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Solar Potential Analysis for Vellore City using GIS

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Abstract:-This paper discusses the application of geographical information system (GIS) to map monthly and yearly solar radiation using raster surface. Solar analysis is an important key factor in many areas like roof top solar analysis, installing photovoltaic and site selection for solar panel placing. Aster DEM as given lot of possibilities for solar analysis. This study has been made to calculate solar potential using Arc GIS over Vellore Taluk. The potential analysis brings out the maximum and minimum solar radiation of every month of 2017 by using "Area Solar Radiation" tool in Arc GIS software. The output solar radiation obtained in Watt per square meter are converted to Kwh/m2. Finally the result is feasible to derive incoming solar radiation with acceptable accuracy.

Keywords :- DEM, Solar Radiation, GIS, Remote Sensing.

I. INTRODUCTION

In the light of ensuring sustainable future and addressing growing impacts of climate change and global warming, clean technologies are gaining importance all over the world. Wind and solar energy are economically viable renewable alternatives for large-scale power generation. Sun is the constant source of energy and the two primary forms of solar energy, heat and light, continuously transform to other renewable energy resources. Amongst all the clean technologies, solar energy serves as an effective renewable energy source to mitigate greenhouse gas emissions and helps to reduce global warming. Interestingly, the amount of solar energy reaching the earth's surface is 6000 times the present global consumption of energy and most of it remains unused for human well-being. Solar energy has an imperative role in ensuring energy security while addressing environmental concerns in developing countries. Solar energy has an immense potential in a tropical country like India. Most parts of the country receive around 300 sunny days in a year with 8 h of daily sunshine. The daily average solar energy incident on India lies between 4 kWh/m2/day and 7 kWh/ m2/day. With the initiation of (JNNSM) Jawaharlal Nehru National Solar Mission in 2009 as a policy framework under (NAPCC) the National Action Plan on Climate Change, India has become one of the forerunners in the renewable energy markets around the world. The contribution of solar power sector in India was 3 MW in 2008; it has grown over 46 MW in 2011 with a target of 20,000 MW by 2020. However, according to a market study conducted by World Bank to understand the barriers in the growth of solar sector, 90% of the developers believe that "the timelines for milestones to be achieved in the draft JNNSM guidelines are almost unrealistic in nature". Policy, infrastructure and unavailability of solar data (including, the mapped suitable land areas for solar power with the potential estimates at local level) are major barriers in the implementation of JNNSM. By mapping solar potential sites in a GIS environment, this study aims to overcome some of these barriers by considering maximum and minimum solar radiation intensity in a particular area for every month of year 2017 and for the whole year 2017.

II. STUDY AREA

Vellore is a City which is located at 12.92°N 79.13°E and 220m above the mean sea level. Having a semi-arid climate condition, this city experiences high temperatures throughout the year & gets less rainfall. This City is present in Vellore district of the South Indian state in Tamil Nadu, 135 km (84 mi) west of Chennai, the state capital. The City lies in Palar river basin and the Eastern Ghats region. The topography with slopes from west to east is almost plain. There are no prominent mineral resources. Black loam soil is found in parts of the city and other soils like sandy, gravelly and stony of the red variety.

The temperature in Vellore City ranges from a maximum of 40.6 °C (105.08°F) to a minimum of 19.7 °C (67.46°F). This City experiences a tropical savannah. Like the rest of the state, the months of April to June is the hottest months and the months of December to January are the coldest months. Vellore receives 1,033.1 mm (40.71 in) of rainfall every year. With an onset in June the southwest monsoon lasts up to September, brings rainfall of 513.1 mm, with September being the rainiest month. The northeast monsoon which lasts from October to December brings rainfall of 385.4mm. The humidity ranges from 40%–63% during summer and 67%–86% during winter.

