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Estimation Of Global Solar Radiation (GSR) Over Biratnagar, Morang, Nepal

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Abstract

Solar energy is a renewable source of energy that can be accessed in any geographical place where electricity and other renewable energy sources are inaccessible. In our country, more than half of people still depend on wood, coal, and petroleum for energy, which causes health issues and destroys the environment. Analytical and accurate data related to global solar radiation is essential for harvesting solar energy, which can play an important role in reducing the use of other nonrenewable energy sources. In this study, we calculated Global Solar Radiation (GSR) using the Angstrom-Prescott model, compared it with the measured value using a CMP6 pyranometer, and showed the relation of GSR with some meteorological parameters. The maximum value of GSR 27.443 $MJ/m^2/day$ was observed on May 09, and the minimum value was 2.542 $MJ/m2/day$ on $September$ 23. We have seen a positive correlation of GSR with sunshine duration and air temperature but a negative correlation with relative humidity, rainfall, and atmospheric pressure. Maximum GSR is found in spring and minimum in winter due to fog, minimum sunshine duration, and high maximum relative humidity. Empirical constants $a = 0.28$ and $b = 0.58$ were obtained using Tiwari and Sangeeta models. The accuracy and performance of the applied Angstrom-Prescot model are tested using statistical tools like $RMSE$, MBE, MPE, MAE, R, and R^2.

Keywords: Solar energy, Meteorological Parameter, Global Solar Radiation (GSR), Sunshine Hours

Introduction

Energy is essential to all living organisms, for their existence depends upon energy. To light a bulb to launch a rocket, we need energy. There are mainly two types of energy that are available on Earth, and they are renewable energy (like energy derived from solar, wind, ocean, hydropower, biomass, and geothermal resources) and nonrenewable energy (like energy derived from petroleum, hydrocarbon gas liquids, natural gas, coal, and nuclear energy). Conventional energy systems, like fossil resources, produce severe environmental damage, like global warming, pollution, and health hazards, and they are expensive. So we need some sustainable and best energy source, which is solar energy [C. Pandey and Katiyar, 2013]. Solar energy powers all atmospheric processes. Solar energy, available as electromagnetic radiation and being renewable, is the world's cheapest and fastest-growing energy source.

Nepal is a mountainous and landlocked country with an area of 147, 516 $sq.km$ located between latitude 260^o and 310^o N and longitude 800^o and 890^o E. Sunshine hours in Nepal condition are about 2100 *hours per year*, and average solar radiation varies from 3.63 - 6.2 $kWhm^{-2}/day$ with an average solar insolation intensity of about 16.92 $MJ/m2/day$, which is favourable insolation [K. R. Adhikari, Gurung, et al., 2013]. According to the NEA report in FY 2020/21, 85 % of total households are using electricity, but still, in rural areas till now, people mainly depend on fossil resources. Every year, demand for energy increases; for example, in FY 2020/21, the energy consumption was 7319 Gwh, which is higher than the corresponding figures 6529 Gwh in the year 2019/20. Biomass, hydroelectricity, petroleum products, natural gas, and coal are the primary energy resources in Nepal. In city areas, people use electricity as their primary energy source. However, due to geographical challenges and lack of knowledge, people in rural areas are still far from using clean energy. Due to geographical difficulties and a low energy budget, it will be hard to provide hydroelectricity to all places shortly. It is hard to start big hydropower projects because of several problems like landslides, sedimentation, damaged aquatic life, changes in the ecosystem, and deforestation. The use of a nonrenewable source of energy affects the environment badly and costs a lot. So the use of solar energy can be the alternative to hydroelectricity and other sources of energy in our country due to its cheap, safe, eco-friendly nature and can be installed at any location, i.e., less geographical challenge in comparison to hydroelectricity [NEA, 2021].

Solar radiation is the electromagnetic energy radiated from the sun to the Earth's surface. A tiny portion of solar radiation on the Earth's surface is due to partial scattering and absorption by the Earth's atmosphere. Global solar radiation is the sum of direct and diffuse radiation on the Earth's surface. Direct solar radiation is the radiation arriving on the ground directly in line with the solar disk and is called direct or beam radiation. Diffuse solar radiation is scattered in the atmosphere that comes into the Earth's surface; reflected solar radiation is the radiation that reaches the Earth's surface but is reflected by the atmospheric constituents. The factors that attenuate the global solar radiation before reaching the Earth's ground are clean, dry air, water vapour, aerosols, air molecules, and dust particles [Ekpe and Nnabuchi, 2012; Iqbal, 2012; Sridharan, 2023].

