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X – RAYING WIND ENERGY AVAILABILITY IN THE COASTAL REGION OF NIGERIA, CASE STUDY: BAYELSA STATE

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ABSTRACT

The over dependence on fossil fuel for power generation is an itching issue to the ears of contemporary scholars in the field of science and engineering. Thus, the way out of this; is a continuous search for cleaner, hazardous free and environmentally friendly energy. Therefore, a study of x – raying wind energy availability and sustainability in the coastal region of Nigeria is one route to the use of brighter energy in our days. Hence, study reveals availability of wind energy across the breadth and length of Nigeria. It attests that the coastal region of Bayelsa State generates up to 5.37ms^{-1} average wind speed during the period considered for the study. Conversely, an average temperature and humidity at the range of (25 – 27)℃ and (63 – 90)% respectively for the wind was recorded .Also, results confirm that optimum wind velocity is obtained during the rainy season, that is between late April – early November of the year. Nevertheless, results affirmed that the coastal lines in Bayelsa State are possessed with stormy wind which will create wind energy sustainability. Therefore, harvesting into wind renewable energy will curb the erratic and epileptic power situation in Nigeria.

1. Introduction

Increase in energy utilization is due to the aspiration of improved living standards, business ventures; and commercial enterprises signify social expansion and rapid economic growth for any developing country. Contrarily, energy variability, scarcity and inconsistency can lead to migration of businesses, relocation of homes and families, etc. Therefore, energy scouting should be considered as one focal cardinal objective of government in ensuring steady economic equilibrium. Meanwhile, the always poignant question on energy generation with respect to environmental degradation is; how suitable, available, sustainable and environmentally friendly is this usable energy to its immediate surroundings? In bid to answer this question, many scholarly researches have been carried out in source of solution.

In the wake of the increasing global environmental hazards and serious concern on greenhouse gases (GHGs), the interest in the alternative energy resources has been increased considerably [1]. This outstanding fact for clean energy generation mostly for the third world countries including Nigeria will be an interesting innovation that will spring and gear up the country's economy. Therefore, the erratic and epileptic state of power supply in our country Nigeria and the concern about global warming presently affecting and controlling the sea level which has been one contributing factor of flooding in the coastal towns and villages of the riverine states of Nigeria is an impending issue for all [2]. Thus, the drive into strong demand for wind renewable energy instead of conventional fossil fuel will set as the solution to the environmental catastrophe. The advantages of converting into wind energy in Nigeria with abundant wind power prospect according to study is due to absence of harmful emissions and almost immeasurable availability of the resource [3,4]. Despite the surplus wind energy recorded in Nigeria, the country still suffers from power shortage; research reveals that only 40% of the nation's population is access to the national grid [3]. This unbalanced energy generation scale in Nigeria can be linked to inadequate energy generation policies and projects in the country. However, a policy driven mission focusing on the following questions will help attack the energy crisis in the country. They are such as: Is there any benefit for Nigeria in the global wind energy resource development? Can the wind energy resource development solve the crisis of energy generation in Nigeria? Thus, finding the solutions and answers to these questions, there is the need to develop knowledge about wind energy potentials across the country.

2. Wind Energy Potentials in Nigeria

Scholarly research reveals that a good number of investigations on wind energy potentials in Nigeria have been carried out with respect to the best locations for wind power generation. According to this report, data accessibility is a vital tool for information justification. Hence, it confirms that wind speed records were analyzed based on location, altitude and time duration. Thus, based on this concept, a reviewed literature reveals that the average wind speed across Nigeria between 1951 to 1960 was about $3ms^{-1}$, though with a higher range of $3.6ms^{-1}$ in the northern part of Nigeria [4]. A similar report for annual average wind speed data collected between 1951 – 1975 from 22 stations across Nigeria was recorded as $3.92ms^{-1}$. Also, another classification of wind speed data obtained in Nigeria from research was classified into four different regimes between 1968 – 1983. They are such as Oshogbo, Minna and Yola regime with 1.0 – $2.0ms^{-1}$, Lagos, Makurdi and Port Harcourt regime with 2.1 – $3.0ms^{-1}$. Others are Enugu, Kano, Maiduguri regime with 3.1 – $4.0ms^{-1}$ and Jos, Nguru, Sokoto regime with > $4.1ms^{-1}$ [4, 5]. This approximately corresponds to a reported investigation of wind data carried out by research scholars in the south-eastern region of Nigeria with wind speed selected for Enugu, Owerri and Onitsha as 5.5, 3.5 and 3.5 ms^{-1}respectively [5, 6]. Meanwhile, a meteorological report of wind data in Nigeria between 1979 – 1988 for over 48 stations records was consistent with the above study. However, [5].mentioned specifically that the average wind speed in Nigeria ranges between 2 – $4ms^{-1}$ and 3.5 – $7.5ms^{-1}$ in the southern and northern regions of Nigeria respectively.

