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ASSESSMENT OF SEASONAL VARIATIONS IN SOLAR RADIATION AND RELATIVE HUMIDITY OVER TORORO.

BY

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JUNE, 2026

DECLARATION

I **Mambo Cedrick** hereby declare that the research work contained in this report is my original work and that it has not been submitted to any university or any other higher education learning institution for the purpose of conferring a degree or another credential

Signature .....

Date 25th/08/2026.....

APPROVAL

The research work that has culminated into this report was done under the supervision of

Dr. Andima Geoffrey

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DEPARTMENT OF PHYSICS

Signature .....

Date 25th/08/2026 .....

DEDICATION

I dedicate this research report to my mother, **Cherotich Grace** and my father, **John Mukung** for the great support, parental care and advice they gave me throughout the course of study.

ACKNOWLEDGEMENT:

I am sincerely thankful to the Almighty God for the gift of life he has granted on to us and for the far He has brought us. This research was as a result of a collective effort from a number of people.

Great thanks to my supervisor, Dr Andima Geoffrey whose mentorship, comments, positive criticism, recommendations and fatherly advice gave me courage and resilience to ensure the success of this research study.

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May God bless them all.

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LIST OF ACRONYMS AND ABREVATIONS

TAHMO-Trans African Hydro meteorological Observatory

SR- : Solar radiation

RH- : Relative humidity

ITCZ- **:** Inter- Tropical convergence Zone

SPSS- **:** Statistical package of social sciences

ABSTRACT

This study assessed the seasonal variations of solar radiation and relative humidity over Tororo district, Uganda using meteorological data collected from Trans-Africa Hydro Meteorological Observatory (TAHMO) weather station for the year 2017 and 2018. The findings revealed that solar radiation was highest during the dry months of January and February and lowest during the wet months of June and July. Relative humidity showed an opposite pattern Correlation analysis showed a weak negative relationship between solar radiation and relative humidity with a correlation coefficient of approximately -0.347. The relationship was not statistically significant at a 95% confidence level. Based on the results, solar radiation and relative humidity over Tororo district are modulated by seasonal weather conditions.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Climate change and climate variability have become major global concerns due to their increasing impacts on agriculture, water resources, energy production, and human livelihoods. Across many developing countries, especially in Sub-Saharan Africa, changes in climatic variables such as rainfall, temperature, solar radiation, and relative humidity have greatly affected socio-economic activities that depend directly on weather conditions. Uganda, being an agricultural country located within the equatorial region of East Africa, is highly vulnerable to climatic fluctuations because the majority of its population depends on rain-fed agriculture for food production and income generation (Eludoyin et al., 2018).

Solar radiation is one of the most important climatic parameters because it serves as the primary source of energy driving atmospheric processes, plant photosynthesis, evaporation, and the hydrological cycle. It directly influences crop growth, evapotranspiration, drying processes, and renewable energy production, particularly solar power generation. High solar radiation levels promote photosynthesis and increase agricultural productivity when moisture conditions are favorable. However, excessive solar radiation combined with prolonged dry conditions may result in heat stress, increased evaporation, soil moisture loss, and reduced crop yields.

Relative humidity, on the other hand, refers to the amount of water vapor present in the atmosphere relative to the maximum amount the air can hold at a given temperature. Relative humidity plays a significant role in cloud formation, rainfall occurrence, evapotranspiration, and plant-water relationships. High relative humidity is usually associated with increased cloud cover and rainfall, while low humidity conditions are linked to dry weather and high evaporation rates. Relative humidity also affects the spread of crop pests and diseases, especially fungal infections that thrive in moist conditions.

The relationship between solar radiation and relative humidity is generally inverse in nature. When relative humidity increases, cloud formation also increases, reducing the amount of solar radiation reaching the Earth's surface. Conversely, periods of low humidity are usually associated

with clearer skies and increased solar radiation intensity. Understanding this relationship is important for agricultural planning, weather forecasting, environmental management, and renewable energy development.

Uganda experiences varying climatic conditions due to differences in topography, vegetation, altitude, and proximity to large water bodies such as Lake Victoria. Studies conducted in different parts of Uganda indicate that the Eastern region receives relatively high solar radiation compared to other regions of the country. According to studies conducted by (Katongole et al., 2023), Eastern Uganda receives average daily global solar radiation ranging between 174.5 W/m² and 225.23 W/m², making the region suitable for solar energy utilization and agricultural activities.