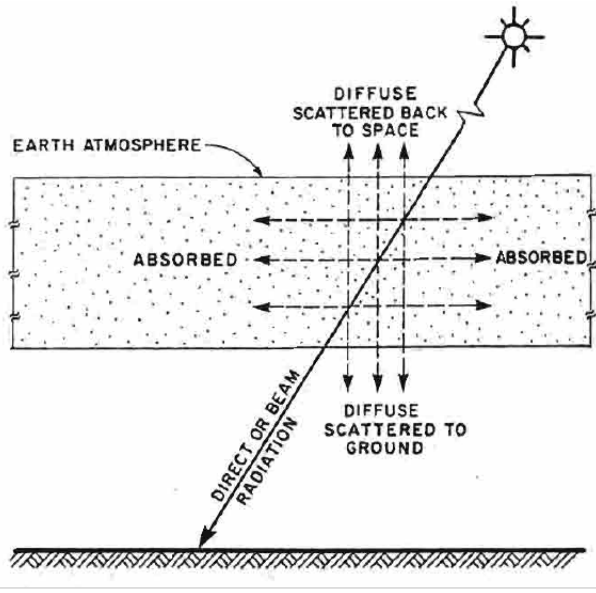

Figure 1: Distribution process of solar radiation on earth's surface [Iqbal, 2012].

The GSR depends on various meteorological factors like rainfall, relative humidity, air pressure, and temperature. Other factors like latitude, sunshine duration, solar declination, solar zenith angle, and Earth's atmosphere also affect GSR. Our main work is to find out the relation of GSR with various meteorological factors and calculate the GSR using sunshine hours in Biratnagar, Morang, in the year 2020.

Objective

Following are the objectives of our work:
• To estimate the Global solar radiation
• To study the impact of meteorological parameters on Global solar radiation

Materials and Methods

The daily data of GSR, air pressure, air temperature, rainfall, and relative humidity on a horizontal surface for Biratnagar, Mornag, for the year, 2020 were collected with the help of the Department of Hydrology and Meteorology, Government of Nepal [Department of Hydrology and Meteorology, 2020]. For analysis and calculation, we have used Excel, Origin software, and Python for analysis and calculation.

Study Area

We have collected data from the Department of Hydrology and Meteorology, Dharan, but the site of my research is Biratnagar, which lies in Morang district located at latitude 26.4525^o N and longitude 87.2718^o E and 80 m above the sea level. It is about 405.2 km east of the national capital, Kathmandu. The climate of Biratnagar is tropical, foggy, and icy in winter but sweltering and humid in summer. The average rainfall here is around 1670 $mm\ per\ year$, and the average annual temperature is about $24.2^o\ C$ [Wikipedia, 2020].

Description of Sensors

The solar radiation on the horizontal surface was measured using a CMP3 thermopile-type Pyranometer with an operating temperature between $-40^o\ c$ and $80^o\ C$ and a spectral range from 300 nm to 2800 nm. The sensitivity and field of view are 5 to 20 $\mu V/W/m^2$ and 180^o, with daily uncertainty of < 10 %. Relative humidity, air temperature, rainfall, and air pressure were measured using a hygrometer, air temperature sensor, manual rain gauge, and barometer. The barometer range and air temperature sensor are between 500 to 1100 $haPa$ and -30 to $800^o\ C$ with a resolution of 0.1 $haPa$ and a resolution of $0.010^o\ C$, respectively, with the accuracy of an air temperature sensor of about $\pm 0.10^o\ C$.

Theoretical Approach

This research is based on two models, the Angstrom-Prescott model and the Tiwari and Sangeeta model, to estimate GSR on the horizontal surface of Birantagar with the help of sunshine duration and latitude [K. R. Adhikari, Bhattarai, et al., 2013; Awasthi and Poudyal, 2018; Iqbal, 2012; Makade et al., 2021; Tsung and Go, 2020]. According to the Angstrom-Prescott model, the monthly average daily GSR on the Horizontal surface (H) is

$$\frac{H}{H_o} = a + b * (\frac{n}{N}) \tag{1}$$

Where,
H = monthly average daily GSR on the Horizontal surface (in $MJ/m^2/days$)
H_o = monthly average daily extraterrestrial radiation (in $MJ/m^2/days$)
a and b = regression constant
n = Sunshine Duration per month (in hours)
N = Monthly average of calculated sunshine hours per day (in hours)
The regression coefficients a and b are estimated by using the Tiwari and Sangeeta model

$$a = -0.11 + 0.235 * cos(\phi) + 0.323 * \frac{n}{N} \quad (2)$$

$$b = 1.45 - 0.553 * cos(\phi) - 0.694 * \frac{n}{N} \quad (3)$$

The extraterrestrial solar radiation (H_o) on a horizontal surface is

$$H_o = \frac{24}{\pi} * I_{sc} * E_o * [\frac{\pi}{180} * w_s * \sin\phi * \sin\delta + \cos\phi * \cos\delta * \sin w_s] \quad (4)$$

