´ South to 0º 18´ North and longitude 33º 58´ and 34º 33´ (Government of Kenya, 2015).

Siaya County has three major geomorphologic areas namely: Dissected Uplands, Moderate Lowlands and Yala Swamp. These have different relief, soils and land use patterns. The altitude of the County rises from 1,140m on the shores of Lake Victoria to 1,400m above sea level on the North. There are few hills found in the County namely; Mbaga, Odiado, Akala, Regea, Nyambare, Usenge, Ramogi hills, Rambugu, Abiero, Sirafuongo and Naya hills. River Nzoia and Yala traverse the County and enter Lake Victoria through the Yala Swamp (Government of Kenya, 2013). The physical features have a bearing on the overall development potential of the County. The high altitude areas that form the Ugenya and Ugunja areas have higher rainfall hence suitable for agriculture and livestock keeping. Rivers Nzoia, Yala and Lake Kanyaboli have a great potential for irrigation. The low altitude areas of Boro, Uranga, Uyoma and Wagai receive less rainfall and thus are suitable for cotton growing and drought resistant crop varieties (ibid.).

The geology of the area is composed of the old Nyanzian system forming exposed rocks in Siaya, Ugenya, Ugunja and Gem. These rocks include basalts, desites and rylites, that consist of coarse and fine aggregates used in the construction industry. The main soil type is ferrasols and its fertility ranges from moderate to low with most soils being unable to produce without the use of either organic, inorganic or in most cases both types of fertilizers. Most of the areas have underlying murram with poor moisture retention (Government of Kenya, 2013).

The County experiences a bi-modal rainfall, with long rains falling between March and June and short rains between September and December. The relief and the altitude influence its distribution and amount. Siaya County is drier in the western part towards Bondo and Rarieda sub-counties and is wetter towards the higher altitudes in the eastern part particularly Gem, Ugunja and Ugenya sub-counties. On the highlands, the rainfall ranges between 800mm – 2,000mm while lower areas receive rainfall ranging between 800 – 1,600mm (Government of Kenya, 2013).

## 2.3 Sources and Types of Data Collected for the Study

In this study secondary data was collected. Secondary data refers to the information that a researcher finds useful for the study at hand, although it was not originated for that purpose (Munyoki & Mulwa, 2012). Secondary data included mean annual maximum, minimum and average temperature; and mean annual rainfall of Siaya County for the period 1986-2015 (Table 1). This was obtained from a secondary source which is Siaya County Metrological Department.

## 2.4 Data Analysis and Presentation

Rainfall and temperature variations overtime (1986-2015) in Siaya County were analyzed through; getting the annual amount of rainfall and the mean annual temperature of Siaya County for the period 1986-2015. Mann-Kendall test was used to ascertain trends or patterns in temperature and rainfall. This was done with the help of XLSTAT version 2016. Rainfall and temperature anomalies were determined to analyze the climatic trends as departures from 1986-2015 averaging the most recent 30 year period for calculating climate normal. This set of data was presented in terms of time series using charts.

## 3.0 Results and Discussions

For temperature, there were highly positive anomalies for the years 1995 and 2007 for temperature and low negative anomalies for the years 1992, 1998, 2003 and 2010 (Figure 2). Since 1986 to 2015, average temperature increased by 0.01 $^{0}$C but the trends were non-significant. On looking at the climatic variations of Siaya County, 1992 had the lowest amount of temperature (27.7$^{0}$C) with 2007 (28.8 $^{0}$C) registering the highest (Figure 2). Siaya County gives a climbing line trend with a positive value equation (y=0.01+ 28.10) an indication that temperatures has been increasing (+0.01 $^{0}$C) in Siaya County between the years 1986 and 2015 however small the variation is.

