DOI: https://doi.org/10.61841/3dn9t554 **Publication URL: https://nnpub.org/index.php/AS/article/view/2207**

THE IMPACT OF ALBEDO, CLOUD COVERS AND GLOBAL SOLAR RADIATION ON GLOBAL WARMING USING UYO COUNTY DATA, NIGERIA.

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ABSTRACT

Ways of countering the causes of global warming in the world involved all researchers. The impact of albedo, cloud covers and global solar radiation on global warming have been studied using atmospheric data from Uyo. The data was obtained from NIMET. The outcomes were achieved using Microsoft Excel and SPSS packages. The result obtained showed that albedo varies directly with cloud covers and indirectly with the surface temperature and global solar radiation. The mean values of albedo, cloud cover and global solar radiation are 0.5823 (about 58%), 72.25% and 15.22358 $MJm^{-2}day^{-1}$. The challenge of low performance of the solar energy systems from April to October is possible.

Uyo may be seen as an unvegetated land, devoid of snow according to this research outcome. Making Uyo a fully forested land, global solar radiation would increase, leading to a decrease in cloud cover. This practice would add to the possible way of resolving the challenge of global warming.

Keyword: *Albedo, Cloud Covers, Temperature, Extraterrestrial solar radiation and Global solar radiation, Warming*

INTRODUCTION

Energy availability for the past years has proved to be an important element to the development of any area, region or nation. The acceptance of Renewable Energy Systems (RESs) has already taken place in our lives. Solar energy is regarded as the feedstock or source for various applications, and thus, the knowledge of the intensity of the incident solar irradiance is essential for monitoring the performance of such systems. Solar energy is fast becoming an alternative to other conventional energy source (Akpabio and Etuk, 2005; Burari, and Sambo, 2001). The world-wide quest for renewable and sustainable energy has provided the spur for increased research in assessment and harnessing of solar energy in any given locality. The atmospheric condition in the southern part of Nigeria, mostly the rainforest belt has been changing yearly because of anthropogenic activities and global warming due to the negative impact of fossil fuel energy on humans and environment. The area has been posed with threat to life and global climate imbalances which affect net radiation, cloud covers, relative humidity and insolation among others. This area usually experienced rainy season from March to October and dry season from November to March (Atat et al., 2023a; 2023b; Atat and Umoren, 20216), but now it is not easily predictable; seasonal variations have developed a great concern for researchers on how to make better predictions

Babatunde et al. (2005) worked on simulated reflected shortwave radiation in Ilorin and observed 0.64 as its peak period of cloud in August; 0.38 was obtained in November as the lowest. In a similar work by Audu and Isikwue (2014), the albedo estimated from Makurdi has the highest value of 0.7 in August and 0.5 as lowest in November.

The main goal of this research is to assess the impact of albedo, clouds covers and global solar radiation on global warming. A lot of experimental works and modelling have already been conducted for determining solar irradiance in some locations. The major unpredictable factor in defining the solar irradiance and the performance of solar energy systems is the presence of cloud covers in the sky in which albedo depends. Albedo is a non-dimensional, unit less quantity that indicates how well a surface reflects solar energy; it varies between 0 and 1. Albedo commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white. A value of 0 also means the surface is a "perfect absorber" that absorbs all incoming energy (Coakley, 2003).

