

# **INTER-RELATIONSHIPS BETWEEN SOLAR RADIATION INTENSITY (RD) AND RELATIVE HUMIDITY (RH) IN KENYA**

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# 1.0 Introduction

- Kenya is in the Eastern coast of Africa.
- The geographical equator passes approximately through the middle of Kenya
- The country generally has four seasons annually: The long rain season (March-May), Dry cold season (Jun-August), Short rain season (September-November) and the Dry hot season (December, January, February). Slight seasonal variations depending on specific locations are, however, possible within the country.

## 1.1 Introduction cont.

- Data from the **KMD**, Nairobi Dagoretti Corner Meteorological station- Latitude **1.30°S**; Longitude **36.75°E**; Area 3B; Altitude **1771m**.
- The Karl Pearson's method of determining the Coefficient of Correlation was employed to establish a negative correlation
- The data was then subjected to the curve fitting exercise, employing the statistical method to obtain equation of the best fitting curve.
- The period covered is the **whole year 1986**. The daily data taken at **9.00 am** for the two parameters.

- Coefficient of correlation was determined for **four other meteorological stations** in different geographical locations within Kenya.
- The Jandel scientific was employed to confirm the results obtained, and also to obtain a scatter plot.
- The **Mega stat** software was employed to do complete data analysis to confirm results of the statistical calculations and those of the Jandel scientific.
- This software gave among others, the sample **scatter** plot. It also gave the full regression analysis reports including the analysis of variance (**ANOVA**) tables for the annual, and seasonal analyses for all the stations.
- The summaries of all these are contained in **tables 1 to 5** in the section of results.

# 2.0 Methodologies

## 2.1 The Karl Pearson's equation

$$r = \frac{\sum \{(x - m_x)(y - m_y)\}}{\sqrt{\left\{ \sum (x - m_x)^2 \sum (y - m_y)^2 \right\}}} \dots\dots\dots(1)$$

Here x = RD in KJ/meter squared per day.

$m_x$  = mean of RD for 1986 for a met station

y = RH as % of moisture content

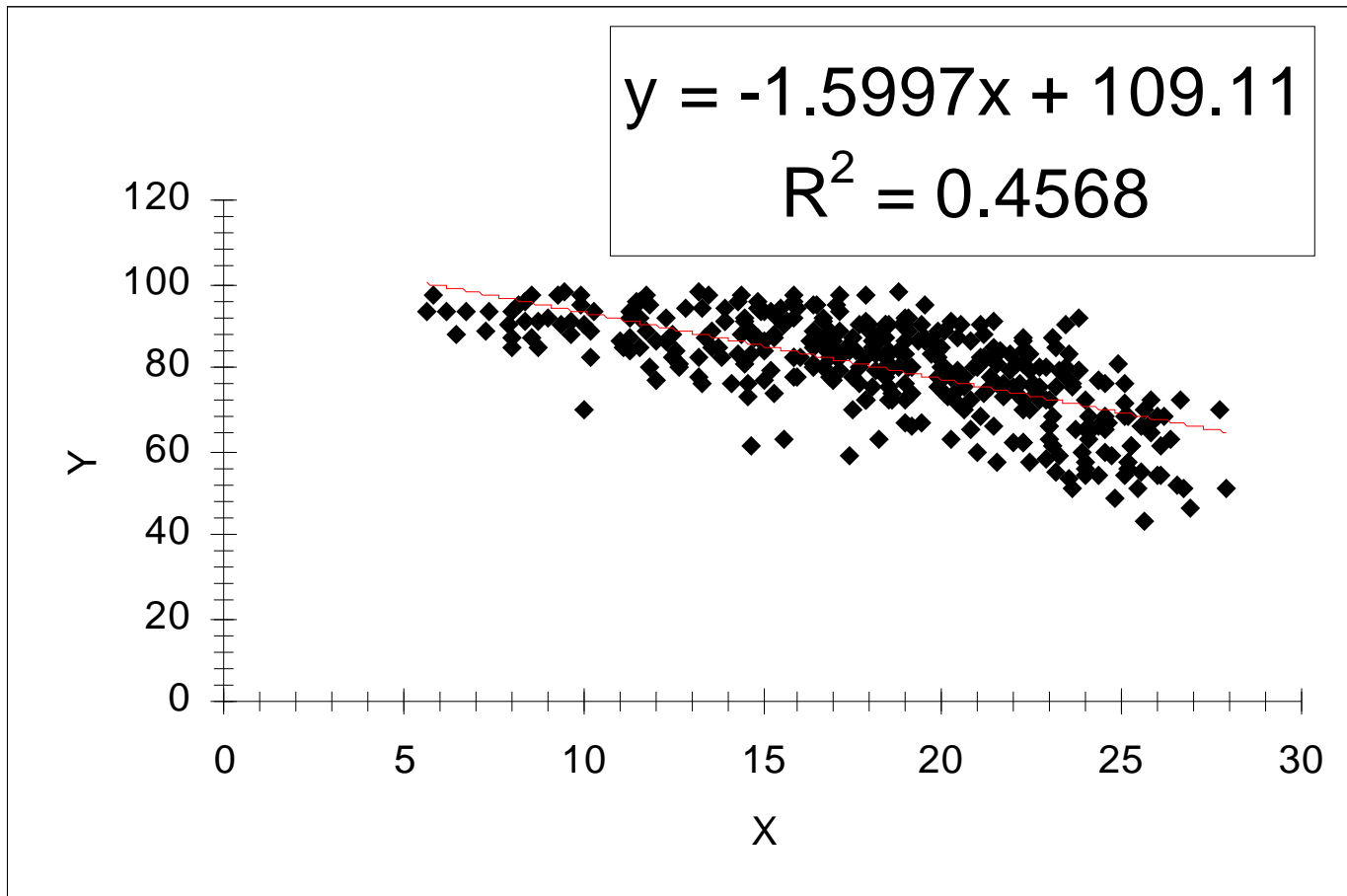
$m_y$  = mean of RH for 1986 for a met station