Where,
Eccentricity correlation factor(E_0) = $1 + 0.33 * \cos\frac{360*N}{365}$
Solar Declination (δ) $= 23.45 * \sin(\frac{360*(N_d+284)}{365})$
N_d = number of days on a specific date (for example, on January 26, there are 26 days, and on October 10, there are 284 days)
Hours angle (w_s) $= \arccos[-\tan\phi * \tan\delta]$
Monthly average of calculated sunshine hours per day(N)= $\frac{2}{15} * w_s$
Solar constant(I_{sc}) = $1367Wm^{-2} = 4.92MJm^{-2}/day$
Latitude of study area = ϕ

Calculations

Based on the above theory and formula, the following calculations which are in Table .

Solar declination (δ) and hour angle (w_s) are calculated in degree, measured sunshine duration (n) and calculated sunshine duration (N) in hour and measured GSR (H_m) and calculated GSR (H_c) are in MJm^{-2}/day.

To measure the accuracy of the model, we calculated the deviation of measured GSR from calculated GSR using statistical parameters, such as $RMSE$, MBE, MBE, MAE, coefficient of regression(R), and the coefficient of determination(R^2) [H. Adhikari and Pantha, 2022; Makade et al., 2021; B. Pandey et al., 2019; Sridharan, 2023].

- **Root Mean Square Error ($RMSE$) =** $\sqrt{\sum_{i=1}^{n} \frac{((H_c)_i-(H_m)_i)^2}{N}}$
- **Mean Bias Error (MBE) =** $\sum_{i=1}^{n} \frac{((H_c)_i-(H_m)_i)}{N}$
- **Mean Percentage Error (MPE) =** $\sum_{i=1}^{n} \frac{\frac{((H_m)_i-(H_c)_i)}{(H_m)_i}}{N}$
- **Mean Absolute Error (MAE) =** $\sum_{i=1}^{n} \frac{|((H_c)_i-(H_m)_i)|}{N}$

Date	n	δ	W_s	N	E_0	H_o	a	b	H_c	H_m
Jan	4.124	-21.121	78.894	10.519	1.032	23.208	0.227	0.682	10.421	9.713
Feb	7.488	-13.152	83.299	11.106	1.023	27.606	0.319	0.485	16.947	15.075
Mar	9.685	-1.949	89.025	11.87	1.008	32.963	0.364	0.388	22.002	19.595
Apr	8.406	9.856	94.984	12.665	0.992	37.419	0.316	0.491	22.407	20.298
May	7.014	19.036	99.908	13.321	0.977	39.901	0.271	0.588	21.208	19.078
Jun	5	23.113	102.281	13.637	0.968	40.657	0.219	0.699	17.611	16.238
Jul	4.044	20.933	100.99	13.465	0.968	40.091	0.197	0.746	15.443	14.4
Aug	6.081	12.967	96.604	12.551	0.977	37.991	0.253	0.626	19.596	18.297
Sep	2.879	2.197	91.098	12.146	0.991	34.299	0.177	0.79	10.756	10.928
Oct	6.899	-10.533	84.668	11.289	1.009	28.657	0.298	0.529	15.985	16.078
Nov	7.214	-19.275	79.962	10.662	1.024	24.113	0.348	0.423	15.012	14.412
Dec	6.306	-23.125	77.7187	10.362	1.032	23	0.312	0.498	13.024	11.027
Average							0.28	0.58	16.701	15.428

Table 1: Climatic parameters for Biratnagar, Morang

Results and Discussion

In this section, we discuss the relationship between GSR and different meteorological parameters like air pressure, air temperature, relative humidity (RH), sunshine hour, and rainfall. We also study the daily, monthly, and seasonal variations of the GSR of Birantagar, Morang, in the year 2020.

