Solar System Mapping of Electrical System And Its Development In Bihar

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Abstract- *Electricity is our need and for this Indian Government announced to setup 100 GW solar power including 40 GW roof top solar systems across the nation. The Bihar state government invested Rs 241 crore in this project for pollution free and low cost electricity. The Centre and the Bihar state government announced that providing 50% subsidy to individual households of Bihar for the micro solar power plants installation. In this research we have proposed a model solar system mapping of electrical system for India as well as Bihar for getting better solar irradiation estimation for generating more electricity by using Inverse Distance Weighting (IDW) interpolation technique for converting poor resolution data into high resolution which will have been taken from other solar mapping source for getting better output. The proposed solar map model will be helpful firstly, to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time; and secondly, to estimate resources for solar system installation in a particular location to generate required amount of energy for both of individual and solar power plant. The proposed model technique will be useful for better forecasting. The proposed solar map has some additional features which are inherited by other previous researches such as GIS map layer for slope estimation, availability of the land and cost estimation, land marks and locality that can effects solar panel efficiency.*

Keywords- solar map, Bihar, IDW, solar irradiance, GIS, solar energy.

I. INTRODUCTION

Electricity is our need and very import for modern world. But most of the state of India are facing problem of shortage of electricity and in some of the rural areas of Indian states including Bihar state where electricity power is totally unavailable which is a bitter truth. India is the second largest most populated developing country after china and majority of the population of Indian states including Bihar belongs from middle and lower class family and they can't afford solar system installation cost which is very expensive in comparison to their total family income to fulfil their electricity need even they know India has an advantage that it is located at solar belt of 350^{o} N to 350^{o} S which is the rich source of pollution free solar renewable energy.

For this reason Indian Government announced that it is going to setup 100 GW solar power including 40 GW roof top solar systems across the India for pollution free and low cost electricity solution as a nation development programme/scheme [11]. This scheme target is to setting up rooftop solar power (as shown in Fig. 1) energy source on buildings owned by individuals or organizations as well as government offices. The Bihar state government has already provided a sum of Rs 241 crore for this project whereas the Centre is releasing funds on the basis of sanctioned projects. A sum of Rs 75,000 for setting up the micro solar power plants generating 1KW of power at rooftops (as shown in Fig. 1) would be required out of which half of the cost would come as subsidy from the Centre and the state in case of individual households of Bihar [12]. In case of institutions, government buildings and social organizations, subsidy would be 25 per cent of the cost whereas commercial or industrial units would not be entitled for any subsidy.

Pollution free solar renewable energy [9] plays a vital role in the field of thermal and electrical energy. The need of the hour is to identify and map solar potential zones collecting data from various sources for diverse applications of solar energy. Solar map and Geographical Information System (GIS) plays an important role for precise determination of the potential zones by solar irradiance (SI) measurement and integrating multi-disciplinary datasets respectively.

Fig. 1. Solar power panels on the rooftop

The aim of this research is to propose a model solar system mapping of electrical system solar map for India [9] as well as Bihar for getting better solar irradiation estimation for generating more electricity by using interpolation techniques i.e. Inverse Distance Weighting (IDW); for pre-processing and enhancement of the data by estimating value(s) of other unknown points by using points data/value such as solar irradiance, temperature, air pressure, pollution level, rain fall data and so on; for converting poor resolution data into high resolution which will have been taken from other solar mapping [8] source and has poor resolution (as shown in Fig. 2); for getting better solar irradiation mapping result. The proposed solar map model will be helpful firstly, to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time in whole day, month and year; and secondly, to estimate resources for solar system installation in a particular location is to generate the required amount of energy for both of individual and solar power plant. The proposed model technique will be useful for better forecasting. The proposed solar map has some additional features which are inherited by other previous researches [7] such as GIS map layer for slope estimation; availability of the land and cost estimate for purchasing the land by using land registration office record; land marks and locality that can effect solar panel efficiency which is retrieved by many government offices such as road construction department etc.