Location and Geology of the Study

Uyo is well known as the capital of Akwa Ibom State, Nigeria. It is one of the cities making up the Niger Delta region. (Figure 1). It lies within latitude $4^{0}55^{1}$N to $5^{0}05^{1}$N and longitude $8^{0}00^{1}$E to $7^{0}50^{1}$E (Atat et al., 2023a). The city has undulating nature and semi equatorial type of climate. The major vegetation belt noted in the area is fresh water swamp and rainforest (Atat et al., 2023a; Ekwere et al., 1994). The area is categorized as coastal plain sands which is the Benin Formation (Mbipom et al., 1996); this Formation edges the Agbada Formation. The Benin Formation is Oligocene and the youngest formation in the Niger Delta sedimentary basin (Atat and Umoren, 2016). Farmers engage in agricultural produce such as cassava, yam, vegetables and plantain among others. Abundant deposits of crude oil are seen. The dry and the wet seasons experienced in other Niger Delta cities (Atat et al., 2020a; Atat et al., 2023c; Ejoh et al., 2023) are also noted in Uyo. Longitudes 5°E and 8°E (Balogun and Obebe, 2013) and latitudes 3°N and 6°N defined the location of Niger Delta (Akpabio *et al.*, 2023a; Reijers *et al.*, 1996). For the month, the mean rainfall is approximately 0.135 m during wet season; to nearly 0.065 m in dry season (Atat et al., 2020a; George *et al.*, 2017; Akpabio, 2023b). The following researchers: Atat *et al.* (2020b), Umoren *et al.* (2020) and Atat et al. (2020c) have noted in their work that the sediment thickness in the region is about 500000km^{3}.

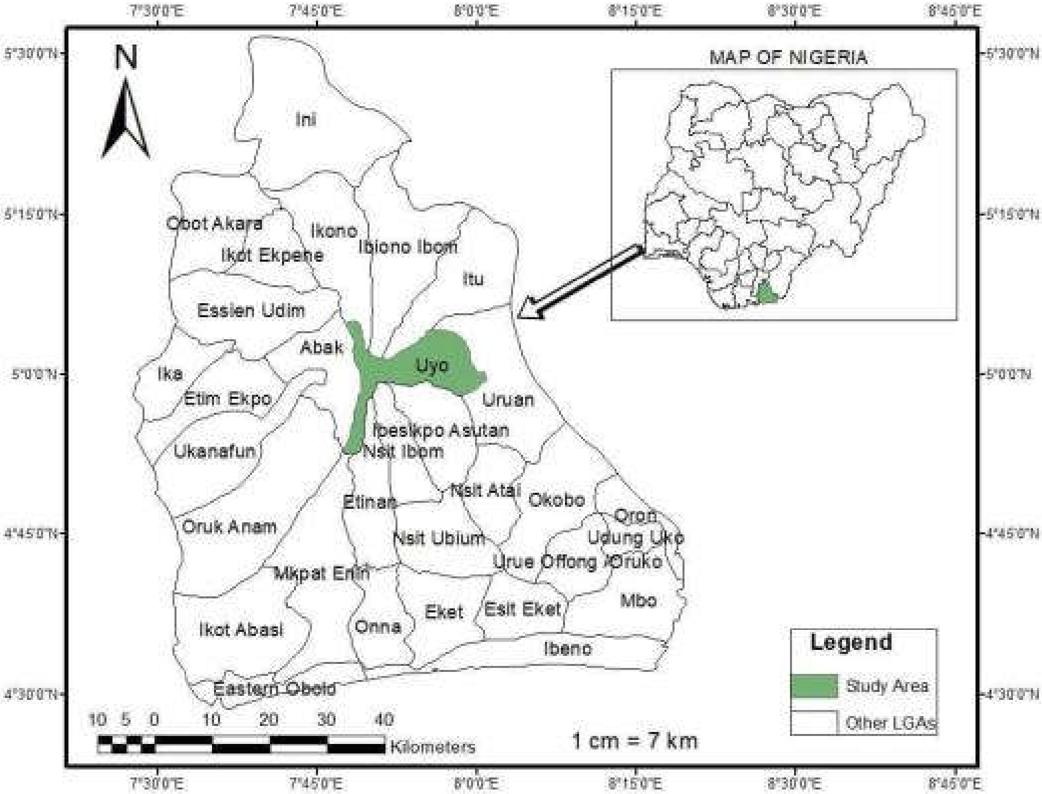

Figure 1: Map of Akwa Ibom State indicating Uyo location (Atat et al., 2023a; Okon *et al*., 2019).

