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Mapping Solar Potential of West India : a GIS based analysis

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Need

- Environmental friendly alternatives
- Sustain the increasing energy demand
- Solar energy has enormous potential and is one of the most under exploited resource of energy.
- India: an ideal country for using solar power
- Target of 2000MW off-grid and 22,000MW grid-connected solar generation by 2022 and even higher capacities beyond that time-frame.

OBJECTIVES

- Mapping potential sites of western India for tapping solar energy is the focus.
- In particular, it explores the effect of temperature on global solar radiation.
- The study employs the Geographical Information System (GIS) to map solar energy

Estimation models

- analytic,
- empirical,
- the use of satellite estimates,
- stochastic(kriging),
- artificial neural networks.

STUDY AREA

- The study area is the Western part of the India comprising of Rajasthan, Gujarat, Maharashtra, parts of Madhya Pradesh, Haryana, Goa and New Delhi.
- The study points are New Delhi, Jaipur, Jodhpur, Ahemadabad, Okha, Bhavnagar, Bhopal, Nagpur, Mumbai, Pune, Hyderabad, Panjim.
- The study points were strategically chosen so as to cover the western zone of India.
- From these points global solar radiation values for the entire west zone is calculated by kriging extrapolation technique

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STUDY AREA (West Zone)

STUDY POINTS

METHODOLOGY

- collect extensive radiation data at a larger number of stations covering all the climatic zones of the region as the reliability of interpolation techniques is strongly dependent on the sample size
- India Meteorological Department (IMD) collect such data at various stations across the country.
- For this study, 12 cities were selected appropriately which spanned the entire West Zone of India. From the India Meteorological Department (IMD), Pune, global solar radiation data was ordered.
- The 12 cities comprises of Jaipur, New Delhi, Jodhpur, Okha, Ahemadabad, Bhavnagar, Bhopal, Nagpur, Mumbai, Pune, Hyderabad, Goa with a period span of 9 years.

TEMPERATURE EFFECT ON SOLAR PANELS

A photovoltaic(PV) module will be typically rated at 25 °C under 1 kW/m^2. However, when operating in the field, they typically operate at higher temperatures and at somewhat lower insolation conditions. In order to determine the power output of the solar cell, it is important to determine the expected operating temperature of the PV module. Most solar panel's power output start to degrade if the temperature of the panel goes over about 25 °C.

NOCT

The Nominal Operating Cell Temperature (NOCT) is defined as the temperature reached by open circuited cells in a module under the conditions as listed below:

- Irradiance on cell surface = 800 W/m^2
- Air Temperature = 20°C
- Wind Velocity = 1 m/s
- Mounting = open back side.

For a typical module it is found to be around 50°C.

An approximate expression for calculating the cell temperature is stated in Eq.:

$$T_{cell} = T_{amb} + [NOCT - 20] \times E/800$$

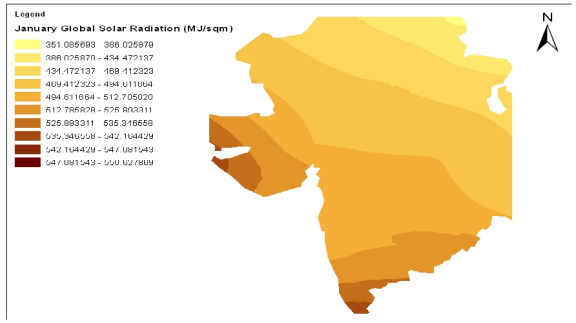
Where T_{amb} is the ambient temperature and E is the insolation level in W/m^2.

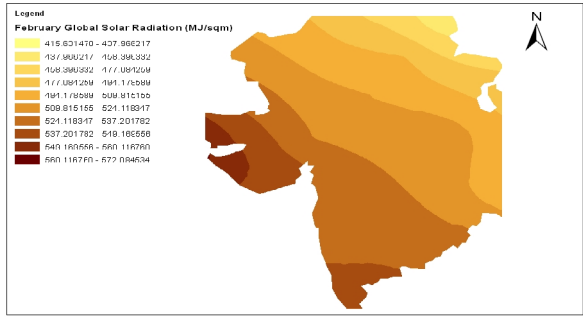
Percentage loss of total solar power output is calculated as in Eq.