Conversely, to authenticate the wind data collection system; a research for an advanced artificial neural networks system was incorporated to predict the wind speeds distribution across Nigeria. Thus, from that study obtained results were compared with the predicted wind speeds data for 28 stations between 1983 – 2003. The analytical results obtained gives a monthly average wind speed ranging from a minimum value of 0.8 ms^{-1} in the southern region (case study – Ondo State) to maximum value of about $13.1ms^{-1}$in the northern region (case study – Kano State) which brings the overall annual average wind speed to $4.7ms^{-1}$ at the end of 2003 [5, 7]. This confirms that Nigeria falls into the moderate wind regime. According to [8] report for wind data energy resources mapping for ten wind turbine sites across Nigeria between 2004 – 2005 are as follows; Sokoto/Badaga site measure wind speed at the height of 30m as $5.4ms^{-1}$, Jos Airport/Kassa measures $5.2ms^{-1}$, while Gembu/Mambila plateau, Jos Pleateau/Pankshin and Kano/Funta measures $5.0ms^{-1}$, $5.0ms^{-1}$ and $4.7ms^{-1}$respectively. Others are Lagos/Lekki beach and Maiduguri/Mainok with $4.7ms^{-1}$ each whereas, Enugu nineth mile, Gumel/Garki and Ibi metrological station are measured as $4.6ms^{-1}$, 4.1 and $3.6ms^{-1}$ respectively.

A scholarly study profiled in [9] analyzes wind speed data between 2000 – 2010 at Ikeja in Lagos State, Nigeria is presented in table 1. It shows that maximum results obtained for wind speed across the range of study falls in year 2007 with an average wind velocity of $11.37ms^{-1}$ at a corresponding month of August which yields$11.77ms^{-1}$ mean wind velocity. However, the wind speed profile is at its trough in 2009 with an average wind velocity of $6.73ms^{-1}$, though having the least harvest of wind speed on November with $5.0ms^{-1}$. Another notable scenario from table 1 is the season at which wind velocity is harvested. Thus, from

September – December across the study range; wind speed seems to decrease exception of some few years (2001, 2002, 2005 and 2006) with fluctuating values whereas wind speed increases sporadically between January – April.

Table 1: Summary of Average wind speeds at Ikeja for the period 2000 - 2010.

Month	Years / wind speed (ms^{-1})											Average Wind Speed (ms^{-1})
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2000 - 2010
January	11.2	9.1	9.6	6.3	6.2	8.9	10.0	7.6	8.5	6.8	5.1	8.12
February	8.6	10.5	11.2	9.0	10.2	11.3	11.8	11.9	10.1	7.4	8.0	10.00
March	10.7	11.4	11.9	9.5	11.5	11.1	12.1	12.7	13.5	8.3	6.7	10.85
April	11.4	10.2	11.1	8.9	10.8	12.1	12.7	14.3	11.6	8.4	8.0	10.86
May	9.9	9.1	10.5	10.3	9.7	9.9	10.7	10.9	9.1	7.0	6.9	9.45
June	8.4	9.0	10.0	9.7	10.1	9.6	7.5	10.4	8.1	6.3	5.9	8.64
July	10.0	12.2	11.0	12.5	12.4	11.2	12.2	13.5	8.0	6.5	10.5	10.91
August	10.5	11.5	13.0	10.8	12.3	12.8	13.2	15.4	11.1	8.0	10.9	11.77
September	9.9	11.6	11.5	8.7	9.5	12.2	11.9	11.3	7.5	6.2	9.4	9.97
October	9.2	9.2	8.3	6.7	9.0	8.8	9.7	11.3	6.3	5.5	7.3	8.30
November	8.4	9.6	8.6	4.9	8.5	9.4	6.6	9.2	5.8	5.0	5.6	7.42
December	8.2	9.3	9.7	4.3	9.4	8.2	7.5	7.9	5.5	5.4	4.8	7.29
Average Wind Speed (ms^{-1})	9.70	10.23	10.53	8.47	9.97	10.46	10.49	11.37	8.76	6.73	7.43	9.47

Source: [9]