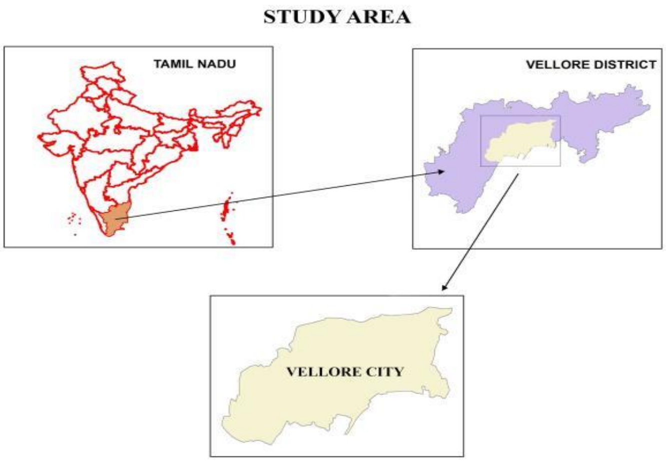

Fig 1 . Study Area

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III. OBJECTIVES

The aim of this study is to estimate land surface temperature by the following objectives in order to persuade the aim are,

- To resample collected DEM.
- To calculate Solar Area Radiation for different months.
- To Identify Minimum and Maximum Solar Potential Areas.
- To prepare Statistical Report

IV. MATERIALS AND METHODS

A. Data Used

During December 1999, the ASTER instrument was built & launched onboard NASA's Terra spacecraft by METI. It had a long-track stereoscopic ability using its near infrared spectral band & its backward-viewing & nadir-viewing telescopes to acquire stereo image data with a base-to-height ratio of 0.6. In the horizontal plane the spatial resolution is 15m. One nadir-looking ASTER (VNIR) Visible & Near Infrared scene consists of about 4,100 samples by 4,200 lines, consisting of about 60 kilometers (km)-by-60 km ground area.

The methodology used to produce the ASTER GDEM involved processing of the entire 1.5-million-scene of ASTER archive automatically, includes stereo-correlation to produce 1,264,118 individual scene-based ASTER DEMs, cloud masking for stacking all cloud-screened DEMs, removing cloudy pixels, removing residual bad values & outliers, correcting residual anomalies before partitioning the data into 1° by 1° tiles & then averaging selected data to create final pixel values. Using a fully automated approach it took approximately 1 year to complete production of the beta version of the ASTER GDEM. Version - 1 differs only slightly from the beta version, with the utmost significant change being that elevation anomalies caused by the residual clouds have been replaced with the values of -9999 for those unusual values detected on north of 60° north latitude in the Eurasian continent.

Tile Size	3601 x 3601 (1°-by-1°)
Posting interval	1 arc-second
Geographic coordinates	Geographic latitude and longitude
DEM output format	GeoTIFF, signed 16 bits, and 1m/DN Referenced to the WGS84/EGM96 geoid
Special DN values	-9999 for void pixels, and 0 for sea water body
Coverage	North 83° to south 83°, 22,600 tiles for Version - 1

Table 1. Basic Characteristics of the ASTER GDEM

The ASTER GDEM comprised of 22,600 1° by 1° tiles & covers land surfaces between 83°N & 83°S. Tiles that contain at least 0.01% land area are added. The ASTER GDEM usually will be in GeoTIFF format with geographic latitude/longitude coordinates & a 1 arc-second (approx. 30 m) grid. It is the WGS84/EGM96 geoid. Table -1 shows the basic characteristics of the ASTER GDEM. Pre-production accuracies estimated for this global product are 20 m at 95 % confidence for vertical data & 30 m at 95 % confidence for horizontal data.

B. Softwares Used

- Arc GIS Pro 2.0
- ERDAS IMAGINE 2015

C. Methodology

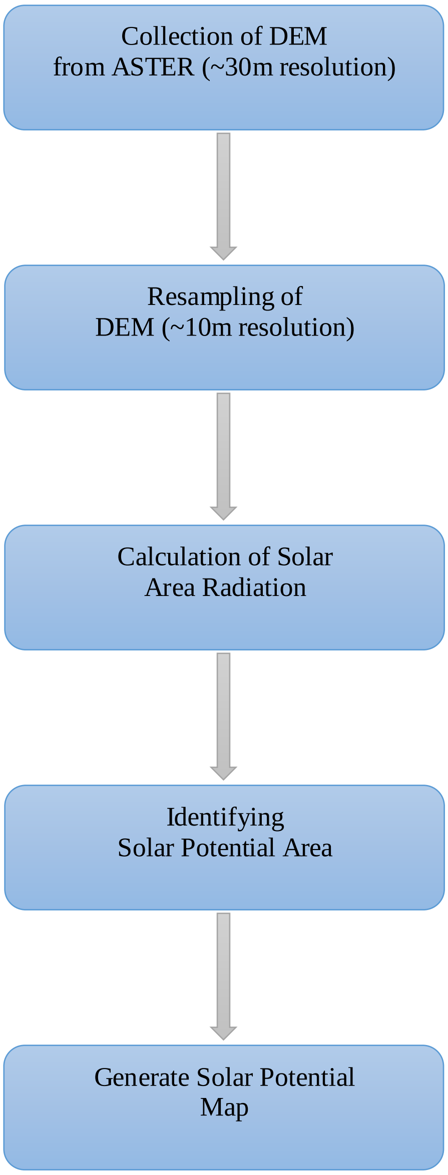

Fig 2. Methodology

D. Process

The solar radiation analysis tools as shown in Fig -3 enable you to analyse and map the effects of sun over a geographic area for a specific time periods.