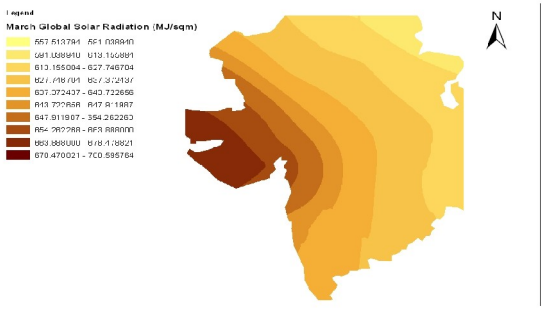
$$\%\ loss\ in\ solar\ power = MPTC \times (T_{cell} - T_{opt})$$

Where the optimum temperature (T_{opt}) of the cell is rated as 25°C.

Maximum power temperature coefficient (MPTC) also known as ‘de-rating’ factor is generally given on the solar panel's specification sheet which is usually around 0.4% per °C


Legend
January Global Solar Radiation (MJ/sqm)
N


Legend
February Global Solar Radiation (MJ/sqm)
N


Legend
March Global Solar Radiation (MJ/sqm)
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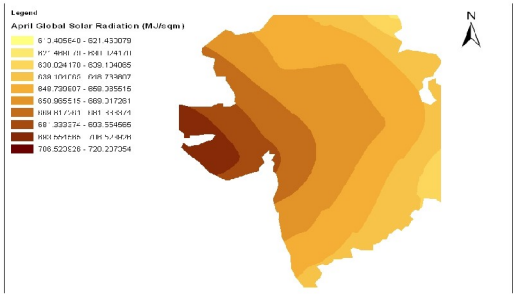
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April Global Solar Radiation (MJ/sqm)
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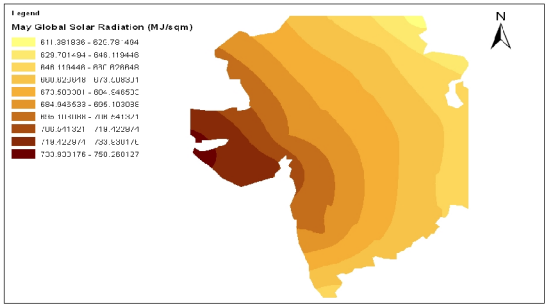
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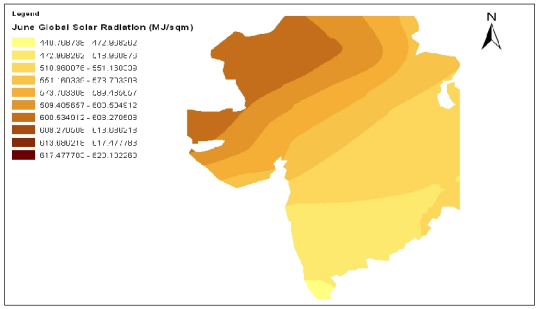
May Global Solar Radiation (MJ/sqm)
N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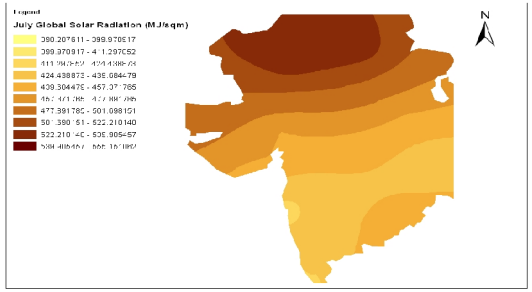
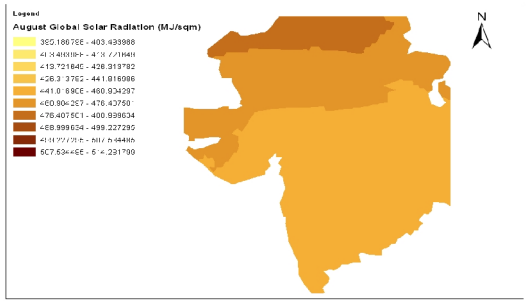
June Global Solar Radiation (MJ/sqm)
N