Tororo District, located in Eastern Uganda, is one of the districts where agriculture forms the backbone of the local economy. Most communities in the district practice subsistence farming and depend heavily on seasonal rainfall patterns and favorable weather conditions. However, in recent years, the district has experienced increasingly unpredictable climatic conditions characterized by prolonged dry spells, erratic rainfall, floods, and changing humidity conditions. These climatic changes have negatively affected agricultural productivity, food security, and household incomes.

Despite the importance of solar radiation and relative humidity in influencing weather patterns and agricultural production, there is still inadequate localized meteorological information concerning their long-term trends in Tororo District. Most previous climate studies in Uganda have focused on rainfall and temperature variations at national or regional scales, with limited attention given to localized studies on solar radiation and relative humidity. In addition, some available studies rely on interpolated satellite data rather than ground-based measurements, which may not fully represent local climatic conditions.

The establishment of the Trans-African Hydro-Meteorological Observatory (TAHMO) weather stations in Uganda has improved access to reliable meteorological data for climate research and environmental monitoring. TAHMO weather stations continuously measure climatic variables such as solar radiation, relative humidity, temperature, rainfall, wind speed, and atmospheric

pressure. These data provide an opportunity to assess local climatic trends and their implications on agriculture and renewable energy development.

Therefore, this study seeks to investigate the trends of solar radiation and relative humidity over Tororo District using meteorological data collected from the TAHMO weather station for the years 2017 and 2018. The findings of this study will contribute to improved understanding of local climate variability and support farmers, researchers, policy makers, and environmental planners in making informed decisions regarding climate adaptation, agricultural planning, and sustainable resource management

1.2 PROBLEM STATEMENT

Tororo District highly depends on rain-fed agriculture, yet the area is increasingly experiencing unpredictable weather conditions such as prolonged droughts, irregular rainfall, and changing humidity levels due to climate change. These climatic changes have negatively affected crop production, food security, and livelihoods of farmers.

Solar radiation and relative humidity are important climatic variables that influence agriculture, weather patterns, and renewable energy production. However, there is limited localized information on their trends and relationship in Tororo District. Most previous studies focused mainly on rainfall and temperature at national or regional levels.

The lack of reliable information on solar radiation and relative humidity makes it difficult for farmers, researchers, and policy makers to make informed decisions on climate adaptation and agricultural planning. Therefore, this study was conducted to investigate the trends of solar radiation and relative humidity over Tororo District using data from the TAHMO weather station for the years 2017 and 2018.

1.3 AIM

To assess the seasonal variations of solar radiation and relative humidity over Tororo district, Uganda using meteorological data from 2017 to 2018

1.4 Objectives

1) To determine the monthly variations solar radiation and relative humidity over Tororo district

2) To determine potential correlation between solar radiation and relative humidity.

1.5 SCOPE OF THE STUDY

This research study investigates if there are significant trends in the amount of solar radiation and relative humidity over Tororo, Uganda and determined the potential correlation between solar radiations and relative humidity using the data of year 2017 and 2018 which is collected from TAHMO weather station located in Busitema university, Nagongera campus in Tororo district, Uganda.



Figure 1. 1: Location of Tororo district in Uganda

Source: maps.google.com

1.7 SIGNIFICANCE

This study provides important information on seasonal variations of solar radiation and relative humidity over Tororo district. The findings of this research shall farmers, policy makers, and agriculture extension workers make informed decision on climate-smart agriculture, weather planning, and environmental management.

The study also contributes to scientific knowledge concerning climatic variability in Eastern Uganda and may serve as a reference for future research in agriculture, meteorology and renewable energy.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Climate change and climate variability have become major environmental challenges affecting many countries worldwide, especially developing countries that depend heavily on agriculture. In Sub-Saharan Africa, changing weather conditions such as prolonged droughts, floods, irregular rainfall, and rising temperatures have negatively affected agricultural production, food security, water resources, and human livelihoods. Uganda is among the countries highly vulnerable to climate variability because the majority of its population depends on rain-fed agriculture for survival.

Among the important climatic variables influencing weather and agriculture are solar radiation and relative humidity. Solar radiation provides energy necessary for photosynthesis, evaporation, and atmospheric circulation, while relative humidity influences cloud formation, rainfall occurrence, evapotranspiration, and plant-water relationships. Understanding the trends and relationship between these climatic variables is important for climate monitoring, agricultural planning, and renewable energy development.

2.1 Solar Radiation and Its Importance

Solar radiation is the energy emitted by the sun in the form of electromagnetic waves including visible light, infrared radiation, and ultraviolet rays. It is the primary source of energy for the Earth's climate system and plays an important role in weather processes, plant growth, and renewable energy production.

(Tang et al., 2011) solar radiation varies depending on atmospheric conditions such as cloud cover, humidity, and seasonal weather patterns. During dry seasons, skies are usually clearer, allowing more solar radiation to reach the Earth's surface, while rainy seasons are associated with reduced solar radiation due to increased cloud cover.

