INDIA'S NATIONAL INITIATIVES AND EXPERIENCES RELATED TO WIND RESOURCE ASSESSMENT

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WIND POWER PROGRAMME IN INDIA -INITIATIVES

- India- Wind power programme- 1983-84
- Wind resource assessment activities and implementation of demonstration projects
- Demonstration project-Tamilnadu-Tuticorin,Maharastra-Devghad, Gujarat- Okha,Orisha- Puri
- First Met mast -1986 –Sultanpet,Coimbatore ,Tamilnadu
- WRA Programme - implemented through the State Nodal Agencies, by MNES (Ministry of Non Conventional Energy Sources) /Center for Wind Energy Technology (CWET).
- The wind-monitoring programe has been a continuous programme since 1985, it has been extended to almost all the states of India including , NE regions, Islands and Union Teritorries.

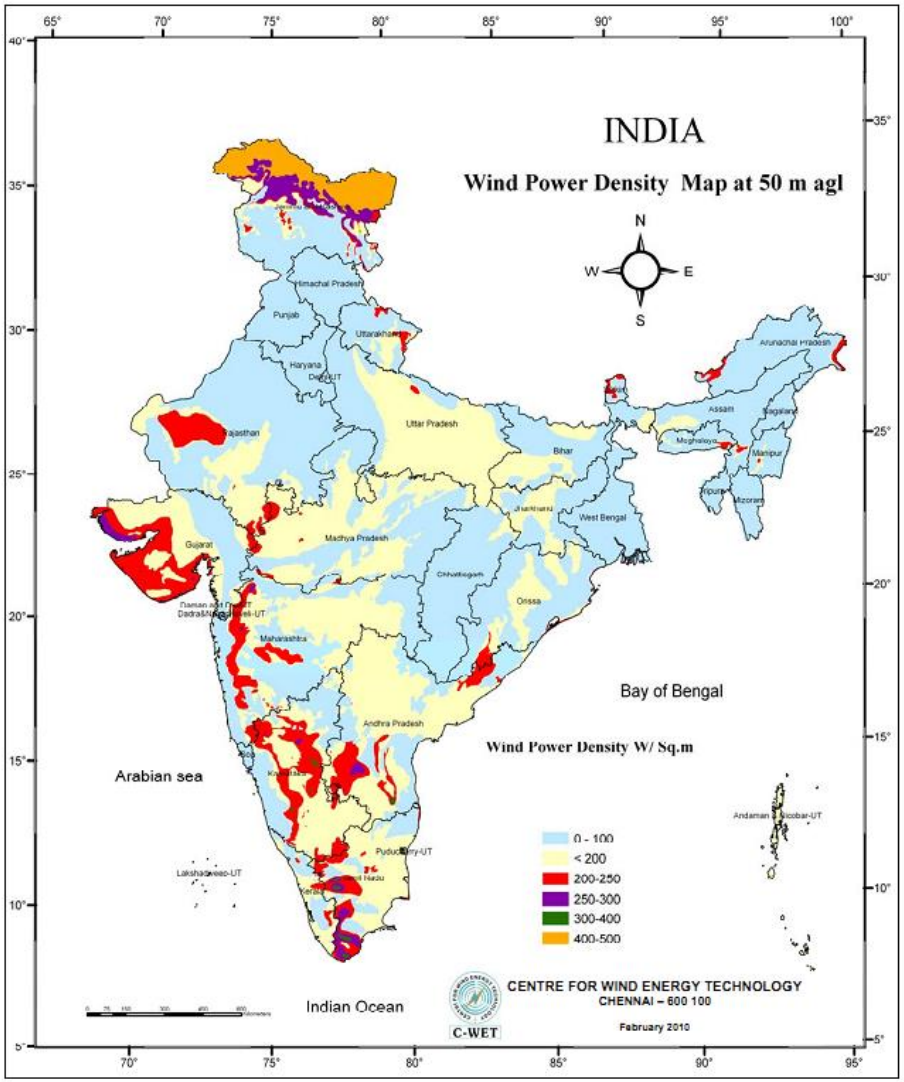
ABOUT C-WET

- C-WET, -an autonomous R&D institution
- ITCS,R&D, Testing, Standards and certification and WRA
- Recognized leader in wind resource assessment -2003-2004
- 706 - Wind Monitoring Stations across the country till date
- 610 - stations are closed down and 96 are operational. minimum 1 year continuous measurements are essential"
- Specialists in WIND RESOURCE ASSESSMENT and handling industrial standard software tools such as **WAsP, WindPro, Wind Farmer, Wind Sim, Meteodyne, Open wind, Windographer, Matlab ,Origin ,ARC GIS, MAP info,Vertical mapper and Bently**
- The team has 3 WAsP (Wind Atlas Analysis And Application Programme) certified specialists to offer "WRA" services to India and Abroad

Consultancy Services Offered by CWET for WRA

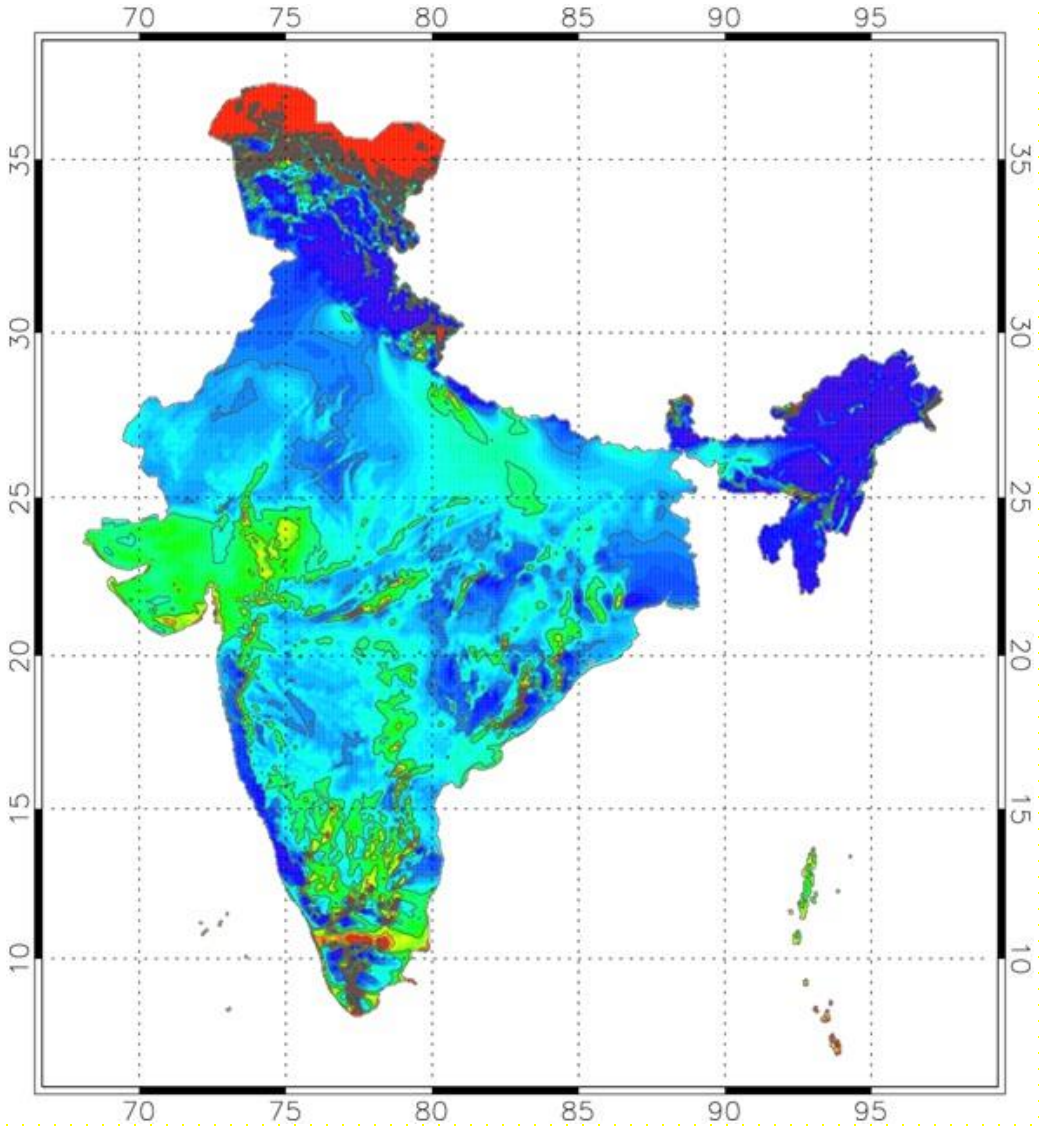
- Site condition assessments for wind monitoring & wind farm development and field visits
- Procurement, installation and commissioning of met mast of 50m to 120 m height
- providing measurement campaign management, assisting clients in the Installation and monitoring of meteorological masts, LIDAR and SODAR stations
- Data collection, management, quality control and wind energy resource reporting
- Analysis of Data with sophisticated software tools and techniques
- Long-Term Trend Data Analysis (NCEP/NCAR/MERRA)
- Turbine array layout design, optimization, field Micro siting and Produce bankable P50 P75, and P90 yield predictions.
- Investment Grade wind energy resource assessment reports (gross/net Preiections, uncertainty analyses, etc.)
- Analysis of existing wind farm operations
- Technical due diligence in complying with international standards.
- Power curve demonstration guarantee test
- DPRs (Detailed Project Report) preparation through State of art software tool to wind farm developers