MATERIALS AND METHOD

Materials

The data available for this research were the monthly mean values of maximum and minimum temperatures, relative humidity, dew point temperature, global solar radiation and cloud covers data. This data was obtained from the Nigerian Meteorological Agency (NIMET). It covers a period of twenty years (that is, from year 2000 to year 2020). With Microsoft Excel and SPSS software packages, statistical analysis, evaluation and computation were easily done accurately.

Method

Figure 2 summarizes the step-by-step approaches taken to arrive at the outcome.

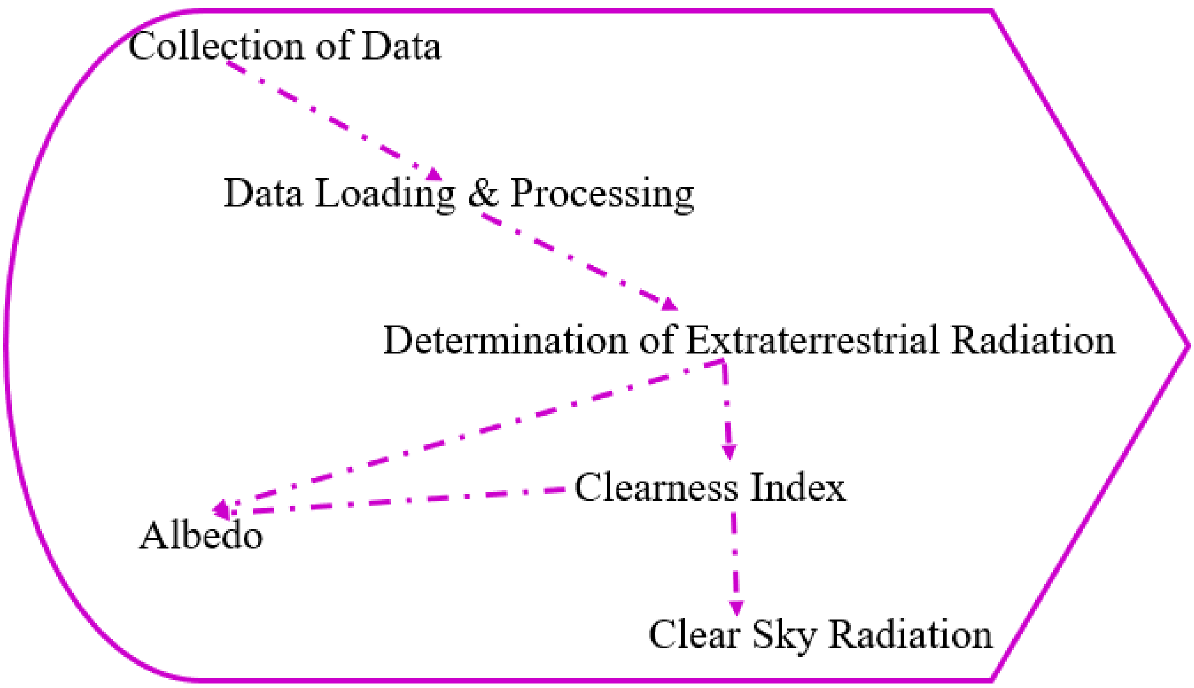

Figure 2: The Workflow of the Study

The solar radiation (H_m) data collected from NIMET in millimetres were converted to MJ/m^2day using a factor of 1.216 (Ododo, 1994). Values for monthly average extraterrestrial global radiation R_o were computed for the fifteenth day of each month (Klein, 1998). According to Duffie and Beckman (1991), Equation 1 is suitable for the determination of the mean of R_o.

$$R_0 = \frac{118.1088}{\pi}(1 + 0.033 \cos(0.9863d))\left(\frac{\pi}{180}\beta_s \sin\phi \sin\partial + \cos\phi \cos\partial \sin\beta_s\right) \quad (1)$$

$$\beta_S = \cos^{-1}(-\tan\Phi \tan\partial) \quad (2)$$

Where ϕ and ∂ are the latitude and declination angles respectively.

$$\partial = 23.45 \sin 360\left(\frac{d+284}{365}\right) \quad (3)$$

Where d is the characteristics day number for each month. For instance, d = 1 on 1st January to 365 on 31st December. d from January to December is given as, Jan = 15; Feb = 46; Mar = 74; April = 105; May = 135, June = 166; July, 196; August = 227; Sept. = 258; Oct. = 288; Nov. 319; Dec. = 349. The values of ϕ in the study areas are ϕ (Uyo) = lat 5.05°, ϕ (Cal) = lat 4.97°; ϕ (P.H) = lat 4.76°.