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We can perform solar radiation analysis for specific location or on a landscape using these methods:

- "The Area Solar Radiation tool" are used to determine the insolation across entire landscape. The calculations are then repeated for each location on the input topographic surface, producing insolation maps for entire geographic area.

- "The Points Solar Radiation tool" are used in a given location to determine the amount of radiant energy. Locations can be stored as x,y coordinates or in a location table point features. Only for specific location solar radiation can be calculated.

For diagnostic purposes, to create graphic representations of the visible sky, we can use the Solar Radiation Graphics tool, the sun's location in the sky through a period of time & the sectors of the sky which influence the amount of (sky map) incoming solar radiation. Conceptually, these "maps" can be used internally during study to determine the total amount of solar radiation for a particular area or location.

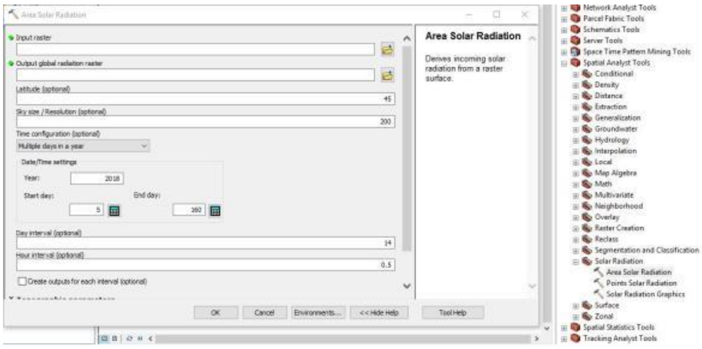

Fig. 3.Area Solar Radiation tool.

V. RESULT AND DISCUSSIONS

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of January - 2017 shows the solar potential varies from 26.53 to 63.99 Kwh/m^2.

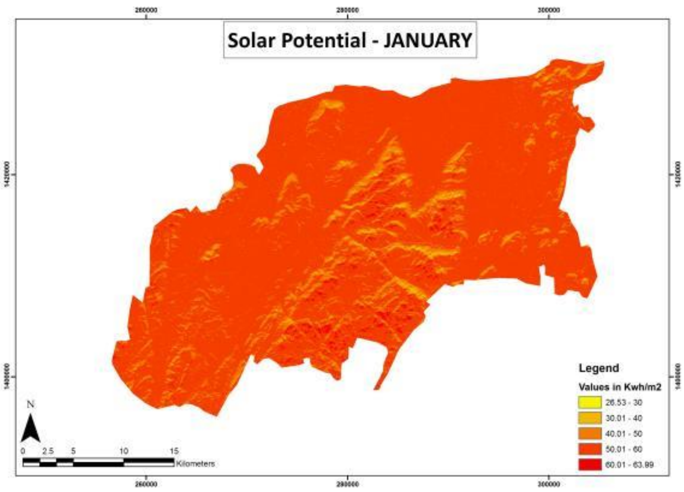

Fig. 4. Solar potential for the month of January.

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of February - 2017 shows the solar potential varies from 37.87 to 96.82 Kwh/m^2

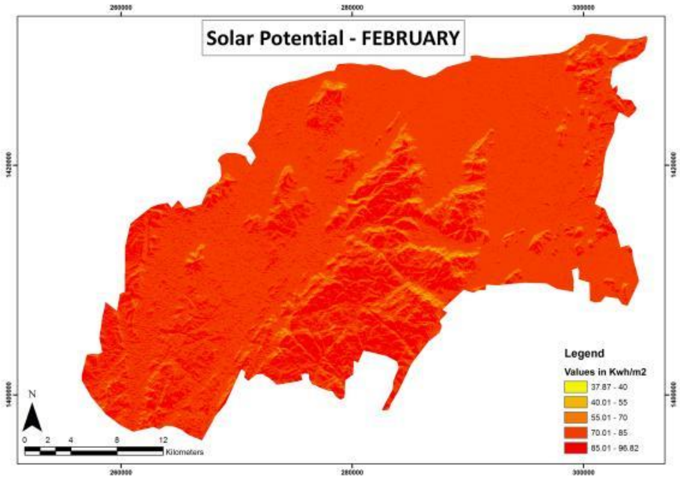

Fig. 5. Solar potential for the month of February.