Daily Variation of GSR

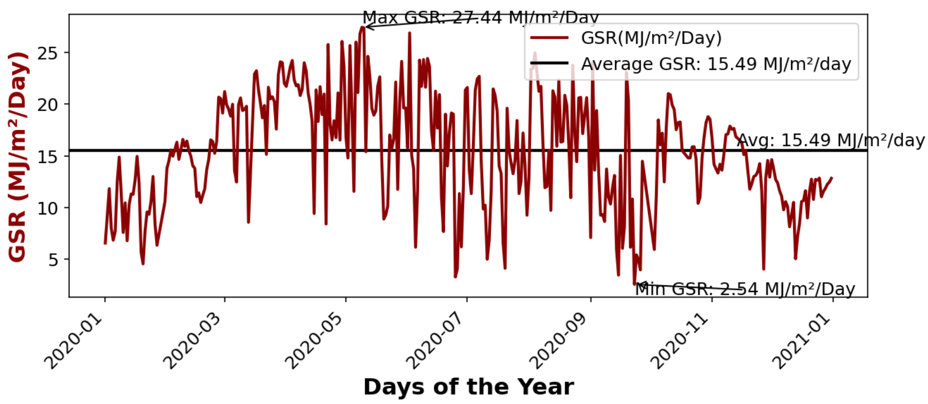

Figure 2: Daily Variation Of GSR

Figure 2 shows the daily variation of global solar radiation in the measuring site, i.e., Birantagar. As we have seen from the graph, there is a continuous increase of GSR and has a maximum value of 27.443 $MJ/m^2/day$ on *May* 09 because, with the ending of the winter season, relative humidity reduces, which influences the GSR and then starts to decrease with some fluctuations due to local climate and the minimum value 2.542 $MJ/m^2/day$ occurs on *September* 23 due to heavy rainfall, a drop in temperature, a rise in air pressure, and minimum sunshine hours.

Monthly Variation of GSR

The graph for the monthly variation of GSR is shown in Figure 3. As we can see, the global solar variation is minimal in $January$, $September$, and $December$ with values 9.713 $MJ/m^2/day$, 10.928 $MJ/m^2/day$, and 11.027 $MJ/m^2/day$, respectively, due to fog and cloudy days. And maximum in $April$, $March$, May, and $August$ with values 20.298 $MJ/m^2/day$, 19.595 $MJ/m^2/day$, 19.078 $MJ/m^2/day$, 18.297 $MJ/m^2/day$, respectively, due to a more clear sky and less aerosol.

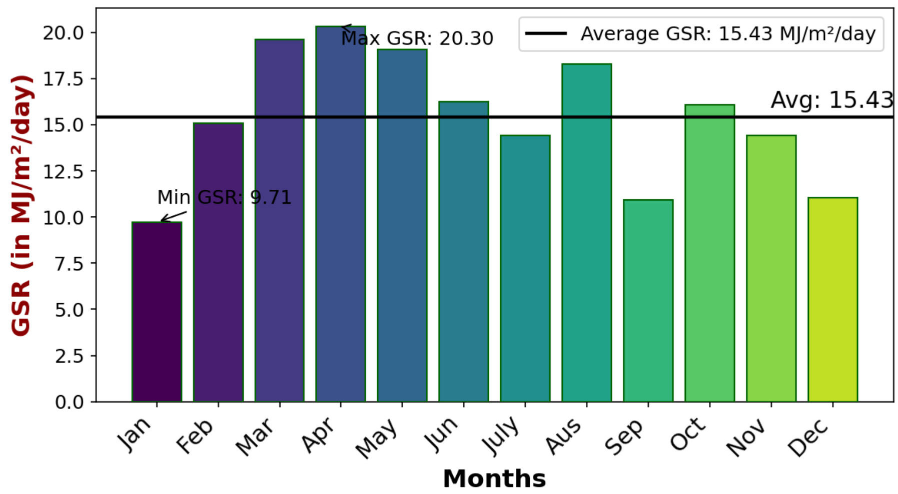

Figure 3: Monthly Variation of GSR

Seasonal Variation of GSR

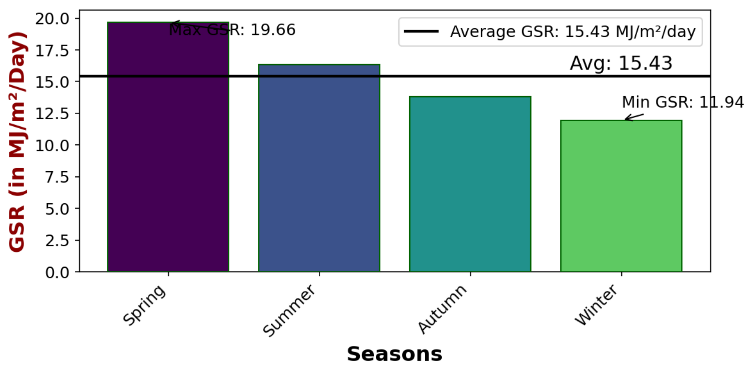

Figure 4: Seasonal Variation Of GSR

As given in Figure 4, global solar radiation on the horizontal surface is maximum (19.657 $MJ/m^2/day$) in spring and minimum (11.938 $MJ/m^2/day$) in winter. In spring, there is a more transparent sky, less aerosol, and minimum relative humidity, which means there are fewer radiation-absorbing and scattering parameters present in the atmosphere. Still, fog and cloudy skies with high relative humidity attenuate the sun's radiation in winter, so global solar radiation becomes minimal.