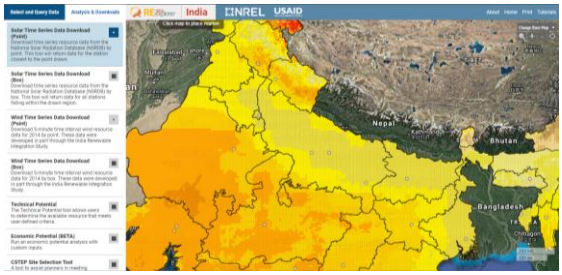


Fig. 2. National Renewable Energy Laboratory (NREL) Toolbox

In this paper, in we will discuss about solar irradiance in section II, literature survey of different of research papers, in section III we will focus on limitations of the papers and their solution, further in section IV we will discuss about different methodologies and formulas which are used in the proposed system and old standard systems. In section V problem formulation and proposed system/technique is discussed. After that in section VI experimental result & discussion has been discussed then conclusion and future scope has been will discussed in section VII. After that literature references are mentioned.

II. SOLAR IRRADIANCE

Solar irradiance (SI) [4], [6] is the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. The solar irradiance integrated over time is called solar irradiation, insolation, or solar exposure.

A. Direct Normal Irradiance (DNI)

Direct Normal Irradiance (DNI) is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky. Typically, you can maximize the amount of irradiance annually received by a surface by keeping it normal to incoming radiation. This quantity is of particular interest to concentrating solar thermal installations and installations that track the position of the sun.

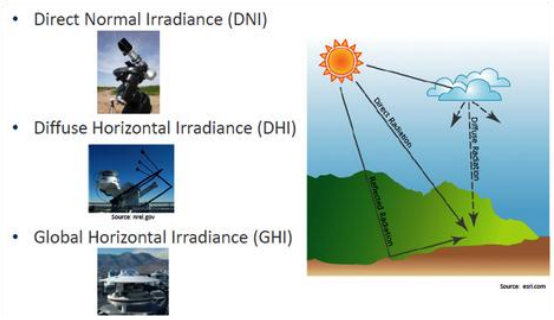
B. Diffuse Horizontal Irradiance (DHI)

Diffuse Horizontal Irradiance (DHI) is the amount of radiation received per unit area by a surface (not subject to any shade or shadow) that does not arrive on a direct path from the sun, but has been scattered by molecules and particles in the atmosphere and comes equally from all directions.

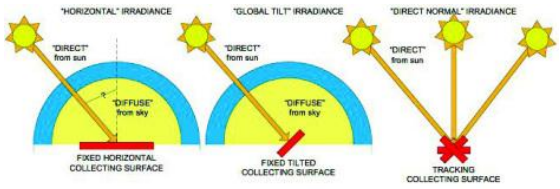
C. Global Horizontal Irradiance (GHI)

Global Horizontal Irradiance (GHI) is the total amount of shortwave radiation received from above by a surface horizontal to the ground. This value is of particular interest to photovoltaic installations and includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI) as shown in Fig. 3 (a) and (b).

Global Horizontal (GHI) = Direct Normal (DNI) X cos(θ) + Diffuse Horizontal (DHI)



(a)



(b)

Fig. 3. DHI, GHI and DNI (a) and (b)

III. LITERATURE REVIEW

In literature review we found many research scholars are working on renewable energy and solar system mapping of electrical system.

[1] Richa et al. this paper focused on mapping of the district-wise potential for concentrating solar power (CSP) and centralized solar photovoltaic (SPV) technology based power plants in India. The evaluation is based on remotely sensed annual average global horizontal irradiance (GHI) [5] and direct normal irradiance (DNI). The solar irradiation data (GHI and DNI), land-use data and Digital Elevation Model (DEM) were used in GIS environment while employing land-use criteria and topography to exclude unsuitable sites for harnessing solar energy. Land-cover factor, number of sunshine hours and conversion efficiencies were taken into account to calculate technical potential in suitable land areas for solar power development.

[2] Haghparast et al. in this paper we studied the theoretical solar irradiation potential in Iran by using an Niroo Research Institute irradiation model based on the geographical and meteorological data. Monthly, seasonal, and annual values of irradiation on the ground surface, and extracted solar energy from different tracking systems, are estimated across the country.

