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Climatic Impacts and Reliability of Large Scale Wind Farms in Tamil Nadu

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Abstract

Objective: The main objective of this paper describes how the large scale windfarms affect the climate of south west monsoon region. **Methods/Analysis:** Method used for analysing climatic parameters of before and after installation of wind farms is Gaussian mixture model. ArcGIS and QGIS software is used for image and geo-information analysis. Data from the commercial wind turbine of south west monsoon region like temperature, relative humidity, precipitation, wind speed is used to find the climatic variation. **Findings:** Large scale wind farms significantly affect the various climatic parameters. These impacts depends on the static stability, increase or decrease in the climatic parameters. **Conclusion/ Application:** Improvements can be made by taking the ground temperature measured by satellite image and identify the warming effect of night and day time warming effect of large scale wind farm area of southwest monsoon regions.

Keywords: Gaussian Mixture Model, Humidity, Precipitation, Temperature, Wind Farm, Wind Speed

1. Introduction

Wind is a most beneficial energy source in Tamil Nadu. It is blessed with good metrological and topological settings. Wind energy in Tamil Nadu has perceived a tremendous growth propelling the state to the number one position in India for renewable energy. In Tamil Nadu, the first demon of wind farm is at Mullaikadu in Tuticorin district during the year of 1986. Only 20 wind farms has been erected in the first stage of demo and they have produced 55kw of wind electric generator. Now, around 11,000 to 13,000 million units per year are produced by the wind farms from different places in Tamil Nadu. So, they gradually introduced and worked for supplant and supplement fossil fuel force plants to reduce greenhouse gases and other contamination outflows. But it has impact on agriculture, health, society and other technologies. Wind farms are growing in more numbers and size, as it is important to examine an effect of environment. The current study is about how the hundreds of wind turbine can influence a weather condition to nearby area of wind farms and its surroundings. The indication of the multiple turbine in a group leads to mixing of air above and below with different beginning condition[1]. Increase or decrease of weather parameters depends on mixing of air. Two different air types are mixed, it can be either warm or cool, moisten or dry which is quite different from original properties of air. Conventional form of energy generation causes multiple pollution in the atmosphere. Amongst wind energy system disturbs the climate. Wind turbines has the potential impact on temperature thereby reduction in wind speed is known as warming effect[2].

In the previous method the regional climatic model, wind tunnel experiment and various method have been used to analyse the climatic changes in wind farms of various places like the United States and Australia. The scholars establish a warming impact of wind farms in night time of Texas in the year of 2003-2011[3]. It warms up to 0.72°C per epoch over nine year era. In this paper, the increments in number and size of operational wind farms

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in Tamil Nadu, it is perpetually imperative to analyse the impacts on nature of this renewable energy sources.

1.1 Data Description

Climatic impact on wind farms analysis is on the south west monsoon region. The monsoon starts at the end of April and at the end of September in a year. Month of July and August are the peak season for the winds. First is Palghat pass, the regions are Coimbatore and erode. Second is of Shencottah pass, the regions are Tirunelveli and Tuticorin, third is of Aralvoimozhi pass regions Aralvoimozhi in Kanyakumari district and the last is Cumbam pass regions is of Dindigul district. During southwest monsoon these four passes endowed with heavy wind flow. The Figure 1 is taken from TANGEDCO website[4]. The table represent the passes and in area they pass.

The parameter used for the prediction of climate is surface temperature (maximum and minimum), precipitation, wind speed and relative Humidity. Datasets have been created for the above four passes of south west monsoon regions that is before and after the wind farm is installed at a particular region. And the observation for the above parameters made by the Climate Forecast System Reanalysis (CFSR) global metrological dataset is downloaded from the Global weather data for SWAT website. Data is taken over the period of January to December from the year of 1979 to 2014. They have taken at a 38 km and with a high resolution.[5-9].From this data the analysis is made for the south west monsoon months. Tamil Nadu district topo sheet is collected from Survey of India. And southwest monsoon regions boundaries is separated from district map by employing ArcGIS software.

Name of passes/Districts	Area
Palghat	Coimbatore, Dindigul
Shengottah	Tirunelveli, Tuticorin
Cumbam	Theni, Cumbam, Andipatti
Aralvoimozhi	Kanyakumari, Radhapuram, Muppandhal

Figure 1. Wind Power passes of Tamil Nadu.

2. Method

It matches the best distribution from the given vectors. Parameters of GMM are estimated in various way amongst, maximum likelihood (ML) is used. It involves the latent variable with unknown parameters and the known data variables. ML parameter is obtained by using the Expectation and maximization algorithm (EM).

$$p(X/\lambda) = \prod_{t=1}^{T} p(x_t/\lambda)$$

Where X is $X = \{x_1 .... x_t\}$

EM algorithm begins with an initial model λ (choose the value of λ^{old}) and E step is to evaluate the responsibilities of $p(Z/X, \lambda^{old})$.

