



## Analysis of Solar Radiation Measurements in Kathmandu, Nepal

Arbin Maharjan<sup>1\*</sup>, Kabina Maharjan<sup>2</sup>

<sup>1</sup>Department of Electrical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal

<sup>2</sup>Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal

\*Corresponding email: arbinmaharjan@ioe.edu.np

Received: November 25, 2025; Revised: 27 January, 2026; Accepted: March 21, 2026

### Abstract

Solar radiation measurement is essential to predict a better output from the solar power installations. This paper presents an analysis of solar radiation measurements obtained for a period of six months (January to June, 2019) from a solar station installed in Kathmandu, Nepal ( $27.6815^\circ$  N  $85.3186^\circ$  E). Direct Normal Irradiance (DNI) is measured by pyrheliometer whereas, Diffuse and Global Horizontal Irradiances (DHI and GHI) are measured by pyranometers. The sensors are thermopile based and are mounted on a 2D-solar tracker at a height of 2m. The data are recorded at a minute interval in a data logger and are analyzed to obtain daily and monthly average values. The maximum daily average is found on March 12 (GHI=471.92 W/m<sup>2</sup>, DNI=570.6 W/m<sup>2</sup>) and June 30 (DHI=247.15 W/m<sup>2</sup>) whereas, the minimum daily average was all found on April 6 (GHI=79.73 W/m<sup>2</sup>, DNI=3.81 W/m<sup>2</sup> and DHI=83.27 W/m<sup>2</sup>). The six months average of GHI, DNI and DHI are found to be 322.49, 308.735 and 156.177 W/m<sup>2</sup> respectively. The maximum monthly average is found on March (GHI=374.56 W/m<sup>2</sup>, DNI=387.75 W/m<sup>2</sup>) and June (DHI=188.89 W/m<sup>2</sup>) whereas, minimum monthly average is on Jan (GHI=256.4 W/m<sup>2</sup>, DHI=124.19 W/m<sup>2</sup>) and June (DNI=250.25 W/m<sup>2</sup>). The monthly average of DNI is found to be greater than GHI for the winter months (Jan-March) whereas, it's opposite for the summer months (Apr-Jun). A min by min plot for a particular day on a winter month and hourly average values of GHI and DNI plots for a 21<sup>st</sup> day of each month is also presented to support the finding.

**Keywords:** Solar Radiation; GHI; DNI; DHI

### 1. Introduction

The total installed electricity capacity in Nepal is approximately 3878 MW (Adhikari, Gyawali, & Joshi, 2025). The country is rich in water resources and majority of electricity in Nepal is produced from hydropower (>95%) however, the solar resource is also abundant and supplements the country's electricity demand by

nearly 3% (GIZ, 2024). The average solar radiation in Nepal is about 4.7 kWh/m<sup>2</sup>/day with average sunshine hours of 6.8 hours/day for approximately 300 days in a year (Kafle, Anderson, & Lohani, 2023). Solar irradiance reaching the earth's surface can be divided into Direct Normal, Diffuse Horizontal (DNI, DHI) and Reflected irradiances. The combination of all three irradiances becomes the Global Horizontal Irradiances (GHI). Instruments/sensors, called pyranometer and pyrhelimeter are available for the measurement of GHI and DNI and respectively. A special arrangement of pyranometer with the shading ball can be made to measure the diffuse horizontal irradiance that blocks the direct normal beam falling on the sensor (Michalsky, et al., 2003).

