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# Overview of Climatic Effect with Respect to Cellular Networks in the Sub-Saharan Region: Nigeria in Perspective

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**Abstract:- In this review, it was determined that the weather conditions that affect cellular networks in the sub-saharan regions are temperatures, humidity, wind and precipitation. Then a study of each of these conditions was done to determine their effect on on Cellular Signal Strength Quality and Call Setup Success Rate (CSSR). In doing this, six related research works were studied and reviewed, and certain finding or conclusions were determined.**

**From this study, we can say that, the sub-Saharan region's high temperatures have a detrimental impact on cellular networks' RSSI; wind effectively attenuates received cellular signals within foliage environments, leading to fluctuations in received signals, particularly during high wind conditions; a decrease in signal strength parameters during rainfall at the user end of a cellular network; and, lastly, an increase in humidity in the sub-Saharan region, which was studied under the parameters of signal strength and CSSR, results in a decrease in signal quality.**

## I. INTRODUCTION

While climate refers to the long-term average of a particular region's weather, weather refers to the short-term atmospheric conditions of an area. Regarding this paper, the weather, or the climatic condition, is a significant engineering concern since it impacts the caliber of communications services. In most cases, weather variations can be measured with basic measuring tools or by tracking ensuing variations in a parameter that depends on the weather metric being tracked (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020). Measuring the quality of the radio link is one approach to accomplish this (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020)

Throughout the majority of the planet's inhabited regions, major telecom network providers have installed cellular phone and data networks (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020). Large-scale long-distance information communication in emerging nations is facilitated by these networks and cellular communications transmission infrastructure. Therefore, any impact on the network of cellular communication is vital.

The ever-changing weather conditions that many wireless networks operating outdoors are subject to potentially seriously deteriorate network signals and reliabilities (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020). Temperatures, humidity, wind, and precipitation are some of the weather factors that can impact telecommunication systems (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020). An overview of the impact of the aforementioned meteorological and climatic factors on call setup success rate (CSSR) and cellular signal strength quality was conducted in this article. A measure of the power in a received radio signal used in telecommunications is called the Received Signal Strength Indicator, or RSSI (Faleti, Nwanya, Njoku , Ikechukwu, & Dzah, 2020).

## II. REVIEWS

Temperatures, wind, precipitation, and humidity are the meteorological factors that impact telecommunication systems, as was mentioned in the previous section. Therefore, we will examine these conditions in further detail in this section.

### A. *Effect of Temperatures*

Given the reputation for high temperatures in Sub-Saharan Africa, it is critical to understand how these conditions impact RSSI. The authors in (Sabu, Renimol, Abhiram, & Premlet, A Study on the effect of Temperature on Cellular Signal Strength Quality, 2017) investigated how temperature affects cellular networks. Since cell phones are making the world a more connected place, cellular signal strength metrics are becoming increasingly important as parameters related to daily life. The effects of temperature on the quality of cellular signal strength were the main topic of the paper. The authors state that in the field of telecommunications, the Received Signal Strength Indicator (RSSI) is a measurement of the power present in a received radio signal. The study examined how temperature affects RSSI values and how that affects cellular communication networks. Temperature and signal strength were measured side by side over a region in order to investigate the impact of temperature on RSSI. While the temperature data was gathered using a specially designed weather station, the signal strength values were obtained using Android smartphones' Android Packaging Index (API). Stated differently, RSSI readings were obtained from a smartphone at various time intervals, and correlation analyses were carried out using the information gathered from the weather station and the cellphone.

**Table 1.** HORIZONTAL AND VERTICAL CORRELATION TABLE
(Sabu, Renimol, Abhiram, & Premlet, A Study on the effect of Temperature on Cellular Signal Strength Quality, 2017)

| No | Horizontal Co-relation of RSSI and Temperature | | | No | Vertical Co-relation of RSSI and Temperature | |
|---|---|---|---|---|---|---|
| | Date | Co-Relation | | | Time of the day | Co-Relation |
| 1 | 28/12/2016 | 0.819 | | 1 | 8am to 9am | 0.7646 |
| 2 | 29/12/2016 | 0.359 | | 2 | 12pm to 1pm | 1 |
| 3 | 30/12/2016 | 0.4513 | | 3 | 4pm to 5pm | 0.95154 |
| 4 | 31/12/2016 | 0.1741 | | 4 | 9pm to 10pm | 0.274351 |
| I | Horizontal Co-relation of Signal Strength Values with Surrounding Temperature | | | II | Vertical Co-relation of Signal Strength Values with Surrounding Temperature | |

According to the authors' observations, 50% of the samples from the vertical correlation studies showed a strong inverse linear relationship, and these samples were concentrated in the afternoon and evening. A weak positive correlation or no correlation at all was found in the remaining 50% of cases. They also noted that the first 50% of cases were the only ones in which temperature and signal strength values displayed an inverse linear relationship and were at all linearly related over the course of the study.

This leads to the conclusion that the high temperatures in the sub-Saharan region negatively impact cellular networks' RSSI.

### *B. Effect of Wind*

The impact of wind in an environment with a lot of vegetation was empirically assessed in (Alor, Okafor, & Abonyi, 2015). The research study field was selected in a hilly area near a dense forest in Nsude, near Enugu, Eastern Nigeria, which is thought to have a high level of vegetation. The researchers performed multiple field measurements for mild breeze, light breeze, and strong wind conditions at a specific location and time during their work. Two years were spent on the experiment. The gathered data was plotted and examined. According to the results, a strong wind can cause variations in the cellular network signal that are received, which can result in poor network receptions.