Solar radiation is very important in agriculture because it supports photosynthesis, which enables plants to manufacture food. However, excessive solar radiation combined with drought

conditions may cause heat stress, increased evaporation, and reduced crop yields. Low solar radiation may also reduce plant growth and productivity.

Uganda has high solar energy potential because of its location near the equator. A study conducted by (Katongole et al., 2023) showed that Eastern Uganda receives relatively high solar radiation ranging between 174.5 W/m² and 225.23 W/m². The study further reported that solar radiation in Uganda changes seasonally, with higher values during dry months and lower values during rainy seasons.

The Eastern region of Uganda, where Tororo District is located, experiences favorable solar radiation conditions suitable for agriculture and solar energy utilization. However, seasonal weather changes greatly influence the amount of solar radiation received throughout the year.

2.2 Relative Humidity and Its Effects

Relative humidity refers to the amount of water vapor present in the atmosphere compared to the maximum amount of moisture the air can hold at a given temperature. It is commonly expressed as a percentage and is an important factor in weather and climate processes.

High relative humidity is usually associated with cloudy conditions and rainfall, while low humidity is linked to dry weather and high evaporation rates. Relative humidity influences evapotranspiration, cloud formation, crop growth, and the spread of pests and diseases.

According to (Xu et al., 2010), atmospheric humidity significantly affects the transmission of solar radiation because water vapor and clouds absorb and scatter sunlight before it reaches the Earth's surface. High humidity conditions therefore reduce solar radiation intensity.

In Uganda, humidity levels vary according to seasons and geographical regions. During rainy seasons, humidity levels are usually high, while dry seasons are characterized by lower humidity. High humidity may encourage the growth of fungal diseases and pests in crops, while low humidity increases moisture loss from plants and soils(Eludoyin et al., 2018).

2.3 Relationship Between Solar Radiation and Relative Humidity

Previous studies indicate that solar radiation and relative humidity are negatively related. When relative humidity increases, atmospheric moisture also increase, reducing the amount of solar radiation reaching the Earth's surface. Conversely, lower humidity levels are associated with clearer skies and increased solar radiation.

(Xu et al., 2010) explained that water vapor and clouds reduce solar radiation through absorption and scattering processes. This relationship affects agricultural production, environmental conditions, and solar energy generation.

Understanding the relationship between solar radiation and relative humidity is important because both variables directly influence crop productivity, soil moisture, weather forecasting, and renewable energy utilization. Farmers and environmental planners can use such information to improve agricultural planning and climate adaptation strategies.

2.4 Climate Variability and Agriculture in Uganda

Agriculture is the backbone of Uganda's economy and employs a large percentage of the population. However, the sector is highly sensitive to climate variability because most farming activities depend on rainfall and natural weather conditions.

According to (Nuwagira & Yasin, 2022), Uganda has experienced increasing climate variability characterized by irregular rainfall patterns, prolonged droughts, floods, and rising temperatures. These climatic changes have negatively affected agricultural productivity, water resources, and food security.

In Eastern Uganda, including Tororo District, climate variability has resulted in crop failures, reduced yields, increased pest outbreaks, and water shortages. Farmers are increasingly finding it difficult to predict planting seasons due to changing weather patterns.

Solar radiation and relative humidity are among the important climatic variables affecting agriculture in the region. High solar radiation during dry seasons may increase evaporation and water stress in crops, while high humidity during rainy seasons encourages disease outbreaks and reduces solar radiation reaching crops.

CHAPTER THREE: METHODS AND MATERIAL

3.1 Introduction

This chapter presents the methods and materials that was used in conducting the study. It describes the study area, research design, sources of data, instruments used for data collection, methods of data analysis, reliability of data, and limitations encountered during the study. The methods and materials were designed to investigate the trends of solar radiation and relative humidity over Tororo District, Uganda.

3.2 Study Area

The study was conducted in Tororo District located in Eastern Uganda near the Kenya–Uganda border. The district experiences a tropical climate characterized by both wet and dry seasons throughout the year. The area receives bimodal rainfall, with the long rainy season occurring from March to May and the short rainy season occurring from September to November.

Agriculture is the major economic activity in the district, with most residents depending on subsistence farming for their livelihoods (Nuwagira & Yasin, 2022). Climatic conditions such as solar radiation, rainfall, temperature, and relative humidity therefore play an important role in agricultural productivity and environmental conditions within the district.

Meteorological data used in this study were obtained from the Trans-African Hydro-Meteorological Observatory (TAHMO) weather station located at Busitema University, Nagongera Campus in Tororo District.