INDIAN WIND ATLAS at 50 HEIGHT



States / UTs	Installable Potential (MW) 50 m Level
Andaman & Nicobar	2
Andhra Pradesh	5394
Arunachal Pradesh*	201
Assam*	53
Chhattisgarh*	23
Gujarat	10609
Himachal Pradesh *	20
Jammu & Kashmir *	5311
Karnataka	8591
Kerala	790
Lakshadweep	16
Madhya Pradesh	920
Maharashtra	5439
Manipur*	7
Meghalaya *	44
Nagaland *	3
Orissa	910
Rajasthan	5005
Sikkim *	98
Tamil Nadu	5374
Uttarakhand *	161
Uttar Pradesh *	137
West Bengal*	22
Total	**49130**

INDIAN WIND ATLAS AT 80 m HEIGHT

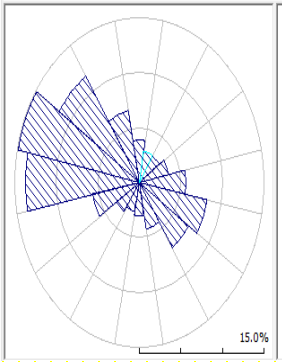


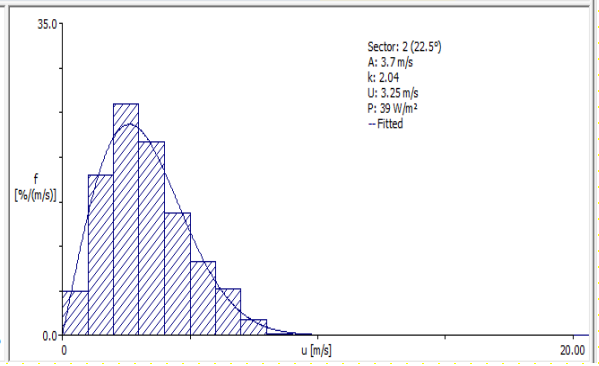
State Name	Installable Potential MW
Andaman &Nicobar Islands	365
Andhra Pradesh	14497
Arunachal Pradesh*	236
Assam*	112
Bihar	144
Chhattisgarh*	314
Dieu Damn	4
Gujarat	35071
Haryana	93
Himachal Pradesh *	64
Jharkhand	91
Jammu & Kashmir *	5685
Karnataka	13593
Kerala	837
Lakshadweep	16
Madhya Pradesh	2931
Maharashtra	5961
Manipur*	56
Meghalaya *	82
Nagaland *	16
Orissa	1384
Pondicherry	120
Rajasthan	5050
Sikkim *	98
Tamil Nadu	14152
Uttarakhand *	534
Uttar Pradesh *	1260
West Bengal*	22
Total	**102788**

WRA-DESKTOP ANALYSIS-MERRA DATA

WRA-DESKTOP ANALYSIS-MERRA DATA

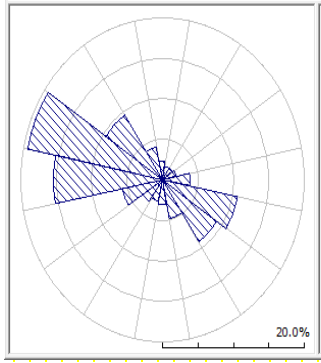
Sector		Wind climate				Power	Quality
number	angle [°]	frequency [%]	Weibull-A [m/s]	Weibull-k	mean speed [m/s]	power density [W/m²]	Speed discrepancy [%]
1	0	3.8	3.9	2.35	3.47	42	0.416%
2	22.5	3.0	3.7	2.04	3.25	39	-0.928%
3	45	2.9	3.8	1.96	3.39	47	-1.103%
4	67.5	3.5	4.1	2.14	3.61	52	-0.015%
5	90	5.6	4.7	2.40	4.17	72	0.350%
6	112.5	8.3	5.4	2.50	4.83	109	0.350%
7	135	7.1	5.1	2.38	4.56	95	0.324%
8	157.5	4.3	4.1	2.17	3.64	52	0.094%
9	180	3.0	3.2	2.02	2.88	28	-0.861%
10	202.5	2.7	3.0	2.06	2.66	21	-0.768%
11	225	3.2	3.1	2.01	2.79	25	-0.947%
12	247.5	5.7	3.9	2.32	3.45	42	0.037%
13	270	13.7	5.6	2.59	4.99	117	-0.212%
14	292.5	14.9	6.6	2.81	5.88	182	0.979%
15	315	11.7	5.8	3.34	5.25	118	1.907%
16	337.5	6.7	4.7	2.84	4.15	63	0.931%
All (emergent)					4.46	94	
Source data					n/a	n/a	