A similar study carried out by [1] reveals wind history of some vital settlement like Abeokuta and Ijebu-Ode of Ogun State in Nigeria. Results from their study analyzed assessment of wind potential within fifteen years (2000 – 2014) and the following data for wind speed were obtained. From 2000 – 2004, an average wind velocity of $5.1ms^{-1}$, $4.8ms^{-1}$, $3.9ms^{-1}$, $4.6ms^{-1}$ and $4.2ms^{-1}$ were recorded. Meanwhile, wind speed analysis for 2005 – 2009 were $3.9ms^{-1}$, $2.5ms^{-1}$, $2.2ms^{-1}$, $3.2ms^{-1}$ and $3.0ms^{-1}$according to their finding. Lastly, at the final range of coverage for their study which was between 2010 – 2014; the average wind speed data analyzed were $2.9ms^{-1}$, $3.0ms^{-1}$, $2.6ms^{-1}$, $2.7ms^{-1}$ and $2.3ms^{-1}$respectively [1]. These results show clear match with established findings from previous scholarly research studies. Conversely, the determination of wind potential across the southern part of Nigeria (Benin City Edo state)between 2015 and 2016 as presented by Nigeria Meteorological Agency (NIMET) in a reported study is $6.0ms^{-1}$ [10]. Likewise, a similar paper presentation on wind energy potentials for Yenagoa, Calabar and Port-Harcourt was carried out with results obtained from NIMET with wind speed data measured at an altitude of 10m over a period of 2013 – 2017 are $1.74ms^{-1}$, $2.85ms^{-1}$ and $1.38ms^{-1}$respectively. According to their study the corresponding analysis gives an annual power densities of $4.64Wm^{-2}$, 7.06 Wm^{-2} and 3.08 $Wm^{-2}$with an equivalent values of annual mean energy densities of 3.24 KWm^{-2}, 4.93 KWm^{-2} and 2.14 KWm^{-2}respectively [11, 12].

In summary of the above numerous reviewed research studies carried out across Nigeria, it has been identified that the country has enough wind energy resource with great prospects for power generation likely to solve the crisis in the power sector. However, there is an established fact that the south-south region of Nigeria generates very weak wind energy. This is the point of interest of this study. Meanwhile, research reminded that high value of wind speed is most harvested in coastal and hilly or mountainous areas. Thus, the states of the south-south region of Nigeria such as Bayelsa, Delta, Rivers, etc, are situated along the riverine coast. Hence, it is proper to review and carry out an intensive study on harnessing wind velocity in the coastal line of any of the mentioned states to ascertain the true nature of wind. Therefore, it is essential to x-ray the availability and sustainability of wind energy in the coastal

region of Nigeria. Thus, study is carried out in Amassoma; – a coastal town in Bayelsa State of Nigeria, the official location of Niger Delta University.

3. Materials and Methods

All the data used for the analysis of this work was generated from Niger Delta University (NDU) Weather House, Amassoma in Bayelsa State of Nigeria. The weather house building is in the main campus of the university not too far from the coastal line of River Nun. Amassoma is situated along this river which flows to the Atlantic Ocean. Figure 1 shows the study area on the map of Nigeria. The geographical coordinates of Amassoma is at 4.97° North latitude and 6.11° East longitude with 79m elevation above the sea level.

