ANALYSIS OF NET LONG WAVE, SHORT WAVE, SOLAR RADIATION FOR THREE SELECTED SITES IN KANYAKUMARI, TAMILNADU

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ABSTRACT

Solar energy is one of the most important renewable and inexhaustible energy resources. It is also one of the cleanest energy resources that does not compromise or add to global warming. Because of its abundance, solar energy can play a prominent role in our energy future and reduce dependency on fossil fuel. The present study examines the distribution of surface radiation balance components measured during March 2019.The aim of this study was to estimate net long wave radiation, net shortwave radiation solar radiation using of limited weather parameters in the selected study area. The result shows that there is variation in the(1- 31March)dry season the maximum value of short wave radiation 26.2154 MJ m^{-2} d^{-1},net short wave radiation 20.13 MJ m^{-2} d^{-1}, net long wave radiation 2.501 MJ m^{-2} d^{-1} was recorded on the 72^{nd} day (i.e.13 March 2019). It also shows high radiation potential in Location III.

Keywords: *Shortwave radiation, Longwave radiation, solar radiation, Radiation balance.*

1. INTRODUCTION

Radiation from the sun drives the energy, water, and biochemical cycles of the earth surface atmosphere system. The incident solar radiation flux determines in large part, the surface temperature and the rate of evapotranspiration, with important consequences on atmosphere surface interactions and the global hydrologic cycle. The surface solar radiation flux is affected primarily by clouds, but also by aerosols, atmospheric absorbers, scatterers, and, to a lesser extent, by surface conditions (Martin et al., 1997). Solar radiation is the radiant energy that comes from the sun. This radiant energy is the primary source of energy that provides light and heat for the earth and energy for photosynthesis. Solar energy is the most adequate renewable energy that occupies one of the most important places among the various possible energy sources. It is free and completely non-polluting in nature (Al-Salaymeh., 2006). Air temperature is not only the primary item of weather forecast but also useful for describing the climate change and energy exchange between the earth surface and the atmosphere (Prihodkoandet al., 1997). Air temperature also plays an essential role in physical processes of evapotranspiration, photosynthesis, and heat transfer (Lakshmi et al., 2001).

Long wave radiation (RL) represent the emitted radiation from the atmospheric contents and the earth surface with a wave length ranged between (4-100) micron (Dharmaratine et al., 1999). Terrestrial radiation happened during the daytime and nighttime while solar radiation happened during the daytime only . Outgoing long wave radiation (RL↑) depend on surface emissivity and surface temperature (Muhammad,1983) .Net long wave radiation (Rnl) represent the difference between the incoming long wave radiation and the outgoing long wave radiation. Normally the outgoing long wave radiation is greater than the incoming long wave radiation. Radiation balance at the surface of the earth is composed of four spectral radiant fluxes: The Incoming shortwave (0.15–4 μm) radiation that arrives from sun (RS↓); the amount of energy that is reflected from the surface (RS↑); the incoming long wave (less than 4 μm) radiation from the atmosphere (RL↓); and the amount of long wave radiation emitted from the surfaces (RL↑). The net radiative flux, Rn, is represented as follows:

$$Rn = (RS\downarrow - RS\uparrow) + (RL\downarrow - RL\uparrow) \quad ... (1)$$

Out of the four terms, the two incoming fluxes (RS↓ and RL↓) are relatively independent of surface conditions (vegetation, bare soil). On a cloud-free day, solar radiation and the atmospheric long wave radiation are approximately the same and are often used interchangeably (at the same elevation and airmass) such that either measurement of the incoming radiation could be considered representative for the entire area, however, on the other hand, the outgoing terms are highly dependent on surface conditions (Riani et al., 1988).

2. DATA AND METHODOLOGY

2.1. Study area

Kanyakumari is the southernmost district of Tamil Nadu. The district is bound by Tirunelveli district on the North and the East. The South eastern boundary is the Gulf of Mannar. On the South and the South West, the boundaries are the Indian Ocean and the Arabian Sea. On the west and

North West it is bound by Kerala. With an area of1672 sq.km it occupies 1.29% of the total area of Tamil Nadu.

The daily values of Maximum Temperature, Minimum Temperature, Relative humidity are the meteorological parameters are used in this study they have been obtained from Automatic weather station (AWS) Indian Meteorological Department, Pune, India (aws.imd.gov.in). The geographical location for the selected study area are given in the Table1.