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of March - 2017, shows the solar potential varies from 69.76 to 143.07 Kwh/m^2

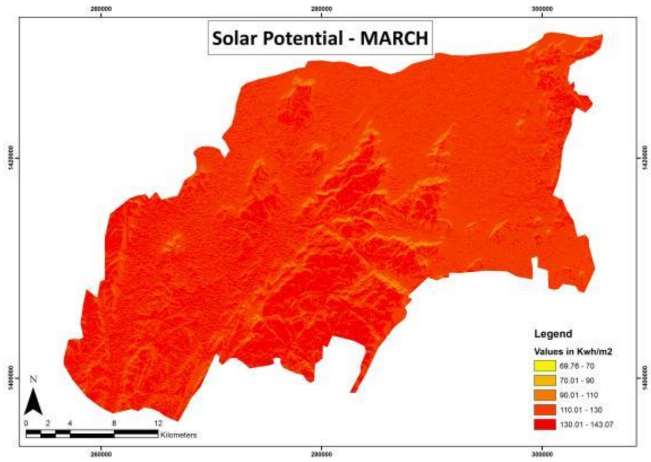

Fig. 6. Solar potential for the month of March

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of April - 2017 shows the solar potential varies from 94.99 to 151.84 Kwh/m^2

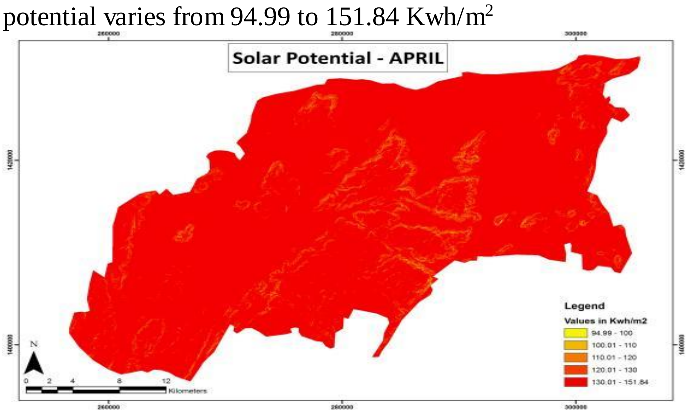

Fig. 7. Solar potential for the month of April

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The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of May - 2017 shows the solar potential varies from 86.18 to 156.77 Kwh/m^2

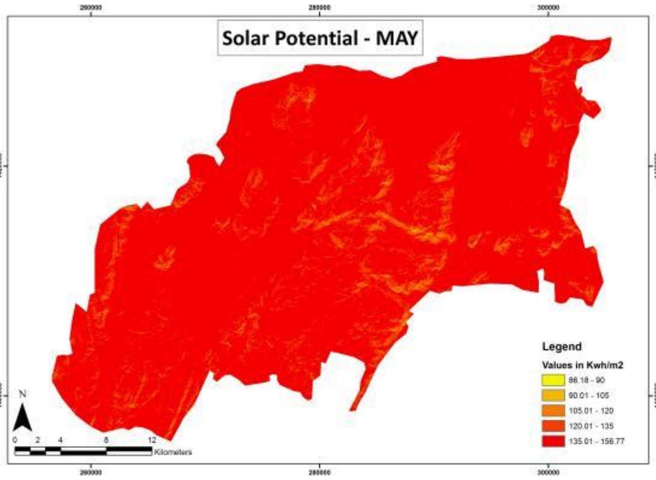

Fig. 8. Solar potential for the month of May

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of June - 2017 shows the solar potential varies from 53.84 to 97.69 Kwh/m^2