3.3 Research Design

The study employed a quantitative research design based on the analysis of secondary meteorological data. Quantitative methods were used because the study involved numerical measurements and statistical analysis of climatic variables, specifically solar radiation and relative humidity.

The design enabled the researcher to examine the monthly and yearly trends of solar radiation and relative humidity and also determine the relationship between the two variables during the study period of 2017 and 2018.

3.4 Sources of Data

The study used secondary data obtained from the TAHMO weather station located at Nagongera Campus in Tororo District. The weather station continuously records meteorological parameters such as solar radiation, relative humidity, temperature, rainfall, wind speed, and atmospheric pressure.

Monthly mean values of solar radiation and relative humidity for the years 2017 and 2018 were collected and used in the analysis.

3.5 Data Collection Instruments

Data used in this study were collected using the ATMOS 41 All-in-One Weather Station installed under the TAHMO project which is located in Tororo district, Busitema University Nagongera campus. The instrument is designed for continuous environmental monitoring and is capable of measuring several climatic variables including solar radiation, relative humidity, air temperature, precipitation, wind speed, and atmospheric pressure.

The instrument automatically records and stores climatic data at regular intervals, making it reliable for climate studies and environmental monitoring.



Figure 3.0: TAHMO weather station at Busitema University, Nagongera campus

3.6 Data Analysis

The collected meteorological data were organized, processed, and analyzed using Microsoft Excel and Statistical package for social sciences (SPSS) software.

Monthly mean values of solar radiation and relative humidity were calculated and presented using tables, line graphs and scatter plots. Microsoft Excel was used to generate graphs showing the monthly and seasonal variation of the two climatic variables over the study period.

Spearman's rank Correlation analysis was carried out using SPSS software to determine the relationship between solar radiation and relative humidity. The statistical analysis helped establish whether changes in relative humidity were associated with changes in solar radiation over Tororo district or no.

Descriptive statistics including mean, standard deviation and variance were also calculated to summarize the characteristics of the climatic variables.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.0 introduction

This chapter presents the analysis, interpretation, and discussion of the findings obtained from the study on the trends of solar radiation and relative humidity over Tororo District, Uganda. The results are presented according to the objectives of the study using graphs and statistical analysis. The chapter also discusses the relationship between solar radiation and relative humidity based on the analyzed data for the year 2017 and 2018.