Monthly Variation of GSR With Sunshine Duration

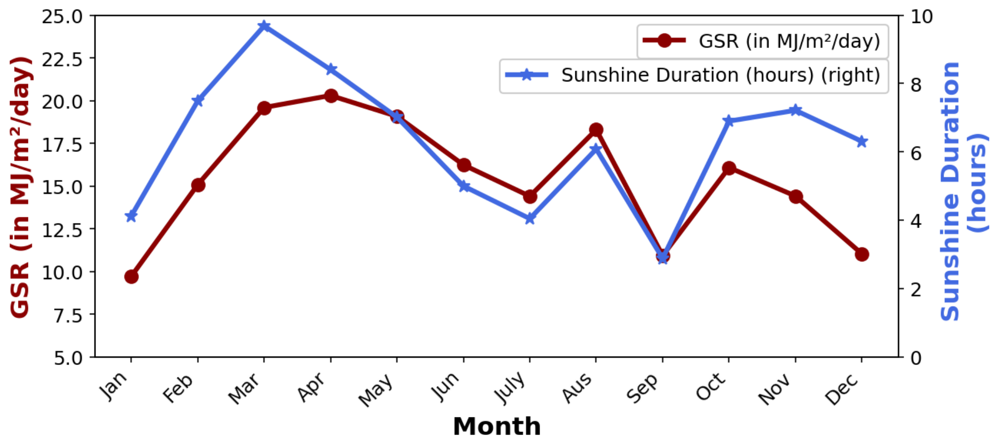

Figure 5: Monthly Variation of GSR With Sunshine Duration

Figure 5 shows the relation between global solar radiation and sunshine duration. As we can see at the start, sunshine hours are minimal and gradually increase with time, and GSR is also increasing. Sunshine hours decrease after reaching their maximum value, and GSR also decreases. It shows a positive correlation between sunshine hours and global solar radiation on the horizontal surface. The sunshine hours are a maximum of 9.685 $hours/day$ in $March$ and a minimum of 2.879 $hours/day$ in $September$. This minimum sunshine duration in $September$ is due to heavy rainfall, and the maximum in March is due to clear skies. The total annual sunshine hours in Birantagar are about 6.41 $hours/day$, which shows that Birantagar has enormous potential for solar farming and producing solar energy.

Monthly Variation of GSR With Relative Humidity

Relative humidity (RH) is a ratio of the amount of atmospheric moisture present relative to the amount present if the air were saturated, expressed in percentage. Figure 6 is the graph between global solar radiation and relative humidity. The chart shows an inverse relation between GSR and relative humidity. As RH decreases from the starting point, GSR increases. It has a maximum value of 20.298 $MJ/m2/day$ in $March$ when there is a minimum relative humidity value of 63.624%. RH value signifies water vapour present in the atmosphere, and maximum RH value means maximum water drops in the atmosphere, which act as a good absorber and reflector of radiation. Hence, the GSR value depends upon the quantity present in the atmosphere. Maximum RH value is found in $September$ 87.681%, however, here, the value of GSR becomes minimum but not lowest because of other local climate conditions.

Daily Variation of GSR With Average Air Temperature

The nature of global solar radiation variation with air temperature is given in Figure 7. As we see, GSR gradually increases with some fluctuations along with air temperature. Still, there is a decrease in global solar radiation between $June$ and $September$ due to rainfall and a decrease in pressure. After that, both GSR and air temperature decrease after reaching their peaks. The maximum temperature $33.55^o\ C$ is on $August$ 04, in which GSR is also maximum 24.964 $MJ/m2/day$ and minimum on $January$ 22 with minimum value 4.528 $MJ/m2/day$ of GSR.

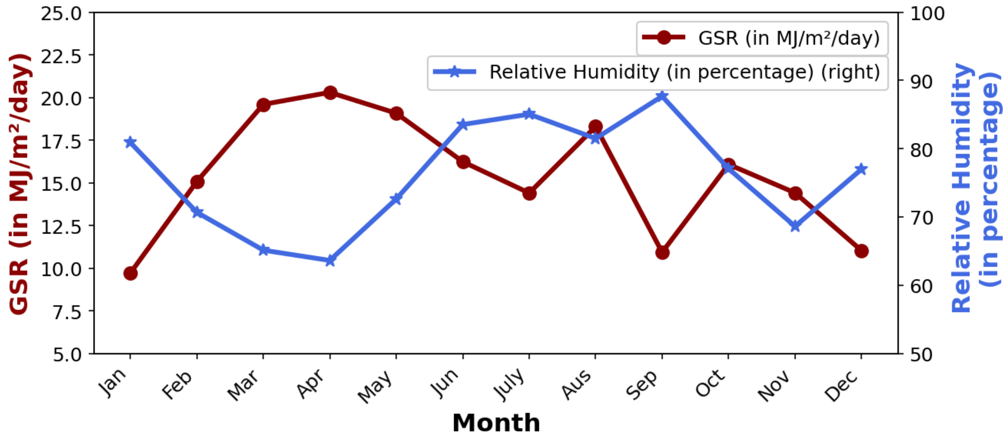

Figure 6: Monthly Variation of GSR With Relative Humidity

This shows a positive correlation between global solar radiation and air temperature. Also, we see that the fluctuation in temperature is more in winter, i.e. $9.15^o\ C$ than in summer, i.e. $7^o\ C$.

