

## SPATIO-TEMPORAL PERSPECTIVES OF WIND POWER ENERGY RESOURCE IN SATARA DISTRICT

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### Abstract

Wind energy is one of the prominent energy sources on earth. During the last decade, it has been tremendous growth, both in size and power energy converters. The wind has proven to be a very effective source of energy due to technological richness, infrastructure, and relative cost attractiveness. The world has enormous potential for wind energy that should be utilized for electricity generation. At present, there are 1872 wind Turbines working in the district and production capacity is over 1506.41 MW wind electricity per year. The Maharashtra states had total installed wind power generation capacity about 4789 Mw (2018). It was the third largest installed capacity among all states of the country's wind power energy. The total installed power energy generation capacity was 43779 Mw after the end of 2018. It was 11 per cent of the total energy generation of India. Satara district accounting the largest share of wind power production in the state 5439 MW in Maharashtra total India's wind power energy production 34,293 MW. The companies like BHEL, NEPC, REPL, Vestas RRB, IWPL/ NEG-Micon, Pioneer Wincon, Suzlon, Enercon, Regen, and Ganesa are generating wind electricity. The study has observed that wind Turbines are mostly concentrated in Patan, Wai, Phaltan, Khandala, Man, Khatav, Koregaon, Satara, and JaoliTahsil, where the blowing of wind velocity is sufficient for rotating the wings of wind turbines. For the present paper the done on investigation the primary data, Collected through Fieldwork, were secondary data obtained from various Wind turbines corporate offices, Socio-economic reviews and District statistical records of the Satara district.

**Key Words:** *Wind Power, Production, Capacity, Concentration, Megawatt, Wind Velocity*

### Introduction

Energy is a prime requirement and essential to fulfilling the basic needs of the people. It has also been recognized as one of the most important inputs for the development of the nation (Natarajan, 2000). Industrial development and their progress are largely depending on the adequate supply of energy. The high population growth rate, development in industry, agriculture, services, transports, and allied sectors have increased the demand for energy. The growing demand for energy is mainly fulfilled through conventional sources of energy, which causes deforestation, depletion of coal, petroleum resources and harming the environment. The oil crises of the World have ever increased the urgent need for developing non-conventional sources of energy and their optimum

utilization to meet the demand for energy. The exhaustion of fossil fuels, as well as the upcoming realization of environmental degradation, has given precedence to the use of conventional and renewable alternative energy sources like solar, wind and solar-hydrogen energy (Demirbas, 2001). There are different sources of renewable energy i.e. biomass, solar, geothermal, hydroelectric, and wind energy. Among these resources, the wind has proved to be a cheaper alternative energy resource and hence extensive research efforts have been put to improve the technology of electricity generation through wind energy. The world has enormous potential for wind energy that should be utilized for electricity generation (Nikam and Kherde, 2015). Wind energy is fast gaining importance among non-conventional sources, which is a function of parameters like the topography of the terrain, weather conditions, etc. (Sholapurkar and Mahajan, 2016).