Where Z is the latent variable. The missing data has been estimated from e step are used instead of actual missing data and M step is to re-estimate the parameter. These re-estimation process increases monotonically in the model's value. The expectation E step is bit an incongruity[10]. Values created in the first step is kept as a fixed value and the data dependent parameter is the Q function.Once the parameter is known the value is fully determined and it is maximized in the second step.

$$\lambda^{new} = \arg\max_{\lambda} Q(\lambda, \lambda^{old})$$

Such that, $\lambda^{old} \leftarrow \lambda^{new}$ .The generated new model will act as precedence for the next model till an appropriate threshold is converged.

Weight

$$\overline{w_i} = \frac{1}{T}\sum_{t=1}^{T} \Pr(i/x_t, \lambda)$$

Mean

$$\overline{\mu_i} = \frac{\frac{1}{T}\sum_{t=1}^{T} \Pr(i/x_t, \lambda).x_t}{\frac{1}{T}\sum_{t=1}^{T} \Pr(i/x_t, \lambda)}$$

Variance

$$\overline{\sigma_i^2} = \frac{\frac{1}{T}\sum_{t=1}^{T} \Pr(i/x_t, \lambda).x_t^2}{\frac{1}{T}\sum_{t=1}^{T} \Pr(i/x_t, \lambda)} - \mu_i^2$$

EM algorithm will find the clusters by determining the Gaussian that fits a given data. Each Gaussian model has its individual mean and variance matrix. The variance is actually a covariance matrix. Each precedence is the point from the Gaussian cluster is considered for the modelling. EM algorithm implies, while initializing the procedure random numbers will be used. The iteration process will not give the identical answers if you call for multiple times with the same input data.

Before and after installation of windfarm, data has been taken for various places of southwest monsoon region. The input data is taken from 1979 to 1986 as one set and from 1987 to 2014 as taken as another set. By using the above algorithm the single cluster is formed so only one mean, variance, weight is obtained. Variance is taken as an output because it tells about the data distribution for each set of data other parameters won't tell. The same step is repeated for the all regions and it has been plotted as a graph and map has been created for that data. To analyse the region having an impact of the large wind farms.

From the Table 1, it is easy to identify the increase or decrease in the given parameter and the warming remains constant for some of the places were the windfarms are not being prolonged, if they remain in the same count of windmills. The warming is deliberated as a local effect and not as a global drift. Overall of southwest monsoon region of windfarm area the temperature is highly affected at Sulur and Muppandhal area.

3. Analysis

In particular, addressing the effects of climate variation of wind farms through the use of statistical data and satellite images was demonstrated for both qualitative and quantitative perspective. Through two separate quantitative analyses, the visual or qualitative assessment was confirmed demonstrating identical results diagrammatically in conjunction with the local metrological wind data. In computing these large datasets have been analyzed using proven methodology that has been focused on the effort to prove these models which append further credibility to the supporting the findings. The remote sensing representational process and GMM analysis has shown to be pronto effective within the quantitative characterization of a large scale wind farm's influence on temperature and other parameters.

4. Results and Discussion

In spite of its (wind energy) role in energy generation, it has its own demerit in climate change. Parameters like temperature, relative humidity, precipitation and wind speed has variation due to windfarms. So, if the

Table 1. Statistical significance from Gaussian model of various places in south west monsoon region

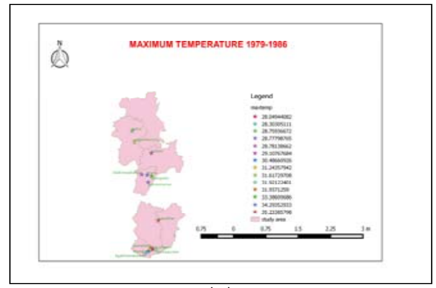
Places	Maximum Temperature (°C)	Minimum Temperature (°C)	Precipitation (mm)	Wind Speed (m/s)	Relative Humidity (%)
Agatheeswaram	0.415378	0.410409	1.01179	0.082271	0.004314
Andipatti	0.54385	0.607738	1.025883	0.03036	0.014621
Sulur	1.227368	0.630914	1.720102	0.045828	0.005789
Gandamanur	0.646856	0.571907	1.466671	0.049233	0.01181
Perungudi	0.436004	0.427338	1.689352	0.100695	0.002371
Panakudi	0.886125	0.634826	0.558575	0.020991	0.00845
Muppandhal	1.110535	0.580198	0.560009	0.039236	0.007587
Palani	1.858569	0.497227	1.684614	0.011341	0.012246
Bodinayakanur	0.337012	0.420021	0.82431	0.111459	0.005501
Radhapuram	0.674234	0.554987	0.386684	0.061695	0.009265
Theni	0.420293	0.660689	1.566581	-0.00957	0.012581
Thovalai	0.808397	0.564145	1.675512	0.046974	0.00454
Kayathar	0.651112	0.736323	0.656257	0.041553	0.012201
Vagaitholuvu	0.623517	0.544717	0.882955	0.031021	0.01004

parameters increases the following affects may occur. Each one degree Celsius increase would make upto 10 percent less rainfall is said by national research council on 2010 report. Much of earth's water ultimately comes from precipitation. Deficient precipitation may end up in dry soil, shallow streams, and shortages of water supplies. Relative Humidity is high the temperature is low there will be a rainfall.