Table 1: Location for the selected study area

Sl.no	Selected site	Latitude (º)	Longitude (º)
1	Pachippari	8.4º N	77.3 º E
2	Neyyoor	8.2114° N	77.3031° E
3	Thiruppathisaram	8.2046° N	77.4494° E

2.2 Net long wave radiation (R_{nl})

The rate of longwave energy emission is proportional to the absolute temperature of the surface raised to the fourth power. This relation is expressed quantitatively by the Stefan-Boltzmann law. The net energy flux leaving the earth's surface is, however, less than that emitted and given by the Stefan-Boltzmann law due to the absorption and downward radiation from the sky.

$$R_{nl} = \sigma \left[\frac{T_{\max K}4 + T_{\min K}4}{2}\right]\left(0.34 - 0.14\sqrt{e_a}\right)\left(1.35\frac{R_s}{R_{so}} - 0.35\right) \text{--------- (2)}$$

Where, R_{nl} is Net outgoing long wave radiation [$MJm^{-2}day^{-1}$],σ is Stefan-Boltzmann constant [$4.903x10^{-9}MJ\ K^{-4}\ m^{-2}\ day^{-1}$],$T_{max,\ K}$ is Maximum absolute temperature during the 24-hour period[K=°C+273.16],$T_{min,K}$is Minimum absolute temperature during the 24-hour period [K=°C+273.16],$e_a$is Actual vapour pressure [kPa],$R_s/R_{so}$is Relative shortwave radiation ,$R_s$is Solar radiation [$MJ\ m^{-2}\ day^{-1}$],$R_{so}$is Clear-sky radiation [$MJ\ m^{-2}\ day^{-1}$].

2.3 Solar or shortwave radiation (Rs)

The amount of radiation reaching a horizontal plane is known as the solar radiation (Rs). Because the sun emits energy by means of electromagnetic waves characterized by short wavelengths, solar radiation is also referred to as shortwave radiation.

$$R_s = K_{Rs}\sqrt{(Tmax - Tmin)}\ R_a \text{------------------------- (3)}$$

Where T_{max} is the maximum temperature, T_{min} is minimum temperature, Ra is the extraterrestrial solar radiation of the area, and KRs is adjustment coefficient. For the 'interior' locations, it is approximately 0.16 and for 'coastal' locations its value is approximately 0.19.

2.4 Net solar or net shortwave radiation (R_{ns})

The net shortwave radiation resulting from the balance between incoming and reflected solar radiation is given by:

$R_{ns} = (1-\alpha) R_s$ -------------------- (4)

Where, R_{ns} is Net solar or shortwave radiation [MJ m^{-2} day^{-1}], α is Albedo or canopy reflection coefficient, which is 0.23 for the hypothetical grass reference crop [dimensionless], $R_s$is the incoming solar radiation [MJ m^{-2} day^{-1}].

2.5 parameters for *net long wave, short wave, global solar* radiation

(a) Relative distance Earth-Sun and Solar declination

The inverse relative distance Earth-Sun dr, and the solar declination, δ is given by

$$d_r = 1 + \ cos\left(\frac{2\pi}{365} J\right)$$ ---------------- (5)

$\delta = 0.409 \sin 2\pi\ 365\ J - 1.39$ ---------------------------- (6)

Where, dr is Inverse relative distance Earth-Sun, J is the Number of the Day in the Year between (January to December).

(b) Sunset Hour angle (ωs)

The sunset angle of a location is calculated using the formula given as

$$\omega_s = arc\ cos[- tan(\varphi)\ tan(\delta)]$$ ------------------ (7)

Where, ωs is the Sunset hour angle [rad], φ is the Latitude [rad], δ isSolar declination [rad].

(c) Extraterrestrial radiation for daily periods (Ra)

The extraterrestrial radiation, Ra, for each day can be estimated using the formula:

$Ra = 24\ (60)\ \pi G scd_r\ \omega_s \sin\varphi \sin\delta + \cos\varphi \cos\delta \sin(\omega s)$ -------------------- (8)

Where, Ra is Extraterrestrial radiation [MJ m-2 day-1],G_{sc} is Solar constant = 0.0820 MJ m-2 min-1, d_r is Inverse relative distance Earth-Sun, ω_s is the Sunset hour angle [rad], φ is Latitude [rad],δ is the Solar declination [rad].