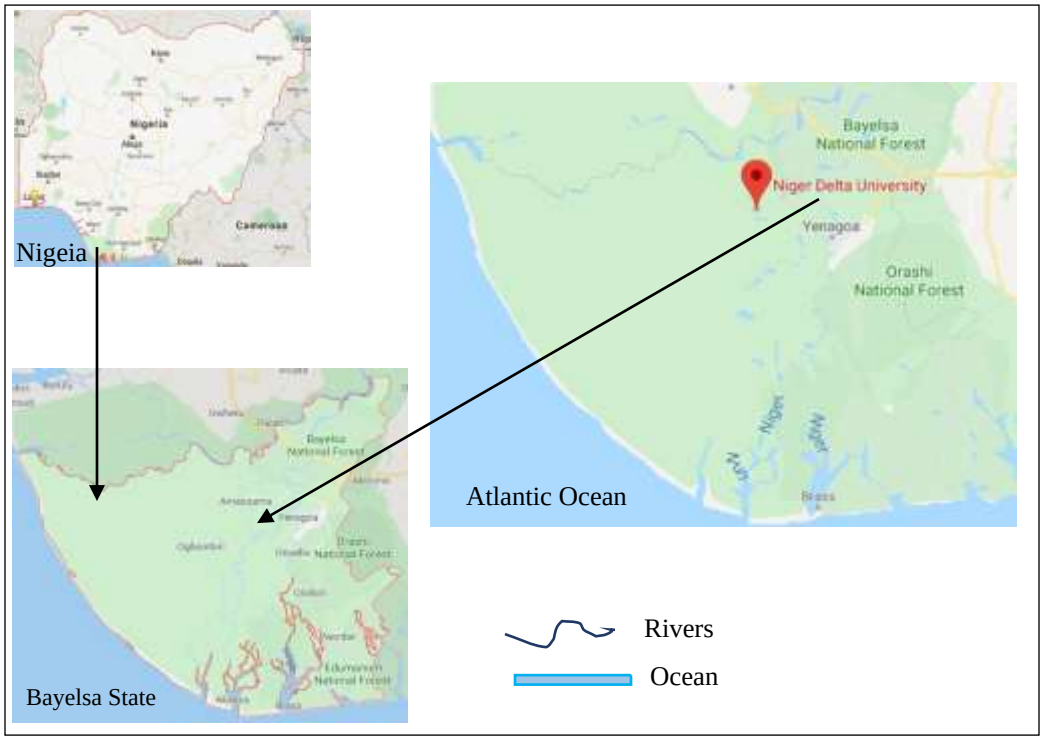

Figure 1: Study Area shown on the Map of Nigeria

Thus, the analysis of wind speed data for this study is between 2010 – 2015. Data were collected based on random selection for four (4) days in a month. Each day is picked from a week; hence the 4-days were selected from each week making up the month. Also, the records provided cover the twenty-four (24) hours in a day. Therefore, analysis of average accumulation of all data collection is presented in the subsequent section for discussion.

4. Results Presentation and Discussion

This section provides the results obtained in the study and are presented in tables 2 – 7 for discussion. Each of the tabular presentation of the result shows the wind speed data from 2010 – 2015. Also, included in this presentation is the corresponding average value of the wind temperature and humidity for each month as obtained from the NDU weather house.

Table 2: Niger Delta University Weather House Record for Average Wind Speed for Year 2010

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	3.5	1.7	0.9	3.5	0.9	23.5	13.0	6.1	5.2	6.1	6.1	4.3	4.3	4.3	3.5	4.3	3.5	2.6	4.3	3.5	0.9	0.0	0.0	0.0	24	93
Feb.	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	4.3	8.7	8.7	6.1	6.1	5.2	11.3	7.0	6.1	7.8	1.7	0.0	0.0	0.0	0.0	0.0	26	90
Mar.	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.9	8.7	7.8	8.7	7.8	8.7	10.4	6.1	5.2	13.0	11.3	7.0	3.5	3.5	0.9	1.7	1.7	26	87
Apr.	0.0	0.9	1.7	0.0	0.0	0.9	0.0	0.9	6.1	6.1	7.0	7.0	9.6	8.7	7.0	15.7	8.7	4.3	6.1	1.7	1.7	1.7	1.7	0.0	25	85
May	0.9	3.5	0.9	1.7	0.9	2.6	1.7	4.3	6.1	7.8	7.8	7.0	7.8	6.1	15.7	9.6	8.7	7.8	7.0	5.2	5.2	4.3	1.7	4.3	26	87
Jun.	4.3	1.7	4.3	0.0	0.9	2.6	0.9	0.9	4.3	5.2	8.7	7.8	3.5	7.8	6.1	6.1	8.7	5.2	4.3	0.9	0.9	1.7	0.9	0.9	26	89
Jul.	0.9	1.7	0.0	0.9	0.9	1.7	1.7	3.5	7.0	7.8	6.1	7.8	7.8	7.0	7.8	10.4	11.3	5.2	3.5	3.5	1.7	0.9	0.9	0.9	26	86
Aug.	0.9	7.8	19.1	10.4	3.5	5.2	6.1	4.3	3.5	4.3	5.2	6.1	5.2	6.1	8.7	8.7	6.1	4.3	0.0	0.0	0.0	0.0	0.0	1.7	25	88
Sep.	0.9	0.0	0.9	1.7	0.0	0.0	0.9	3.5	6.1	8.7	9.6	8.7	6.1	8.7	9.6	8.7	10.4	11.3	9.6	8.7	6.1	4.3	3.5	0.9	26	87
Oct.	1.7	0.0	3.5	1.7	0.9	0.9	5.2	4.3	5.2	12.2	11.3	5.2	10.4	23.5	4.3	5.2	9.6	9.6	1.7	2.6	1.7	0.0	1.7	0.9	25	91
Nov.	3.5	3.5	1.7	0.9	0.0	0.9	0.9	0.0	4.3	6.1	7.8	7.0	5.2	5.2	2.6	4.3	5.2	1.7	1.7	0.0	0.9	0.0	0.0	0.0	26	86
Dec.	1.7	0.9	0.9	1.7	1.7	1.7	1.7	1.7	3.5	4.3	8.7	9.6	8.7	6.1	6.1	9.6	7.8	4.3	1.7	1.7	0.0	0.9	0.9	0.9	26	89

Table 3: Niger Delta University Weather House Record for Average Wind Speed for Year 2011