The analyses of rainfall data showed a significant increase in the mean annual rainfall (Figure 3) by 4.7542mm annually since 1986. There was high inter-annual rainfall variability, with the years 1986 to 1989 and 2011 to 2015 registering an increase on the amount of rainfall. The years 1989 to 1992 registered a decrease on the amount of rainfall and the years 1993 to 2000 registering constant fluctuations (Figure 3). The year 2015 represented by the number 30 had the highest amount of rainfall while 2011 represented by the number 26 having the lowest amount of rainfall (Figure 3). The fluctuations on rainfall amount helps in determining the flooding and drought seasons of Siaya County.

Temperature and rainfall of Siaya County has shown so much variations between the periods 1986 to 2015. This has an influence on the impact, vulnerability and adaptation levels of households, communities and government to climate change. The Mann- Kendall results from mean annual average temperature, and mean annual rainfall has indicated that Siaya County has no significant trends on rainfall and temperature over time (1986-2015). This does not mean that there is no variation on the same as consecutive years vary so much on the temperatures and rainfall levels.

## 4.0 Conclusions and Recommendation

From the study findings, there are significant variations on rainfall and temperature overtime (1986-2015) in Siaya County. The study has provided information on the possibility of getting the variations on rainfall and temperature which can be used to help in predicting and giving a trend on how climate will possibly change in the future. This information can be used to develop adaptation and mitigation strategies with focus being on avoiding conflict of interest between policy makers, community members and policy implementers on how best resilience to climate change can be achieved at the household or even individual level.

The metrological department of Siaya County should find a way of ensuring that rainfall and temperature variations data of the county is made available to community members as this can help them to identify the shocks, stresses and trends that may put people's livelihoods at risk as a result from the climatic changes. This is because attaining the data to be used for this study was not that easy and this may apply to other local community members within the County.

## 5.0 Acknowledgements

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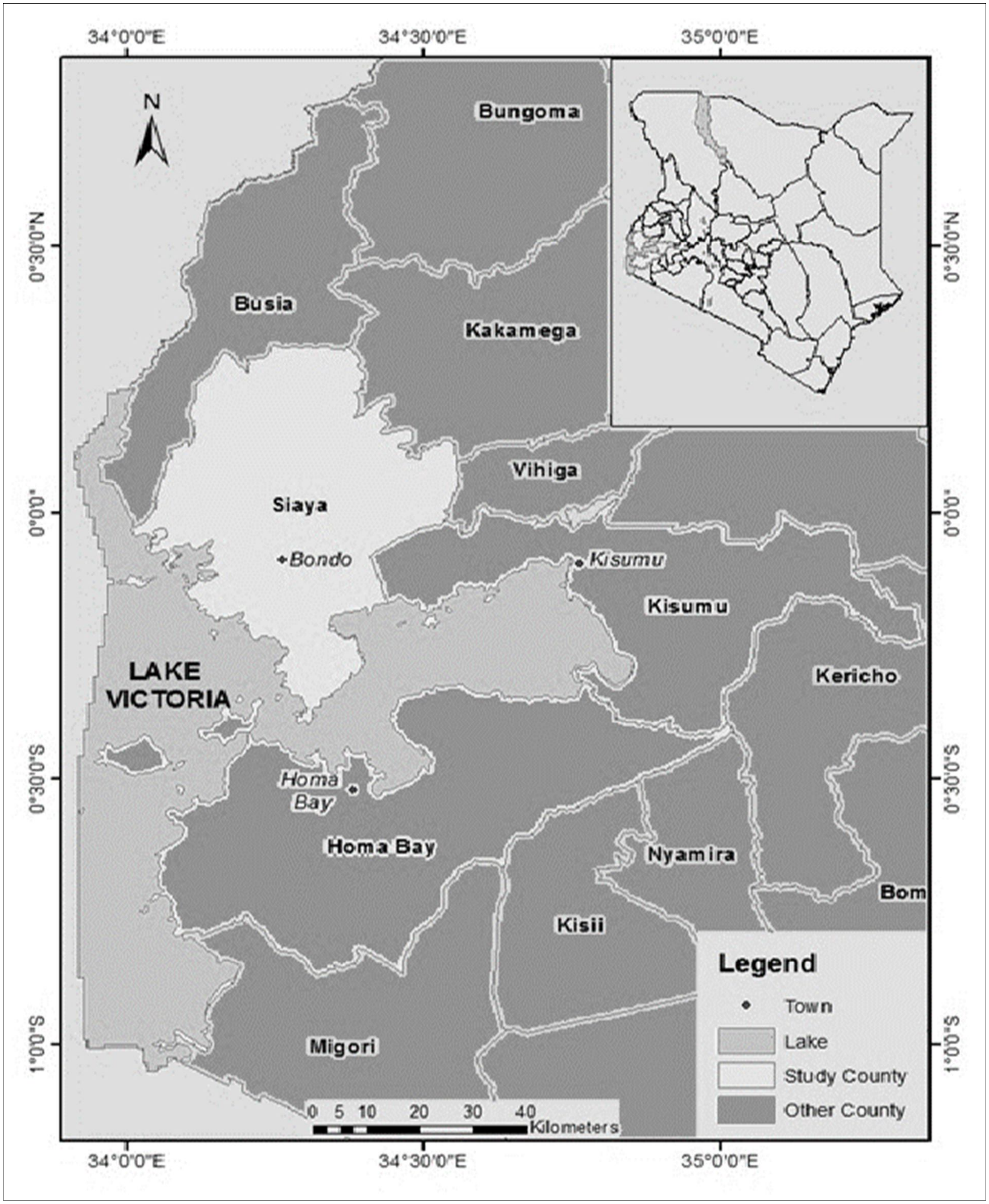