(d) Clear-sky solar radiation (R_{so})

The calculation of the clear-sky radiation, R_{so}, can be estimated using the formula:

$$R_{so} = (0.75 + 2\ 10^{-5} z)\ R_a$$ -------------------- (9)

Where Z is Station elevation above sea level [m].

(e) Actual vapour pressure (e_a) derived from relative humidity data

The actual vapour pressure can also be calculated from the relative humidity. Depending on the availability of the humidity data, different equations should be used.

$$e_a = \frac{e^o(T_{min})\frac{RH_{max}}{100} + e^o(T_{max})\frac{RH_{min}}{100}}{2} \text{------------------- (10)}$$

Where, $e_a$is Actual vapour pressure [kPa], e°(T_{min}) is Saturation vapour pressure at daily minimum temperature [kPa], e°(T_{max})is Saturation vapour pressure at daily maximum temperature [kPa], RH_{max} is Maximum relative humidity, RH_{min} is Minimum relative humidity [%].

3.RESULT

The daily variation for the month of March during the year 2019 was computed using equation (2-4) and its the graphical representation of the net long wave, short wave, global solar radiation for three selected sites in KanyakumariDistrict are depicted in the below figure

Figure 1: Distribution of daily average solar radiation

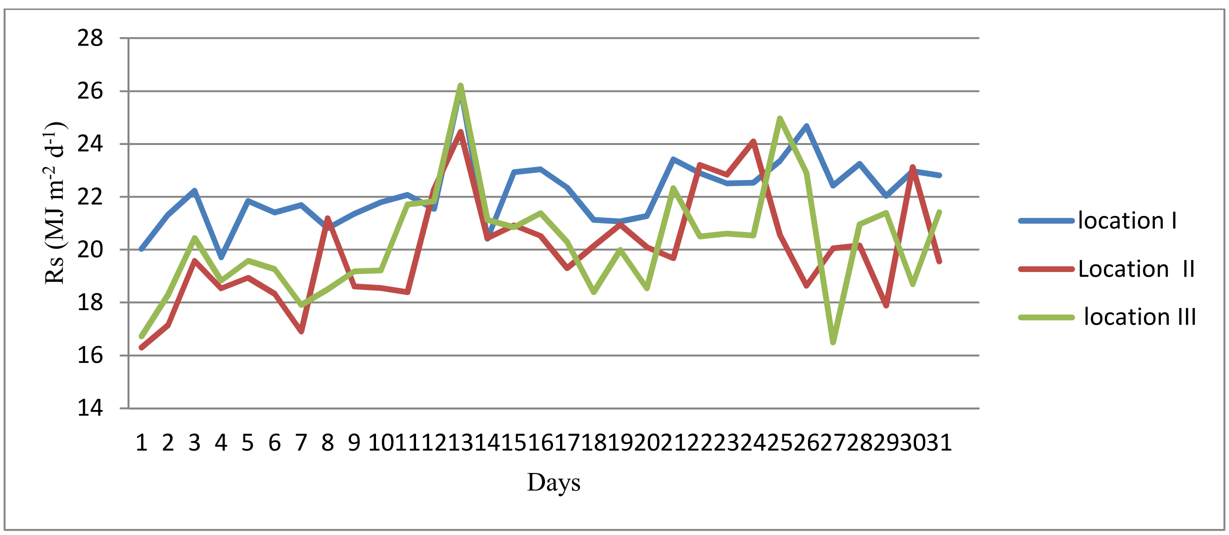

Figure1 represents the distribution of daily average solar radiation, Rs, during the period from 1^{st}March– 31^{st} March dry season. The maximum value of 26.2154 MJ m^{-2} d^{-1} was recorded on the 72^{nd} day (i.e.13 March 2019) in Location III and for I and II 26.15 MJ m^{-2} d^{-1} ,24.461 MJ m^{-2} d^{-1}The minimum value of about 19.7156 MJ m^{-2} d^{-1} was recorded for 86 thday (i.e.27 March 2019) in Location III and 16.3089 MJ m^{-2} d^{-1} , 19.7156 MJ m^{-2} d^{-1} was recorded in LocationI and II.