## 2.1.1 Use of Microsoft excel to calculate correlation coefficient, $r$ .

A value of  $r = -0.6758618$  was obtained using this method for the Nairobi Dagoretti Corner Met station

## 2.2 The Scatter Diagrams

- The Jandel Scientific gave linear scatter plot with negative gradient.
- The Mega Stat software analysis gave similar scatter plot.
- Sample Plot is shown in the next slide



## 2.3 The method of Least Squares to fit the curve

- From the scatter plot the eqn. to be fitted is

$$y = a + bx$$

- In which case the normal equations are:

$$\sum (y) = ma + b*\sum (x) \quad \text{and}$$

$$\sum\{(x)*(y)\} = b*\sum (x^2)$$

- Here, **a** and **b** are constants to be determined.
- $m = 365$ , the number of days in the year 1986.

## 2.3.1 Least Squares cont.

- Microsoft excel functions gave:  
 $\sum(y) = 29107$ ;  $\sum(x) = 6699.96$ ;  
 $\sum(x^2) = 131759.9$ ;  $\sum\{(x)*(y)\} = 520224$
- Hence the normal equations become:  
 $29107 = 365a + 6699.96b$  and  
 $520224.2 = 6699.96a + 131759.9$
- Solving the two simultaneous equations, we get:be:  
 $a = 109.11$  and  $b = -1.6$ .
- So the assumed straight line to be fitted to the data becomes:  
 $y = 109.11 - 1.6x$  Or  $RH = 109.11 - 1.6RD \dots(2)$

## 2.4 Line of Regression of Relative Humidity on Radiation

It is given by the expression:

$$y - m_y = \frac{r\sigma_y(x - m_x)}{\sigma_x}$$

$$\text{W here } \sigma_x = \frac{\sqrt{\left\{ \sum (x - m_x)^2 \right\}}}{m}; \quad \sigma_y = \frac{\sqrt{\left\{ \sum (y - m_y)^2 \right\}}}{m}$$

The calculations arrived at the values,  $\sigma_x = 4.91$   
and  $\sigma_y = 11.61$ .