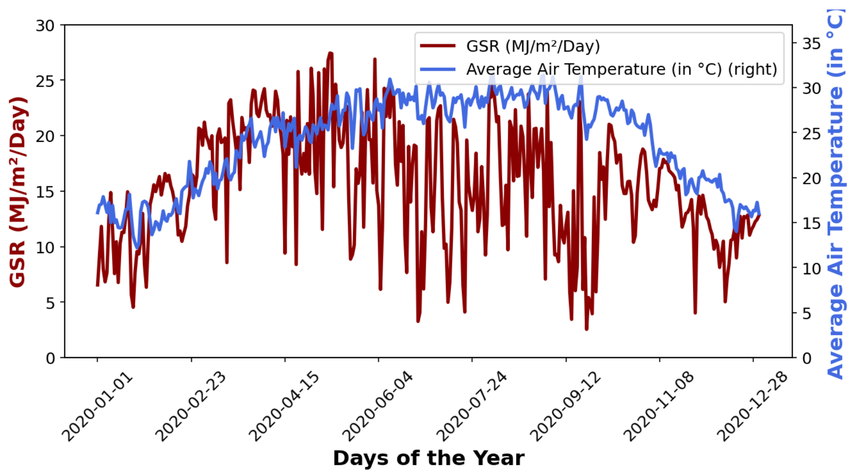

Figure 7: Daily Variation Of GSR With Average Air Temperature

Daily Variation of GSR With Average Rainfall

As we see from Figure 8, there is an inverse relationship between average rainfall and global solar radiation. There is a drop in GSR when rainfall occurs, as we see from the graph. The heaviest rainfall, 125 mm, occurred on $September$ 24, when GSR dropped to its lowest value of 2.542 $MJ/m2/day$. This is because water drops in the atmosphere attenuate solar radiations due to rainfall, and the duration of sunshine is also affected by rainfall due to clouds in the sky. So, there is an inverse relationship between global solar radiation on the horizontal surface and rainfall. In Birantagar, annually, 7.289 mm of rainfall occurs on average, so Birantagar is best for agriculture and solar energy production.

Daily Variation of GSR With Air Pressure

The diurnal variation of global solar radiation with air pressure is given in Figure 9. The pressure exerted by the weight of air in the atmosphere is called air pressure, and it depends

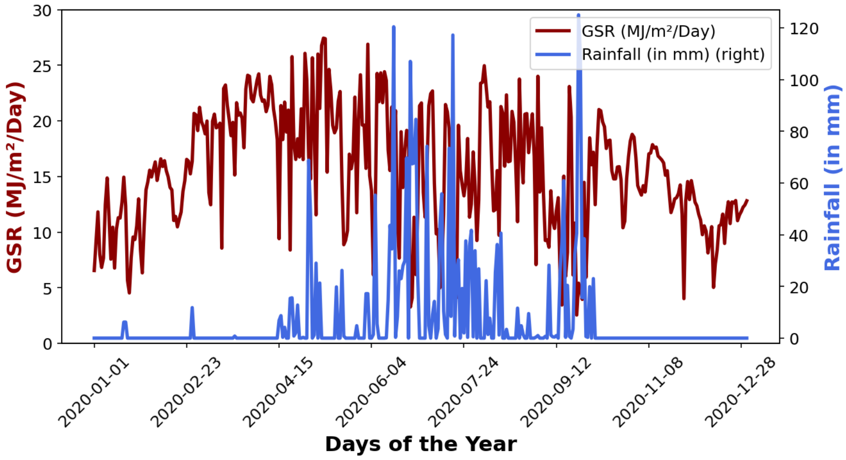

Figure 8: Daily Variation Of GSR With Average Rainfall

on gravitational force. High pressure means a high amount of air molecules present in the atmosphere. That means many air particles are present to absorb or scatter radiation, decreasing global solar radiation. As we can see in the graph, there is a decrease in air pressure with the days, but GSR increases. However, after some lowest value, pressure rises, and global solar radiation decreases. In the lowest value of air pressure 995.92 hPa on $August$ 04, there is the high value of GSR 24.964 $MJ/m^2/day$, but in the high value of air pressure 1021.125 hPa on $January$ 02, GSR is low, i.e. 9.211 $MJ/m^2/day$. This shows a negative correlation between global solar radiation and air pressure. The annual air pressure of Birantagar in 2020 is 1008.984 hPa, and the fluctuation in air pressure is about 25.205 hPa.