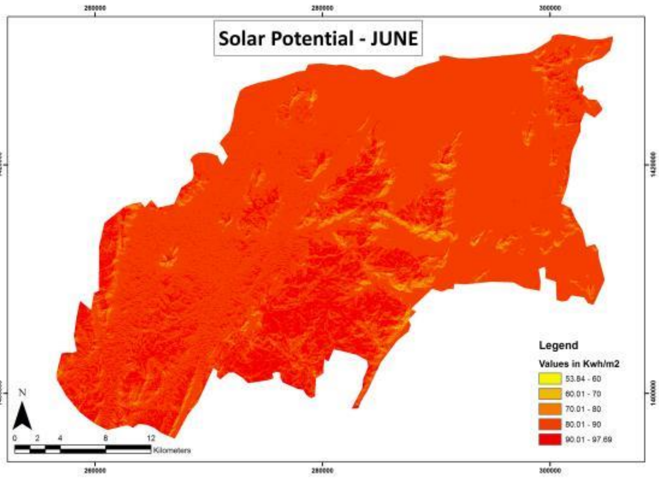

Fig. 9. Solar potential for the month of June

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of July - 2017 shows the solar potential varies from 78.81 to 147.22 Kwh/m^2

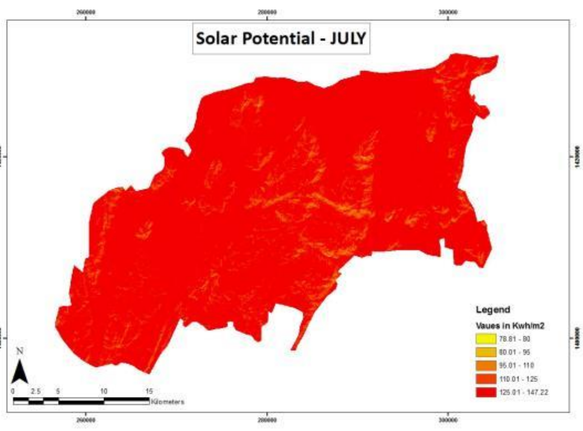

Fig. 10.Solar potential for the month of July

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of August - 2017 shows the solar potential varies from 95.45 to 159.47 Kwh/m^2

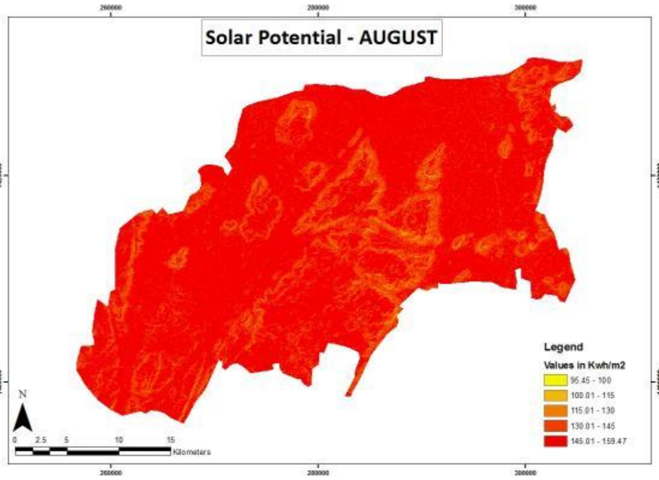

Fig. 11. Solar potential for the month of August

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of September - 2017 shows the solar potential varies from 76.64 to 144.04 Kwh/m^2

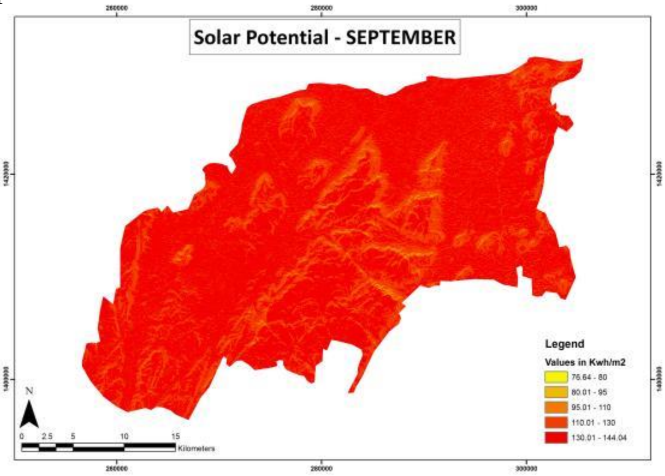

Fig. 12.Solar potential for the month of September

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of October - 2017 shows the solar potential varies from 49.9 to 122.24 Kwh/m^2