On substituting the values, the eqn obtained is:

$$y = 103.31 - 1.6x. \text{ Or } \mathbf{RH = 103.31 - 1.6RD}$$

**This is similar to the previous eqn except for slight difference on value of intercept.**

## 3.0 Results

- The cor. Coef.(r) between RD and RH for NBI Dag is **-0.6758618** by man stat Cal in Excel
- The least squares method gave the equation:  
 **$RH = 109.11 - 1.6RD$**
- Results of regression line, and those of Jandel Scientific confirmed this.
- Tables 1 to 5 give results of regression analysis using Mega Stat software for all stations and seasons.

**Table 1. Results of reg analysis from the  
Mega stat for the year (1986).**

<b>Station</b>	<b>Lat</b>	<b>Long</b>	<b>Altitude, m</b>	<b>cor coef. r</b>	<b>Coef. Of det. r<sup>2</sup></b>	<b>P-value</b>	<b>Linear equation</b>
Nairobi	1.30°S	36.75°E	1,789.9	-.676	0.457	4.87E-50	RH=-1.60RD+109.11
Kericho	0.37°S	35.27°E	1,964.5	-.550	0.302	3.40E-30	RH=-1.33RD+ 94.80
Kisumu	0.10°S	34.75°E	1,142.1	-.458	0.210	2.35E-20	RH=-1.43RD+100.55
Mombas a	4.03°S	39.65°E	5.5	-.587	0.344	3.90E-35	RH=-0.94RD+100.51
Garissa	0.48°S	39.63°E	127.3	-0.16	0.026	0.002	RH=-0.36RD+ 78.40
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Table 2. Results of reg anal from the Mega stat for the Long rain season (March-May, 1986).

Station	Lat.	Long.	Altitude, m	Cor. Coef., r	Coef. of det., r <sup>2</sup>	P-value	Linear equation
Nairobi	1.30°S	36.75°E	1,789.9	-.688	0.446	3.5E-13	RH=-1.36RD+107.24
Kericho	0.37°S	35.27°E	1,964.5	-.536	0.287	3.74*10 <sup>-8</sup>	RH=-1.22RD+ 93.15
Kisumu	0.10°S	34.75°E	1,142.1	-.483	0.234	1.06*10 <sup>-6</sup>	RH=-1.12RD+ 99.73
Mombasa	4.03°S	39.65°E	5.5	-.350	0.540	7.6E-17	RH=-1.05RD+103.00
Garissa 12/6/2006	0.48°S	39.63°E	127.3	-.197	0.039	0.060	RH=-1.40RD+ 80.38

Table 3. Results of reg anal from the Mega stat for the Dry cold season (Jun-August, 1986).

Station	Lat	Long	Altitude, m	Cor. Coef , r	Coef.o f det. , r <sup>2</sup>	P-value	Linear equation
Nairobi	1.30°S	36.75°E	1,789.9	-0.610	0.361	2.40*10 <sup>-10</sup>	RH=-1.16RD+102.56
Kericho	0.37°S	35.27°E	1,964.5	-0.280	0.078	0.007	RH=-0.65RD+ 86.29
Kisumu	0.10°S	34.75°E	1,142.1	-0.658	0.433	1.06*10 <sup>-12</sup>	RH=-1.75RD+108.94
Mombasa	4.03°S	39.65°E	5.5	-0.243	0.059	0.020	RH=-0.33RD+ 90.52
Garissa 12/6/2006	0.48°S	39.63°E	127.3	-0.181	0.033	0.085	RH=-0.40RD+ 76.94

Table 4. Results of reg anal from the Mega stat for the Short rain season (Sept-Nov, 1986).