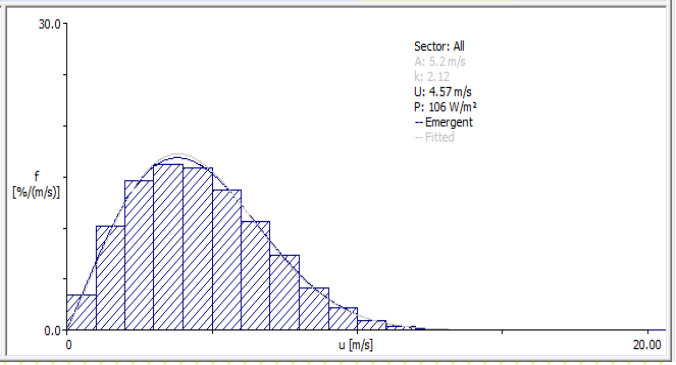




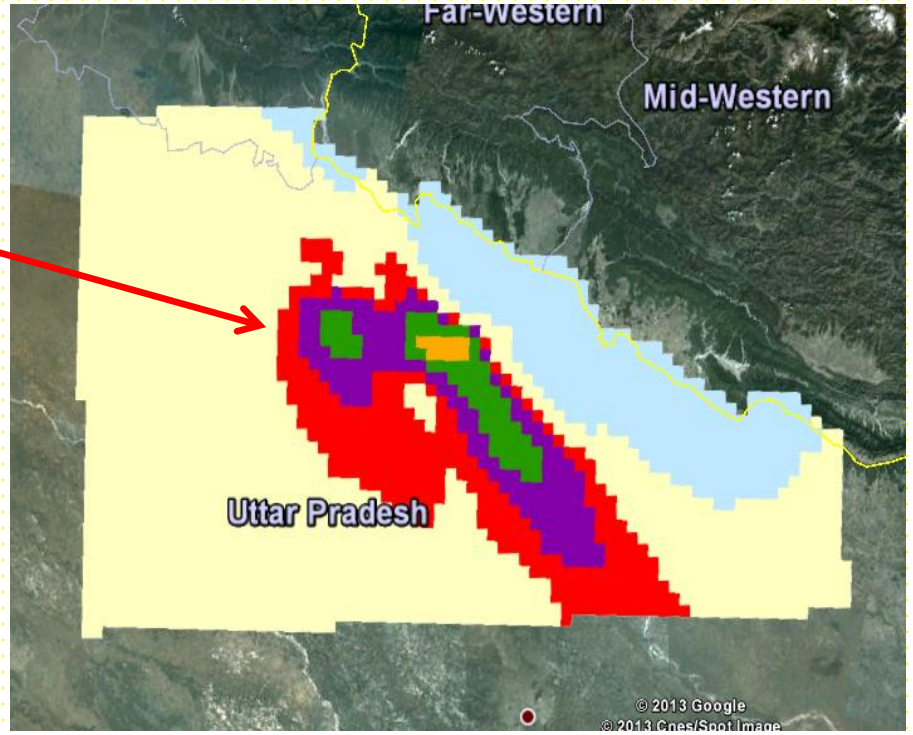
Wind | Histogram bins | Location information | Statistics

Sector		Wind climate				Power	Quality
number	angle [°]	frequency [%]	Weibull-A [m/s]	Weibull-k	mean speed [m/s]	power density [W/m²]	Speed discrepancy [%]
1	0	2.3	3.6	2.08	3.23	38	0.754%
2	22.5	1.8	3.4	1.77	3.05	38	-0.874%
3	45	1.7	3.4	1.68	3.02	39	-1.523%
4	67.5	2.0	3.6	1.82	3.21	43	0.162%
5	90	3.9	4.5	2.05	4.02	74	0.377%
6	112.5	10.7	6.1	2.42	5.45	160	0.403%
7	135	9.3	5.5	2.29	4.84	117	-0.051%
8	157.5	4.9	4.1	2.16	3.63	52	0.553%
9	180	3.0	3.2	2.00	2.82	26	0.171%
10	202.5	2.7	2.9	1.95	2.60	21	-0.164%
11	225	3.3	3.1	1.83	2.77	27	-1.234%
12	247.5	5.8	3.8	2.05	3.40	45	-0.172%
13	270	15.4	5.5	2.50	4.91	115	0.262%
14	292.5	19.4	6.6	2.75	5.86	182	0.959%
15	315	9.7	5.4	2.85	4.82	99	1.562%
16	337.5	4.2	4.3	2.42	3.81	55	1.348%
All (emergent)					4.57	106	
Source data					n/a	n/a	