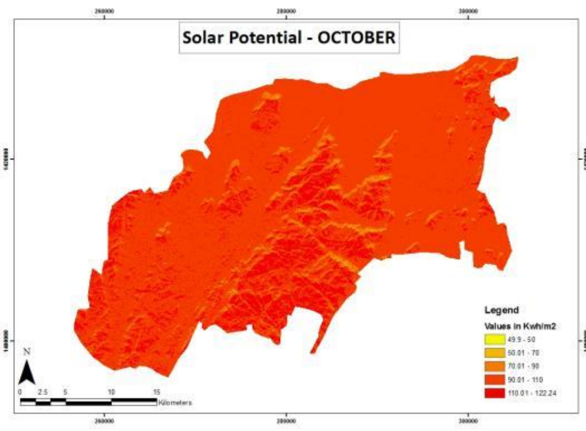

Fig. 13. Solar potential for the month of October

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The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of November - 2017 shows the solar potential varies from 28.43 to 72.45 Kwh/m^2

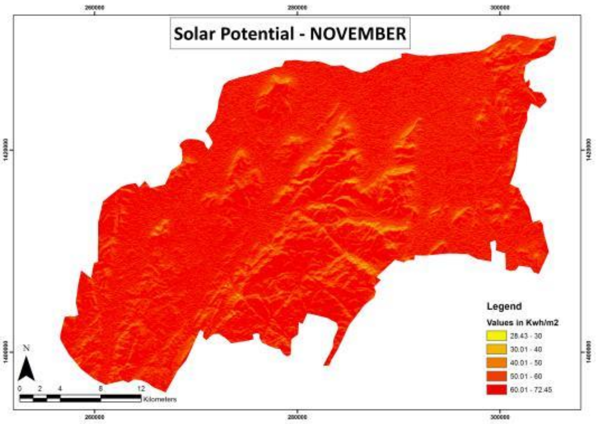

Fig. 14. Solar potential for the month of November

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the month of January, 2017 shows the solar potential varies from 22.34 to 39.14 Kwh/m^2

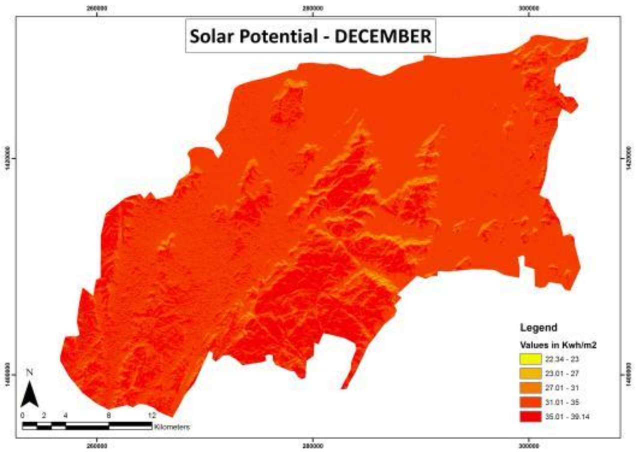

Fig. 15. Solar potential for the month of December

The Aster DEM used in the Area Solar Radiation tool of Arc GIS for the whole year of 2017 shows the solar potential varies from 1027.11 to 1937.86 Kwh/m^2

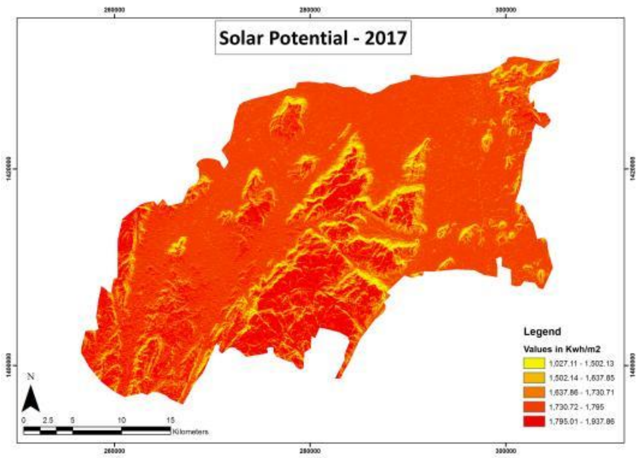

Fig 16. Solar potential for the year 2017.