4.1 Monthly variation of relative humidity over Tororo

4.2.1 A graph showing relative humidity of the year 2017 over Tororo

Figure 4.0 shows the monthly mean values of relative humidity for the year 2017

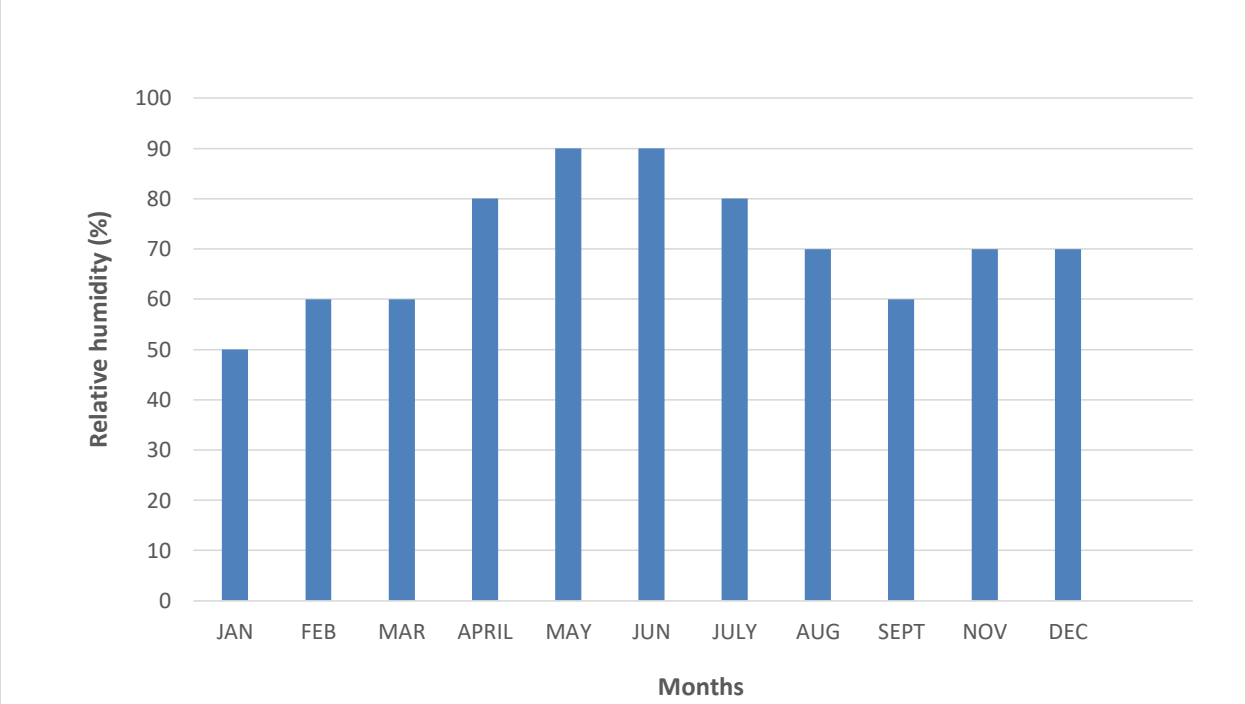


Figure 4. 1: A graph of relative Humidity of the year 2017 over Tororo

From figure 4.0, the results indicate that relative humidity gradually increased from January to July. The lowest humidity values of approximately 50% were recorded in January and February, while the highest values of about 90% were recorded in June and July. After July, relative humidity gradually decreased towards December.

The increase in relative humidity during the middle months of the year is associated with the rainy season experienced in Eastern Uganda. The lower humidity values recorded at the beginning and end of the year are associated with dry season conditions characterized by reduced rainfall and clearer skies.

These findings agree with previous studies conducted in East Africa which reported that humidity levels are usually higher during wet seasons and lower during dry seasons due to seasonal climatic variations.

4.2.2 A graph showing the relative humidity of the year 2018

The figure 4.1 shows the monthly values of relative humidity of the 2018

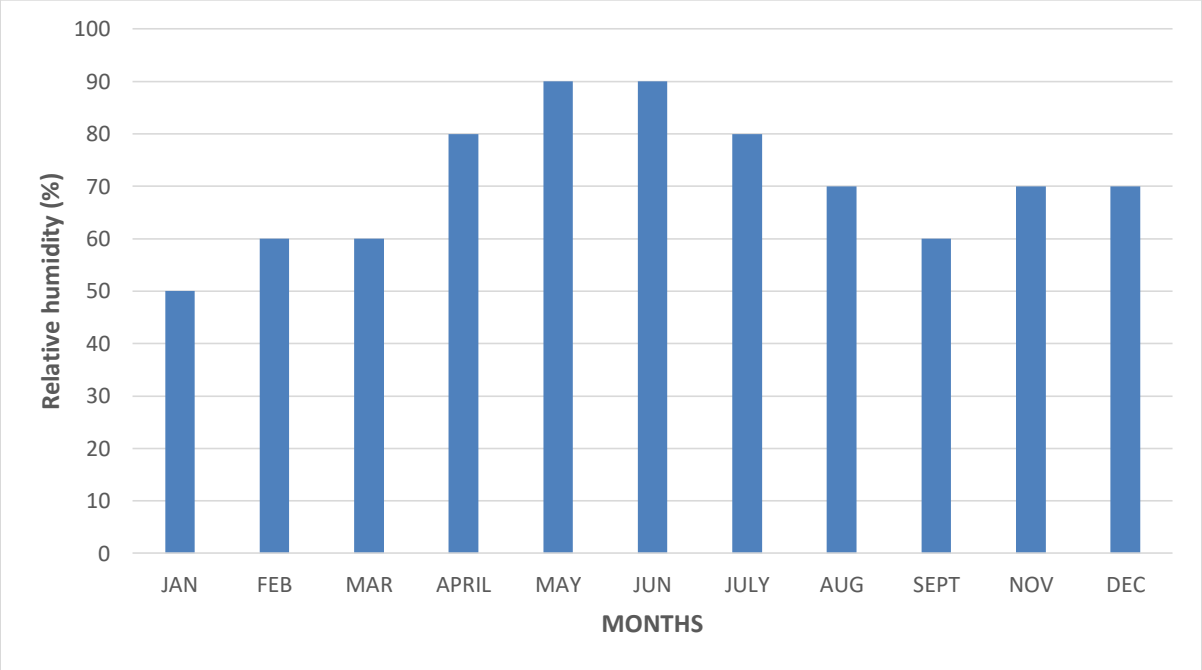


Figure 4.1: A graph of relative Humidity of the year 2018 over Tororo

From figure 4.1, the results show a similar trend to that observed in 2017. Relative humidity values ranged between 50% and 90% throughout the year. Higher humidity values were observed between April and July, while lower values occurred during January and February.