**Source**: Lake Victoria Fisheries Organization (2009).

**Figure 1: Siaya County Boundaries and Surrounding Counties**

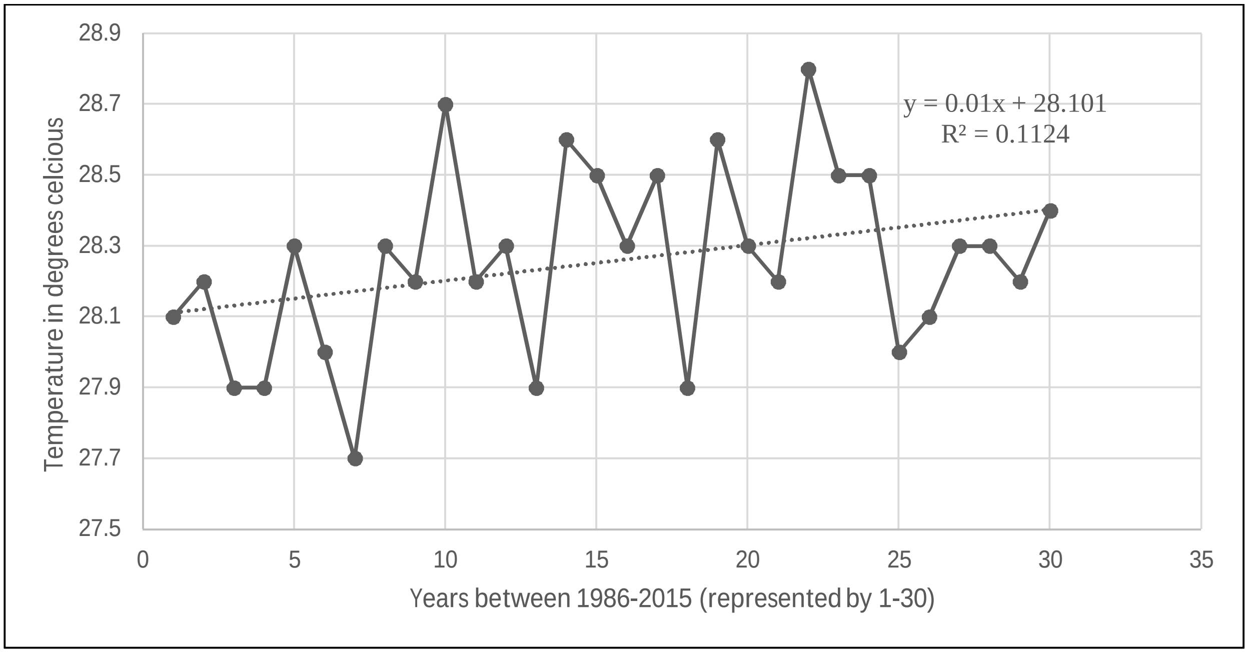


**Figure 2: Time Series Annual Mean Temperature ($^0$C) for Siaya County Calculated as Departures from 1986-2015 average.**

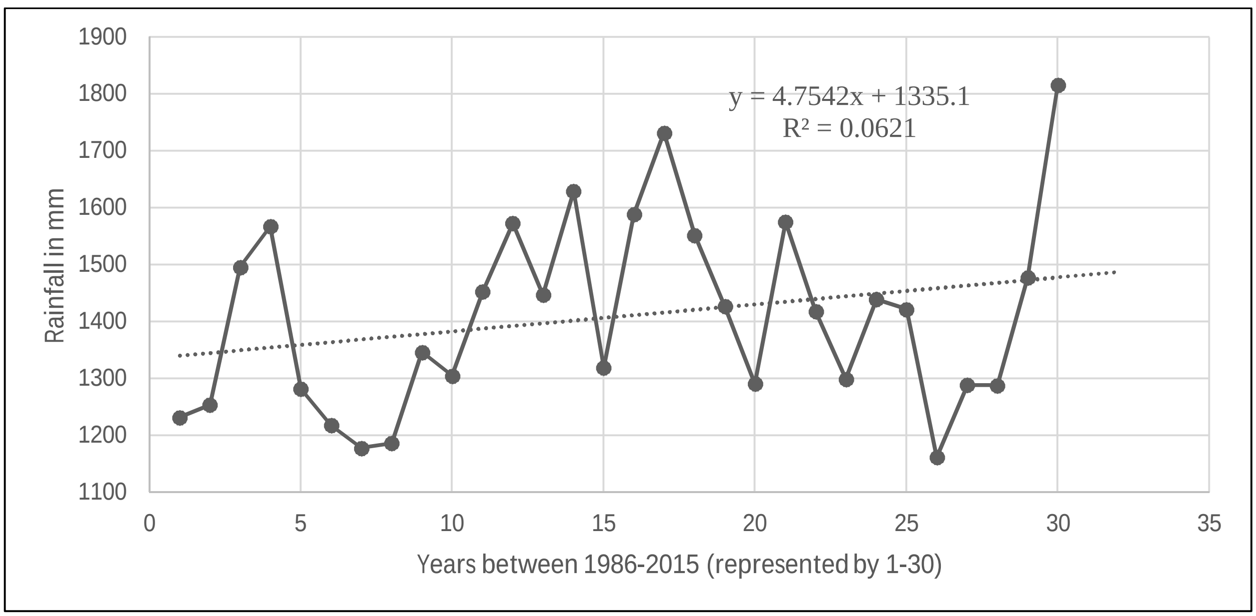


**Figure 3: Time Series Annual Mean Rainfall (mm) for Siaya County Calculated as Departures from 1986-2015 Average.**

**Table 1: Temperature (Mean Annual Maximum, Minimum & Average) and Rainfall (Mean Annual Average) for Siaya County for the period 1986-2015**

