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Electricity Distribution System using Geospatial Technology – A Case Study for Hosur Town, Krishnagiri District

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***Abstract*- Utility services are an important component of the physical structure of towns and there is a need for detailed information about the location and condition of their infrastructure. Acquiring data in the conventional way is time consuming and costly. The integration of GIS with electric utilities is tremendously improving the planning and operation of the system. GIS and GPS are also integrated for mapping and analysis of electric distribution system. In the present paper, the location of each distribution transformer in the Hosur town was collected using GPS. Hosur town was delineated from the satellite image using the GIS technique. Survey of India toposheets and satellite imageries are used to prepare various thematic layers viz landuse/landcover map, transportation network map. The solar radiation on the rooftop of each building was determined using the solar radiation tools in the arctool box of ArcGIS. The thematic layers were finally integrated into ArcGIS software to estimate the regions that are prone to high solar radiation for the installation of Photo Voltaic panels.**

***Keywords*- Distribution transformer, Remote sensing, Solar radiation, GPS, Point solar radiation tool**

I. INTRODUCTION

Electricity is an aspect of the utility sector that is very essential to the smooth and meaningful development of a society. The primary purpose of an electricity distribution system is to meet the customer's demand for energy after receiving the bulk electrical energy from transmission or sub transmission substation. Complexity of electrical distribution power system is the only reason for introducing new technologies such as RS and GIS technology. Database plays an important role in planning. There exists a relation between every spatial object and its non spatial database, for example, location of pole on earth is called spatial data and its height information is non spatial data. Satellite images are used in the identification of the spatial features. If an identity is not visible in satellite image then a GPS receiver can be used to establish its location. In the present study, the electricity distribution system of Hosur town which lies between the longitude 77°48'28" E to 77°50'37" E and latitude 12°42'36" N to 12°45'12" N have been studied. The distribution system comprises power lines and voltage-step-down equipment for electric service at industrial, commercial and residential sites. A distribution system may comprise three phase transmission lines, with typical operating voltages of 12 to 25kv line to line, and three phases, two phases or single phase tapped lines. Distribution feeders emanating from a substation are generally controlled by a circuit breaker which will open when a fault is detected. Automatic Circuit Reclosers may be installed to further segregate the feeder thus minimizing the impact of faults.

The use of GIS in power system has greatly enhanced the efficiency in energy sector. Proximity to the furthest customer and high cost to invest capital, are the reasons that make the distribution system as an important part of electrical utility, which endeavor to improve the reliability of general power system. The power industry is expected to keep track of the electrical facilities (poles, power lines and transformers) involved in the distribution of energy to the end-users. With the aid of GIS, variety of information can be better organized on a computer system linking the database to an output map. Solar energy is widely used for power generation since it is non- polluting and a renewable resource. Nguyen and Pearce [1] have used an open domain approach to compute radiation including temporal and spatial variation of albedo and solar photovoltaic yield.

II. STUDY AREA

The present study area Hosur which lies between the longitude $77^{0}48'28''$ E to $77^{0}50'37''$ E and latitude $12^{0}42'36''$ N to $12^{0}45'12''$ N is a town and municipality in Krishnagiri district in the Indian state of Tamil Nadu. It is the headquarters of the Hosur taluk of Krishnagiri district. It is located about 40 kilometers south east of Bangalore, 48 kilometers northwest of Krishnagiri, the district headquarters and 306 kilometers west of Chennai, the state capital. Hosur is known for its expanding manufacturing industries and its pleasant climate. The National Highway NH207 starts from Hosur in Tamilnadu and it ends at Dobbasapete in Karnataka. National Highway NH 44(Old Number NH7) is starting from Varanasi or Banaras in Uttar Pradesh and it ends at Kanyakumari in Tamil Nadu and this road is passing through this city. This city is well connected by road and rail network.