The observed trend confirms the existence of seasonal climatic patterns in Tororo District where wet months are associated with increased atmospheric moisture. The consistency in humidity

patterns between 2017 and 2018 suggests that the district experiences relatively stable seasonal changes in atmospheric conditions.

4.2 The trend of solar radiation over Tororo.

4.2.1 solar radiation trend for the year 2017

The monthly mean values of solar radiation were recorded and the information obtained is represented as shown below.

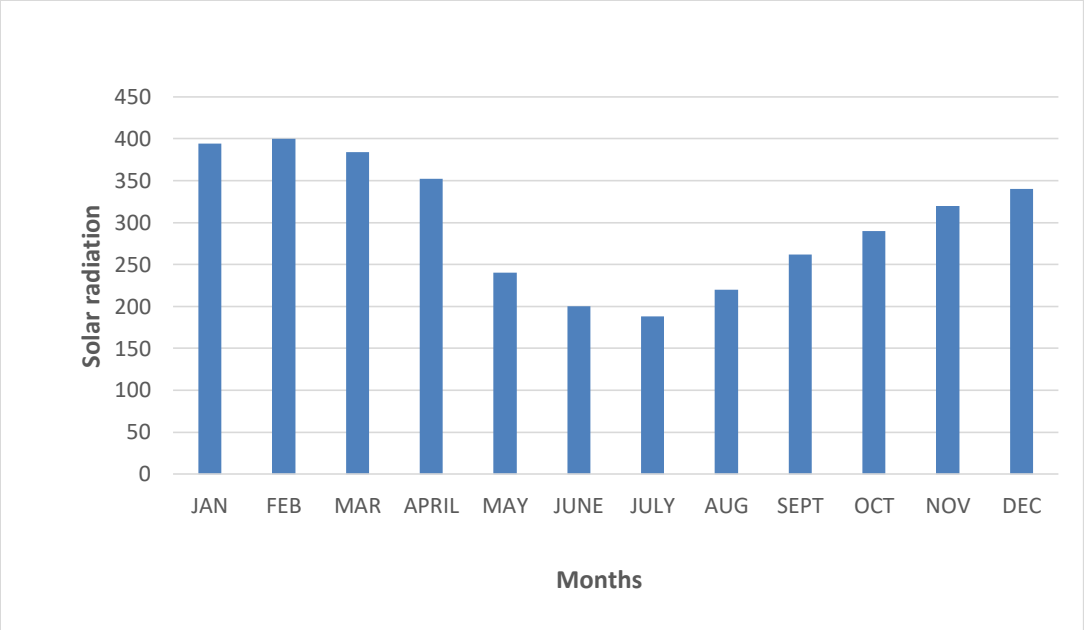


Figure 4. 2:A graph of solar radiation of the year 2017 over Tororo

From figure 4.2, the results indicate that solar radiation was highest during January and February, with values exceeding 400 W/m². Solar radiation gradually decreased from March to July, reaching the lowest value of approximately 190 W/m² in July. From August onwards, solar radiation increased steadily towards December.

The high solar radiation values recorded at the beginning of the year are associated with dry weather conditions and reduced cloud cover, which allow more sunlight to reach the Earth's surface. The decrease observed between May and July is linked to increased cloud cover and rainfall during the wet season, which reduce the amount of incoming solar radiation.

The results are consistent with findings by Katongole D. N. et al. (2023), who reported that solar radiation in Uganda varies seasonally and is generally lower during rainy periods due to cloud cover.

4.2.4 The trend of solar radiation of the year 2018 over Tororo

The monthly mean values of solar radiation were recorded and the information obtained was represented as below.