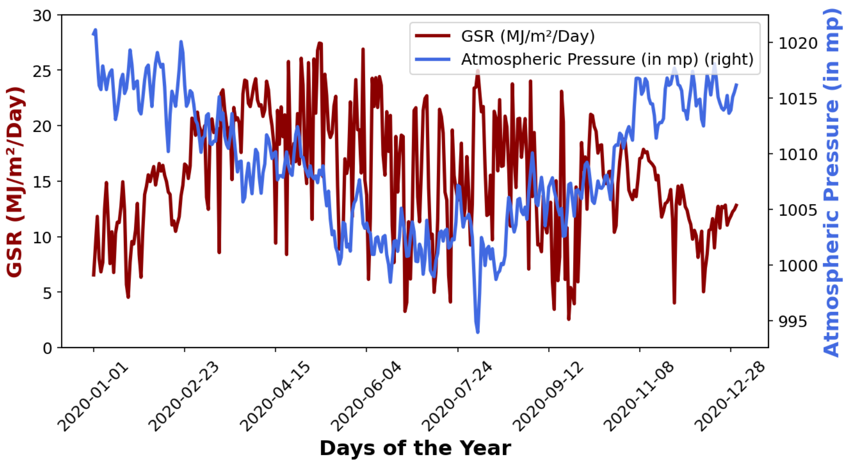

Figure 9: Daily Variation Of GSR With Air Pressure

Study of Empirical Model, Coefficient of Regression (R), Coefficient of Determination(R^2)

This research is based on two models: the Angstrom-Prescot model to calculate global solar radiation on horizontal surfaces and the Tiwari and Sangeeta model to calculate empirical constants a and b, which are 0.28 and 0.58. We use this empirical value in equation (1) to predict the value of global solar radiation.

$$\frac{H}{H_o} = 0.28 + 0.58 * (\frac{n}{N_d}) \tag{5}$$

Here, $\frac{H}{H_0}$ gives the clearness index, which signifies the sky condition, i.e., cloudy or clear, so a high clearness index means a clear sky condition, which means global solar radiation on the horizontal surface is high. The regression coefficient (R) and coefficient of determination (R^2) were estimated using linear best fit using XM-grace and Python software, whose values are 0.96 and 0.92, respectively. The plot between measured clearness index ($\frac{H_m}{H_0}$) vs calculated clearness index ($\frac{H_c}{H_0}$) is given Figure 10.
Overall atmospheric transmission for an overcast sky condition i.e. $\frac{n}{N}$ = 0 is signified by emperical constant (a and b) is the rate of increase of ($\frac{H_c}{H_0}$) with $\frac{n}{N}$. The regression coefficient (R) and coefficient of determination (R^2) explain the relation between independent and dependent variables. For our case, R = 0.96 means a positive correlation exists between independent and dependent variables, and 96 % the independent variables give the value of dependent variables. The values of R and R^2 lie between 0 and 1.

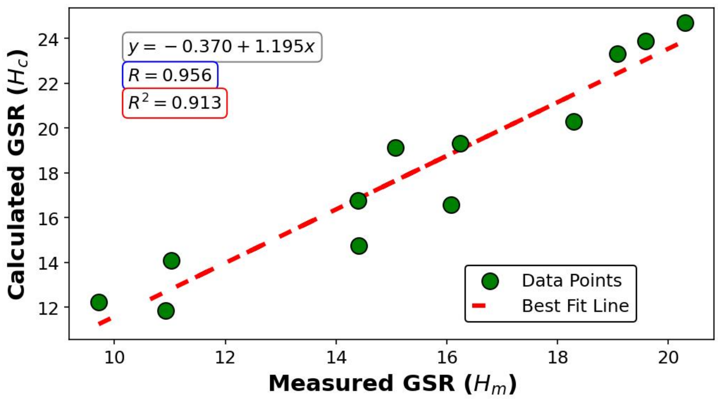

Figure 10: Graph between Measured clearness index($\frac{H_m}{H_0}$) vs Calculated clearness index($\frac{H_c}{H_0}$)

Error Analysis

The error means a lack of accuracy due to the instrument or the model. Here, we found some errors in our experimental data. The deviation of measured and calculated global solar radiation is calculated using some statistical parameters, which are given in the Table .

RMSE (MJ/m^2)	**MBE** (MJ/m^2)	**MPE** (%)	**MAE** (MJ/m^2)
1.523	1.273	-8.04	1.317

Table 2: Statistical tools

The actual value of RMSE used to be zero or near zero, but in our calculation, it came up with 1.523 MJ/m^2, which shows a deviation of measured GSR values from calculated GSR values. We also calculated other factors like MBE, MPE, and MAE with values 1.273MJ/m^2, – 8.04 %, 1.317 MJ/m^2 respectively.