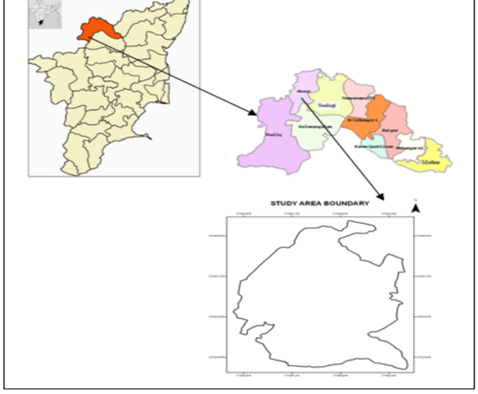

Fig. 1 Map showing the study area

III. MATERIALS AND METHODS

TABLE 1. DETAILS OF SATELLITE IMAGE

Satellite	Acquisition year	Spatial Resolution
SPOT image	2012	PAN – 1m

TABLE 2. DETAILS OF TOPOSHEET

Toposheet No	Scale	Year of survey
57H/13 & 57H/14	1:50,000	2011

The secondary data used in this study includes

- Data collected from TNEB
- Data collected from field survey

The image of the study area is taken by the satellite SPOT. It is a high-resolution, optical imaging Earth observation satellite system operating from space. The Panchromatic Resolution is 1 m and multispectral resolution is 4m. The number of bands is 4 (B, G, R & NIR). The software ERDAS IMAGINE 9.1 is used for visual and digital interpretation, ArcGIS10 is used for vector layer generation, maintaining of database and layout preparation. The collected toposheets of study area were scanned, registered and mosaicked using ERDAS IMAGINE 9.1 software. Satellite data were collected, preprocessed & geo-corrected with respect to registered toposheet. Landuse/landcover map has been created for the study area. Secondary data are collected by field survey and stored in database.

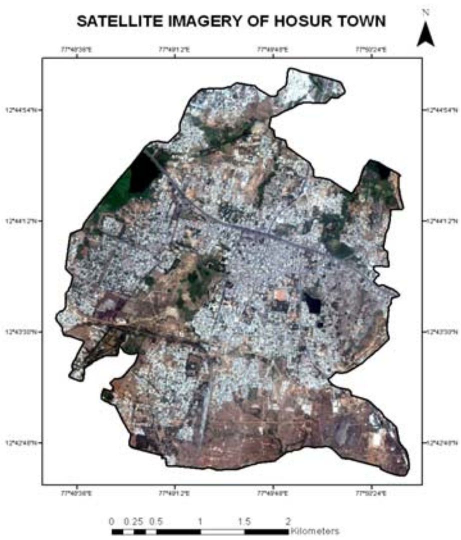

Fig. 2 Satellite imagery of the study area

The data acquisition began with the physical phenomenon to be measured. The first step in the methodology of this work was the collection of the required data from the study area. In this case, there are two types of GIS data involved such as spatial data and non-spatial data. The geographic location of each distribution transformer was acquired from the field survey using GPS instrument. The Cartosat DEM was used to generate the slope map of the study area.

3.1 Landuse/landcover Map

Landcover is that which covers the surface of the earth and land use describes how the landcover is modified. Land cover includes: water, snow, grassland, forest, and bare Soil. Landuse includes agricultural land, builtup land, recreation area, wild life management area etc. The Land cover reflects the biophysical state of the earth's surface and immediate subsurface, thus embracing the soil material, vegetation, and water. Land use refers to man's activities on land which are directly related to the land.

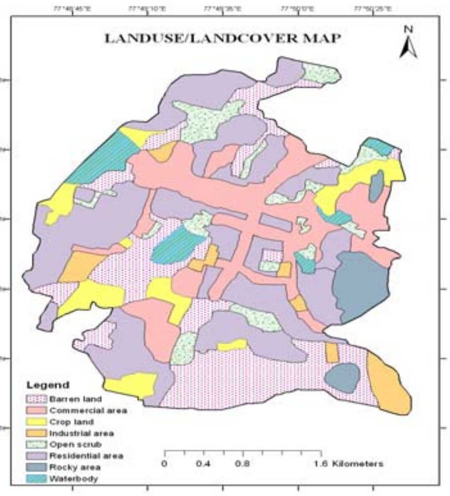

Fig. 3 Landuse/landcover Map

The landuse/landcover map prepared includes seven classes such as open scrub, rocky area, water body, residential area, commercial area, industrial area and agricultural land.