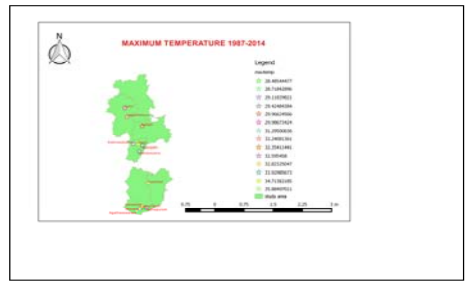
The immediate effect of wind energy is unexpected, though the aberrant climatic benefit develops from zero with time as power from wind decreases carbon dioxide discharges and moderates the development of fixations. Research of this paper suggests the climatic impact of wind energy is non negligible and climatic changes in wind power is predicted by GMM for quantitative analysis.

Windfarms impact will be below average than the normal variability in weather and ramification from man-made climate change. The turbines anticipated to trigger changes in climate is recognized, yet these were still viewed as insignificant: temperature may rise or fall, from the analysis made in the study area is less than are equal to 1°c change in the temperature. Precipitation may expand in some of the places around zero to five percent in total. The maps were created in QGIS using the data obtained from the algorithmis shown in figure (2A-2B)-(6A-6B). Wind speed will get low when it passes through many turbines. So, the wind becomes drier and drier when it passes to each of the turbines.

In the previous work, Baidya Roy and Traiteur (2010) led a learn at the San Gorgonio region wind farm, which is a sweeping establishment in Southern California, to focus and break down its effect on surface air temperatures. They ran a little meteorological field crusade in which it was found that there was a cooling impact amid the day and warming impact during the evening downwind. In this manner these specialists ran the RAMS to figure out whether the air model could repeat the saw close surface air temperature designs. RAMS was utilized as a part of 306 recreations in which comparative examples were observed[11-13]. By using the RAMS method there is 0.5 degree Celsius change in the temperature. With this finding they further explored, using the model, different rotors and ran the model to determine what the effects may be in order to identify which rotor would best minimize the previously observed temperature effects. This study however was merely done over a short time period.

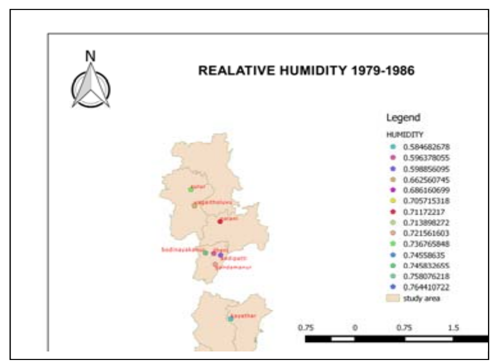


(a)



(b)

Figure 2 (A and B). Map of Maximum temperature for 35 years



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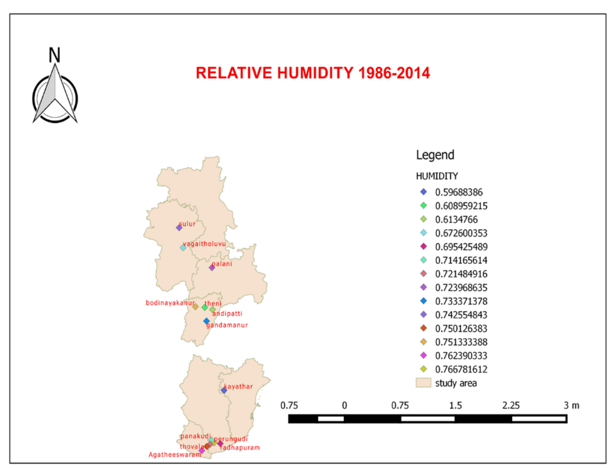

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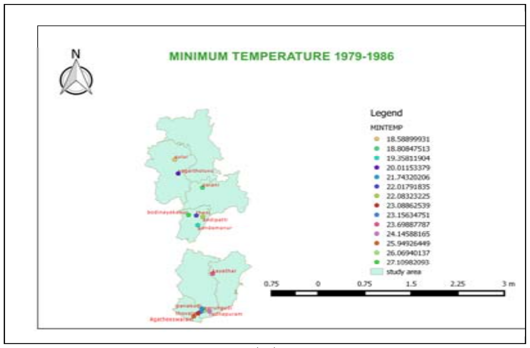
Figure 3 (A and B). Map of Relative Humidity for 35 years.