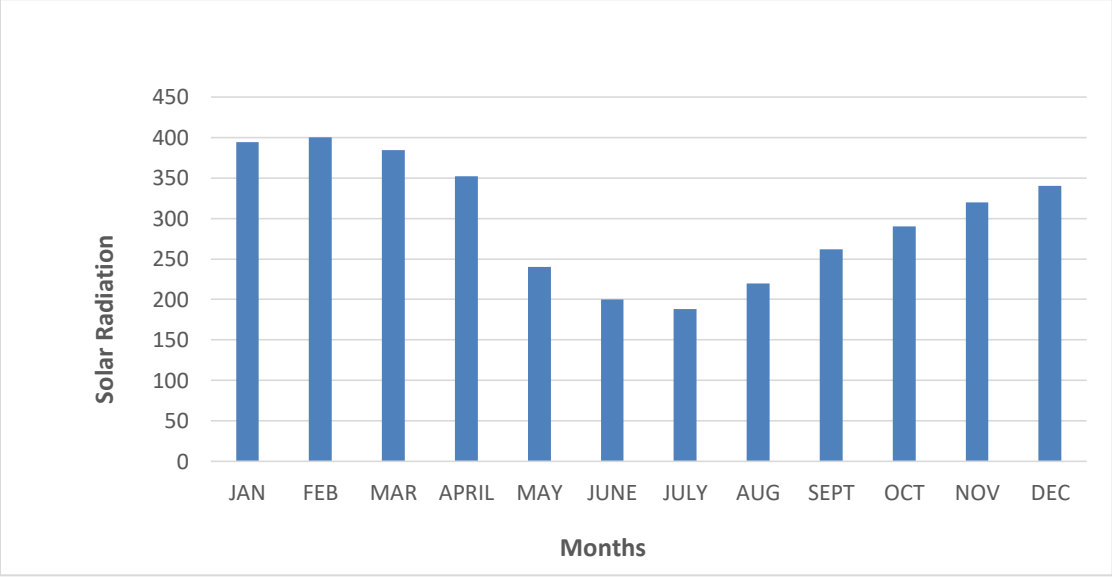


Figure 4. 3: A graph of solar radiation of the year 2018 over Tororo

The results show that solar radiation remained high from January to April, with the highest value recorded in February at approximately 400 W/m². A sharp decrease in solar radiation was observed from May to July, followed by a gradual increase from August to December.

The observed seasonal trend is similar to that recorded in 2017, indicating a consistent pattern of solar radiation variation in Tororo District. The reduction in solar radiation during wet months is mainly caused by increased atmospheric moisture which block incoming sunlight.

These findings further confirm that seasonal weather conditions strongly influence solar radiation distribution in Eastern Uganda.

4.2.2 correlation between the relative humidity and solar radiation

Monthly mean values of relative humidity and solar radiation for 2017 were recorded and spearman's rank correlation co efficient was calculated using SPSS software. The following data/ results were obtained.

4.2.6 Scattered diagram of solar radiation and relative humidity

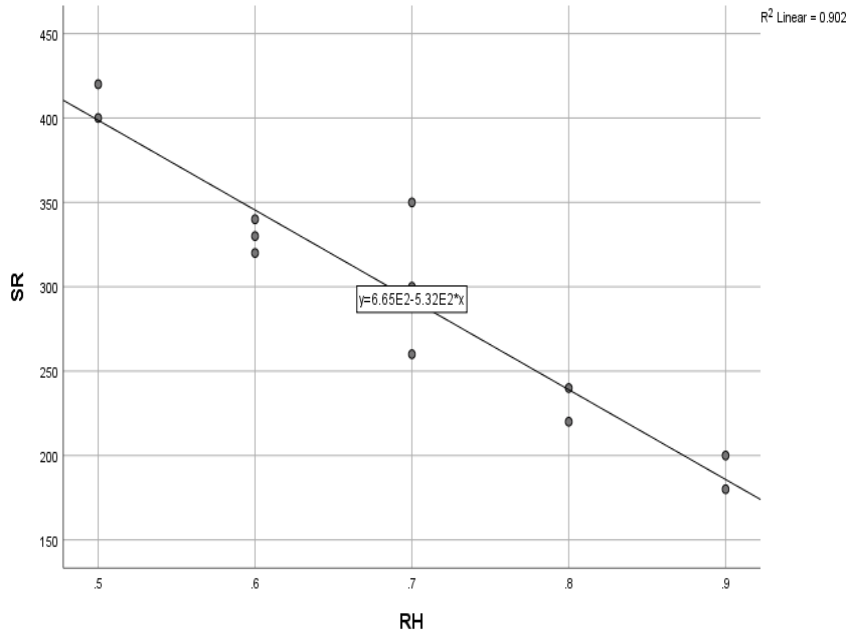


Figure 4. 4:Scattered diagram of solar radiation and relative Humidity of the year 2017