The monthly mean clear sky radiation (R_{so}) was obtained by inserting the value of station elevation (Z) and the corresponding extraterrestrial radiation (R_o) into equation (4).

$$R_{so} = (0.75 + 2 \times 10^{-5} Z) R_o \quad (4)$$

The albedo (α) may be determined using Equation 5 (Ahren et al., 2005).

$$\alpha = \frac{\left[1-\left(\frac{H_m}{R_o}\right)\right]R_o}{R_o} \quad (5)$$

Where R_o is extraterrestrial radiation; $\frac{H_m}{R_o}$ is the clearness index; the numerator of Equation 5 defines the reflected radiation (Coakley, 2003).

RESULTS AND DISCUSSIONS

Results

The results of this findings are really appreciable and its contribution to knowledge is enormous. Figure 3 presents the variation in the values of GSR, Cloud, Extraterrestrial radiation, Clearness index (purple) and Albedo with different Months. The outcome of Albedo, Global Solar Radiation and Cloud Cover which could influence Solar energy applications in Uyo in shown in Figure 4.

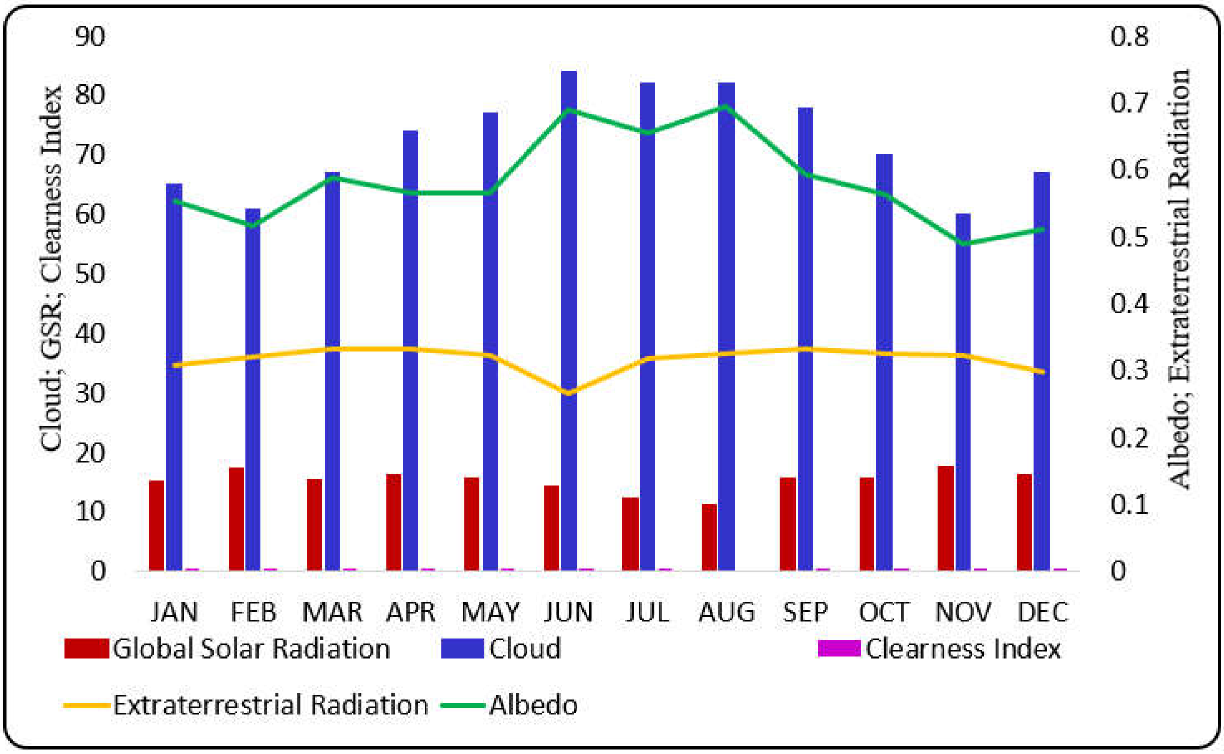

Figure 3: Outcome of Discrepancy of GSR (dark red), Cloud (blue), Extraterrestrial radiation (yellow), Clearness index (purple) and Albedo (green) with Months.

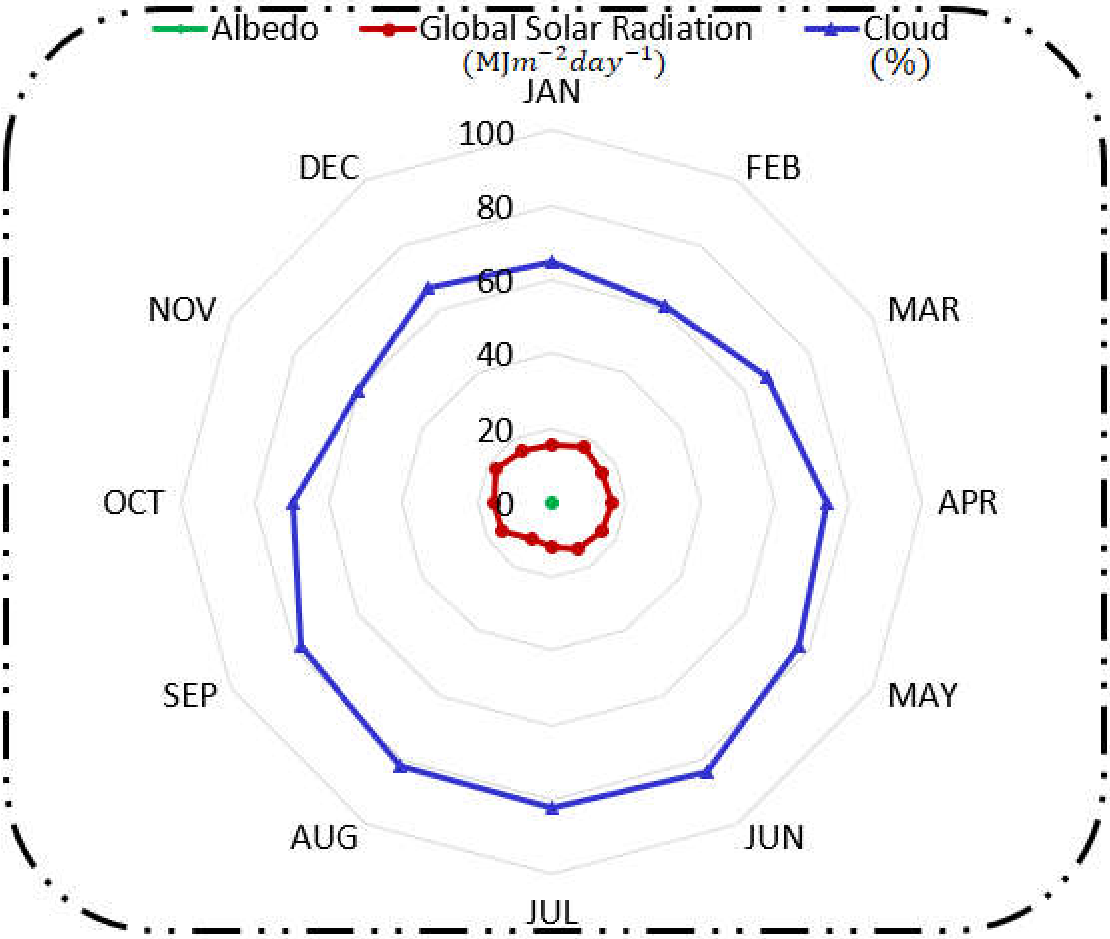

Figure 4: Radar presentation of the Variation of Albedo, Global Solar Radiation and Cloud Cover with Months.