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	0.0	0.9	0.0	3.5	0.9	0.0	3.5	4.3	5.2	6.1	7.0	21.7	8.7	7.0	4.3	7.0	5.2	5.2	1.7	1.7	2.6	1.7	7.8	6.1	23	95
Feb.	3.5	3.5	3.5	1.7	0.9	4.3	5.2	4.3	4.3	7.0	7.8	8.7	7.8	7.8	4.3	4.3	2.6	15.7	7.0	5.2	3.5	1.7	4.3	4.3	24	90
Mar.	4.3	1.7	0.0	0.0	3.5	0.9	0.0	4.3	4.3	5.2	6.1	10.4	8.7	7.8	8.7	8.7	7.8	5.2	6.1	0.9	0.0	0.0	0.0	0.0	25	88
Apr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	6.1	7.8	7.8	7.8	6.1	6.1	5.2	6.1	9.6	7.8	6.1	4.3	3.5	2.6	1.7	0.0	26	85
May	1.7	0.9	1.7	1.7	0.0	0.0	0.0	4.3	5.2	7.0	8.7	4.3	7.8	6.1	5.2	9.6	8.7	4.3	3.5	2.6	1.7	0.0	0.9	0.9	27	85
Jun.	0.0	0.0	0.0	0.9	0.9	0.0	0.0	4.3	5.2	6.1	5.2	6.1	6.1	5.2	11.3	7.8	7.8	3.5	1.7	1.7	1.7	2.6	0.0	0.0	26	89
Jul.	1.7	1.7	1.7	0.9	0.0	0.0	0.9	4.3	5.2	7.8	7.0	6.1	11.3	12.2	10.4	7.0	4.3	4.3	5.2	4.3	1.7	1.7	1.7	1.7	25	92
Aug.	0.9	0.9	1.7	1.7	0.9	1.7	3.5	4.3	0.9	4.3	6.1	6.1	4.3	7.0	7.0	7.8	5.2	1.7	0.9	1.7	0.9	1.7	2.6	0.0	24	94
Sep.	0.0	0.0	0.0	1.7	0.9	0.9	1.7	4.3	3.5	5.2	7.8	8.7	8.7	6.1	7.0	12.2	8.7	8.7	4.3	11.3	8.7	4.3	1.7	3.5	26	86
Oct.	3.5	2.6	1.7	1.7	2.6	5.2	6.1	4.3	3.5	4.3	6.1	7.0	8.7	7.0	7.0	7.0	5.2	1.7	1.7	4.3	3.5	0.9	0.0	0.0	26	85
Nov.	0.0	0.0	0.0	0.0	1.7	0.9	0.9	4.3	4.3	7.0	6.1	6.1	7.0	7.0	6.1	4.3	9.6	6.1	2.6	1.7	0.0	0.9	0.0	0.9	26	88
Dec.	0.0	1.7	1.7	3.5	0.9	1.7	0.9	4.3	4.3	6.1	6.1	6.1	5.2	7.8	5.2	11.3	10.4	5.2	4.3	3.5	1.7	1.7	3.5	0.9	26	90

Presented results for 2010 as shown in table 2 indicates average values of wind speed in May, August, September and October as 5.36ms^{-1}, 4.88ms^{-1}, 5.37ms^{-1} and 5.14ms^{-1} respectively with an average wind temperature between (25 and 26)℃ and corresponding humidity ranging from (87 – 91)%. Similarly, the optimum results obtained for wind velocity in the analysis for 2011 where on January with 4.67ms^{-1}, September with 4.99$ms^{-1}$and February with 5.13ms^{-1}; having average temperature and humidity values as (23, 26 and 24)℃ and (95, 86 and 90)% respectively. However, it is been established that certain hours in the day recorded high values of wind velocity. This is as a result of abnormal occurrences either from violent storm or heavy down pour of rain though the resultant effect of increase in wind speed is advantageous with regards to the study even as the wind velocity experience some turbulence. Thus, the turbulent wind velocity recorded in the study period between 2010 and 2011is at the range of (10-23.5)ms^{-1} which occur mostly in October and September. Meanwhile, corresponding values of recorded stormy wind speed are (12.2, 11.3, 10.4 and 23.5)ms^{-1} for 2010 and (12.2 and 11.3)ms^{-1} for 2011.

Table 4: Niger Delta University Weather House Record for Average Wind Speed for Year 2012