| Item Number | Year | Temperature ($^0C$) | | | Mean Annual Rainfall (Mm) |
|---|---|---|---|---|---|
| | | Max | Min | Average | |
| 1 | 1986 | 35.6 | 20.5 | 28.1 | 1,232 |
| 2 | 1987 | 35.8 | 20.6 | 28.2 | 1,254 |
| 3 | 1988 | 35.4 | 20.3 | 27.9 | 1,496 |
| 4 | 1989 | 35.3 | 20.4 | 27.9 | 1,567 |
| 5 | 1990 | 35.8 | 20.8 | 28.3 | 1,282 |
| 6 | 1991 | 35.4 | 20.6 | 28.0 | 1,218 |
| 7 | 1992 | 35.3 | 20.0 | 27.7 | 1,178 |
| 8 | 1993 | 35.9 | 20.6 | 28.3 | 1,186 |
| 9 | 1994 | 35.7 | 20.7 | 28.2 | 1,347 |
| 10 | 1995 | 36.6 | 20.8 | 28.7 | 1,305 |
| 11 | 1996 | 35.7 | 20.6 | 28.2 | 1,453 |
| 12 | 1997 | 35.8 | 20.8 | 28.3 | 1,573 |
| 13 | 1998 | 35.2 | 20.6 | 27.9 | 1,447 |
| 14 | 1999 | 36.4 | 20.7 | 28.6 | 1,629 |
| 15 | 2000 | 36.3 | 20.6 | 28.5 | 1,319 |
| 16 | 2001 | 35.5 | 21.0 | 28.3 | 1,589 |
| 17 | 2002 | 36.1 | 20.8 | 28.5 | 1,732 |
| 18 | 2003 | 35.1 | 20.6 | 27.9 | 1,552 |
| 19 | 2004 | 36.8 | 20.4 | 28.6 | 1,427 |
| 20 | 2005 | 35.9 | 20.6 | 28.3 | 1,291 |
| 21 | 2006 | 35.6 | 20.8 | 28.2 | 1,576 |
| 22 | 2007 | 36.8 | 20.7 | 28.8 | 1,418 |
| 23 | 2008 | 35.9 | 21.0 | 28.5 | 1,300 |
| 24 | 2009 | 35.6 | 21.3 | 28.5 | 1,439 |
| 25 | 2010 | 35.4 | 20.5 | 28.0 | 1,422 |
| 26 | 2011 | 35.8 | 20.5 | 28.1 | 1,162 |
| 27 | 2012 | 36.0 | 20.6 | 28.3 | 1,289 |
| 28 | 2013 | 36.0 | 20.6 | 28.3 | 1,288 |
| 29 | 2014 | 35.8 | 20.6 | 28.2 | 1,477 |
| 30 | 2015 | 36.1 | 20.7 | 28.4 | 1,816 |

**Source:** Metrological Department Siaya County, 2016.

## 6.0 References


Biasutti, M., & Sobel, A. (2009). *Delayed Sahel Rainfall and Global Seasonal Cycle in a Warmer Climate.* Geophysical Research Letters, 36(L23), 707.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, X.G., Held, I., Jones, R., Kolli, R.K., Kwon, W-T., Laprise, R., Rueda,V.M., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A., Whetton-Christiansen, J.H., Hewitson A., Busuioc, A., & others, (2007). *Regional climate projections, chap. 11.* In Solomon, S., Qin, D. , Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., & Miller, H.L. (Eds.), Climate Change 2007—the Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K., pp. 849–940.

Diallo, I., Sylla, M. B., Camara, M., & Gaye, A. T. (2013). *Inter-Annual Variability of Rainfall Over The Sahel Based On Multiple Regional Climate Models Simulations.* Theoretical and Applied Climatology, 113(1–2), 351–362.

Funk, C., Eilerts, G., Davenport, F., & Michaelson, J. (2010).*Climate Trend Analysis of Kenya-August 2010.* USGS, Fact Sheet 2010–3074.

Government of Kenya (2010). *National Climate Change Response Strategy-2010.* Nairobi, Government Printers

Government of Kenya, (2013). *Siaya County Integrated Development 2013-2017*. Nairobi, Kenya: Government Printers.

Government of Kenya (2015). *Kenya County Government of Siaya Medium Term County Annual Development Plan 2016-2017. Nairobi*. Government Printers.

Haarsma, R. J., Selten, F. M., Weber, S. L., & Kliphuis, M. (2005). *Sahel Rainfall Variability and Response to Greenhouse Warming.* Geophysical Research Letter, 32, L17702.