Kathmandu, the most populated city of Nepal is located at an elevation of 1324m with many small home solar systems and institutional solar systems adopted as the secondary source of electricity during the grid failures/cut-offs. As per Nepal Electricity Authority (NEA), grid connection of the solar power installation for systems not less than 500W can be done by means of a net-metering (NEA, Jul 2017). Hence, many developers are interested to invest in the solar sector. In this regard, an assessment of the intermittent solar resources at a given location is essential to ensure more energy output from any solar project. Estimations can be made using satellite driven data but realistic data will be obtained with ground measurements in real environment. Some earlier efforts on analysis of global solar irradiance in Kathmandu have been presented by using the data measurements from department of hydrology and meteorology (DHM) obtained by a single pyranometer for the year 2018 (Shrestha, et al., 2024). Apart from that, efforts have been made to estimate and analyze the global solar irradiance based on models and compare them with the measured data from DHM (Adhikari, Bhattarai, & Gurung, 2013). There are not much literatures done in Nepal for the analysis of solar radiations especially, the analysis of Direct Normal and Diffuse Horizontal radiation, which may be due to lack of data or solar measuring stations to measure them.

This paper presents the analysis of much precise ground measurements of direct normal, diffuse and global horizontal irradiances obtained from solar measurement station installed at a building in Kathmandu. The data recordings of six months are analyzed to obtain maximum and minimum daily and monthly average solar irradiances. Six months averages of GHI, DNI and DHI are also calculated using the data.

## 2. Materials and Methods

The thermopile-based sensors, 1-pyrhelimeter for the measurement of DNI (Class A, CHP 1) and 2-pyranometers (Class A, CMP 21) for the measurement of GHI and DHI (pyranometer with shading ball) are mounted at a height of 2m on a 2D-SOLSYS2 solar tracker manufactured by Kipp & Zonen as shown in Fig 1. The solar station is located on the roof of Block-B at Pulchowk Campus (27.6815° N 85.3186° E). Per minute average data of irradiances are recorded on a data logger. The sun tracker and sensors were calibrated. They were well maintained and cleaned on a daily basis. The installation was a part of Renewable Energy Resource Mapping and Geo Spatial Planning Project (ID: P150328), supported by Energy Sector Management Assistant Program (ESMAP), administered by the world bank.

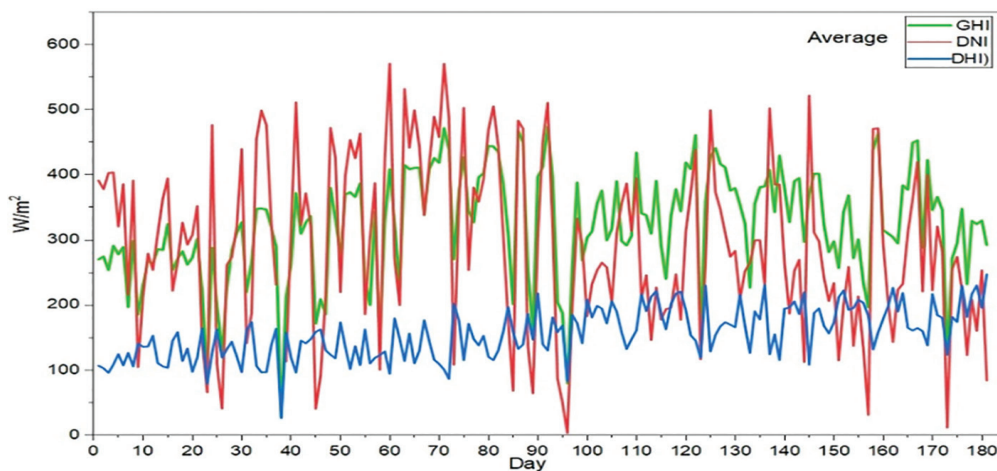


**Figure 1:** 2D-Solsys2 solar tracker mounted with the sensors

The data for a period of six months (Jan-June, 2019) are extracted from the data logger and are analyzed to obtain daily and monthly average values of GHI, DNI and DHI. Similarly, the days with maximum and minimum daily and monthly average value all three irradiances are also obtained. A min-by-min plot of GHI, DNI and DHI of March 22, 2019 is also presented to see intermittency and differences of incoming solar irradiances. An hourly average value of all three different irradiances for 21<sup>st</sup> day of each month is also presented to compare the difference in irradiances.