Figure 2: Distribution of daily average net short wave radiation

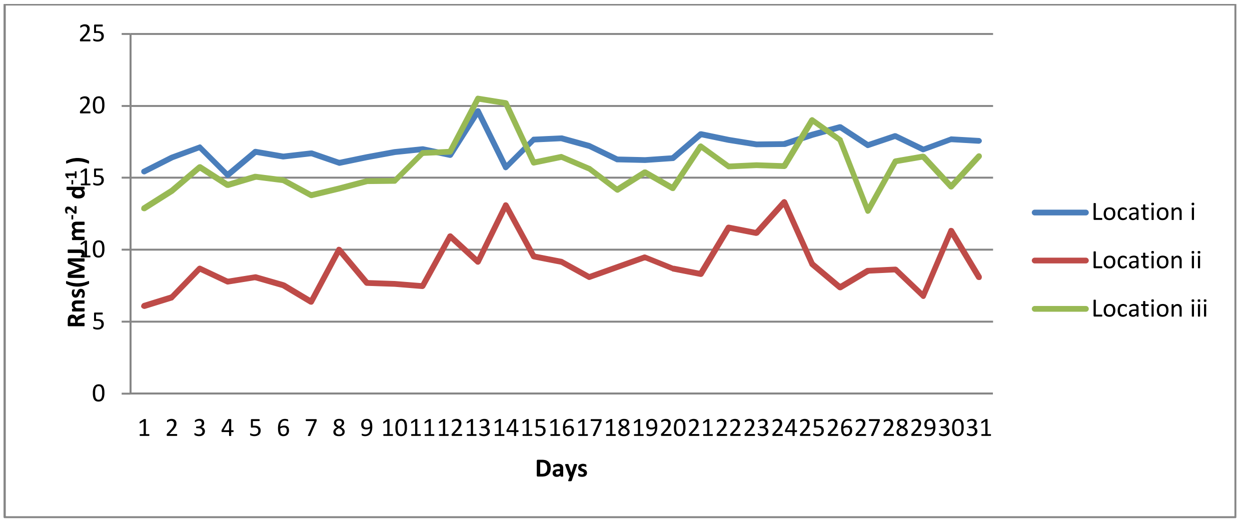

Figure 2 shows the distribution pattern of the net shortwave radiation for the period March 2019. This is similar to the pattern of solar radiation. It is extremely low in Location II and high in Location III. The minimum value was 6.038 MJ m^{-2} $d^{-1}$and this increased to20.13 MJ m^{-2} d^{-1}. The maximum value ranges between 20.501 - 13.09 MJ m^{-2} d^{-1} and the time of occurrence in the 13th March.