Legend
July Global Solar Radiation (MJ/sqm)
N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August Global Solar Radiation (MJ/sqm)
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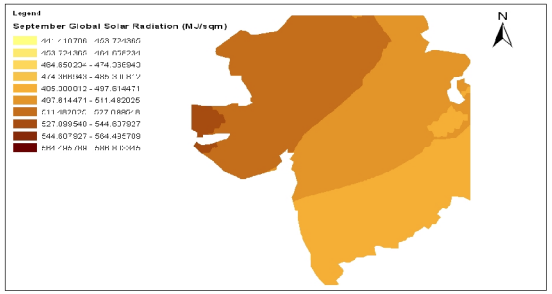
Legend
September Global Solar Radiation (MJ/sqm)
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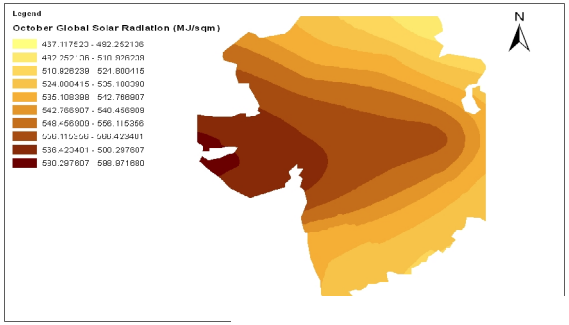
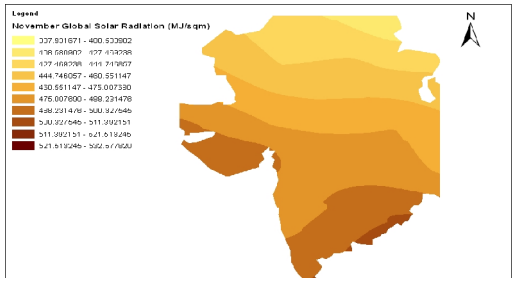
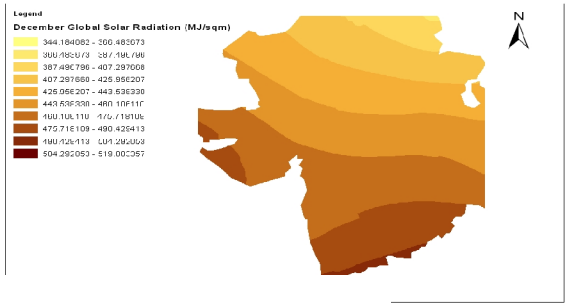
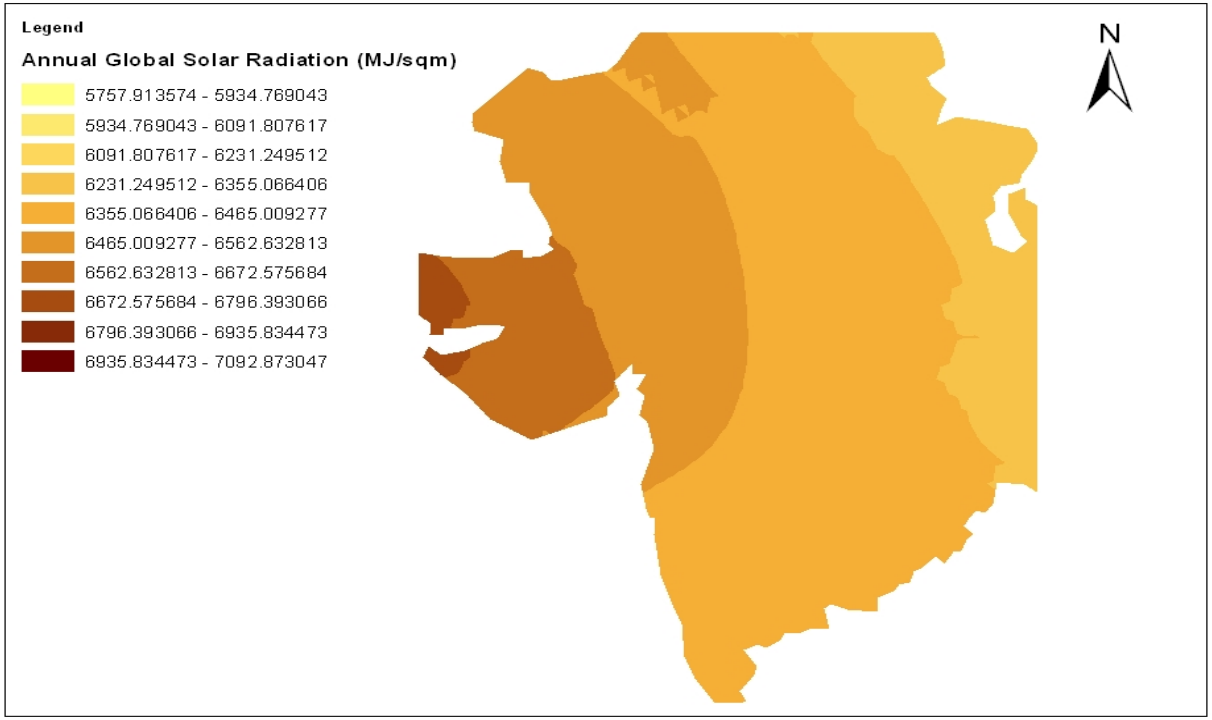