### 3. Results and Discussion

#### 3.1 Daily Average Irradiance



**Figure 2:** Daily average value of GHI, DNI and DHI

The daily average irradiance plot of Global Horizontal, Direct Normal and Diffuse Horizontal Irradiances from Jan 1 to Jun 30, 2019 for Kathmandu is shown in Fig 2. The maximum daily average is found on March 12 (GHI=471.92 W/m<sup>2</sup>, DNI=570.6 W/m<sup>2</sup>) and June 30 (DHI= 247.15 W/m<sup>2</sup>) whereas, the minimum daily average was all found on April 6 with GHI=79.73 W/m<sup>2</sup>, DNI= 3.81 W/m<sup>2</sup> and DHI= 83. 27 W/m<sup>2</sup>. The daily average values of GHI, DNI and DHI for six months are found to be 324.194, 294.07 and 157.078 W/m<sup>2</sup> respectively.

The plot clearly shows that for winter days between Jan to March, DNI is higher than GHI whereas, in the summer days between Apr to June, DNI is lesser than GHI (World Bank, 2021) (Jia, et al., 2021). This is because the winter days in Kathmandu has less rainy days in comparison to summer days (Acharya & Devkota, 2023). Thus, the atmospheric aerosol concentration is much higher due to the emission from vehicles and industries. The aerosol concentration absorbs the incoming solar irradiances and also scatters them due to which sufficient irradiances couldn't reach the earth (Sah Telee, Chaudhary, Yadav, & Karki, 2024) (Dumka, Kosmopoulos, Ningombam, & Masoom, 2024).