[3] Pariksheet et al. the main object objective of the research is to forecast the solar irradiation potential of India using artificial neural networks (ANNs) method. Second objective of the paper is mapping the predicted potential using GIS software on monthly basis. Solar forecasting using ANN feed forward and feed forward back propagation algorithm have been compared in this paper.

In our research and literature survey we observed that all research scholars are focusing on GIS data such as slope and location features but they are not focusing in interpolation techniques for developing better high resolution solar system mapping from low resolution solar map data.

The aim of this research paper is to develop solar system mapping of electrical system and its development in Bihar for getting better solar irradiation estimation for generating more electricity. The proposed solar map model will be helpful to find out location of maximum solar irradiation for maximum time and it will be useful for better forecasting and decision making.

IV. METHODOLOGIES

D. INVERSE DISTANCE WEIGHTED (IDW)

The Inverse Distance Weighting interpolator assumes that each input point has a local influence that diminishes with distance. It weights the points closer to the processing cell greater than those further away. The Inverse Distance Weighting (IDW) algorithm effectively is a moving average interpolator that is usually applied to highly variable data. The interpolated surface, estimated using a moving average technique, is less than the local maximum value and greater than the local minimum value.

The IDW technique calculates a value for each grid node by examining surrounding data points that lie within a user-defined search radius. Some or all of the data points can be used in the interpolation process. The node value is calculated by averaging the weighted sum of all the points. Data points that lie progressively farther from the node influence the computed value far less than those lying closer to the node. A radius is generated around each grid node from which data points are selected to be used in the calculation.

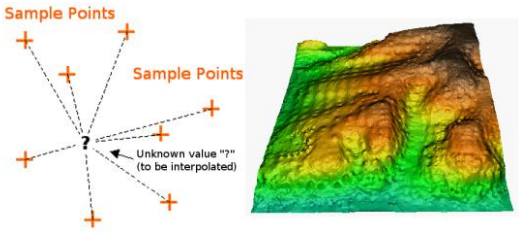


Fig. 4. IDW Interpolation; Courtesy

IDW Formula,

$$\hat{v}_1 = \frac{\sum_{i=1}^{n} \frac{1}{d^p{}_i} v_i}{\sum_{i=1}^{n} \frac{1}{d^p{}_i}} \quad (1)$$

Where,
i = i^{th} term
V= Weight-age
p = order of IDW
d = the distance between two points of know weight-age and unknown weight-age (as shown in Fig. 4 and Fig. 5).

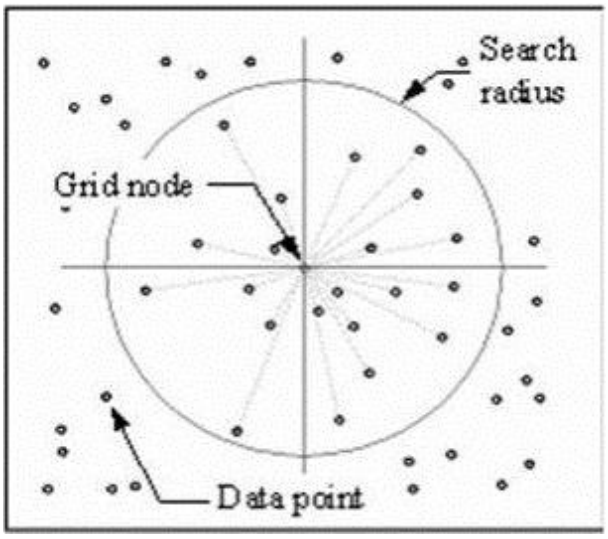


Fig. 5. IDW Interpolated Surface; Courtesy

Note: The optimal power (p) value is determined by minimizing the root mean square prediction error (RMSPE).

1) Advantages

a) Can estimate extreme changes in terrain such as: Cliffs, Fault Lines.
b) Dense evenly space points are well interpolated (flat areas with cliffs).
c) Can increase or decrease amount of sample points to influence cell values.

2) Disadvantages

a) Cannot estimate above maximum or below minimum values.
b) Not very good for peaks or mountainous areas.

V. PROPOSED SYSTEM

In this research we have studied about hybrid solar plant and observed its dynamic behavior towards the nature such as effect of the sun position towards solar panel, effect of cloudy weather and different seasons etc. So, it don't produce electricity in constant manner.