Discussion

Employing Equations 1 to 5, the determination of necessary parameters was achieved. Equation 1 yields extraterrestrial radiation; Equations 2 and 3 were adequate to assessed the unknown variables in Equation 1. Equation 4 satisfied the determination of the mean clear sky radiation and albedo was calculated using Equation 5. The clearness index was determined using the ratio of the solar radiation to extraterrestrial radiation.

From Figure 3, the cloud peaks at about 84% in June although other values noted in April, May, July, August, September and October are about 70% and above (the picture of how the cloud approaches the 80% circumference within these months are presented in Figure 4), but less than the one noted in June. April to October is certainly the period of rainfall. The lowest cloud values are recorded in the months of February and November as 61% and 60% respectively. The values of cloud, Global Solar Radiation (GSR) and clearness index are read from the primary vertical (left) axis; the right one which is the secondary vertical axis presents the values of albedo, extraterrestrial radiation. Increase in albedo leads to a decrease in extraterrestrial radiation. Cloud also increases with albedo but reduces with increase in extraterrestrial radiation.

Solar energy depends on albedo or reflectivity of the surface; the outcome of this research shows that the mean value of albedo is 0.5825 (about 58%). It could be due to location, season and land cover type. This information classifies Uyo as an unvegetated ground devoid of snow [for albedo of unvegetated ground devoid of snow ranges from 0.1 to 0.6] If it were to be from 0.08 to 0.15, it would have been defined as fully forested land (http://www.britannica.com/science/climate-meteorology/climate-and-changes-in-the-albedo-of-the-surface; Petty, 2006; Liou, 2002; Rogers and Yau, 1989; Houze, 1993; http://www.britannica.com/science/climate-meteorology/climate-meteorology/Biosphere-impacts-on-precipitation-processes).

Cloud is the building up of tiny water droplets that are suspended in the atmosphere. When the energy of the sun enters the atmosphere, some of it is reflected off of clouds. Therefore, high cloud cover contributes to a cooling consequence as more radiation reflected result in the presence of less heat in the atmosphere, although the duration and type of cloud cover also affect temperature. Some of the radiation from sun pass through the clouds and heat up the ground. The ground emits that heat back to the sky. If there is thick blanket of clouds, some of that heat is absorbed by the cloud layer and makes the ground insulated. The absorption is due to greenhouse effect. Clouds consist of water vapour which act as a very strong green house gas. Greenhouse gases cause almost 50% of heat to be retained, contributing to warming. Albedo determines how much the incoming solar energy is immediately reflected to space. Albedo varies inversely with global solar radiation. This statement agrees with the findings of Audu and Isikwue (2014) and Asime and Don-Lawson (2024).

From this study, it implies that there will be a challenge of low performance of the solar energy systems from April to October. Albedo values are low during the dry season months (November to February). The global solar radiation values increases and the amount of sunshine increases due to less reflectivity. Williams (2016), Babatunde *et al*. (2005) and Audu and Isikwue (2014) realized this same information. As the clearness index increases, the reflectivity decreases. The higher the albedo, the lower the reflectivity.
If the albedo is reduced to within 0.08 and 0.15 by engaging in making Uyo a fully forested land, global solar radiation will increase, leading to a decrease in cloud cover. This practice would contribute to the possible way of resolving the challenge of global warming.

CONCLUSION

The impact of surface albedo, cloud covers and global solar radiation on global warming have been studied. Albedo varies inversely with global solar radiation and increases with cloud cover. The challenge of low performance of the solar energy systems from April to October is possible. The mean outcome of albedo defines Uyo as having an unvegetated ground devoid of snow. If the albedo is reduced to within 0.08 and 0.15 by engaging in making Uyo a fully forested land, global solar radiation will increase, leading to a decrease in cloud cover. This practice would contribute to the possible way of resolving the challenge of global warming.

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