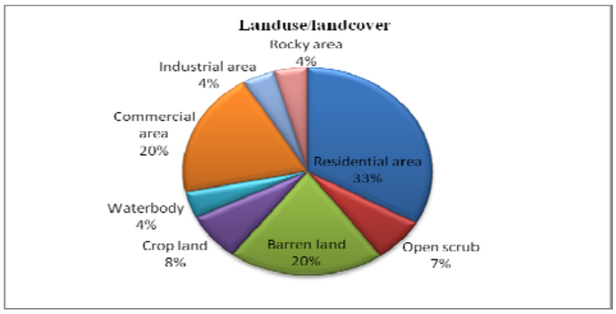

Fig.4 Chart depicting the % of landuse/landcover in the study area

3.2 DEM and Slope

The Cartosat DEM image downloaded from NRSC Bhuvan website was used to prepare slope map after georeferencing and clipping the study area using ArcGIS software.

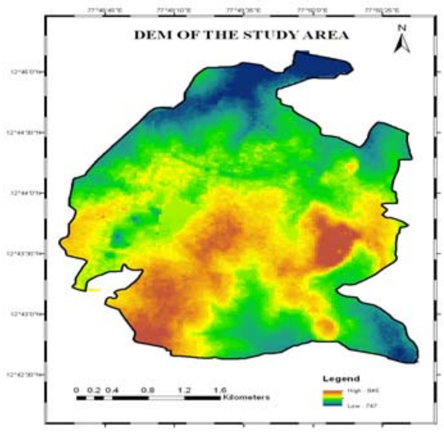

Fig. 5 Digital Elevation Model

The point solar radiation tool derives incoming solar radiation for specific locations in a point feature class. The polygon shape file of the buildings is converted into point shape file. The Cartosat DEM and the point feature of the buildings are given as input to this tool. The time configuration was given as whole year with monthly interval and others are kept default. Then it was processed to obtain the monthly solar radiation of each building rooftop in wh/m^2

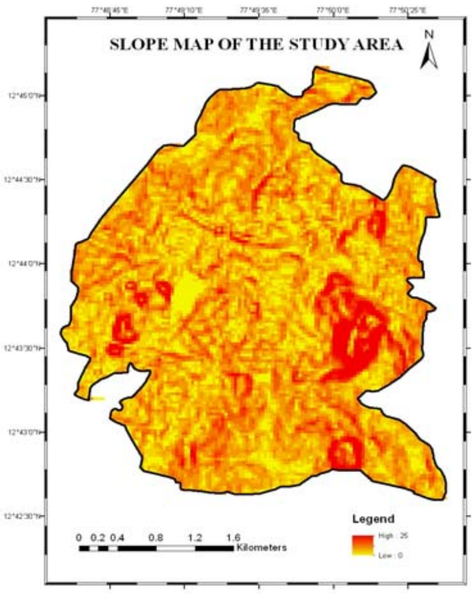

Fig. 6 Slope Map

3.3 Solar Radiation Analysis

The solar radiation analysis tools are used to map and analyze the effects of the sun over a geographic area for specific time periods. The Area Solar Radiation tool is used to calculate the insolation across an entire landscape. The calculations are repeated for each location in the input topographic surface, producing insolation maps for an entire geographic area. The Points Solar Radiation tool is used to calculate the amount of radiant energy for a given location. Locations can be stored as point features or as x, y coordinates in a location table.

The global radiation depends upon direct and diffused radiation. They can be calculated in the form of both feature class and raster image. The direct radiation is the radiation that falls directly on the ground. The diffused radiation reaches the surface after diffusing in the cloud and atmosphere.

Global radiation ($Global_{tot}$) is calculated as the sum of direct (Dir_{tot}) and diffuse (Dif_{tot}) radiation of all sun map and sky map sectors, respectively.