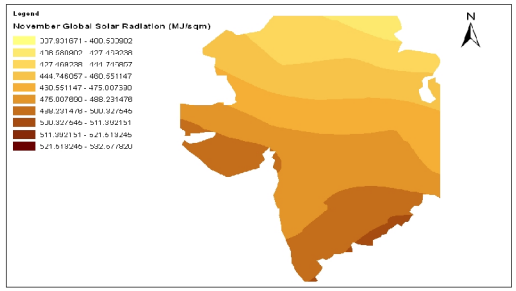


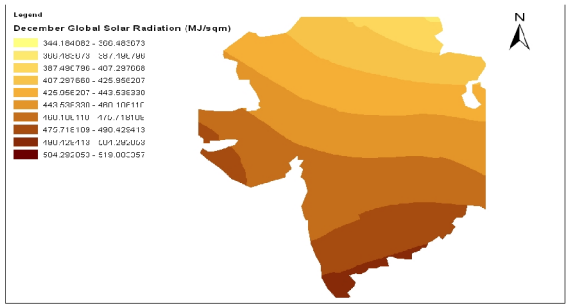


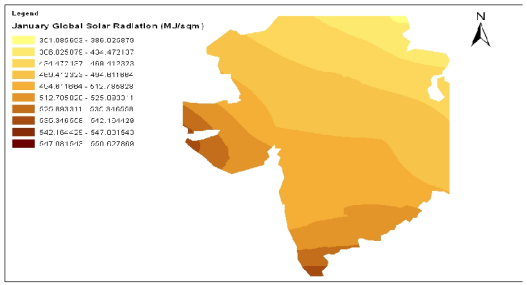


WINTER

It comprises of the November, December and January months. Southern parts of Gujarat and Maharashtra receive maximum global solar radiation. The total solar energy that could be exploited over this period is between 350-550 Mj/sqm per month which is much lesser as compared to the Summer season. This could be attributed to the factors such as fog which are common during winter seasons. However the energy losses due to the temperature effect is lower during this period.