In the research we have proposed a model solar system mapping of electrical system for India as well as Bihar for getting better solar irradiation estimation for generating more electricity by the use of Inverse Distance Weighting (IDW) interpolation technique for converting poor resolution data into high resolution which will have been taken from other solar mapping source for getting better output. The proposed solar map model will be helpful firstly, to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time; and secondly, to estimate resources for solar system installation in a particular location to generate required amount of energy for both of individual and solar power plant. The proposed model technique will be useful for better forecasting. The proposed solar map has some additional features which are inherited by other previous researches such as GIS map layer for slope estimation, availability of the land and cost estimation, land marks and locality that can effects solar panel efficiency.

A. *Data Collection*

The proposed solar map object is to collect poor resolution solar map from other solar map and reprocess the solar map for making high resolution solar system map of electricity system for India as well as Bihar state for better forecasting and decision making.

We have taken historical solar map in hourly basis of Patna from "National Renewable Energy Laboratory (NREL) website https://maps.nrel.gov/gst-india/" of 01-Jan-2005 to 31-Dec-2014 for our research.

B. *Pre-Processing*

Apply pre-processing procedure in the collected solar map data for retrieving relevant data in right format for solar mapping as per requirement.

C. *Interpolation*

Implement interpolation technique in the pre-processed poor resolution solar map data for converting poor resolution data for making high resolution solar system map of electricity system for India as well as Bihar state for better forecasting and decision making.

We have used Inverse Distance Weighting (IDW) interpolation technique for interpolation which is calculated by using equation (1).

D. *Apply GIS*

Apply Geographical Information System (GIS) for integrates multi-disciplinary datasets for precise determination

of the potential zones, it means to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time in whole day, month and year; and secondly, to estimate resources for solar system installation in a particular location to generate required amount of energy for both of individual and solar power plant. GIS map layer for slope estimation; availability of the land and cost estimate for purchasing the land by using land registration office record; land marks and locality that can effects solar panel efficiency which is retrieved by many government offices such as road construction department etc. Block diagram of the proposed system is showing in Fig. 6.

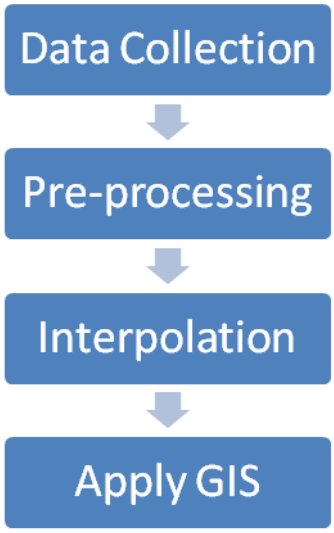


Fig. 6. Block diagram of the proposed technique

VI. EXPERIMENTAL RESULT AND DISCUSSION

A. EXPERIMENTAL SETUP

For the performance and accuracy evaluation of the proposed technique we have gathered historical weather data in hourly basis of Patna from "National Renewable Energy Laboratory (NREL) website https://maps.nrel.gov/gst-india/" of spatial resolution of 10km x 10km from 01-Jan-2005 to 31-Dec-2014.

After that the pre-processing procedure has been applied in the collected solar map data for retrieving relevant data in right format for solar mapping.

B. EXPERIMENTAL EVALUATION

We have implemented Inverse Distance Weighting (IDW) interpolation technique in the pre-processed poor resolution solar map data for converting poor resolution data for making high resolution solar system map of electricity system for India as well as Bihar state for better forecasting and decision making. Equation (1) has been used for interpolation computation in this paper.

As we know that the spatial resolution of 10km x 10km which has been taken from NREL is a poor spatial resolution. So, we have divided the taken spatial resolution of 10km x 10km into 10m x 10m spatial resolution which better in comparison to 10km x 10km spatial resolution.

Fig. 7 and Fig. 8 are showing original sampling and output of interpolation after interpolation using IDW respectively which giving satisfactory.