$Global_{tot} = Dir_{tot} + Dif_{tot}$

Since radiation can be greatly affected by topography and surface features, a key component of the calculation algorithm requires the generation of an upward-looking hemispherical viewshed for every location in the Digital Elevation Model (DEM). The hemispherical viewsheds are similar to upward-looking hemispherical (fisheye) photographs, which view the entire sky from the ground. The amount of visible sky plays an important role in the insolation at a location.

IV. Results And Discussions

4.1 Location Details of Distribution Transformers

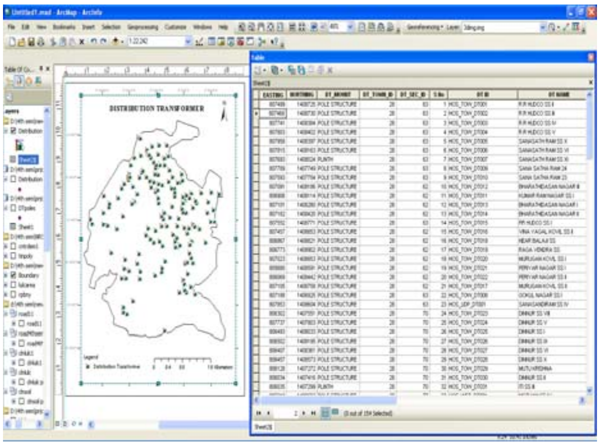

Fig. 7 Distribution transformer details

The geographic location of each distribution transformer in the study area was acquired using GPS instrument. It was found that there were 154 distribution transformers which were pole mounted. The details such as distribution transformer (DT) ID, its voltage capacity, pole structure, section ID, etc was collected from the Tamilnadu Electricity Board. A database has been created from the GPS locations and other transformer details.

4.2 Solar radiation at each building rooftop

The buildings in the Hosur town have been digitized from the SPOT image. There were approximately 13580 buildings in the study area. The monthly average solar radiation at each rooftop was calculated using spatial analyst tool in ArcGIS and it was observed that the solar radiation was high during the months of August, September, October and November. Each building rooftop receives different radiation at different times. The rooftop in which the radiation is high can be identified using the point solar radiation.

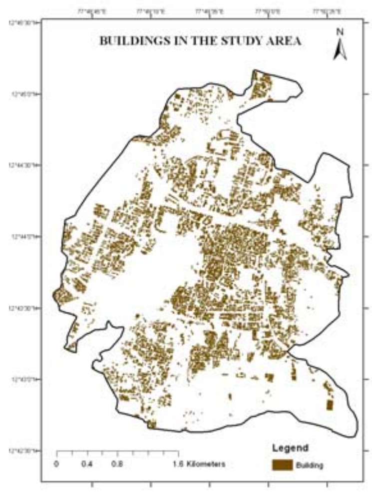

Fig. 8 Map showing the digitized buildings

4.3 Spatial Interpolation Map

The spatial interpolation process gives a raster image using the point file generated from the point solar radiation tool. It adds close range radiation points together and forms a raster image. Interpolation predicts values for cells in a raster from a limited number of sample data points. It can be used to predict unknown values for any geographic point data, such as elevation, rainfall, chemical concentrations, and noise levels. This spatial interpolation map shown below has been generated using the Kriging technique.

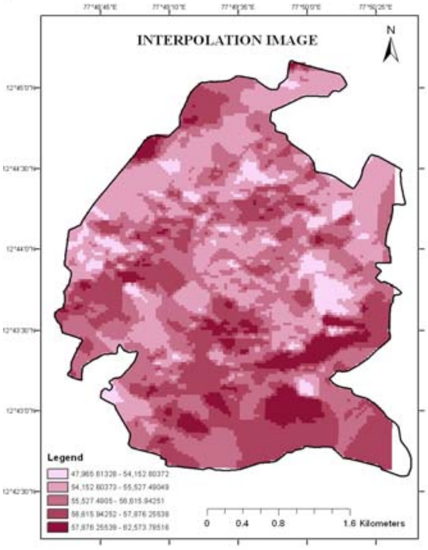

Fig. 9 Spatial Interpolation Map

Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set of points with z-values. Kriging is a geostatistical method of interpolation and they are based on statistical models that include autocorrelation (the statistical relationship among the measured points). Because of this, geostatistical techniques not only have the capability of producing a prediction surface but also provide some measure of the certainty or accuracy of the predictions.