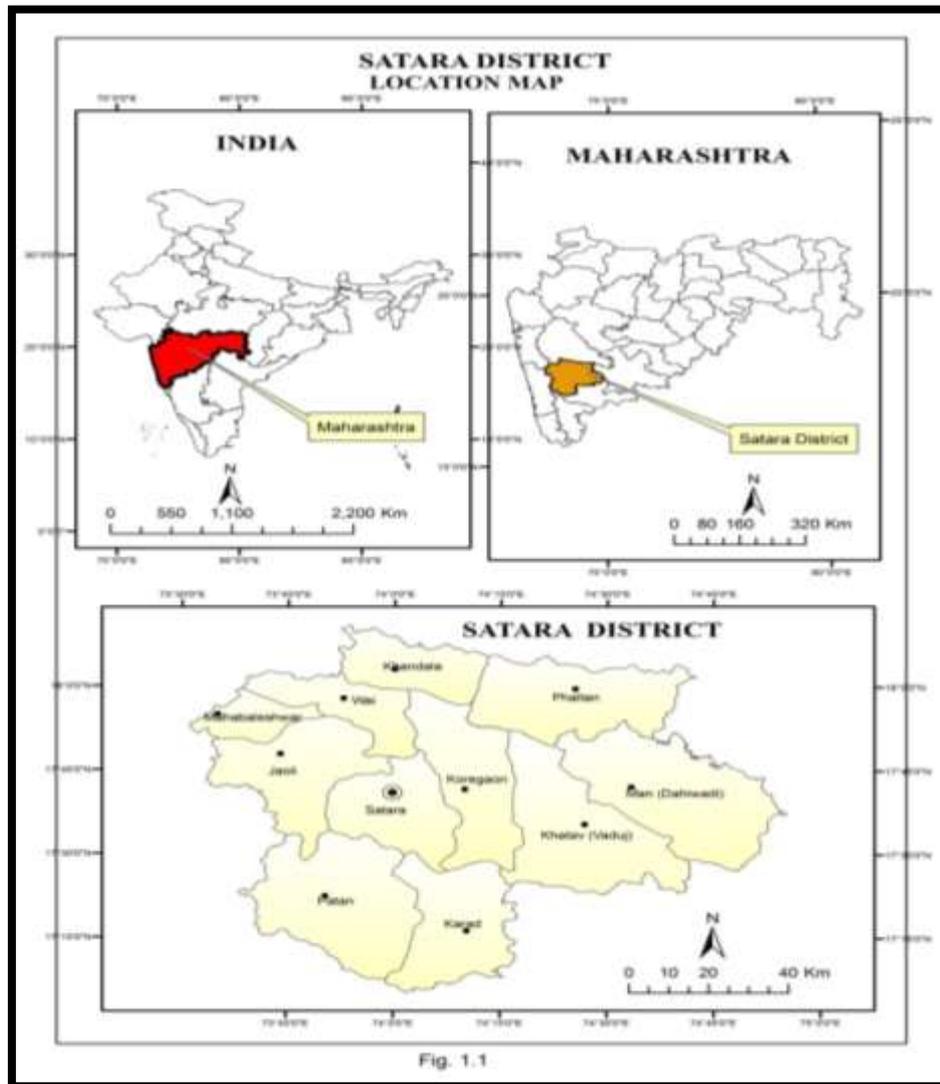
India has the fourth-largest installed wind power capacity in the world. Jaisalmer Wind Park is the largest operational onshore wind farm in India, located at Amarsagar in Jaisalmer district of Rajasthan. Its installed capacity of 1,064 MW which makes it one of the largest wind farms in the world and largest of its kind in India. The states with the highest wind power concentration are Tamil Nadu, Maharashtra, Gujarat, Rajasthan, Karnataka, Madhya Pradesh, and Andhra Pradesh. The Windpower program in India was initiated towards the end of the Sixth Plan, in 1983-84 (Gunjker and Deshmukh, 2016). The government of India has made the policy of wind energy in October 2015. In India, there are 237 Station for the economically good for electricity. India currently has an installed wind power generation capacity of 34. 293 GW.

Maharashtra is the largest power generating state in India. Maharashtra Energy Development Agency is taking this energy and supply for the Indian grid Network. Today wind Electricity in Maharashtra is 4655.25 MW in which Satara district produces the 1506.41 MW wind electricity. At present, 1872 wind turbines are working in the district. Satara region is the first largest wind power producer region in Maharashtra. In Satara district there are BHEL, NEPC, REPL, Vestas RRB, IWPL/ NEG-Micon, Pioneer Wincon, Suzlon, Enercon, Regen, and Ganesa is generating the wind electricity. Satara district (Maharashtra) with encouraging policy for private investment in wind power projects resulted in significant wind power development in Maharashtra state, particularly in the Satara district.

The main aim of the present paper studies to the Spatio-temporal aspects of the growth of wind power in the Satara district, including parameter i.e. Tahsil wise distribution of wind power production, Capacity in MW and concentration of wind turbines the Satara District of Maharashtra. The growth of wind power has manifold effects on the socio-economic conditions of the district.

## Study Area

Satara district is situated in western part of Maharashtra and lies between north latitudes  $17^{\circ} 05'$  and  $18^{\circ} 11'$  and east longitude  $73^{\circ} 33'$  and  $74^{\circ} 54'$ . The geographical area of the district is 10480 sq. km.



The district is bounded in the north by the Pune district on the east by Solapur district, on the south by Sangli district and the west by Ratnagiri district of the Konkan region of the state. Sahyadri hills of western ghat form the western boundary, while the Nirariver forms the northern boundary of the district. The gross cultivable area is 7992 km<sup>2</sup> whereas the net area sown is 5576 sq.km. The region receives rainfall mainly from the southwest monsoon, ranging between 5000mm to 200 mm.from west to east. The average annual rainfall of the district is 1426 mm, the temperature ranges from 11.6 0 C to 37.50 C. The total population of Satara district is 30,03741persons according to the 2011 Census. It has eleven talukas and 1547villages. Eleven Tahsil is Satara, Wai, Khandala, Koregaon, Phaltan, Man, Khatav, Karad, Jaoli, Mahabaleshwar, Patan. The area under study is one of the drought-prone and low socioeconomic develop regions of the state of Maharashtra.