### 3.2 Monthly Average Irradiance

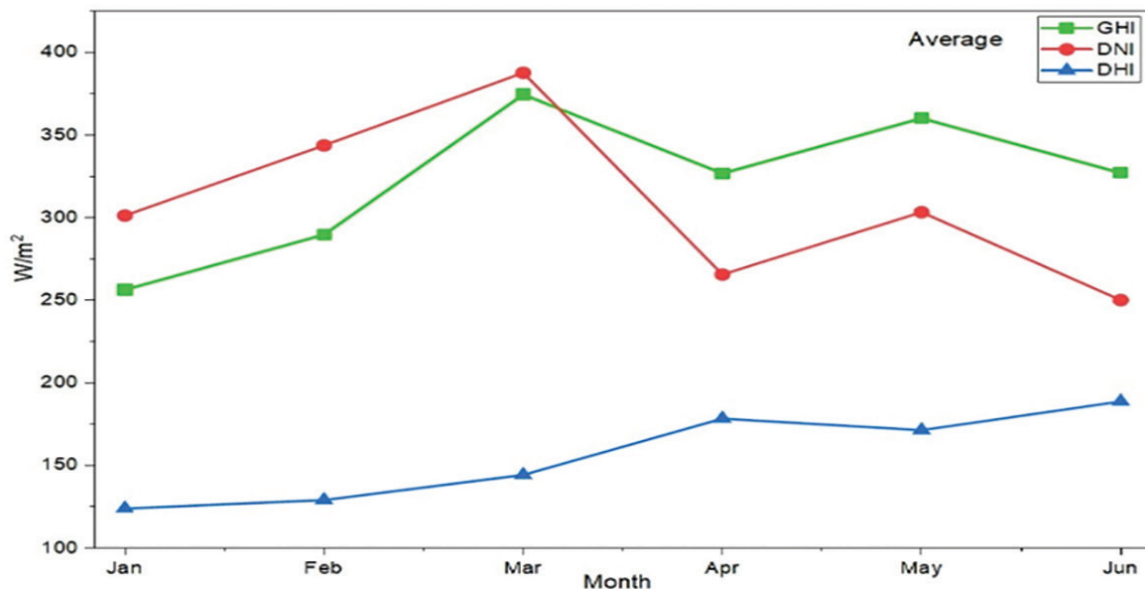


Figure 3: Monthly average value

The monthly average irradiance plot of GHI, DNI and DHI is shown in fig 3. The maximum monthly average irradiance for GHI and DNI are found on March (GHI=374.56 W/m<sup>2</sup>, DNI= 387.75 W/m<sup>2</sup>) whereas for DHI, the maximum was found on June (DHI= 188.89 W/m<sup>2</sup>). Similarly, the minimum monthly average for GHI and DHI are found on Jan (GHI= 256.4 W/m<sup>2</sup>, DHI= 124.19 W/m<sup>2</sup>) but the minimum average DNI is found on June (DNI=250.25 W/m<sup>2</sup>). The plot clearly shows that the monthly average of DNI is clearly higher than GHI for the winter months (Jan to March) and the case is opposite for the summer months (April to June). The six months average for GHI, DNI and DHI are found to be 322.49, 308.735 and 156.177 W/m<sup>2</sup> respectively.

### 3.3 Hourly Average Irradiance

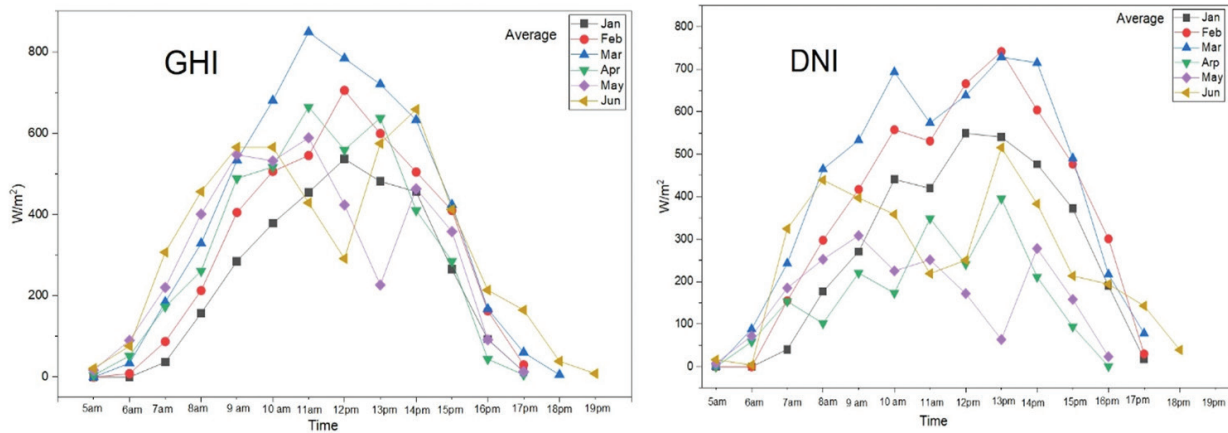


Figure 4: Hourly variation of GHI and DNI, 21<sup>st</sup> day, Jan to June, 2019.

Table 1: Daily average value of GHI and DNI for 21<sup>st</sup> day, Jan to June, 2019

Day	GHI (W/m <sup>2</sup> )	DNI (W/m <sup>2</sup> )
Jan-21	302.13	352.43
Feb-21	373.49	453.58
Mar-21	444.64	469.41
Apr-21	340.96	210.83
May-21	327.56	187.32
Jun-21	346.40	283.24

Similarly, an hourly average irradiance of GHI and DNI are plotted for 21<sup>st</sup> day of each month as shown in fig 5 and daily average value for those days is presented in table 1. The plot and values in the table clearly shows that DNI for the winter days (Jan, Feb and March) is higher than GHI whereas, DNI for summer days (Apr, May and June) is lower than GHI hence, the result obtained is consistent.