After that, we have applied Geographical Information System (GIS) for integrates multi-disciplinary datasets for precise determination of the potential zones to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time in whole day, month and year; and secondly, to estimate resources for solar system installation in a particular location to generate required amount of energy for both of individual and solar power plant. GIS map layer for slope estimation; availability of the land and cost estimate for purchasing the land by using land registration office record; land marks and locality that can effects solar panel efficiency which is retrieved by many government offices such as road construction department etc.

C. UNIQUENESS OF THE WORK

The uniqueness of the work is that interpolation techniques have been used in solar mapping for better resolution and more accurate result.

D. EXPERIMENTAL RESULTS

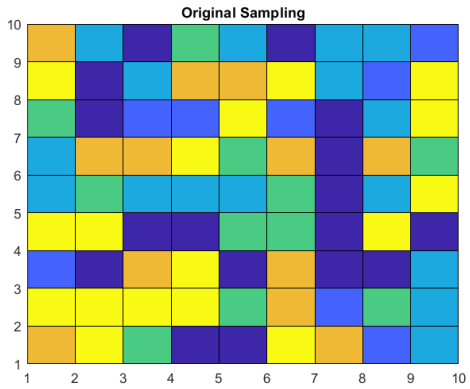


Fig. 7. Original Sampling

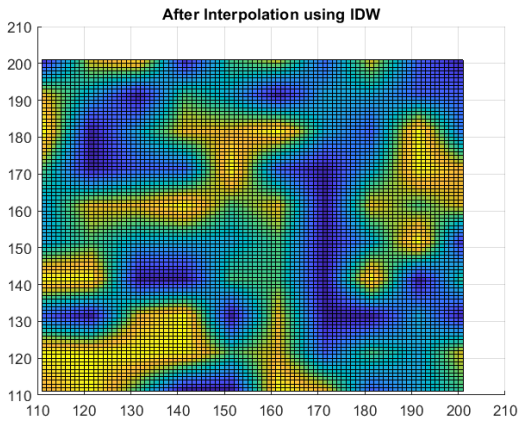


Fig. 8. After Interpolation Using IDW.

VII. CONCLUSION AND UPCOMING WORK

Electricity is our need and very import for modern world. But most of the state of India are facing problem of shortage of electricity and in some of the rural areas of Indian states including Bihar state where electricity power is totally unavailable which is a bitter truth. India is the second largest most populated developing country after china and majority of the population of Indian states including Bihar belongs from middle and lower class family and they can't afford solar system installation cost which is very expensive in comparison to their total family income to fulfil their electricity need even they know India has an advantage that it is located at solar belt of 350^{o} N to 350^{o} S which is the rich source of pollution free solar renewable energy. For this reason the Government of India announced to setup 100 GW solar power including 40 GW roof top solar systems across the nation. The Bihar state government invested Rs 241 crore in this project for pollution free and low cost electricity. The Centre and the Bihar state government announced that providing 50% subsidy to individual households of Bihar for the micro solar power plants installation.

In this research we have studied about lots of solar mapping techniques, their advantages and limitation, financial status of India and central and Bihar government schemes towards development in the field of electricity. Further, we studied about solar energy, its advantages, disadvantages and limitations. After that we analysed interpolation techniques for getting better result.

In the research we have proposed a model solar system mapping of electrical system for India as well as Bihar for getting better solar irradiation estimation for generating more electricity by the use of Inverse Distance Weighting (IDW) interpolation technique for converting poor resolution data into high resolution which will have been taken from other solar mapping source for getting better output. The proposed solar map model will be helpful firstly, to find out the location for solar plant establishment where solar power plant can absorb maximum solar irradiation for maximum time; and secondly, to estimate resources for solar system installation in a particular location to generate required amount of energy for both of individual and solar power plant. The proposed model technique will be useful for better forecasting. The proposed solar map has some additional features which are inherited by other previous researches such as GIS map layer for slope estimation, availability of the land and cost estimation, land marks and locality that can effects solar panel efficiency. We have taken hourly solar map data of 1st Jan. 2005- 31st Dec. 2014 from National Renewable Energy Laboratory (NREL) for the demonstration and research.

We will extend this research work by adding additional social, economical, environmental and geographical properties and features for enhanced solar mapping, better estimation and vast utilization. We will try other advance interpolation techniques for the enhancement.

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