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	1.7	1.7	0.0	1.7	3.5	0.0	0.0	1.7	6.1	3.5	4.3	6.1	3.5	7.0	6.1	3.5	8.7	4.3	4.3	0.9	0.0	0.9	0.0	0.9	25	90
Feb.	0.9	0.0	0.0	0.9	0.9	0.9	0.0	0.9	4.3	7.0	5.2	7.0	8.7	8.7	8.7	7.0	4.3	5.2	0.9	0.9	0.9	0.9	0.0	0.0	27	84
Mar.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	7.8	7.8	7.0	4.3	6.1	6.1	4.3	1.7	4.3	0.9	0.9	0.0	0.0	0.0	27	85
Apr.	3.5	0.0	0.0	0.0	0.0	0.0	0.9	3.5	4.3	5.2	7.0	7.8	8.7	7.0	6.1	6.1	13.9	7.8	3.5	0.0	0.0	0.9	0.0	0.9	26	88
May	0.0	0.0	0.9	0.9	0.9	0.0	0.0	0.0	3.5	5.2	6.1	6.1	6.1	5.2	5.2	5.2	5.2	1.7	1.7	2.6	0.9	0.9	1.7	3.5	26	88
Jun.	20.9	8.7	7.0	3.5	5.2	2.6	3.5	3.5	4.3	5.2	3.5	6.1	8.7	6.1	2.6	5.2	7.8	3.5	4.3	4.3	0.0	0.0	0.0	0.0	26	90
Jul.	3.5	0.0	0.0	0.0	0.0	0.0	0.9	3.5	4.3	5.2	7.0	7.8	8.7	7.0	6.1	6.1	13.9	7.8	3.5	0.0	0.0	0.9	0.0	0.9	24	89
Aug.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	7.8	7.8	7.0	4.3	6.1	6.1	4.3	1.7	4.3	0.9	0.9	0.0	0.0	0.0	25	89
Sep.	0.0	0.0	0.9	0.0	0.9	1.7	0.0	0.9	3.5	5.2	7.8	7.0	7.0	5.2	6.1	4.3	2.6	4.3	8.7	3.5	1.7	0.9	0.9	0.0	26	82
Oct.	0.0	0.9	0.9	0.9	0.9	0.0	0.9	0.0	2.6	4.3	7.8	7.8	8.7	7.8	7.0	6.1	4.3	0.9	0.0	3.5	1.7	0.9	0.0	0.0	26	85
Nov.	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.9	0.0	1.7	6.1	5.2	7.8	7.0	6.1	5.2	1.7	0.0	0.9	3.5	1.7	0.9	0.0	0.0	26	88
Dec.	0.0	1.7	0.0	0.9	1.7	1.7	0.9	5.2	6.1	6.1	7.0	6.1	8.7	7.8	7.0	8.7	4.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0	26	87

Table 5: Niger Delta University Weather House Record for Average Wind Speed for Year 2013

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	0.0	0.0	1.7	0.0	0.0	0.0	0.9	0.0	0.9	6.1	7.8	7.0	5.2	5.2	6.1	6.1	5.2	7.0	3.5	0.9	1.7	0.9	0.0	0.9	27	86
Feb.	0.9	0.9	0.0	0.0	0.9	0.0	0.9	1.7	1.7	5.2	6.1	6.1	6.1	8.7	6.1	5.2	7.8	7.8	6.1	1.7	1.7	0.9	0.9	0.9	26	88
Mar.	0.0	0.9	0.0	0.0	0.0	0.9	0.0	1.7	4.3	5.2	7.8	9.6	7.8	7.0	6.1	5.2	1.7	5.2	4.3	4.3	0.9	0.0	0.0	0.0	25	85
Apr.	0.9	0.0	0.0	0.0	0.0	0.9	0.9	3.5	5.2	7.0	7.0	7.0	7.0	9.6	9.6	7.8	7.0	7.0	3.5	3.5	0.0	0.9	1.7	1.7	27	88
May	1.7	1.7	3.5	0.9	0.0	1.7	3.5	3.5	3.5	4.3	3.5	5.2	7.8	6.1	6.1	4.3	1.7	1.7	2.6	3.5	0.9	0.9	1.7	0.9	27	87
Jun.	0.9	0.9	0.0	0.0	0.0	0.9	0.9	0.9	3.5	4.3	6.1	7.8	7.0	10.4	7.8	4.3	0.9	0.0	3.5	0.0	1.7	0.9	0.0	0.0	27	83
Jul.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	3.5	5.2	7.8	9.6	12.2	8.7	9.6	8.7	9.6	5.2	0.0	0.9	0.9	0.0	0.0	0.9	26	76
Aug.	0.0	0.9	0.9	0.9	0.0	0.0	0.9	9.6	7.8	5.2	6.1	8.7	9.6	7.0	6.1	7.0	5.2	0.9	0.0	0.9	0.0	0.0	0.9	0.9	25	77
Sep.	0.0	0.0	1.7	0.0	1.7	1.7	1.7	0.9	4.3	6.1	7.8	9.6	7.0	8.7	7.0	4.3	4.3	3.5	0.0	0.9	0.0	0.0	0.0	0.0	24	77
Oct.	0.0	0.0	0.0	0.9	0.9	0.9	0.9	0.9	11.3	9.6	11.3	8.7	10.4	8.7	7.8	7.0	4.3	1.7	0.0	0.9	0.0	0.0	0.0	0.0	24	77
Nov.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	3.5	4.3	5.2	6.1	7.0	7.0	6.1	4.3	3.5	1.7	1.7	0.9	0.0	0.9	1.7	0.9	24	77
Dec.	3.5	0.0	0.0	0.0	0.0	0.0	0.9	3.5	4.3	5.2	7.0	7.8	8.7	7.0	6.1	6.1	13.9	7.8	3.5	0.0	0.0	0.9	0.0	0.9	26	80