WRA-DESKTOP ANALYSIS-WIND ATLAS



WRA-DESKTOP ANALYSIS –ATLAS BASED

SITE VISIT & SELECTION



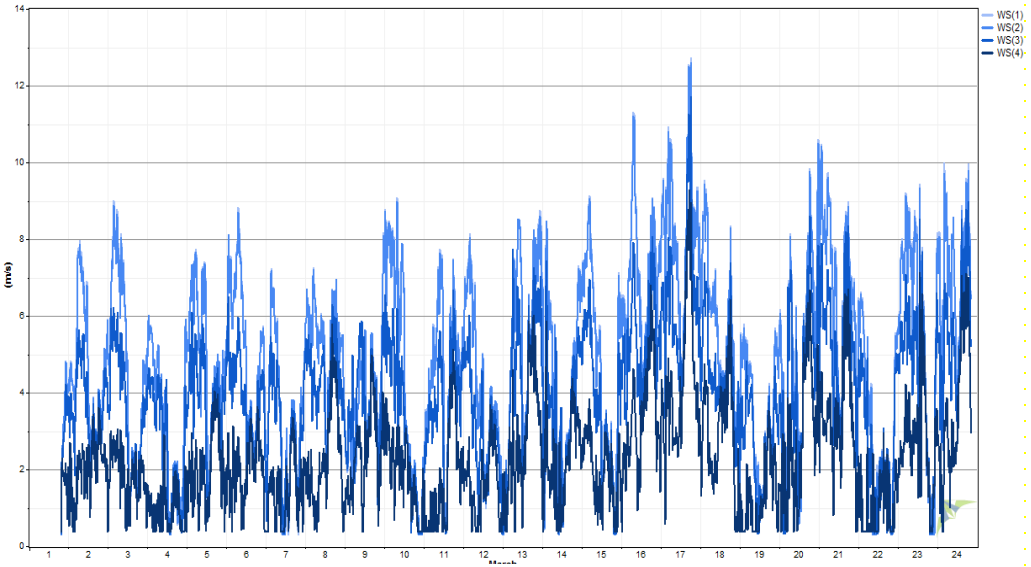


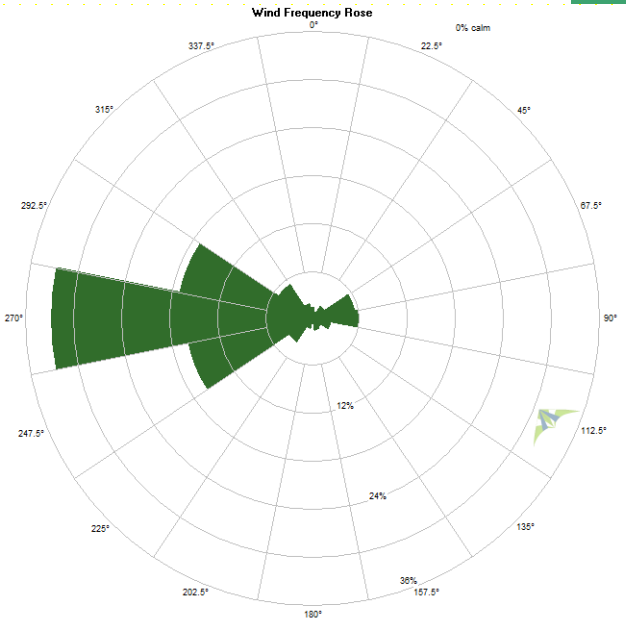


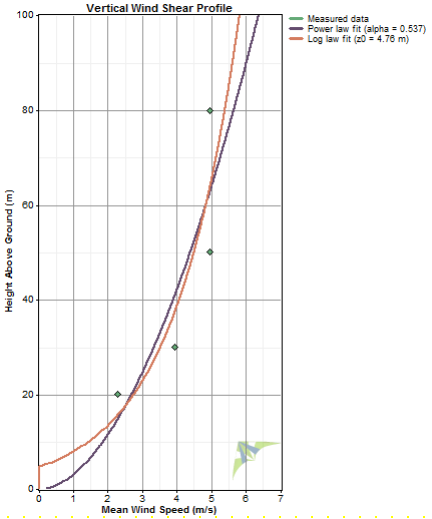


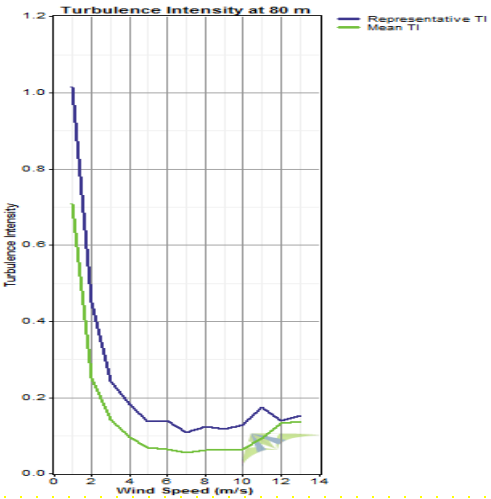
MET MAST INSTALLATION AND COMMISSIONING

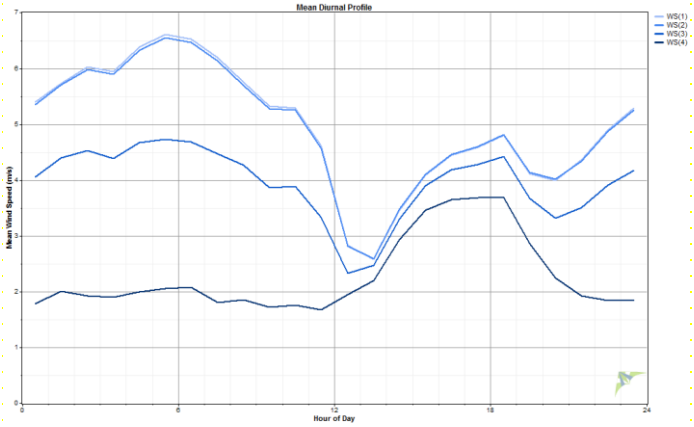
DATA COLLECTION AND ANALYSIS











LESSONS LEARNED

Lessons learned from site selection in India

- Permission is required for the erection of a meteorological mast - parallel permission
- Proper co-ordination with the local authority and the local population
- The chosen wind turbine contractor should be required to guarantee a power curve for use in analysis and also approve the turbine siting (e.g. minimum turbine spacing)

Lessons Learned : during installation of WMS:

- Lightning earth cable should be provided as shield cable. Otherwise the sensors will get damaged.

- If the connecting thread is broken in any of the instruments like an Anemometer or Wind vane, we cannot reuse those instruments.

- When installation of Tubular type WMS, the accurate North cannot be fixed due to zero axis error. The acceptable changes +or- 10^0 between level 1 & level 2.

- Once we fixed the wind wane level 1 & level 2 (eg: Level1-80m & Level2-50m), after commissioned of tubular type WMS cannot be changed even difference is more than acceptable changes between level 1 & level 2.

Lessons Learned : during installation of WMS:

- If the tubular type WMS boom is bended, the contractors are reused that bended boom for Wind Wanes. It may change the exact North level of wind wane.

- Need of Steel belt is to be good mechanical strength for fixing the boom.

- Every instrument cable should be provided at individually. Otherwise if any one instrument gets damaged, the other instruments also damaged.

- Solar panel cable should be lay inside of the mast.

Lessons Learned : during installation of WMS:

- The contractor (installation team) should be experienced person as mast should be align to exact 90^0 .
- When the installation of WMS if the NOMAD2 Data logger is in more than $+40^0$ and below 17^0 temperatures, the Data logger Analog channels are not working properly.
- Aviation lamp should be provided at the top of the WMS
- During Installation or any other rectification/ Dismantling work, if land is of Private owner we had to ask to private land owner to do work as majority of times land owner uses that land for farming purpose.
- As sites are in remote places many times it is in forest, so in rainy season it is difficult to reach the site due to water clogging problem and foundation get weak to heavy rainfall by that mast get damaged while erection.
- After installed the WMS, security should be important due to the safety of the instruments and Data logger.
- solar panel and +12v battery must be necessary at all site for power backup to reduce the data loss.

LESSONS LEARNED FROM THE IMPLEMENTATION OF THE WRA PROGRAM:

- Responsibilities - maintain registers to track the movement of memory devices.
- Insurance coverage is definitely to be extended to the hardware in the field
- Strategies are to be made to reduce the outages, data gaps etc.
- Specify who will carry out the data quality checks
- Training schedule is to be included.
- Specify the type of data and periodicity of data supply on a routine basis.

LESSONS LEARNED –Onsite measurement

The following are some important measures:

- anemometers calibration
- Regular visit to the mast location-check of the tower components as well as measuring equipment
- Onsite plan
- minimize any data loss
- spare parts record must be maintained
- An early assessment should be made of the necessity for securing the mast site as equipment theft can produce long gaps in data records,as happened on the in Bihar•

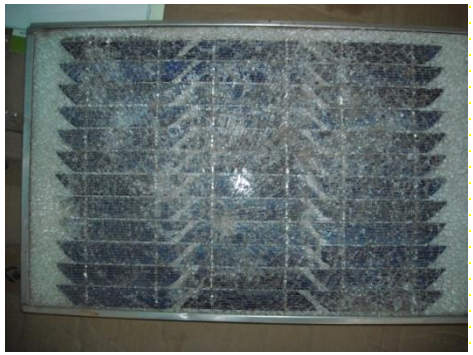
Local residents should be made aware of the reason behind the erection of a mast, possibly with an information campaign, so that

a) complaints can be minimised, and

b) through their involvement, people could act as unofficial guards.