Station	Lat.	Long.	Altitude, m	Cor. Coef , r	Coef . of det. , r <sup>2</sup>	P-value	Linear equation
Nairobi	1.30°S	36.75°E	1,789.9	-0.592	0.35	6.26*10 <sup>-10</sup>	RH=-1.32RD+104.39
Kericho	0.37°S	35.27°E	1,964.5	-0.566	0.32	5.11*10 <sup>-9</sup>	RH=-1.26RD+ 89.11
Kisumu	0.10°S	34.75°E	1,142.1	-0.431	0.19	1.97*10 <sup>-5</sup>	RH=-0.98RD+ 83.90
Mombasa	4.03°S	39.65°E	5.5	-0.420	0.18	3.48*10 <sup>-5</sup>	RH=-0.85RD+ 98.34
Garissa	0.48°S	39.63°E	127.3	-0.162	0.03	0.125	RH=-0.40RD+ 78.74

**Table 5. Results of reg anal from Mega stat for Dry hot season (December, January, and February 1986).**

<b>Station</b>	<b>Lat.</b>	<b>Long.</b>	<b>Altitude, m</b>	<b>Cor. Coef , r</b>	<b>Coef. of det. , r<sup>2</sup></b>	<b>P-value</b>	<b>Linear equation</b>
Nairobi	1.30°S	36.75°E	1,789.9	-0.593	0.351	7.59*10 <sup>-10</sup>	RH=-2.06RD+115.99
Kericho	0.37°S	35.27°E	1,964.5	-0.622	0.386	6.27*10 <sup>-11</sup>	RH=-1.74RD+104.15
Kisumu	0.10°S	34.75°E	1,142.1	-0.353	0.125	6.00*10 <sup>-4</sup>	RH=-1.50RD+100.13
Mombasa	4.03°S	39.65°E	5.5	-0.466	0.217	3.66*10 <sup>-6</sup>	RH=-0.73RD+ 93.27
Garissa	0.48°S	39.63°E	127.3	-0.197	0.037	0.0 70	RH=-0.46RD+ 82.29
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## 4.0 Discussions

- Other than Garissa Met station, the analysis of variance (ANOVA) tables indicated t-values well above  $-2$ .
- In all cases of Garissa station, the t-values obtained were below this threshold value.

- Increase in radiation results in a decrease in relative humidity and vice versa.
- The correlation coefficient determined lies between  $-1$  and  $+1$ . Hence, the values obtained are reliable
- The line of best fit is a straight line with a negative gradient, confirming the variations of relative humidity with radiation. So the equation can be adopted to explain the relationship between the two parameters.
- Jand. Sc and Maga Stat confirm results

## 4.1 Discussions cont.

- Garissa results could be attributed to the unique climatic characteristics of that region.
- Garissa is in the semi arid region of the country, with different wind patterns.
- Need to investigate effect of these unique climatic features on the relationship between the two parameters for a future report.
- Same procedures can be adopted to study relationships between different pairs of climatic parameters, e.g. RD & WV, RD & Temp etc.

## 4.2 Discussions cont.

- Similarity in the relationships for the stations show that data from the stations can be relied upon
- The data period needs to be lengthened and more stations included for better results.
- The relationship is an indication that the two parameters are directly or indirectly linked to the solar activities.
- This linkage is currently under invest. by us using ground data and the solar activity proxy data.

## 5.0 Conclusions

- The study of Inter-relationships between solar radiation intensity and relative humidity using **ground measured Kenya data** was carried out at five meteorological stations for the first time.
- Significant correlation exists between the solar radiation and relative humidity at seasonal and annual levels.
- The following hypotheses have been affirmed:

## 5.1 Conclusions cont.

- There is a significant linear relationship between RD and RH for the whole year.
- There is a significant linear relationship between RD and RH during the long rain season.
- There is a significant linear relationship between RD and RH during the dry cold season.
- There is a significant linear relationship between RD and RH during the short rain season.
- There is a significant linear relationship between RD and RH during the dry hot season.

## 5.2 Conclusions cont.

- The negative correlation between solar radiation intensity and relative humidity is a sign that the two climatic parameters are influenced by the solar activities.

## 6.0 Acknowledgements

- KMD staff for dedication in availing data.
- Colleagues Dr.F Otieno and Dr. J Kihoro for suggesting usage of Jandel Sc. And Mega Stat respectively.
- The UN/NASA and IHY organizing committees for making it possible for me to present these findings in this meeting.
- Above all, the Almighty God.

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