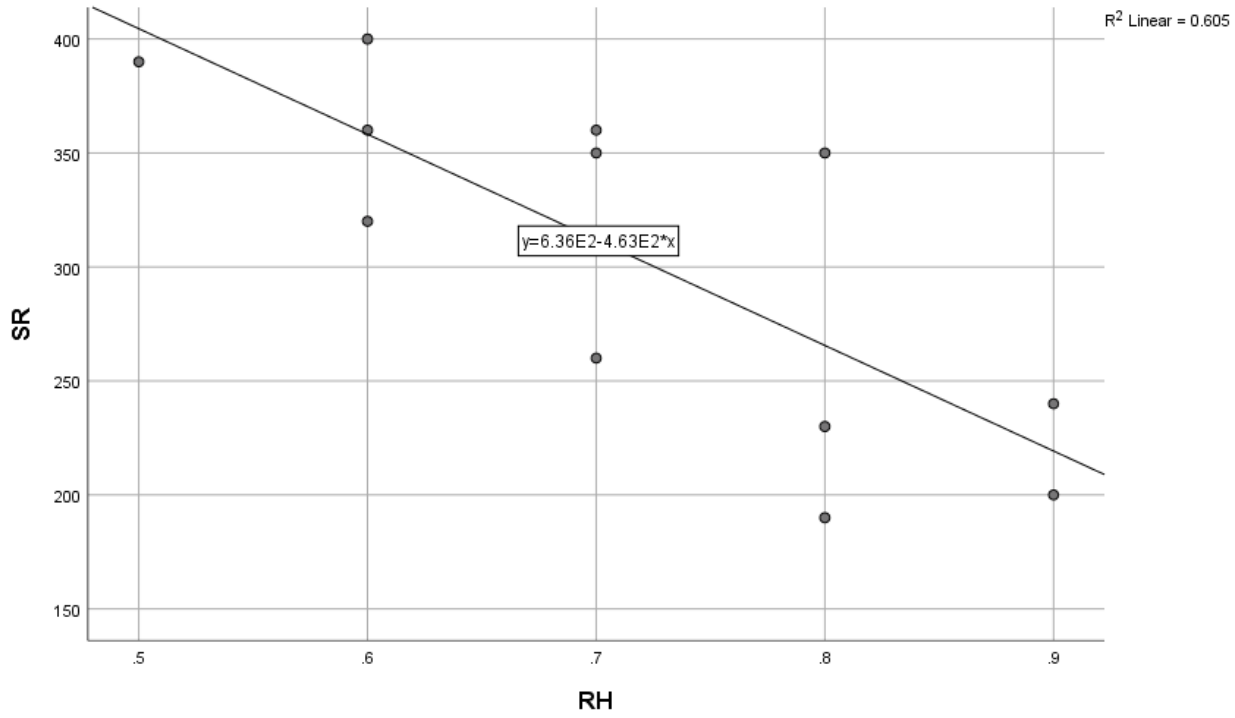


Figure 4. 5:Scattered diagram of solar radiation and relative Humidity of the year 2018

The analysis showed a negative correlation coefficient of approximately -0.347 between solar radiation and relative humidity. This indicates that an increase in relative humidity is associated with a decrease in solar radiation.

Although the relationship was weak to moderate, the negative correlation confirms that atmospheric moisture and cloud cover reduce the amount of solar radiation reaching the Earth's surface. During periods of high humidity, clouds absorb and scatter solar energy, resulting in reduced solar radiation intensity.

However, the relationship was not statistically significant at the 95% confidence level. This suggests that although solar radiation and relative humidity are inversely related, the relationship during the study period was relatively weak

The findings agree with studies by Xu C. et al. (2010), who reported that increased atmospheric humidity reduces solar radiation transmission due to cloud and water vapor effects.

5.0 CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study assessed the seasonal variations of solar radiation and relative humidity over Tororo District, Uganda using meteorological data collected from the TAHMO weather station for the years 2017 and 2018. The findings revealed that both solar radiation and relative humidity exhibited clear seasonal variations throughout the study period.

The results showed that solar radiation was highest during the dry months of January and February and lowest during the wet months of June and July. In contrast, relative humidity was lowest during the dry season and highest during the rainy season. This indicates that seasonal weather conditions greatly influence the distribution of solar radiation and atmospheric moisture in Tororo District.

Correlation analysis further revealed a negative relationship between solar radiation and relative humidity. As relative humidity increased, solar radiation decreased due to increased cloud cover and atmospheric moisture which reduce the amount of sunlight reaching the Earth's surface. However, the relationship was not statistically significant at the 95% confidence level

The study therefore concludes that seasonal variations climatic conditions strongly influence the distribution of solar radiation and relative humidity in Tororo district. These variations have important effects on agriculture, environmental conditions, and solar energy utilization within the district.

Overall, the findings of this study provide important information that can support climate monitoring, agricultural planning, renewable energy development, and climate adaptation strategies in Tororo District and other regions with similar climatic conditions.

5.2 Recommendations

Based on the findings of the study, the following recommendations was proposed:

1. The people of Tororo district should wear clothes such as hats, long-sleeved garments, sunglasses and sunscreen during months of intense solar radiation to minimize the harmful effects of excessive sun exposure.
2. The residents of Tororo districts should wear raincoats, gumboots and other waterproof protective gear to safeguard their health and maintain productivity despite changing weather conditions.

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