Consequently, the obtained results for wind speed measurement in 2012 and 2013 predominantly have low values. This attests little change in the climatic condition against the preceding years. However, records still indicate average wind velocity of $3.63ms^{-1}$ for April and July, $4.85ms^{-1}$ for June and $3.04ms^{-1}$ for September all in 2012. Meanwhile, the corresponding values of wind speed for 2013 are $3.63ms^{-1}$ recorded for July and December, whereas $3.82ms^{-1}$ and $3.59ms^{-1}$ are for April and October respectively. Nevertheless, results also reveal wind data report for turbulent wind speed. These records were identified in April and July with corresponding value of $13.9ms^{-1}$ whereas with $20.9ms^{-1}$ recorded for June, 2012. Similarly, $10.4ms^{-1}$, $12.2ms^{-1}$ and $11.3ms^{-1}$ are turbulent wind speed report for June, July and October, 2013. Thus, the average temperature and humidity have similar pattern with 2010 and 2011.

Table 6: Niger Delta University Weather House Record for Average Wind Speed for Year 2014

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	0.0	0.0	0.9	0.0	0.9	0.0	0.9	1.7	5.2	5.2	7.0	7.8	7.0	6.1	6.1	5.2	1.7	0.9	0.9	7.8	7.0	1.7	0.0	0.0	27	83
Feb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	7.8	7.8	7.0	4.3	6.1	6.1	4.3	1.7	4.3	0.9	0.9	0.0	0.0	0.0	27	85
Mar.	0.9	0.0	0.0	0.0	0.9	0.0	0.0	1.7	3.5	6.1	8.7	7.8	6.1	6.1	5.2	5.2	4.3	6.1	4.3	4.3	0.0	0.0	0.9	0.9	27	83
Apr.	0.9	0.0	0.0	0.9	0.9	0.9	0.0	0.9	1.7	7.8	7.0	7.8	7.8	8.7	7.0	7.8	6.1	6.1	3.5	4.3	3.5	0.9	0.9	1.7	28	84
May	0.9	0.9	1.7	0.0	0.9	1.7	3.5	4.3	4.3	5.2	7.0	8.7	9.6	9.6	8.7	4.3	5.2	3.5	0.9	10.4	3.5	1.7	0.9	0.0	28	81
Jun.	0.0	0.0	1.7	1.7	3.5	6.1	5.2	5.2	4.3	5.2	7.0	5.2	9.6	8.7	11.3	7.8	6.1	3.5	0.0	0.9	0.9	0.0	0.0	0.0	27	80
Jul.	0.0	0.0	0.9	1.7	1.7	3.5	6.1	5.2	4.3	4.3	4.3	7.8	9.6	8.7	7.0	6.1	5.2	3.5	0.0	0.0	0.0	0.0	0.0	0.0	27	75
Aug.	0.9	7.8	19.1	10.4	3.5	5.2	6.1	4.3	3.5	4.3	5.2	6.1	5.2	6.1	8.7	8.7	6.1	4.3	1.7	0.9	1.7	0.9	1.7	2.6	27	79
Sep.	0.9	0.0	0.0	2.6	3.5	5.2	7.0	6.1	6.1	5.2	11.3	10.4	10.4	7.8	7.0	7.0	4.3	4.3	0.0	0.0	4.3	0.9	0.0	0.0	27	71
Oct.	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	2.6	1.7	2.6	1.7	3.5	4.3	2.6	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27	73
Nov.	0.9	0.9	0.0	1.7	1.7	3.5	4.3	6.1	7.0	7.8	7.0	9.6	9.6	8.7	9.6	7.0	7.0	1.7	0.9	0.9	3.5	4.3	0.9	0.0	27	70
Dec.	0.9	0.9	0.0	0.0	1.7	3.5	4.3	4.3	6.1	5.2	7.8	8.7	10.4	8.7	7.0	7.0	4.3	2.6	5.2	5.2	1.7	0.0	0.0	0.0	27	75

Table 7: Niger Delta University Weather House Record for Average Wind Speed for Year 2015