## Objectives

For the present study, the following objectives are employed to assess the wind energy resources in the district of Satara.

1. To examine the Spatial Distribution of wind farms in the study region.
2. To study wind energy production in the district.

## Database and Methodology:

The present study is based on primary and secondary sources of data. The primary data has been collected through a sample survey and personal interview taken throughout the study region. Secondary data obtained from Socio-economic abstract of the Satara district, District Census handbook, Gazetteers, Fieldwork, Wind farms corporate Offices of Satara district. Statistical tools like percentage, average have been used in the study.

The collected data and information is analyzed by employing the appropriate methods and cartographic techniques and presented through the tables and relevant graphs and diagrams.

## Spatial distribution of Wind Turbans and Wind power Production in Satara District

Wind energy can be converted into electricity by using wind turbines. The amount of electricity generation depends on the amount of energy contained in the wind that passes a turbine in a unit of time called wind power density, which, depends on wind speed and air density. For wind power generation, wind speed is a prime source and mover, which makes the rotor blades to rotate, and converts wind kinetic energy into mechanical energy. The geographical location of Satara is conducive to wind power harnessing. A wind energy park or wind farm is where a large number and several types of wind turbines are located in an area having the required velocity of wind for power generation. Generally, areas, where annual mean wind speed is at least 18 km/ph, preferably above 20 km ph, are viable for harnessing the wind power economically (Rangarjan, 1995). The wind speed is required between 4 m/s and 30 m/s for driving wind turbine generators and producing electrical energy.

Satara district is one of the leading districts in wind energy production which has an abundant potential of wind energy, due to its geographic location. Its typical plague location gives a more suitable situation for wind power generation. The average elevation of Crestline of Sahyadri within the area is about 1200 mtChalkewadi and Vankusavade are main subranges passes through the district. Thoseghar, Chalkewadi, Vankusavade, Marewadi, Sadawaghpur, AgaswadiChavneswar, and Kas. And *Sahyadri hills* sub-ranges very close go through Satara, Wai, Khandala, Koregaon, Phaltan, Man, Khatav, Karad, Jaoli, Mahabaleswar, and Patantehsil. The left ramp of these sub-ranges is very favorable for wind power generation and wind power density is between 1 zone 200 to 250, 2 zone 250 to 300, 3 zone 300 to 400, 4 zone above 400 Watts per sq/mt. become more suitable for wind energy therefore district is one of the pioneer districts for wind energy. Out of the total wind

electricity of Maharashtra, 10 percent of the electricity is occurring in this district. Potential sites for the wind from in Satara are Thoseghar, Chalkewadi, Vankusavade, Matrewadi, Sadawaghpur, Agaswadi, Chavneswar and Kas. Today around 1872 are wind turbines in the Satara district. The total daily capacity of these wind turbines is 1506.41 MW.

**Table No.1**  
**Number of Wind Turbines and their Capacity of Energy Production, (2018)**

Sr. No	Wind Turbine Company Name	No of Machine	% Of Machine	Capacity of Machine (MW)	% Of Machine Capacity in MW
1	BHEL	08	0.43	2.000	0.13
2	Suzlon Energy	821	43.86	567.45	37.67
3	NEPC	02	0.11	0.450	0.03
4	REPL	01	0.05	0.320	0.2
5	Vestas RRB	90	4.81	35.625	2.36
6	Enercon India	289	15.44	149.26	9.91
7	NEG-Micon	29	1.55	21.75	1.44
8	IWPL	04	0.21	1.000	0.07
9	Vestas Wind Tech.	65	3.47	121.25	8.05
10	Pioneer Wincon	35	1.87	8.75	0.58
11	Elecon	4	0.21	2.400	0.16
12	Gamesa	44	2.35	36.5	2.42
13	Southern Windfarms	71	3.79	15.975	1.06
14	Shriram-EPC	78	4.17	34.5	2.36
15	Kenersys	62	3.31	126.8	8.42
16	Regen	119	6.36	178.5	11.85
17	GE-India	106	5.66	169.600	11.26
18	Windworld	44	2.35	35.200	2.34
<b>Total</b>					