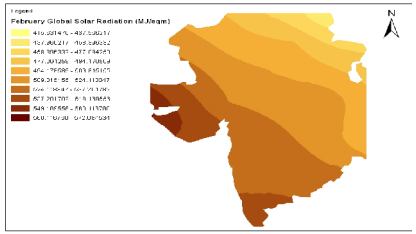


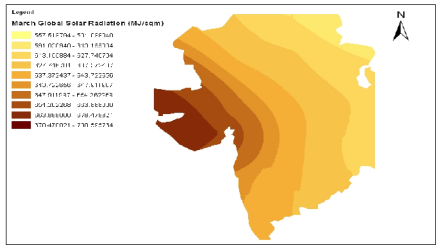


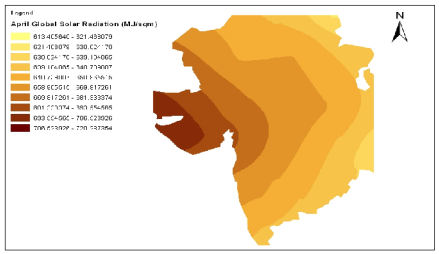


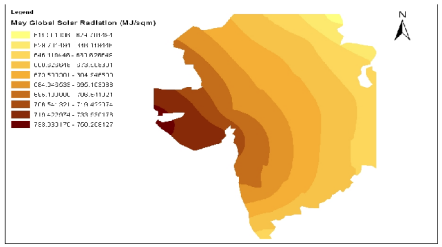
SPRING and SUMMER

It comprises of months from February to May. There is an increasing trend in total solar energy that could be exploited over this period. Total solar energy ranges between 415-750 Mj/sqm per month. Western part of Gujarat is the region that receives maximum global solar radiation with a gradual decrease as we move eastwards from it. Although the total solar energy losses due to temperature are higher but still the solar energy that could be exploited is huge because of the high amount of global solar radiation falling during this period which can be attributed to the clear sky which is huge enough to negate it's effect.



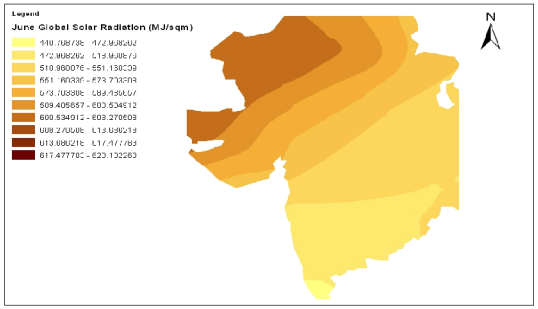


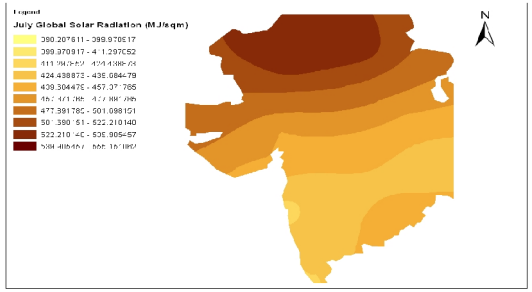


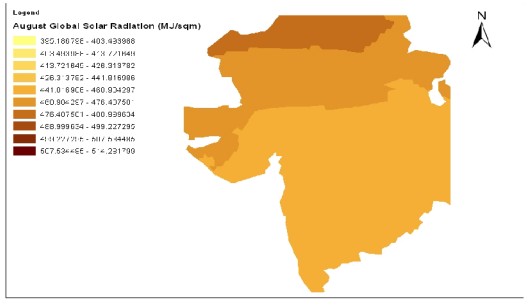


RAINY

It comprises of the June, July and August months. With the onset of monsoon which is attributed to dense cloud cover, there can be seen a decline in the global solar radiation all over the west zone. Since, the monsoon reaches the southern India first and travels from south to north direction, Rajasthan receives maximum global solar radiation. The monthly total solar energy that could be exploited ranges from 450-615 Mj/sqm