LESSONS LEARNED –
During Wind Resource Assessment Done

- The case studies within the project provided some good opportunities for the management of data gaps. The data records for the site Songirpada,Maharastra contained a gap of nearly 9 months because of equipment vandalism and also at Shankar Nagar, Bihar –data logger theft



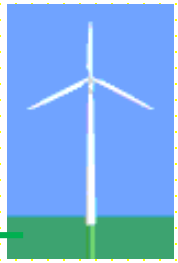
Lessons Learned in Data Collection and Validation-from pvt. WMS

The following points are observed during analysing the data

- Erroneous values (0.4m/s constant values) zero and are recorded.
- Peculiar values are recorded.
- Sometimes scale factor and offset values were mismatching with the calibration certificates.
- Serial numbers and height of the sensor are not available in the raw data.
- Relevant software is not available to process the old NRG Plus data.
- Sometimes data is in encrypted code.
- Data is repeated in different channels.
- Sometimes data is missing for the long period.
- The data in the anemometer levels (Example 65m and 50m) are interchanged.
- Most of the customers are not providing the reference WMS (wind Monitoring Station) details when they approach to C-WET.

APPLICATION OF GEOSPATIAL TECHNOLOGY IN RENEWABLE ENERGY

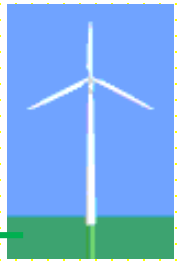
GEOSPATIAL ANALYSIS IN RENEWABLE ENERGY



- Energy from renewable source is primarily constrained by geographic factors and utility factors.
- Geospatial analysis allows researchers to efficiently and cost effectively understand and analyze complex spatial issues associated with renewable energy development.
- GIS based modelling enables analysis of terrain, which significantly impacts the quality of wind at a particular site.
- GIS have powerful analytic capabilities, exceptional spatial data management, storage, retrieval functionality, and an array of visualization tools that make them an invaluable tool for site suitability analysis.
- Wind maps include the effects of the terrain and ground cover.

C-WET

GIS SERVICES FOR RENEWABLE ENERGY



GIS provides significant benefits to countless types of users. Here are a few examples related to renewable energy management:

- Wind and Solar resource mapping
- Optimize the placement of wind farms and turbines
- Large-area detailed shade modeling
- City-wide solar and wind potential database development
- GIS as a decision support system for site suitability
- Online mapping and project visualization
- Create high quality printed maps for project presentations
- Analyze spatial patterns

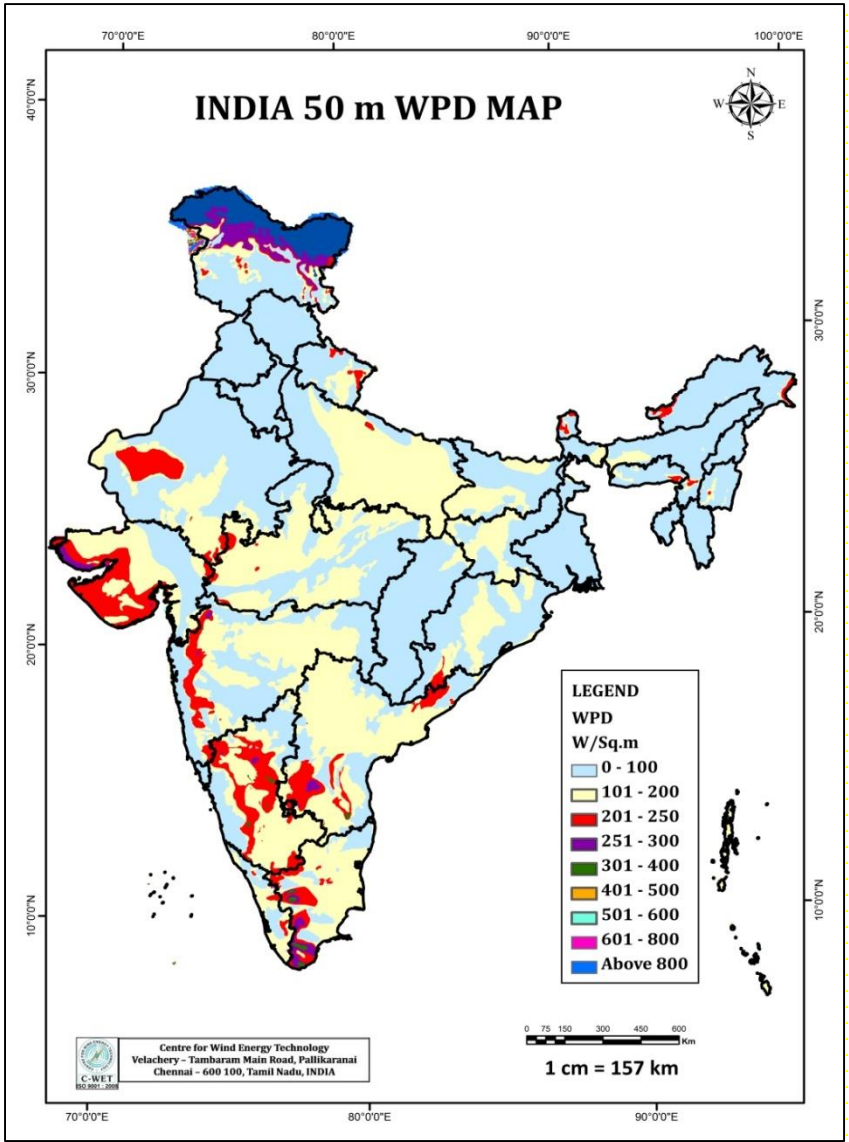
CWET's ONGOING GEOSPATIAL PROJECTS

- Micro level Wind Atlas Map Preparation
- Roughness Map Preparation
- Mapping Wind Monitoring Stations
- Identifying wind potential sites using GIS

CWET FUTURE GEOSPATIAL PROJECTS

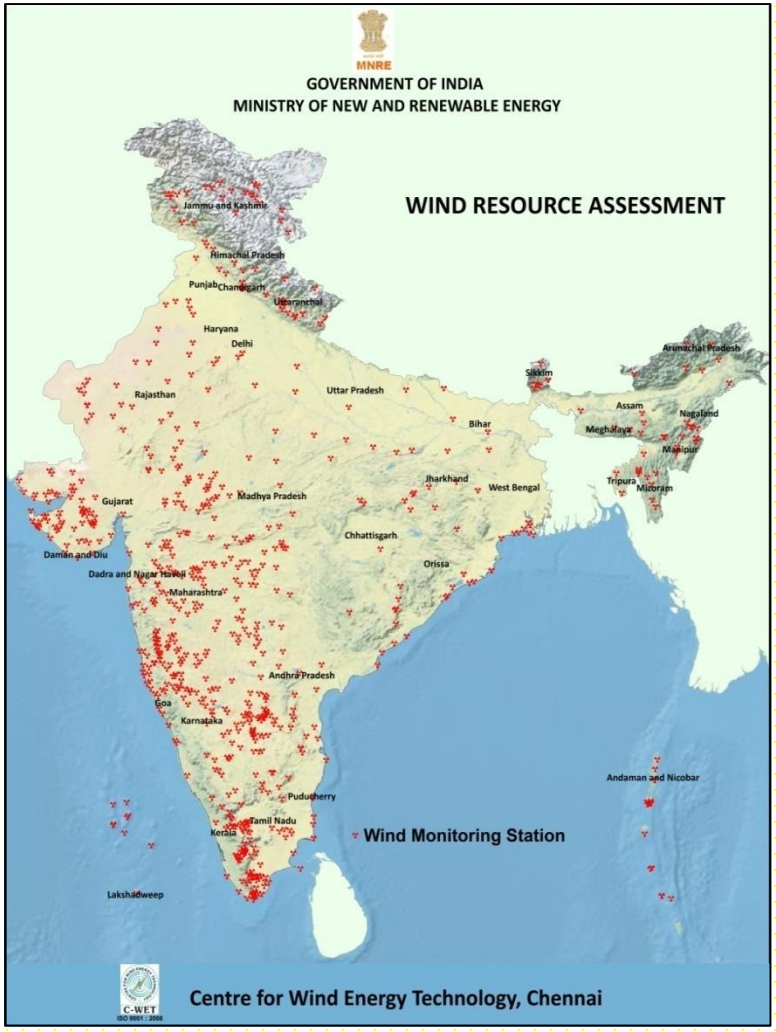
- Build Geodatabase for Wind Resource Assessment
- Terrain Modeling generation for Visualization of Wind farm
- Offshore Wind farm Site Establishment
- GIS data layer on Existing Wind Farm Locations using Web GIS