*Source: www.sitewisedistributioninwindenergyinsataradistrict.com March.2018*

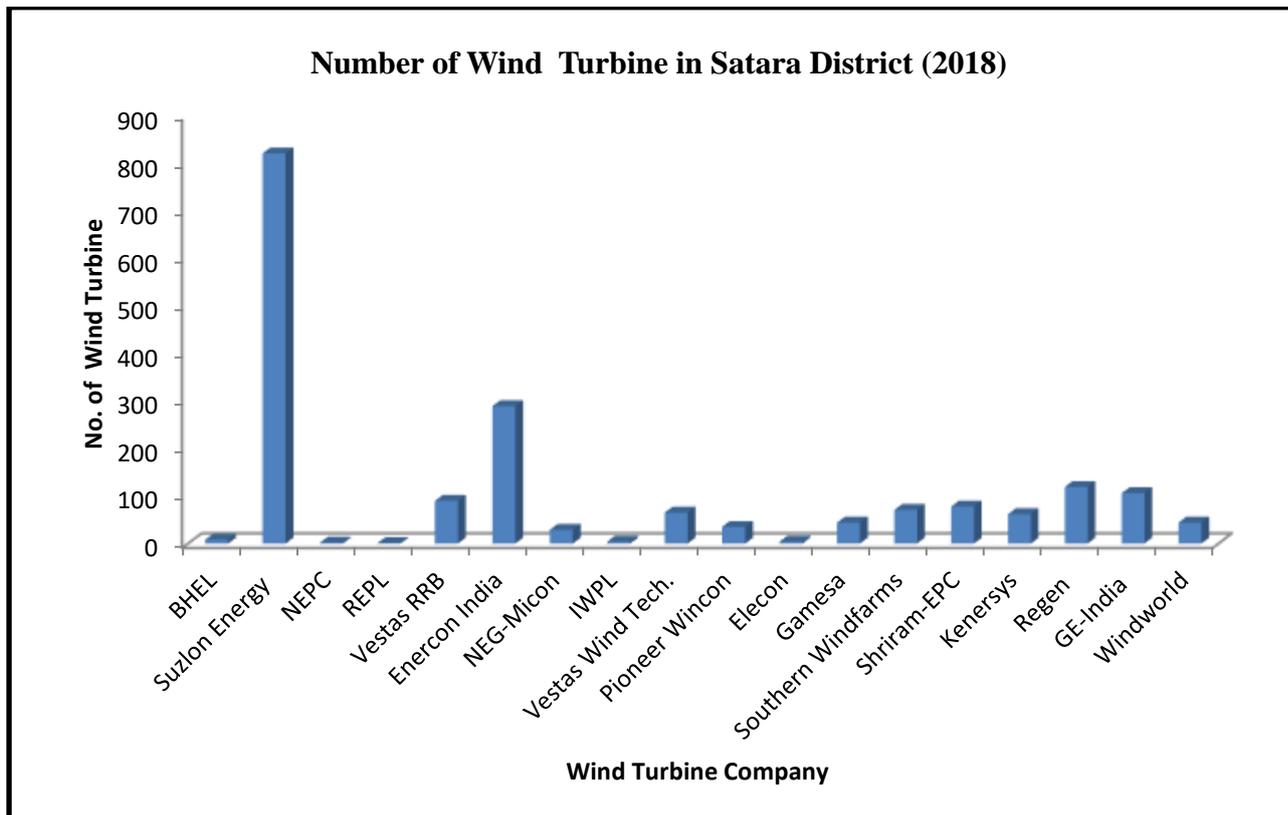


Fig.1

Table no.1 show that the Number of wind turbines and producer in Satara district. Suzlon is the largest company in terms of the installation of wind power generation in the Satara District. It has 821 wind machines and having 43.86 percent share in the total number of machines. The total installed capacity of this company is 567.45MW, about 37.67 percent of the total installed capacity of the district. The Enercon is the second-largest companies have been producing wind power in the Satara district. It has 289 machines and 149.26MW installed capacity, which is 9.91per cent of the total. The NPEC, IWPL, and BONUS play a little role in wind power generation n the state Vankusavade site large numbers of wind machines (638) have been installed, with 34.09 percent of total installed wind machines of the state. At the same time, it has also the highest installed capacity of wind power generation (242.825 MW) that constituted about 16.11 percent of the total installed capacity of wind power generation of the district. It is followed by Ambheri having 140 machines with 133.925 MW total installed capacities.