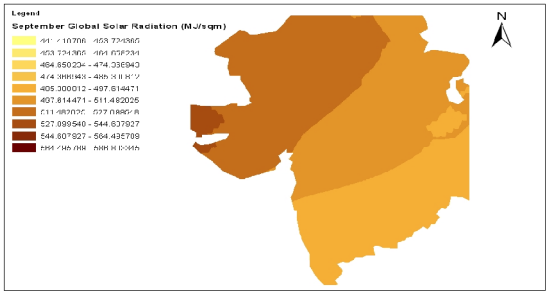


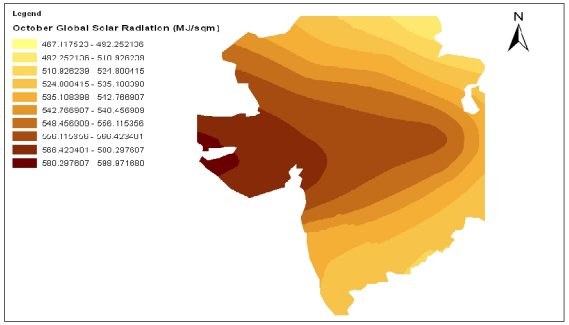




AUTUMN

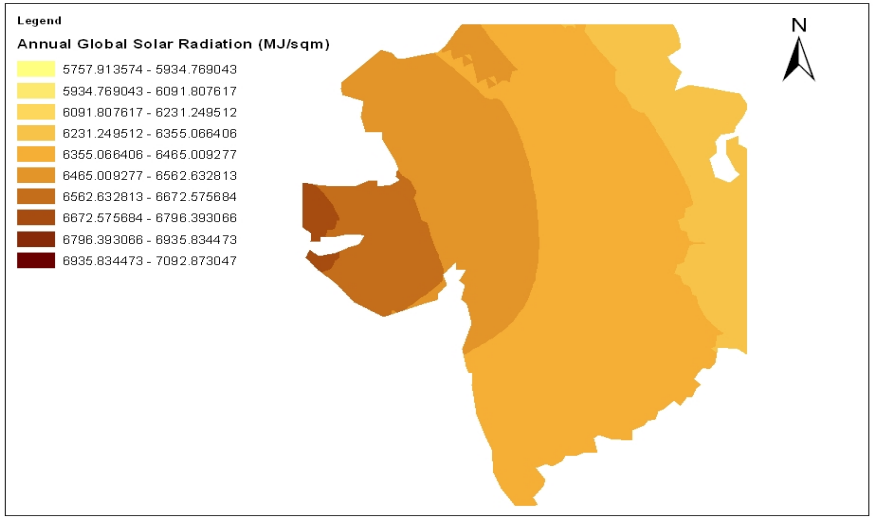
It comprises of the months September and October. The global solar radiation increases gradually over this period with the end of monsoon. Mean monthly solar energy ranges from 450-600 Mj/sqm. Western parts of Gujarat and Rajasthan receive maximum global solar radiation





ANNUALLY

The annual Solar Energy that could be exploited ranges around 6000-6800 Mj/sqm. regions with maximum global solar radiation vary with different seasons but we can observe that the western parts of Gujarat receive the highest solar energy followed by the rest of Gujarat and western parts of Rajasthan.



CONCLUSION

The study identifies western part of Gujarat as the most potential region for setting up of solar farms with around 6700 MJ/m^2 annual solar energy that could be exploited. While rest of Gujarat and western Rajasthan are also regions with rich global solar radiation.

The study was carried out with global solar radiation and temperature data for 12 stations over a span of around 10 years. However, more number of stations and consideration of a spectrum of climatographic parameters such as sunshine hours, fog, altitude etc. that have direct or indirect effect on the solar energy, is expected to show better results. Although, the results have been in accordance as the major solar energy power plants are situated in the state of Gujarat.

Thank you

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