Figure 3: Distribution of daily average net long wave radiation

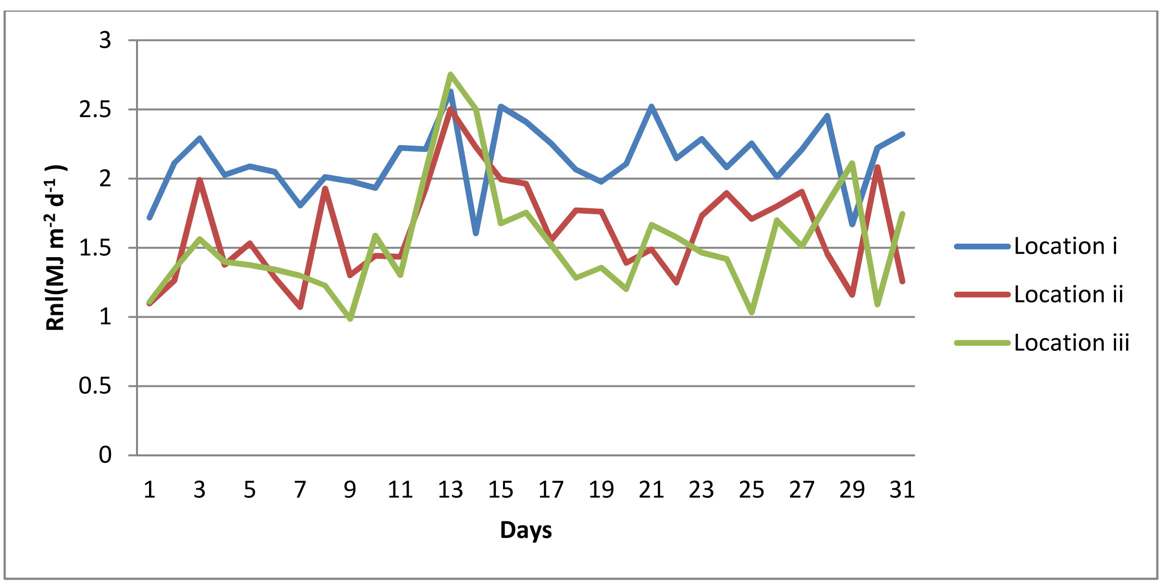

Figure 3 shows the distribution pattern of the net long wave radiation. The different maximum values attained during13th March for the three locations during the period of the study. The maximum value for the study area ranged between 2.753 MJ m^{-2} $d^{-1}$and 2.501MJ m^{-2} d^{-1}. It was observed that the upward flux (k↑) predominates during the period with minimum values ranging 1.66 MJ m^{-2} $d^{-1}$to 9857 MJ m^{-2} d^{-1}

Figure 4: Daily mean distribution of Temperature

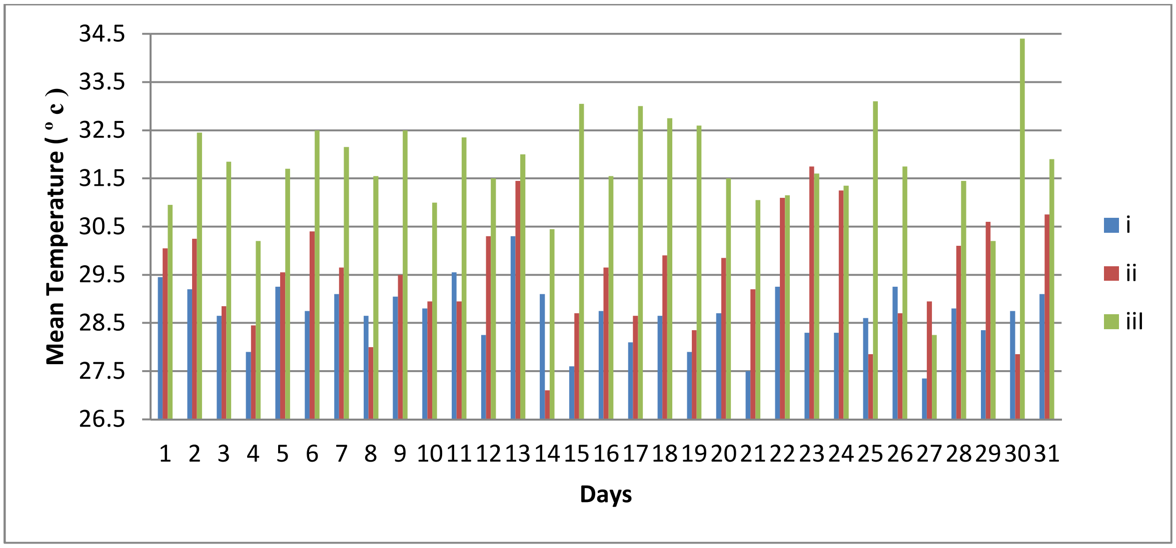

Figure 4 represents the daily mean temperature during the month March 2019. The variation of temperature during the study period varied in the selected sites. The maximum temperatures are 29.55˚C, 31.75˚C, 34.94˚C for the three regions respectively. The minimum temperatures are 27.35˚C for first Location and 27.1˚C, 30.2˚C for second and third Location.