**Wind power Production and Spatial Distribution in Satara District (2018)**

The Satara district ranks first in wind power production in Maharashtra state. It is situated in Sahyadri Hills. Where wind velocity is adequate for the generation of energy. There are maximum numbers of potential sites for wind energy generation. Wind power generation mainly depends on wind speed, which varies from region to region. The successful efforts of MNES and MEDA brought an ideal condition for wind power generation in Maharashtra with the survey they have identified wind potential sites. Generally, annual mean at least 18 km/ph wind speed is essential for wind power generation

Table No.2

## Tahsil wise Distribution of Wind Mills and Energy Production (2018)

Sr. No	Tahsil	No. of Windmills	% of Windmills	Wind energy Production in MW	% of Wind energy Production
1	Mahabaleshwar	00	00	00	00
2	Wai	44	2.35	35.20	2.34
3	Khandala	125	6.68	200.95	13.34
4	Phaltan	00	00	00	00
5	Man	237	12.66	392.80	26.07
6	Khatav	30	1.60	62.80	4.17
7	Koregaon	332	17.74	207.52	13.78
8	Satara	197	10.52	79.96	5.31
9	Jaoli	20	1.07	27.30	1.81
10	Patan	887	47.38	499.87	33.18
11	Karad	00	00	00	00
<b>Total</b>		1872	100	1506.41	100

Source: [www.sitewisedistributioninwindenergyinsataradistrict.com](http://www.sitewisedistributioninwindenergyinsataradistrict.com) March.2018

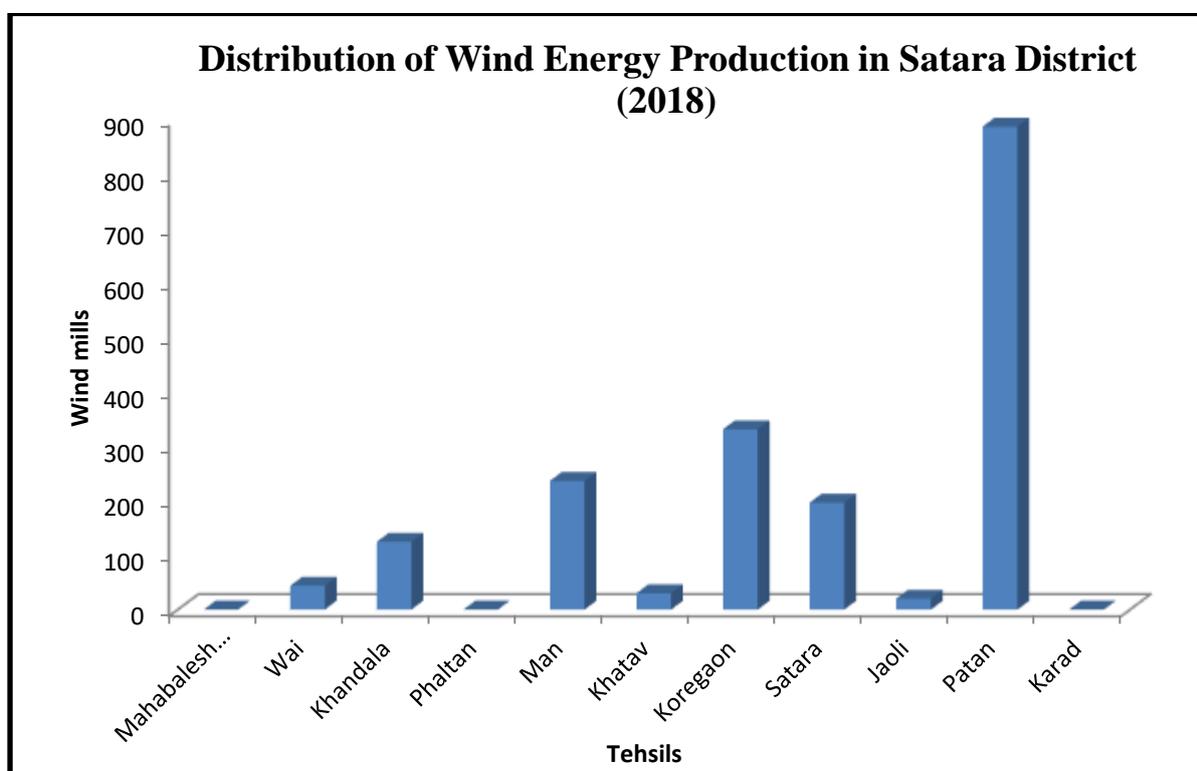
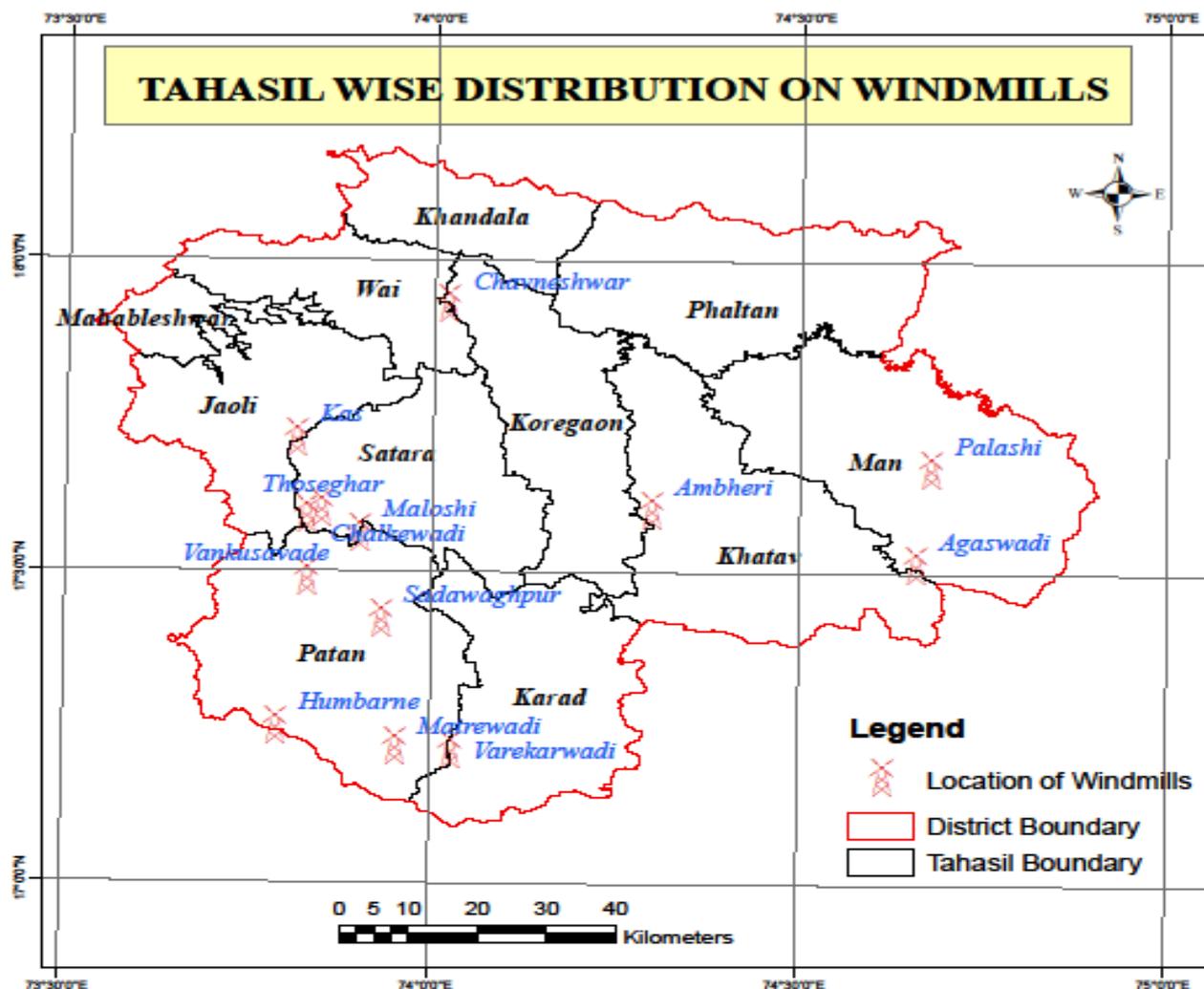