Hartmann, D. L., Klein Tank, A. M. G., Rusticucci, M., Alexander, L. V., Brönnimann, S., Charabi, Y., Dentener, F. J., Dlugokencky, E. J., Easterling, D. R., Kaplan, A., oden, B. J., Thorne, P.W., Wild, M. & Zhai, P. M. (2013). *Observations: Atmosphere and Surface.* In: T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P. M. Midgley (Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Hulme, M. R., Doherty, T., Ngara, M., & New, D. L. (2001). *African Climate Change: 1999-2100*. Climate Research 17:145-168

Ibrahim, B., Karambiri, H., Polcher, J., Yacouba, H., & Ribstein, P. (2014). *Changes in Rainfall Regime over Burkina Faso under the Climate Change Conditions Simulated By 5 Regional Climate Models.* Climate Dynamics, 42, 1363–1381.

Intergovernmental Panel on Climate Change (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Summary for Policy Makers, London, Cambridge University Press.

Intergovernmental Panel on Climate Change (2013). *Climate change 2013. The Physical Science Basis*. Working Group I Contribution to the IPCC Fifth Assessment Report, S. Joussaume, J. Penner, F. Tangang (eds). Stockholm, Sweden.

Lake Victoria Fisheries Organization. (2009). *The Contribution of Lake Victoria Fisheries to National Economies.* African Journal of Tropical Hydrobiology and Fisheries. Jinja, LVFO. 12:47-51.

Mohino, E., Janicot, S., & Bader, J. (2011). *Sahel Rainfall and Decadal To Multi-Decadal Sea Surface Temperature Variability*. Climate Dynamics, 37(3), 419–440.

Moyo, M., Mvumi, B. M., Kunzekweguta, M., Mazvimavi, K., Craufurd P. & Dorward, P. (2012). *Farmer Perceptions on Climate Change and Variability in Semi-Arid Zimbabwe in Relation to Climatology evidence*. African Crop Science Journal.20 (2): 317 – 335.

Munyoki, J. M. & Mulwa, A. S. (2012). *Social Science Research Hand Book*. Nairobi, Downtown Printing Works Ltd.

Nyong, A. & Niang-Diop, I. (2006). *Impacts of Climate Change in the Tropics: The African Experience*. In: Schellnhuber, H.J. (Eds.), Avoiding Dangerous Climate Change. Cambridge University Press, Cambridge.

Opiyo, F., Nyangito, M., Wasonga, V., & Omondi, P. (2014). *Trend Analysis of Rainfall and Temperature Variability in Arid Environment of Turkana, Kenya*. Environmental Research Journal, 8:30-43.

Seth, A., Rauscher, S. A., Biasutti, M., Giannini, A., Camargo, S. J., & Rojas, M. (2013). CMIP5 *Projected Changes in the Annual Cycle of Precipitation*. Journal of Climate, 26, 7328–7351.

Sylla, M. B., Gaye, A. T., Jenkins, G. S., Pal, J. S., & Giorgi, F. (2010). *Consistency of Projected Drought Over The Sahel With Changes In The Monsoon Circulation And Extremes In A Regional Climate Model Projections*. Journal of Geophysical Research-Atmosphere, 115, D16108.

Taylor, K. E., Stouffer, R. J., & Meehl, G. A. (2012). *An overview of CMIP5 and the Experiment Design*. Bulletin American Meteorological Society, 93, 485–498.

Wagesho, N., Goel N.K. & Jain, M.K. (2013). *Temporal and spatial variability of annual and Seasonal rainfall over Ethiopia*. Hydrological Sciences Journal-Journal Des Sciences Hydrologiques, 58 (2): 354-373.

Williams, P., & Funk, C. (2010).*Westward Extension of the Tropical Pacific Warm Pool Leads to March through June Drying in Kenya and Ethiopia*. U.S. Agency for International Development, Washington, D.C.