### 3.4 A min by min plot for a day

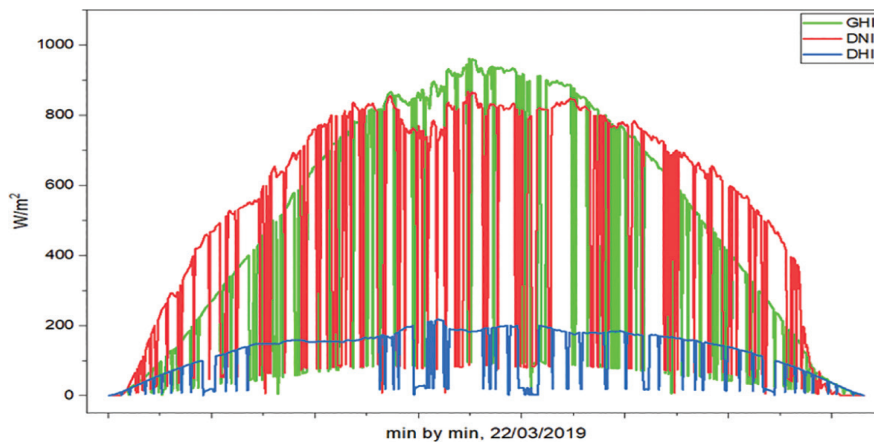


Figure 5: Min by min plot, 22/03/2019

To further analyze, a min by min plot on March 22, 2019 is shown in fig 4, which clearly shows the intermittency and differences of all the incoming solar irradiances of that day. The plot clearly shows that GHI is slightly higher than DNI for only few hours whereas, DNI for the particular day has higher values for the remaining sunshine hours. The daily average DNI ( $505.17 \text{ W/m}^2$ ) for the day is found to be higher than GHI ( $443.88 \text{ W/m}^2$ ).

#### 4. Conclusions

An analysis of global horizontal irradiance, direct normal irradiance and diffuse horizontal irradiance data of six months (Jan to June, 2019) obtained from highly precise solar measurement station installed at Kathmandu, Nepal is presented here. The solar station is equipped with three well calibrated sensors of pyranometers and pyrhelimeter for the measurement of all three irradiances (GHI, DHI and DNI) on a solar tracker. The data are analyzed to obtain maximum and minimum averages of daily and monthly irradiances.

Results show that monthly average DNI in Kathmandu is found to be higher than GHI for the winter (Jan to March) whereas, in the summer (Apr to June), DNI is lesser than GHI. This is because winter in Kathmandu has less rainy days and the concentration of aerosols like dust and smoke is much higher than in summer. The highest daily average is found on March 12 (GHI= $471.92 \text{ W/m}^2$ , DNI= $570.6 \text{ W/m}^2$ ) and June 30 (DHI= $247.15 \text{ W/m}^2$ ) whereas, the minimum daily average were all found on April 6 (GHI= $79.73 \text{ W/m}^2$ , DNI= $3.81 \text{ W/m}^2$  and DHI= $83.27 \text{ W/m}^2$ ). The six months average of GHI, DNI and DHI are found to be  $322.49$ ,  $308.735$  and  $156.177 \text{ W/m}^2$  respectively with highest monthly average on March (GHI= $374.56 \text{ W/m}^2$ , DNI= $387.75 \text{ W/m}^2$ ) and June (DHI= $188.89 \text{ W/m}^2$ ). Similarly, minimum monthly average is found on Jan (GHI= $256.4 \text{ W/m}^2$ , DHI= $124.19 \text{ W/m}^2$ ) and June (DNI= $250.25 \text{ W/m}^2$ ).

#### Acknowledgements

The authors would like to thank Energy Sector Management Assistant Program (ESMAP), administered by the World Bank for the installation of the solar measurement station and CSP Services GmbH, Germany for providing the data.