Fig.2.



Map.1.

Table.2 Reveals that the spatial distribution of the number of Windmills and production in the Satara district. In the year 2018 total windmills and wind power, the energy production of Satara district is 1872, 1506.41 MW respectively. It has been found from the above table that the largest number of wind turbines concentrated in the Patantehsil (887), followed by Koregaon (332), Satara (197), Man (237), Khandala (125), Wai (44), Khatav (30), Jaoli (20) Tahsil respectively. There are Mahabaleshwar and KaradTahsil not having any wind turbines. Beside of that wind power energy by PatanTahsil have highest production (33.18 percent) followed by Man (26.07 percent), Koregaon (13.78 percent), Satara (5.31 percent), Man (26.07 percent), Khandala (13.34 percent), Wai (13, 33 percent), Khatav (4.16 percent) and Jaoli (1.81 percent) Tahsil respectively. A higher percentage of wind turbines is positively influenced the wind power production, because of useful environmental conditions for wind power generation.

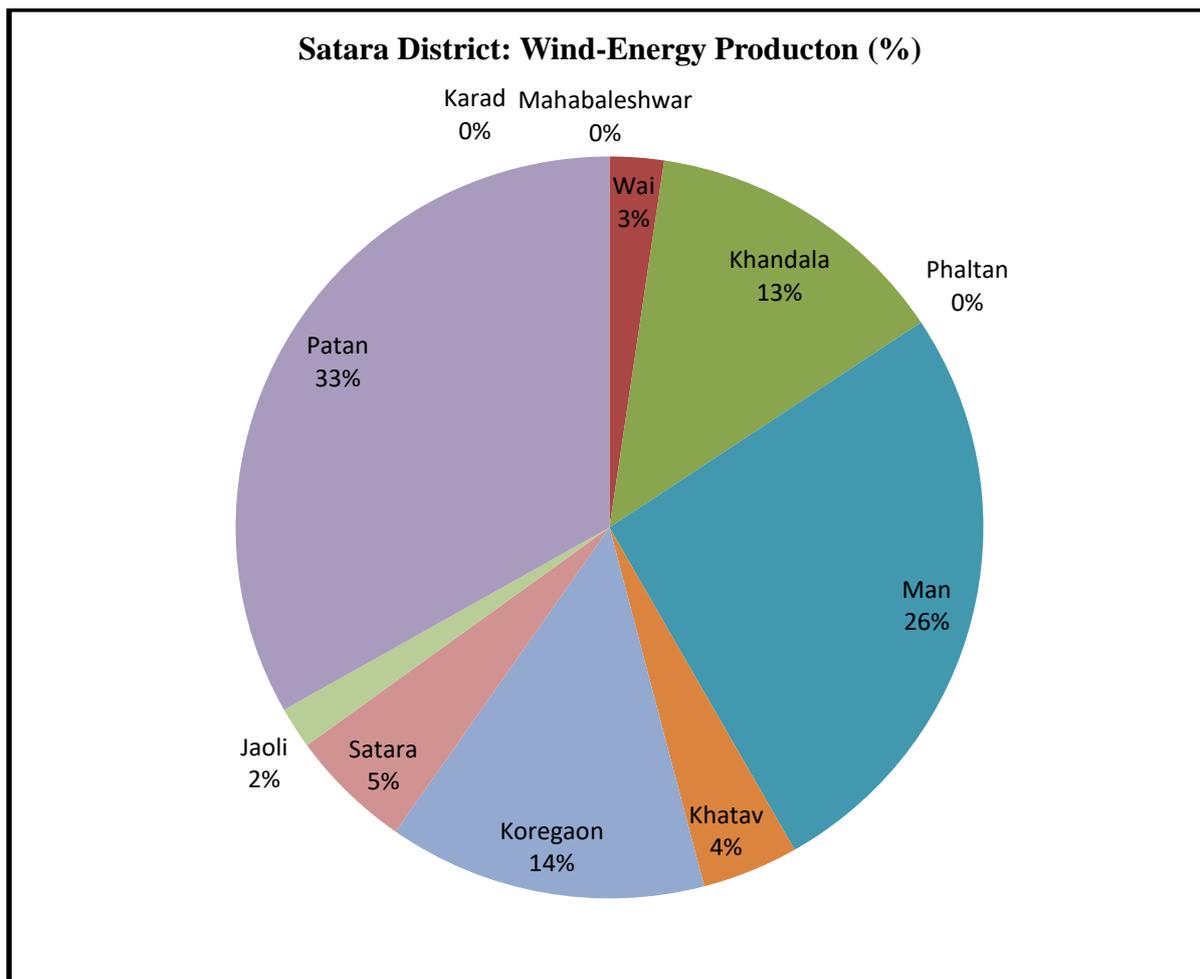


Fig.3

**The trend of Windpower Energy Production in Satara District**

The development of wind power in India began in 1986 with the first wind farms being set up in coastal areas of Maharashtra. Today Maharashtra is one of the most important states in terms of wind power generation. Maharashtra Energy Development Agency" for expansion of wind power projects. All the major companies of wind turbines counting Suzlon, Vestas, Gamesa, Regen, LeitnerShriram have a presence in Maharashtra. With a promising policy for a private share in wind power projects lead to in significant wind power development in Maharashtra state, mainly in the Satara district. The generation of wind power started at Chalkewadi in July 1997. At present, there are 1872 wind turbines working in the district and production capacity is over 1506.41 MW wind electricity per year.