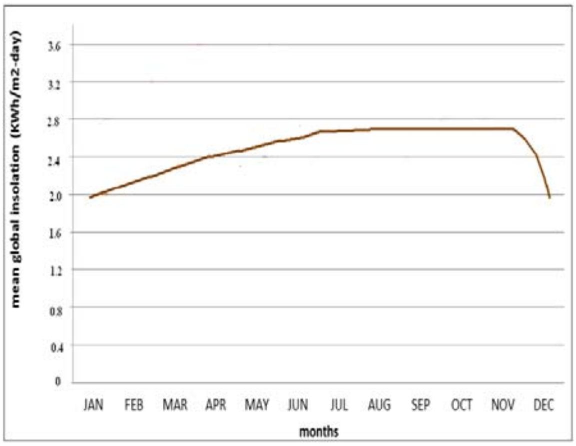

Fig. 10 Graph showing the mean global radiation variation in Kwh/m^2

V. CONCLUSION

This study helps to estimate the rooftop solar potential of a particular building or a selected area. The locations of high solar radiation are determined using the point solar radiation tool and it is found that the months of September, October and November have high potential of solar radiation. Hence, those locations which have high solar potential can be selected for the rooftop photovoltaic panel installation. This study utilized GIS and GPS to determine the geographic location of each distribution transformer in the study area and a database was created for the routine maintenance.