#### References

- Acharya, M., & Devkota, A. (2023). Trend analysis on climate variability in Kathmandu Valley. *Ecofeminism and Climate Change*, 4(1), 18-23. doi: <https://doi.org/10.26480/efcc.01.2023.18.23>
- Adhikari, K. R., Bhattarai, B. K., & Gurung, S. (2013). Estimation of global solar radiation for four selected sites in Nepal using sunshine hours, temperature and relative humidity. *Journal of Power and Energy Engineering*, 1(1), 1-9. doi: <https://doi.org/10.3126/ppj.v4i2.79166>
- Adhikari, R. S., Gyawali, S., & Joshi, H. P. (2025, Nov). From Policy to Practice- Barriers to Solar Energy Development in Nepal: A Systematic Literature Review. *International Journal of Advanced Research (IJAR)*, 13(11), 1775-1786. doi: <https://doi.org/10.21474/IJAR01/22317>
- Dumka, U. C., Kosmopoulos, P. G., Ningombam, S. S., & Masoom, A. (2024). Impact of aerosol and cloud on the solar energy potential over the central Gangetic Himalayan region. *Remote Sensing*, 13(16), 3248. doi: <https://doi.org/10.3390/rs13163248>
- GIZ, (2024). *Security, affordability, and sustainability in Nepal's electricity mix: The case for complementing hydropower with utility-scale solar electricity*. Kathmandu: Alternative Energy Promotion Centre (AEPCC) & Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). [https://www.aepc.gov.np/docs/1488/135\\_GIZ%202024%20%E2%80%A2%20Complementing%20Hydropower%20with%20Utility-Scale%20Solar%20Electricity%20EN%20\(v4\).pdf](https://www.aepc.gov.np/docs/1488/135_GIZ%202024%20%E2%80%A2%20Complementing%20Hydropower%20with%20Utility-Scale%20Solar%20Electricity%20EN%20(v4).pdf)
- Jia, D., Hua, J., Wang, L., Guo, Y., Guo, H., Wu, P., . . . Yang, L. (2021). Estimations of global horizontal irradiance and direct normal irradiance by using Fengyun-4A satellite data in northern China. *Remote Sensing*, 13(4), 790. doi: <https://doi.org/10.3390/rs13040790>
- Kafle, U., Anderson, T., & Lohani, S. P. (2023, Jan). The Potential for Rooftop Photovoltaic Systems in Nepal. *Energies*, 16(2), 747. doi: <https://doi.org/10.3390/en16020747>

<https://doi.org/10.3390/en16020747>

- Michalsky, J. J., Dolce, R., Dutton, E. G., Haeffelin, M., Major, G., Schlemmer, J. A., . . . McArthur, L. J. (2003). Results from the first ARM diffuse horizontal shortwave irradiance comparison. *Journal of Geophysical Research: Atmospheres*, 107(D15), 4108. doi: <https://doi.org/10.1029/2002JD002825>
- NEA, (Jul 2017). *Net Metering of Energy Generated from Photovoltaic Solar Systems*. Kathmandu: Nepal Electricity Authority (NEA). [https://energypedia.info/images/4/43/Purchase\\_of\\_Electricity\\_from\\_Soalr\\_PV\\_System.\\_Unofficial\\_English\\_Translation.pdf](https://energypedia.info/images/4/43/Purchase_of_Electricity_from_Soalr_PV_System._Unofficial_English_Translation.pdf)
- Sah Telee, L. B., Chaudhary, A. K., Yadav, U. K., & Karki, M. (2024). Monitoring air quality in Kathmandu with trend and public health risks. *Journal of Nepalese Management Academia*, 21, 19-30. doi: <https://doi.org/10.3126/jnma.v2i1.80763>
- Shrestha, P. M., Gupta, S. P., Rai, K. B., Joshi, U., Chapagain, N. P., Karki, I. B., & Poudyal, K. N. (2024). Comparative study of solar radiation at four sites of Nepal: A case study. *Patan Prospective Journal*, 4(2), 79-90. doi: <https://doi.org/10.3126/ppj.v4i2.79166>
- World Bank, (2021). *Regional Adaptation of Solargis Solar Model Based on Solar Measurement Data in Nepal*. Kathmandu: World Bank (ESMAP). [https://energydata.info/dataset/ead8d2fa-de59-48d3-8693-817b36b3a470/resource/551e2cc3-d094-40a2-b493-0008f87a1194/fs\\_download/solargis\\_solar-model-adaptation\\_nepal\\_esmap-wbg.pdf?preview=False](https://energydata.info/dataset/ead8d2fa-de59-48d3-8693-817b36b3a470/resource/551e2cc3-d094-40a2-b493-0008f87a1194/fs_download/solargis_solar-model-adaptation_nepal_esmap-wbg.pdf?preview=False)