**Table No 3: Growth Trend of Wind Power Energy Production in Satara District**

Year	Wind power energy production (MW)	Growth rate (%)
2003-04	306.61	00
2004-05	310.16	1.15
2005-06	320.76	3.41
2006-07	329.01	2.57
2007-08	386.16	17.34
2008-09	461.38	19.47
2009-10	548.73	18.93
2010-11	717.13	30.68
2011-12	888.08	23.83
2012-13	971.18	9.35
2013-14	1154.03	18.82
2014-15	1200.69	4.04
2015-16	1360.25	13.28
2016-17	1410.25	3.67
2017-18	1506.04	6.79

Source: [www.sitewisedistributioninwindenergyinsataradistrict.com](http://www.sitewisedistributioninwindenergyinsataradistrict.com)

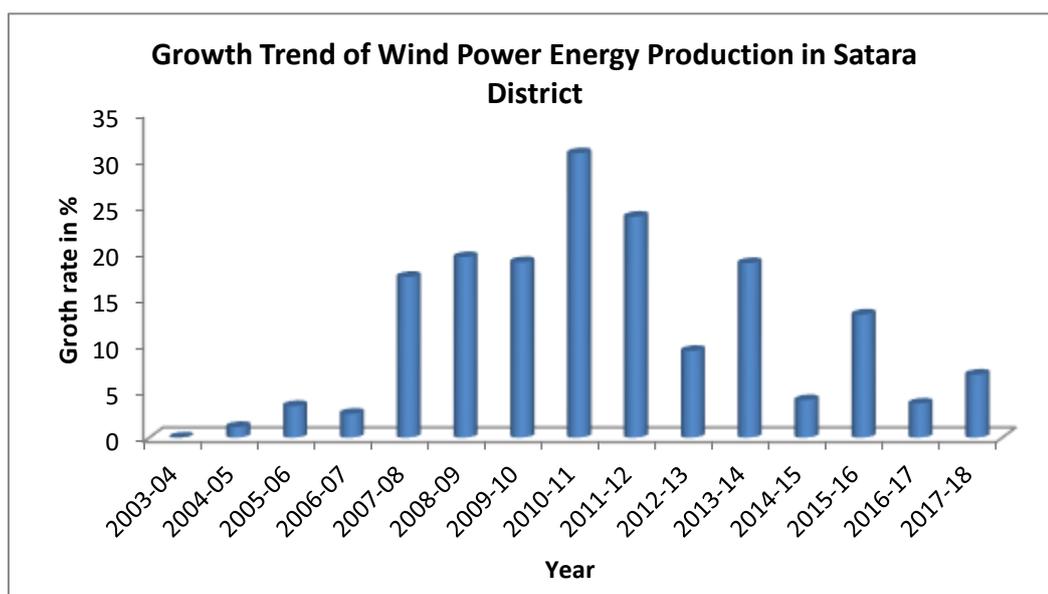


Fig.4

Table No 3 Shows the growth of wind power energy production in the Satara district from 2003-04 to 2017-18. It is observing the table No.3 that from 2003-04 to 2017-18 the Windpower energy Are continuously increased from 306.61 MW to 1506.04 MW, with a 391.19 percent growth rate. In the beginning, 2003-04 the state was having only 10 installed wind machines of which wind power energy production was 306.61 MW. In 2007-08, the total wind power energy production was enhanced by 17.34 MW. From 2007-08 to 2011-12the growth rate in wind power energy production was appreciable. In the year 2010-11, the Satara district recorded the highest growth rate in wind power production. Maharashtra state has declared the wind power generation policy in 1995, the main aim of which was to attract the promoters for wind power generation from the non-conventional energy sources. The state successfully increased its wind power installed capacity and recorded fast growth. From the year 2003-04 to 2017-18.there were remarkable growths recorded in the installation of wind turbines. However, these rapid progressive trends are not remaining for a long period

### **Conclusion**

Based on the above study it concludes that the growth of the wind power in the Satara district is largely controlled by the physio - economic conditions prevailing in the district. Regional disparity in the proportion of Wind turbines area is mainly related to the climatic condition and availability of a consistent supply of wind. Wind farms are mostly concentrated in Wai, Phaltan, Khandala, Man, Khatav, Koregaon, Satara, Jaoli and Patan where climatic condition is suitable for wind power energy production. Wind power energy production of the Satara district is continuously increased from 2003-04 to 2017-18. There is a need to formulate a suitable strategy and strengthening of infrastructure facilities. Energy is a basic requirement of the society. The development of varies sectors and the standard of living of the people is dependent on the availability of power with reasonable charges. With the help of power, we can produce more jobs; bulk production of a variety of commodities and can bring qualitative changes in various social sectors. The ever-growing demand for electricity cannot be meeting from conventional energy sources. Therefore nonconventional power resources can play a vital role in social and economic development. India is a leading country in the world but it has a problem of electricity shortage. However, India is rich in non-conventional energy sources. Wind power is one of the most important renewable source worldwide distributed and has a great potential of electricity.

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