SOLAR RADIATION MONTHLY			
SN	MONTH	MINIMUM SOLAR POTENTIAL (Kwh/m2)	MAXIMUM SOLAR POTENTIAL (Kwh/m2)
1	JANUARY	26.53	63.99
2	FEBRUARY	37.87	97.06
3	MARCH	69.76	143.07
4	APRIL	94.99	152.07
5	MAY	86.18	156.77
6	JUNE	53.84	97.69
7	JULY	78.81	147.22
8	AUGUST	95.45	159.47
9	SEPTEMBER	76.64	144.04
10	OCTOBER	49.9	122.24
11	NOVEMBER	28.43	72.63
12	DECEMBER	22.34	39.14

Table. 2. Monthly Solar Radiation

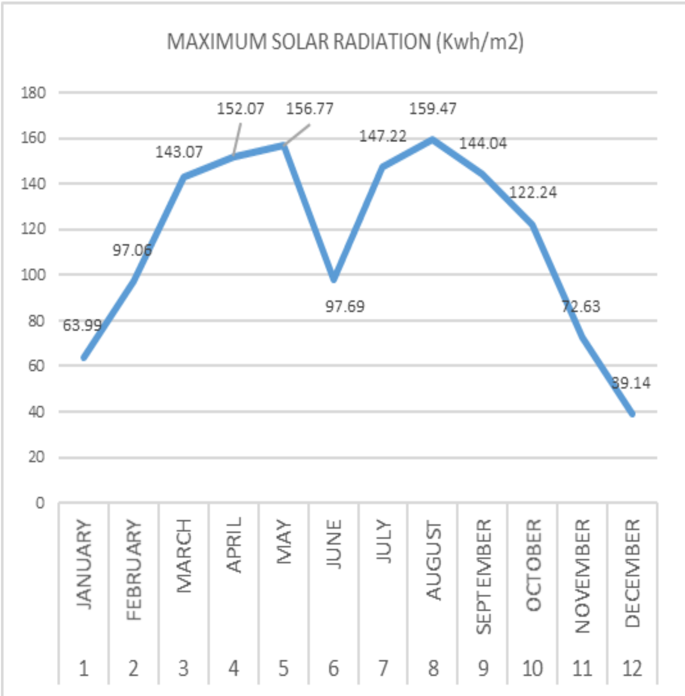

Fig. 17. Maximum solar radiation

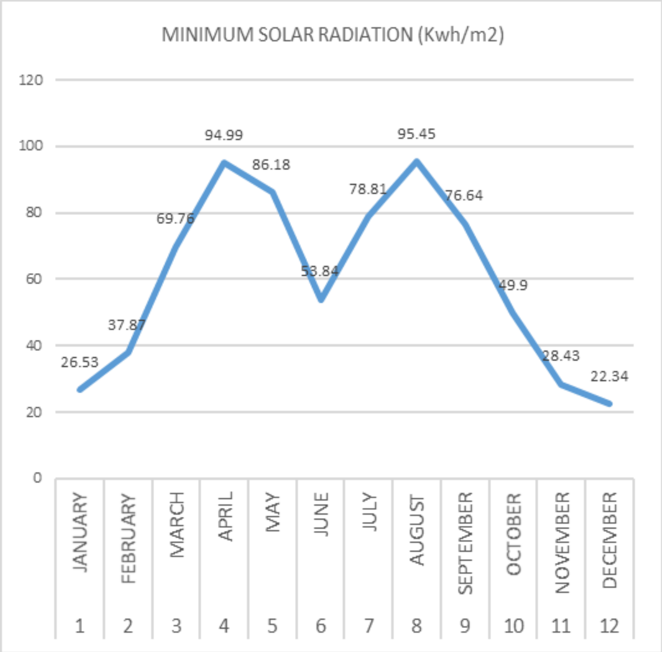

Fig. 18. Minimum solar radiation

VI. CONCLUSION

The Solar potential of an area for every month of year 2017 was determined using Arc GIS tool (Area Solar Radiation). The output values projected from the tool in wh/m^2 are converted to Kw/m^2 .The resulting outputs (Table - 2) shows minimum and maximum solar potential. January, November and December are the months where the recorded solar radiations are minimum (less than 30 Kwh/m2) whereas April, May and August are the months where the solar radiations are maximum (more then 150 Kwh/m2). Hence with the help of Area Solar Radiation tool in Arc GIS can be used to determine the solar potential of an area for any period of time, (as seen in Fig - 17 and 18) in which these data's can be used for maintaining the power generation of a particular area.

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