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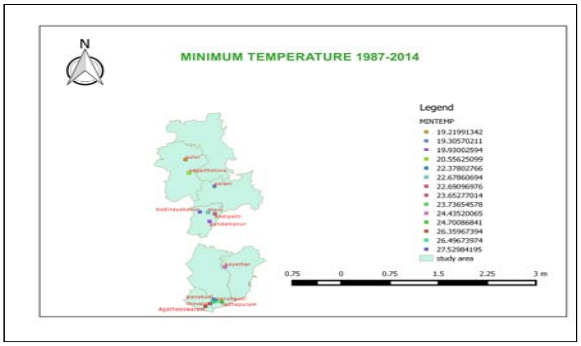
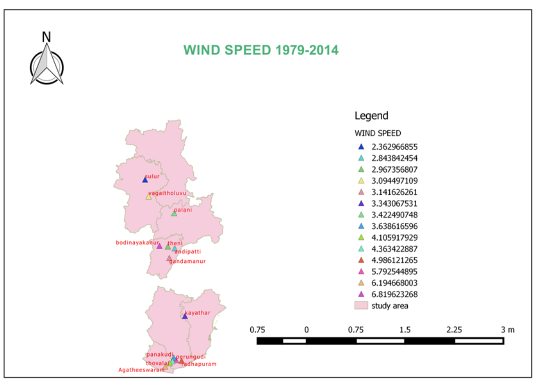


(b)

Figure 4 (A and B). Map of Minimum Temperature for 35 years



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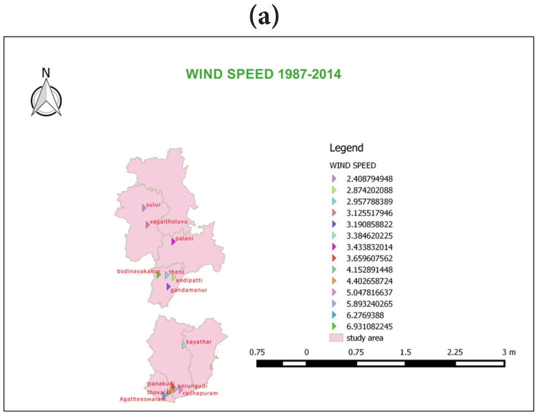
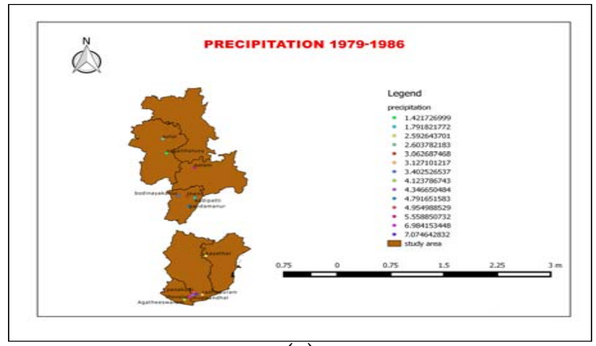


(b)

Figure 5 (A and B). Map of Wind speed for 35 years



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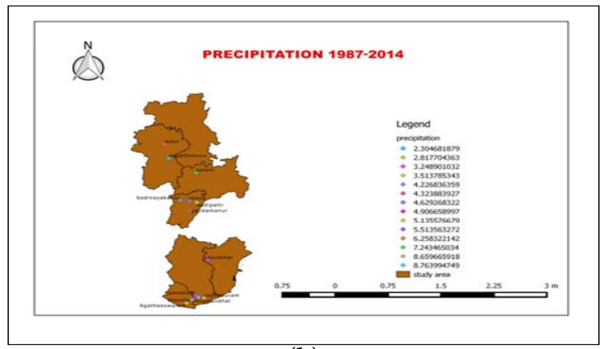

(b)

Figure 6 (A and B). Map of Precipitation for 35 years

The new method has been used in this paper and by using the above algorithm there is a change in the climatic parameter in the wind farm area. For further studies the night time and morning time data has been taken for analyse the upwind and downwind windfarm area and their climatic parameters can be analysed.

The Figures 2(A and B) – 6(A and B) reveals about which area had maximum and minimum variation in the climatic parameters of before and after installation of wind farms.

5. Conclusion

This study reveals out the effect of windfarms over climatic condition in Tamil Nadu. GMM approach used in this paper conveyed the local variation in temperature, relative humidity, precipitation and wind speed which will be useful for harvesting the wind energy.

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