Conclusions

In this study, based on Angstrom-Prescot and Tiwari and Sangeeta models, we have calculated global solar radiation and empirical constants and compared them with the measured value and tried to find the relation of GSR with different meteorological parameters like relative humidity, rainfall, air temperature, and air pressure in the year 2020 of Birantagar. GSR's maximum and minimum values are 27.443 $MJ/m^2/day$ and 2.542 $MJ/m^2/day$ on May 09 and $September$ 23, respectively. The plot of daily variation of GSR with meteorological parameters shows a positive correlation of GSR with Sunshine Duration and air temperature. Still, it negatively correlates with relative humidity, rainfall, and atmospheric pressure. As shown in the figures, this fluctuation of GSR is due to variations in the zenith angle, the earth's revolution, and atmospheric conditions. The accuracy and performance of the applied Angstrom-Prescot model are tested using some statistical tools, which are $RMSE$, MBE, MPE, MAE, R, and R^2 with values 1.523 $MJ/m^2/day$, 1.273 $MJ/m^2/day$, -8.04 %, 1.317 MJ/m^2, 0.96, and 0.92 respectively. We have also seen a variation of GSR with seasons and found that there is a minimum global solar radiation value in the winter season due to fog and fewer sunshine hours, but due to a clear sky, fewer aerosols, air particles, and water drops are present in the atmosphere in the spring season, so maximum solar radiation can be obtained. The annual air temperature, rainfall, sunshine duration, and global solar radiation are 24^o C, 7.289 mm, 6.4 $hours/day$, and 15.49 $MJ/m^2/day$, which shows Birantagar is suitable for harvesting solar energy, agriculture, as well as tourism.

References

Adhikari, Homchandra and Nurapati Pantha (Sept. 2022). "Estimation of Global Solar Radiation (GSR) From the Sunshine Hour of Guranshe, Surkhet, Nepal." In: *BIBECHANA* 19, pp. 150–159. DOI: 10.3126/bibechana.v19i1-2.46408.

Adhikari, Krishna R, Binod K Bhattarai, and Shekhar Gurung (2013). "Estimation of global solar radiation for four selected sites in Nepal using sunshine hours, temperature and relative humidity." In: *Journal of Power and Energy Engineering* 1.03, p. 1.

Adhikari, Krishna R, Shekhar Gurung, and Binod K Bhattarai (2013). "Solar energy potential in Nepal and global context." In: *Journal of the Institute of Engineering* 9.1, pp. 95–106.

Awasthi, Janaki and Khem Narayan Poudyal (2018). "Estimation of global solar radiation using empirical model on meteorological parameters at Simara Airport, Bara, Nepal." In: *Journal of the Institute of Engineering* 14.1, pp. 143–150.

Department of Hydrology and Meteorology (2020). *Climate Data for Biratnagar*. https://www.dhm.gov.np. [Online; accessed June 2021].

Ekpe, JE and MN Nnabuchi (2012). "Solar radiation in Onitsha: A correlation with average temperature." In: *Scholarity Journals of Biotechnology* 1.5, pp. 101–107.

Iqbal, Muhammad (2012). *An introduction to solar radiation*. Elsevier.

Makade, Rahul G, Siddharth Chakrabarti, and Basharat Jamil (2021). "Development of global solar radiation models: A comprehensive review and statistical analysis for Indian regions." In: *Journal of Cleaner Production* 293, p. 126208.

NEA (2021). *Annual Report*. [Online; accessed September 2021]. URL: https://www.nea.org.np/annual_report.

Pandey, B, RP Aryal, CL Gnawali, KN Poudyal, IB Karki, and I Koirala (2019). "Estimation of Monthly average daily diffuse solar radiation using empirical models for Kathmandu, Nepal." In: *Journal of Nepal Physical Society* 5.1, pp. 6–13.

Pandey, CK and AK Katiyar (2013). "Solar radiation: Models and measurement techniques." In: *Journal of Energy* 2013.

Sridharan, M (2023). "Generalized regression neural network model-based estimation of global solar energy using meteorological parameters." In: *Annals of Data Science* 10.4, pp. 1107–1125.

Tsung, Kheng Yew and Yun Ii Go (2020). "Sunshine-based Global Solar Radiation Modelling: Case Study of Putrajaya, Malaysia." In: *Journal of Energy and Safety Technology (JEST)* 3.1.

Wikipedia (2020). *Location Information*. `https://en.wikipedia.org/wiki/Biratnagar`. [Online; accessed September 2021].