Months	Monthly Average Wind Speed																								
	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	Ave. Temp.	Ave. Humidity
Jan.	0.9	0.9	0.0	1.7	4.3	4.3	6.1	7.0	6.1	6.1	8.7	10.4	9.6	10.4	7.8	7.0	4.3	1.7	0.9	0.0	0.0	0.0	0.0	0.0	27	68
Feb.	0.0	0.0	0.0	0.0	0.0	0.0	4.3	3.5	6.1	8.7	8.7	8.7	7.0	9.6	7.0	6.1	5.2	1.7	3.5	0.0	0.0	0.0	0.0	0.0	25	63
Mar.	0. 9	0.9	1.7	0.0	0.9	1.7	3.5	4.3	4.3	5.2	7.0	8.7	9.6	9.6	8.7	4.3	5.2	3.5	0.9	10.4	3.5	1.7	0.9	0.0	28	81
Apr.	0.0	0.0	1.7	1.7	3.5	6.1	5.2	5.2	7.0	5.2	7.0	5.2	9.6	8.7	11.3	7.8	6.1	3.5	0.0	0.9	0.9	0.0	0.0	0.0	27	80
May	0.0	0.0	0.9	1.7	1.7	3.5	6.1	5.2	4.3	4.3	4.3	7.8	9.6	8.7	7.0	6.1	5.2	3.5	0.0	0.0	0.0	0.0	0.0	0.0	27	75
Jun	0.0	0.0	0.0	0.0	0.9	0.9	0.9	3.5	6.1	7.0	7.0	6.1	6.1	7.8	7.0	7.8	5.2	0.9	3.5	4.3	3.5	0.9	0.0	0.0	27	79
Jul.	0.9	0.0	0.0	2.6	3.5	5.2	7.0	6.1	6.1	5.2	11.3	10.4	10.4	7.8	7.0	7.0	4.3	4.3	0.0	0.0	4.3	0.9	0.0	0.0	27	70
Aug.	0.9	0.0	0.0	0.9	0.9	0.9	0.0	0.9	1.7	7.8	7.0	7.8	7.8	8.7	7.0	7.8	6.1	6.1	3.5	4.3	3.5	0.9	0.9	1.7	28	84
Sep.	0.9	0.9	0.0	1.7	1.7	3.5	4.3	6.1	7.0	7.8	7.0	9.6	9.6	8.7	9.6	7.0	7.0	1.7	0.9	0.9	3.5	4.3	0.9	0.0	28	70
Oct.	0.9	0.9	0.0	0.0	1.7	3.5	4.3	4.3	6.1	5.2	7.8	8.7	10.4	8.7	7.0	7.0	4.3	2.6	5.2	5.2	1.7	0.0	0.0	0.0	27	75
Nov.	0.9	0.9	0.0	1.7	4.3	4.3	6.1	7.0	6.1	6.1	8.7	10.4	9.6	10.4	7.8	7.0	4.3	1.7	0.9	0.0	0.0	0.0	0.0	0.0	27	68
Dec.	0.0	0.0	0.0	0.0	0.0	0.0	4.3	3.5	6.1	8.7	8.7	8.7	7.0	9.6	7.0	6.1	5.2	1.7	3.5	0.0	0.0	0.0	0.0	0.0	25	63

Another set of results with close match of average wind speed to 2010 and 2011 are those of 2014 and 2015. Thus, recorded results for August are 5.21ms^{-1} while that of September and November is 4.35ms^{-1} for 2014. Meanwhile, values for 2015 are 4.34ms^{-1} average wind speed at July and September; and 4.09$ms^{-1}$for January and November. Likewise, turbulence in wind speed is equally registered in aforementioned years with highest occurrence of 19.1ms^{-1} in August 2014 and 11.3ms^{-1} in July at 2015.Conversely, results attained from study is summarized as follows; average wind speed for 2010 – 2015 are (5.19, 4.93, 3.84, 3.64, 4.78 and 4.22)ms^{-1} respectively. This proves that the average wind speed in the study area is little above the presume values as stated in the review literature. Thus, attesting and confirming with a scholarly study that the coastal region has equal capacity like the hilly and mountainous regions in generating wind energy for sustainable power generation.

4. Conclusion

Villages and towns along the coastal region have relative effects from coastal storms though sometimes hazardous to the environment but useful in this case for wind energy generation. Over 80% of settlements in Bayelsa State of Nigeria are situated along the coastal region (riverine). This feature in terms of settlement is advantageous because coastal areas are usually windy and they provide suitable location for wind turbine farms. Thus, the manifestation of coastal region characteristics is obvious from the

result findings of this study as discussed in the previous section. Hence, the following conclusions with regards to the study are reached:-

- The highest wind velocity was recorded on stormy hours in the day.
- The highest average wind speed data were obtained mostly on September of the years considered for the study. However, other months like April – August and October – November got the same level of wind speed occurrence.
- This signifies that the peak wind velocity in a wind turbine farm could be achieved in September if built in the coastal line. However, the likelihood of having steady wind energy as confirmed above is possible during the rainy season which is approximately between late April – early November of the year in Nigeria.
- Lesser wind speed is likely to be achieved during dry season (late November – early April).
- The study area (Bayelsa State) is capable of generating wind energy for sustainable power generation.

Therefore, the study of x – raying wind energy availability and sustainability in the coastal region of Nigeria is proven feasible. Hence, diversifying Nigeria's economy with regards to wind turbine renewable energy will impinge positive development on the economic growth of the nation. Finally, development in this sector will secure electric power availability, and consequently create avenue for small and medium scale businesses for our timing unemployed youths.

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