Figure 5: Daily mean distribution of Relative Humidity

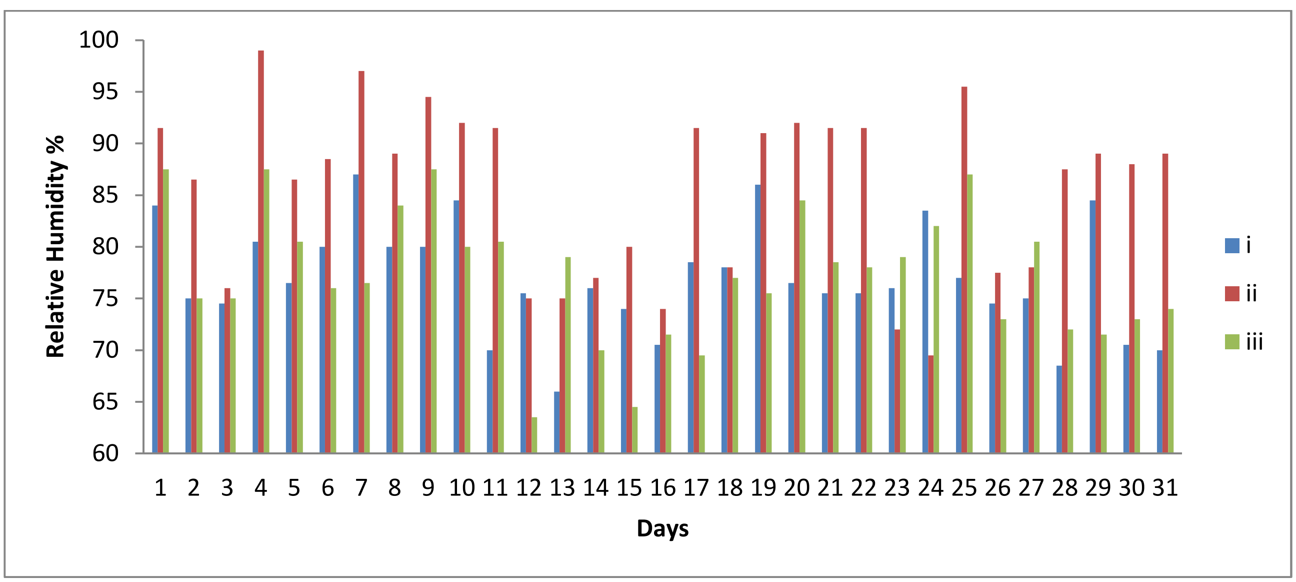

Figure 5 gives the information about the mean monthly Relative Humidity of the selected study area. In the first region humidity varied from 84.5% - 66%, for the second region the variation from 95.5% - 74%, and for the third region maximum and minimum values is 87.5% -63.5%.

4. DISCUSSIONS

The net long wave, short wave, solar radiation for three selected sites for the dry (March) seasons using the maximum and minimum temperature Relative humidity data obtained from the achieve of weather online limited from their website –aws.imd.gov.in. The computations for various parameters were carried out using MS EXCEL package. The result shows that there is clear variation between solar radiation and net long wave radiation during dry seasons for the selected location. It shows that solar radiation is very high in Location III than the other two Location [Figure 1]. It also shows that net long wave radiation is high in Location III than the other two Location [Figure 3] and also shows that net short wave radiation is high in Location III than the other two Location [Figure 2]. The solar radiation and net long wave radiation, short wave Radiation in March was seen to be generally high though oscillating in the selected sites, except at the middle of March which shows some deviation from its general trend. The sharp lowest values in solar radiation, net long wave, and net short wave radiation may be attributed to sudden change in weather conditions such as rainfall, humidity, air temperature on those days.

This information will be very important for irrigation farmers on the need to have manageable size of farm which can be taken care of carefully than having a large one without proper attention. Furthermore, this difference between the radiations in the selected site should be a thing of concern for environmentalists and water sectors personnel as many plants in the environment may not be able to adjust quickly to such as a sharp difference, hence the extinction of many species. Many ground waters such as ponds may likely dry up during the dry season; proper planning for future occurrence is to be put in place by respective bodies.

5. CONCLUSION

The above results represent typical empirical relationships between the components of net radiation (net shortwave and net longwave radiation) and global radiation. The study was carried out during the dry season. An empirical relationship was obtained between net short wave, net longwave radiation and global radiation respectively. It is hoped that the above equations, if properly calibrated for the environmental conditions, could be used to simulate either of the components of net radiation from solar radiation.

(1) The net shortwave and the net long wave radiation during the period covered a range of about (2.630 - .9857) MJ m^{-2} $d^{-1,}$, (19.00 MJ m^{-2} d^{-1} - 6.0838 MJ m^{-2} $d^{-1)}$respectively.

(2) The global radiation varied between 26.215 and 16.300 MJ m^{-2} d^{-1}

The analysis of solar radiation, net long wave, and net long wave radiation in different sites with various climate conditions and latitudes in Kanyakumari has been estimated in each area. This investigation shows high solar radiation potential of Kanyakumari especially in Location III Tirupathisaram.

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