T ABLE 3. MONTHLY AVERAGE SOLAR RADIATION AT EACH BUILDING ROOFTOP IN WH/M^2

Table

Points5_img1

Shape *	OBJECTID *	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
Point	1	59134.635576	62484.09431	66748.672371	71415.225862	75723.304153	79850.749957	80795.015895	82013.475422	82155.303056	81772.275389	81026.779028	5782.753387
Point	2	59134.635576	62484.09431	66748.672371	71415.225862	75723.304153	79850.749957	80795.015895	82013.475422	82155.303056	81772.275389	81026.779028	5782.753387
Point	3	58699.411604	62111.382854	66404.346926	71123.15151	75533.577214	79790.664076	80874.233544	82304.315595	82487.373012	82135.772082	81419.757502	5812.403114
Point	4	58493.231763	61844.38798	66224.301919	70973.479233	75430.708657	79529.354487	80735.381367	82169.060952	82439.4179	82163.55135	81485.545438	5817.508083
Point	5	57908.980511	61311.081036	65781.894622	70562.042998	75146.940442	79143.327429	80348.57013	82082.553516	82417.936359	82162.901868	81556.705434	5818.2729
Point	6	58013.915034	61354.437584	65821.692787	70641.486885	75186.411922	79472.706418	80709.061957	82253.21389	82660.039527	82446.375108	81816.078977	5845.608344
Point	7	58493.231763	61844.38798	66224.301919	70973.479233	75430.708657	79529.354487	80735.381367	82169.060952	82439.4179	82163.55135	81485.545438	5817.508083
Point	8	57908.980511	61311.081036	65781.894622	70562.042998	75146.940442	79143.327429	80348.57013	82082.553516	82417.936359	82162.901868	81556.705434	5818.2729
Point	9	58013.915034	61354.437584	65821.692787	70641.486885	75186.411922	79472.706418	80709.061957	82253.21389	82660.039527	82446.375108	81816.078977	5845.608344
Point	10	57020.900174	60402.99267	64965.789934	69899.767131	74667.178872	78876.949212	80333.4575	82329.299854	82932.830034	82852.359479	82361.228305	5880.761608
Point	11	58493.231763	61844.38798	66224.301919	70973.479233	75430.708657	79529.354487	80735.381367	82169.060952	82439.4179	82163.55135	81485.545438	5817.508083
Point	12	57020.900174	60402.99267	64965.789934	69899.767131	74667.178872	78876.949212	80333.4575	82329.299854	82932.830034	82852.359479	82361.228305	5880.761608
Point	13	57908.980511	61311.081036	65781.894622	70562.042998	75146.940442	79143.327429	80348.57013	82082.553516	82417.936359	82162.901868	81556.705434	5818.2729
Point	14	58745.260522	62141.248342	66470.517566	71138.923354	75563.635135	79446.000863	80657.744064	82046.019517	82221.489288	81801.674591	81115.312487	5785.915305
Point	15	58493.231763	61844.38798	66224.301919	70973.479233	75430.708657	79529.354487	80735.381367	82169.060952	82439.4179	82163.55135	81485.545438	5817.508083
Point	16	57020.900174	60402.99267	64965.789934	69899.767131	74667.178872	78876.949212	80333.4575	82329.299854	82932.830034	82852.359479	82361.228305	5880.761608
Point	17	57020.900174	60402.99267	64965.789934	69899.767131	74667.178872	78876.949212	80333.4575	82329.299854	82932.830034	82852.359479	82361.228305	5880.761608
Point	18	56300.729186	59728.091929	64346.69783	69366.986504	74207.692434	78557.280242	79990.468876	81849.647876	82636.298734	82673.097824	82229.283873	5878.331801
Point	19	56847.227012	60279.612592	64822.29703	69842.341777	74598.847863	78945.676071	80679.965547	82479.631721	83163.430884	83135.611876	82649.508995	5908.639358
Point	20	56300.729186	59728.091929	64346.69783	69366.986504	74207.692434	78557.280242	79990.468876	81849.647876	82636.298734	82673.097824	82229.283873	5878.331801
Point	21	57508.731948	60917.334314	65334.234217	70256.662756	74929.072535	79122.639672	80839.072699	82620.954789	83103.270359	82989.723887	82413.21669	5884.729802
Point	22	56847.227012	60279.612592	64822.29703	69842.341777	74598.847863	78945.676071	80679.965547	82479.631721	83163.430884	83135.611876	82649.508995	5908.639358
Point	23	57011.948681	60392.963325	64954.594325	69887.265641	74654.318422	78864.064201	80318.393524	82365.406354	82981.932399	82919.116592	82457.937343	5889.458001
Point	24	57508.731948	60917.334314	65334.234217	70256.662756	74929.072535	79122.639672	80839.072699	82620.954789	83103.270359	82989.723887	82413.21669	5884.729802
Point	25	56929.365771	60415.733745	64956.608774	69980.637009	74673.679842	78893.179019	80585.871256	82349.753596	82936.174148	82866.425117	82394.354417	5891.847894
Point	26	57508.731948	60917.334314	65334.234217	70256.662756	74929.072535	79122.639672	80839.072699	82620.954789	83103.270359	82989.723887	82413.21669	5884.729802
Point	27	56847.227012	60279.612592	64822.29703	69842.341777	74598.847863	78945.676071	80679.965547	82479.631721	83163.430884	83135.611876	82649.508995	5908.639358
Point	28	57011.948681	60392.963325	64954.594325	69887.265641	74654.318422	78864.064201	80318.393524	82365.406354	82981.932399	82919.116592	82457.937343	5889.458001
Point	29	57011.948681	60392.963325	64954.594325	69887.265641	74654.318422	78864.064201	80318.393524	82365.406354	82981.932399	82919.116592	82457.937343	5889.458001
Point	30	56459.393404	59842.625677	64358.43419	69412.210951	74200.035211	78478.136881	79973.570056	81871.316174	82456.355835	82439.978237	82043.568265	5860.2066
Point	31	56929.365771	60415.733745	64956.608774	69980.637009	74673.679842	78893.179019	80585.871256	82349.753596	82936.174148	82866.425117	82394.354417	5891.847894
Point	32	57011.948681	60392.963325	64954.594325	69887.265641	74654.318422	78864.064201	80318.393524	82365.406354	82981.932399	82919.116592	82457.937343	5889.458001

1 (0 out of 13580 Selected)

Fig. 11 Map depicting a part of Hosur town with extruded buildings

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