ROUGHNESS MAP PREPARATION

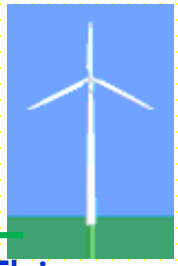


WIND MONITORING STATIONS MAP

- Thematic Maps
- Wind Geodatabase

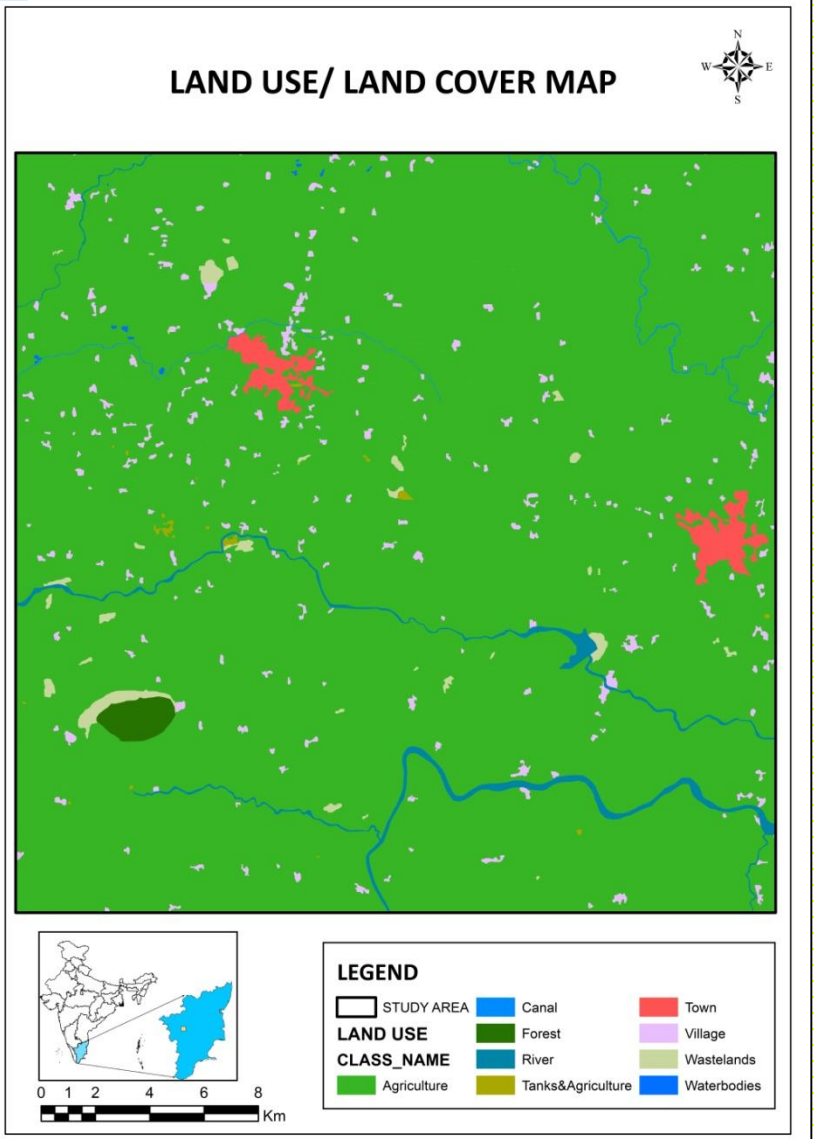


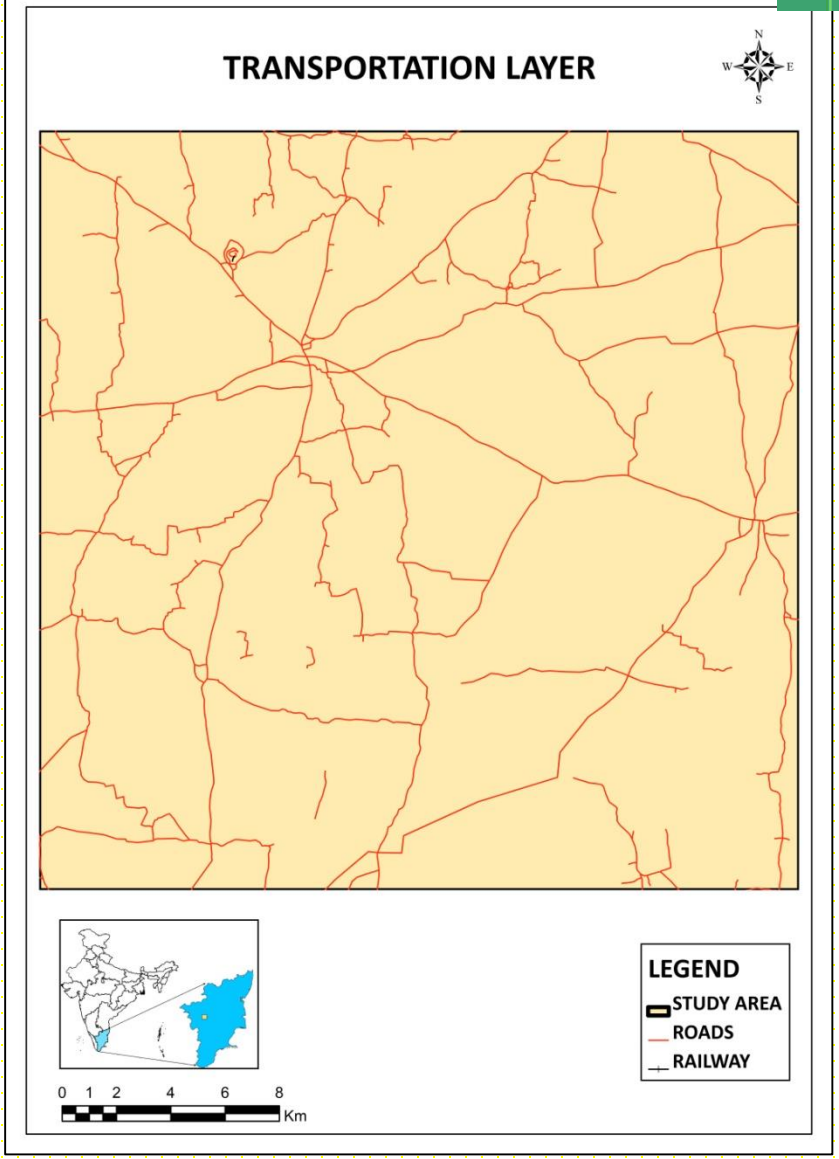
IDENTIFYING WIND POTENTIAL SITES USING GIS



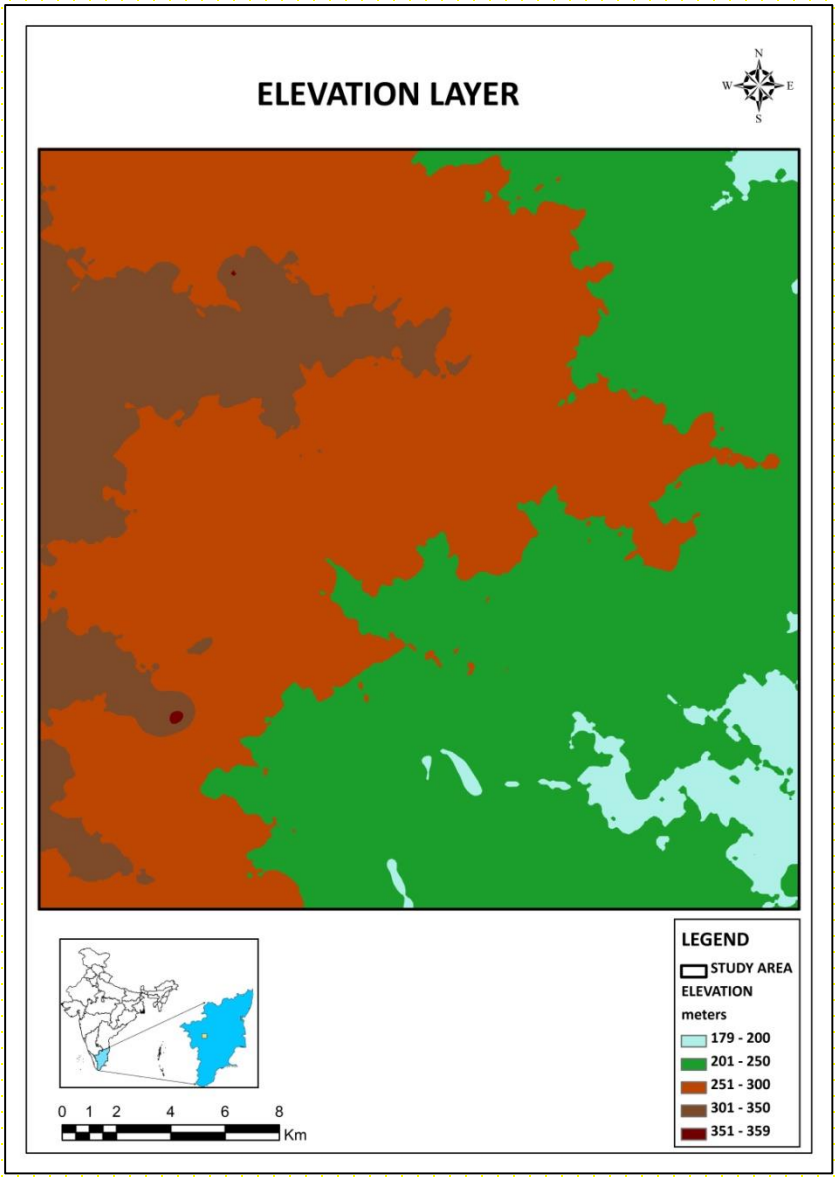
- GIS is a spatial decision support tool for wind farm location analysis. This is done based on various site-screening criteria.
- Various factors are the determinants for selecting sites that may be suitable for a new wind farm development.
- The criteria include exclusion factors are human settlement, commercial places, water bodies, major roads, railways, forest and reserved areas.
- Elevation, slope, and wind power density are such important parameters to taken into account for wind resource assessment.
- The GIS system performs geographic filtering in order to exclude unsuitable places for wind farm sitting.
- The result is a number of good sites that satisfy the requirements of a proposed wind farm