The project comprised a thorough empirical investigation of how various wind conditions affect the reception of signals on cellular networks. Quiet freeze, light breeze, and strong wind are the wind categories that were examined. After analyzing the data, they concluded that wind significantly reduces the amount of cellular signal that is received in a foliage environment. This results in fluctuations in the received signal, particularly in situations with high wind. Call drops occur if the situation worsens or lasts longer.

### *C. Effect of Precipitation (Rainfall)*

In (Sabu, Renimol, Abhiram, & B Premlet, Effect of rainfall on Cellular Signal Strength. A study on the variation of RSSI at user end of smartphone during rainfall, 2017), the impact of rainfall on cellular networks was investigated. The researchers claimed that rainfall is a worldwide natural phenomenon with a highly variable temporal and geographical distribution. Rainfall causes a loss in network quality for wireless communications, which can have a temporary negative impact on regional communication. Given that Nigeria is renowned for experiencing heavy rainfall—even to the point of flooding—cellular network providers may have concerns about rainfall. Concerns about climate change are becoming more and more pressing, which motivates research into how natural events like rainfall affect other quantifiable metrics. They investigated how rainfall affected the user's cellular signal strength, specifically the RSSI (Received Signal Strength Indicator).

Natural interference from rain can be a problem for microwave links that are transmitting radio waves. They obtained RSSI readings in real time from smartphones by using Signal Strength Android Application Programming Interface Keys, or APIs for short. With rain gauges, the intensity of the rainfall was measured. Upon analysis of these data, it was determined that rainfall causes a decrease in RSSI values relative to the all-day mean.

The study's researchers cited a different Robert A. Nelson paper ("Rain – how it affects the communications links", 2000), which claimed that rainfall attenuates electromagnetic signals that are transmitted between stations. Aside from losses in free space, it also results in power loss throughout the links. Raindrops scatter some of the incident energy out of the beam and absorb a portion of it. The attenuation that results increases with both the number and size of raindrops along the signal's path. In addition to producing water films on antennas, rainfall can lower the power of microwave signals. There are two ways that rain can impact electromagnetic signal transmission: The signal is polarized and attenuated as a result.

It was concluded that, at the user end of a cellular network, signal strength parameters decrease in the presence of rainfall. Studies using cellular towers have shown a marked drop in signal strength during rainy seasons, but they were unable to find a comparable drop at the user's end.

### *D. Effect of Humidity*

Calabar, Nigeria served as the research site for the study conducted in (Ewona & Ekah, , 2021). The work examined the impact of tropospheric variables on mobile network signals. Temperature and relative humidity were simultaneously measured using a digital thermometer/hygrometer, and log files of signal strength for each of the four networks were obtained using TEMS investigation software installed on a laptop. Weekly averages were calculated using the collected data. For every network, graphs showing the signal strengths versus the tropospheric variables were plotted; in each case, the dependent variable was the signal strength and the independent variable was the tropospheric variables. In order to better describe and comprehend how tropospheric variables affect the signal strengths of mobile networks operating in Calabar, correlation and regression analysis were also conducted.

The results demonstrate that temperature and relative humidity had an impact only on signals from the MTN network. For Glo, Airtel, and 9mobile, a weak correlation was found between tropospheric variables and signal strength. Similar studies were conducted in (Ekah & Onuu, 2022). In Cross River State, Nigeria, the study examines how four mobile networks—MTN, Airtel, Globacom, and 9mobile—account for call setup in relation to weather variables such as temperature, relative humidity, wind speed, and rainfall. The study used six years of Call Setup Success Rate (CSSR) data from the Nigerian Communication Commission (NCC), the telecommunications regulatory body, and six years of weather variable data from the Nigerian Meteorological Agency (NiMet), both spanning from January 2015 to December 2020. Plots of the gathered data were made, with the tropospheric variables acting as the independent variables and the CSSR acting as the dependent variable in each instance. Regression models were also developed in order to predict each network's CSSR, assuming that the tropospheric variable at each period is known. Ultimately, the variables were correlated to provide an image of the relationship between each tropospheric variable and the networks' CSSR. A weak negative correlation between temperature and relative humidity was found for the MTN network. The temperature result is consistent with the findings of the study carried out in (Sabu, Renimol, Abhiram, & Premlet, A Study on the effect of Temperature on Cellular Signal Strength Quality, 2017). There was a weak positive correlation for the Airtel network between temperature and CSSR. Relative humidity did, however, increase the success rate of call setups. Rainfall had very little effect on call setup on the Globacom network, but increases in temperature and relative humidity moderately decreased the number of successful call setups. Ultimately, a rise in temperature resulted in a moderate rise in call setup for the 9mobile network. Wind speed and relative humidity had very little impact on call setup. We can infer from the findings of (Ewona & Ekah, , 2021) and (Ekah & Onuu, 2022) that the sub-Saharan region experiences a decline in signal quality when humidity levels rise. This phenomenon was examined in relation to signal strength and CSSR.

## III. CONCLUSION

Four factors—temperature, humidity, wind, and precipitation—have been used to examine how the climate in Sub-Saharan Africa affects cellular networks. This overview study leads us to the following conclusions: rain causes a drop in signal strength parameters at the user end of a cellular network; high temperatures in the sub-Saharan region negatively impact RSSI of cellular networks; wind effectively imposes an additional attenuation on received cellular signal within foliage environment, causing fluctuations on received signal especially during strong wind conditions; and finally, increased humidity in the sub-Saharan region results in a decrease in signal quality, which was studied under the parameters of signal strength and CSSR.

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