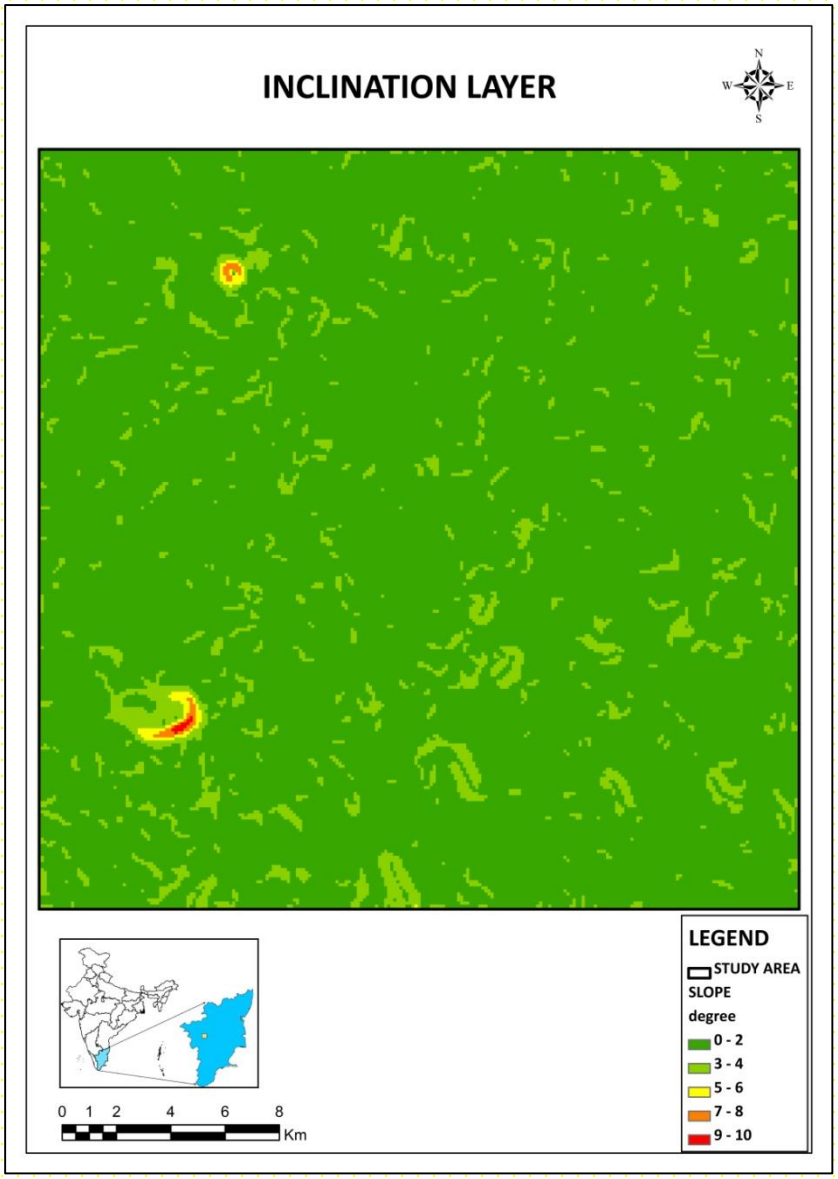
LAND USE LAND COVER MAP



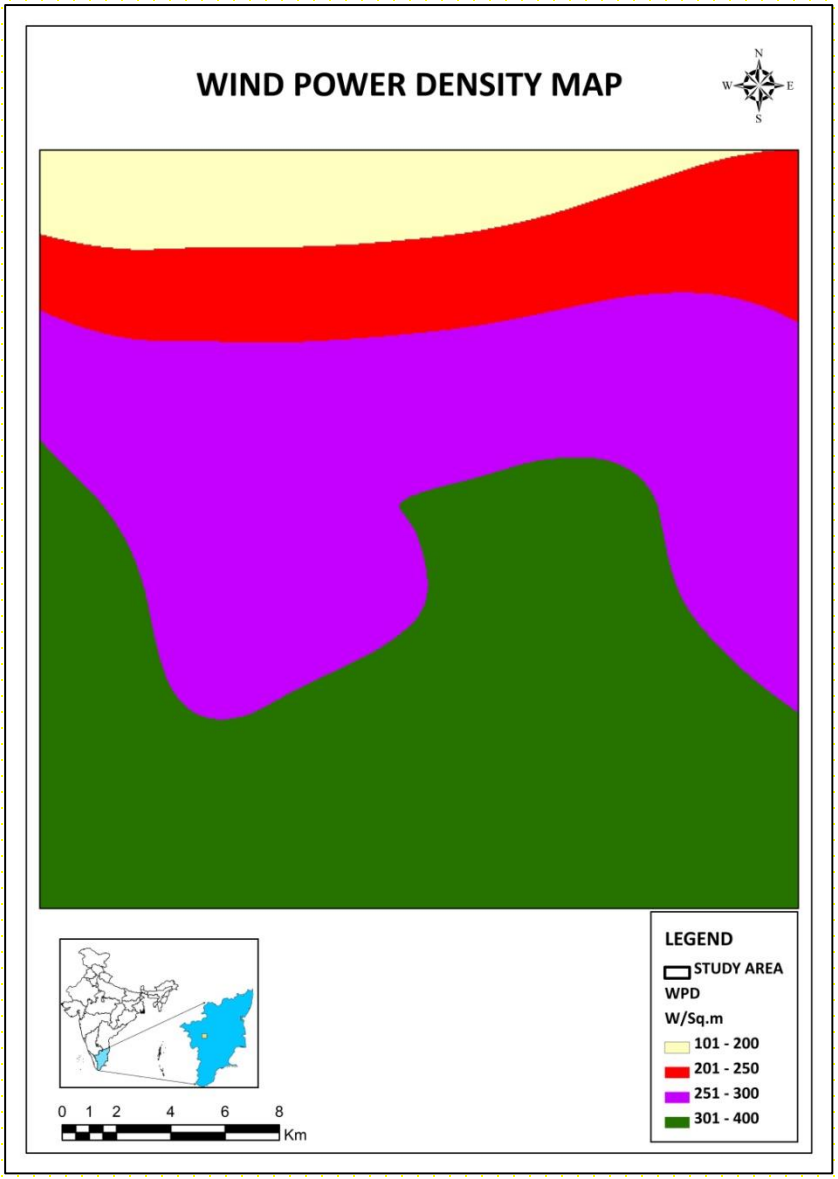


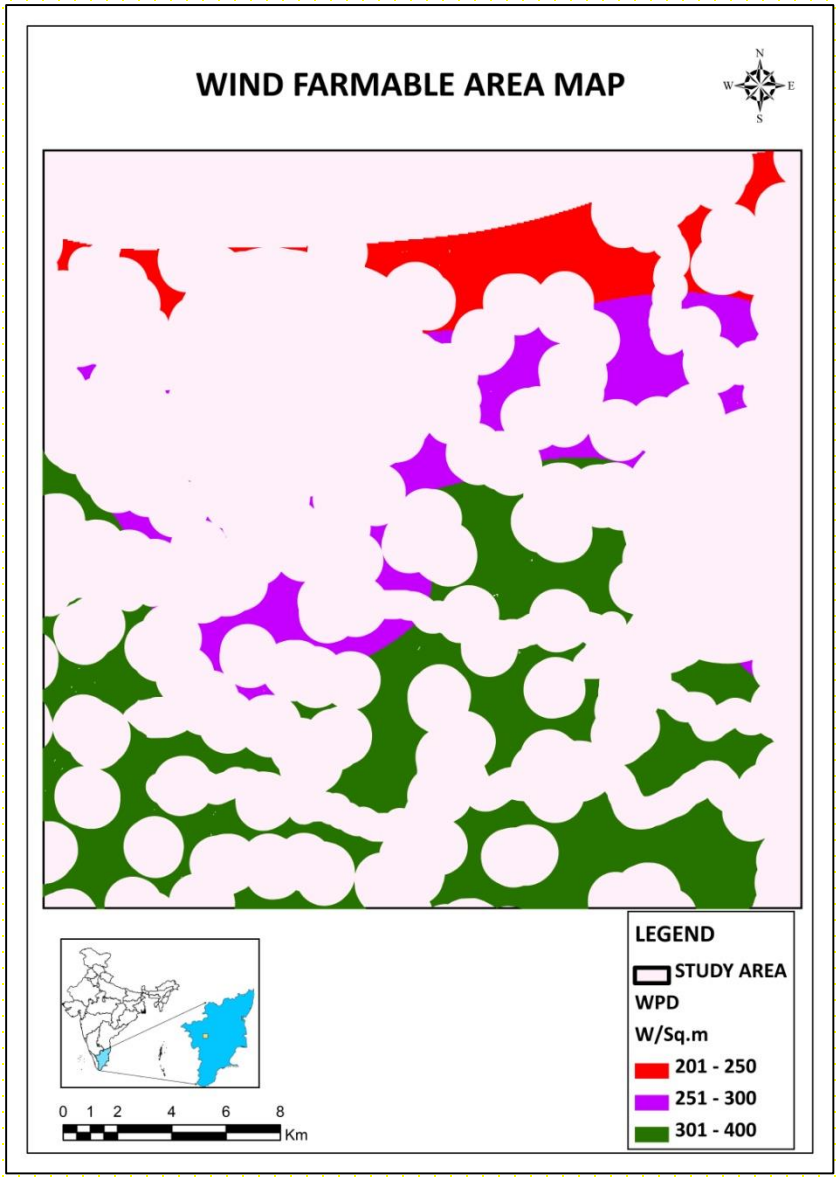
LAYER SEPERATION





WIND FARMABLE AREA





CWET'S RESEARCH –wind resource

- Wake behind a wind turbine
- wind shear study
- offshore wind profile measurement
- Micro level wind atlas preparation
- study on flow over hills
- wind power forecasting

WIND RESOURCE POLICY

- WRA Programme -Centre for Wind Energy Technology (C-WET), Chennai to identify the potential sites for setting up grid connected wind power projects-
- implemented in association with Nodal agencies for New & Renewable Energy programmes in concerned States.
- private participation;
- The raw data as collected -examined and certified by C-WET
- Based on C-WET's recommendations concerned SNA will accord necessary clearances and NOC for setting up wind farm.
- After 3/5 years, when the site is declared open for others, all data of the site will be treated as part of C-WET knowledge bank and will be given in the normal list of potential stations by C-WET

THANK YOU