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Evaluation of the technical wind energy potential of Kisii region based on the Weibull and Rayleigh distribution models

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ABSTRACT

The research sought to investigate the long term characteristics of wind in the Kisii region (elevation 1710m above sea level, 0.68ºS, 34.79º E). Wind speeds were analyzed and characterized on short term (per month for a year) and then simulated for long term (ten years) measured hourly series data of daily wind speeds at a height of 10m. The analysis included daily wind data which was grouped into discrete data and then calculated to represent; the mean wind speed, diurnal variations, daily variations as well as the monthly variations. The wind speed frequency distribution at the height 10 m was found to be 2.9ms^{-1} with a standard deviation of 1.5. Based on the two month's data that was extracted from the AcuRite 01024 Wireless Weather Stations with 5-in-1 Weather Sensor experiments set at three sites in the region, averages of wind speeds at hub heights of 10m and 13m were calculated and found to be 1.7m/s, 2.0m/s for Ikobe station, 2.4m/s, 2.8m/s for Kisii University stations, and 1.3m/s, 1.6m/s for Nyamecheo station respectively. Then extrapolation was done to determine average wind speeds at heights (20m, 30m, 50m, and 70m) which were found to be 85.55W/m^2, 181.75W/m^2, 470.4W/m^2 and 879.9W/m^2 respectively. The wind speed data was used statistically to model a Weibull probability density function and used to determine the power density for Kisii region.

Key words: Wind speed, wind power, scale factor and shape factor.

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1.0. INTRODUCTION

Energy plays a key role in the social-economic development of any country in the world. The level and the intensity of energy use in a country is a key indicator of economic growth and development (Kenya Energy Report, 2014). According to energy survey 2013, biomass provides 69% of the Kenya's overall energy requirements while petroleum accounts for about 22% and electricity 9%. 74.5% of the country's electricity component is generated using renewable energy sources while fossil fuel provides the balance of 25.5% (Choge et al. 2013). Of the 74.5%, wind energy takes only 0.2%. (Kanyi, Wambugu, 2017). This clearly indicates why intensive study needed to be done in the area. The challenges facing wind energy investment in Kenya includes; high upfront costs, most potential areas for wind energy generation being far away from the grid and load centers requiring high capital investment for transmission lines, inadequate wind regime data, limited after sales service, inadequate wind energy industry standards due to the fast changing technologies and enhanced capacities of turbines, competing interest in land use with other commercial users and lack of RD&D in wind technologies(Kenya, National Energy Policy, 2014). Wind as a resource, is very clean and alternative source of power. Wind energy technologies are free of carbon iv oxide production which is the major culprit contributing to global warming. With countries working on alternatives sources of energy that will help to prevent this menace, wind stands at a better chance as the alternative (Kirui, 2006). In assessment of wind, the first step should be to determine the major wind flow contributing to the resource. These can include westerly winds, mansoon winds which are seasonal winds caused by large annual differences over a land and sea areas or meso-scale winds associated with the topographical features of a place. Step two is to analyze the observed data in order to determine the magnitude and scale of wind for each scale of motion. (Oludhe, 2007)

Kenya as a country experiences frequent power outages due to overreliance on electricity generation from hydropower and geothermal power plants. During droughts and prolonged dry seasons, hydrological and geothermal sources get depleted hence making the country face electric power shortages or resort to power rationing (Kiplagat, J. K. et. al 2011). When this happens, people are forced to use generators as power backups. In the process of generating electricity from fuel-generators, the fuels are burnt thus producing harmful emissions to the environment. Such emissions includes; carbon iv oxide, hydrocarbons, airborne particles, solid ash and waste, hydrochloric acid, ionization radiation and trace elements. Of the gases produced, it is estimated that about 80% of them contribute to greenhouse effect of the atmosphere. To reduce overreliance on generators as back-ups during power outages, alternative sources of energy like wind need be investigated to help back up electricity generation. Though wind stands a chance to solve this problem, lack of site's adequate wind profile to enable informed choice on whether to invest in wind as energy source in the region is still a challenge. (Saoke, O. C. 2011). This research therefore, sought to establish the region's wind profiles to help investors make informed choice on whether to invest on wind as an alternative source of power during power outages if it can't be enough for large scale production and on selection of the best machine marching the region's wind profiles for optimum production of energy.

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2.0. MATERIALS AND METHODS

2.1. Experimental set-up and data collection

Data was obtained by installing AcuRite weather stations with 5-1 sensors in three stations in Kisii region (0.68ºS, 34.79ºE). The stations were set at the sites at two different hub heights and data collected by two indoor display boards set inside the room within a radius of 100m from the stations. The boards were programmed to receive data from the two stations simultaneously at an interval of 12 minutes each through remote sensing. By use of the PC connect software; data received and stored by the indoor display boards was transferred to the computer for analysis. Then the data was used to determine the wind shear and roughness parameters of the sites. A 10 year data from the kisii meteorological station was also analyzed together with the data from the sites and results used to determine the region's long term characteristics of wind.

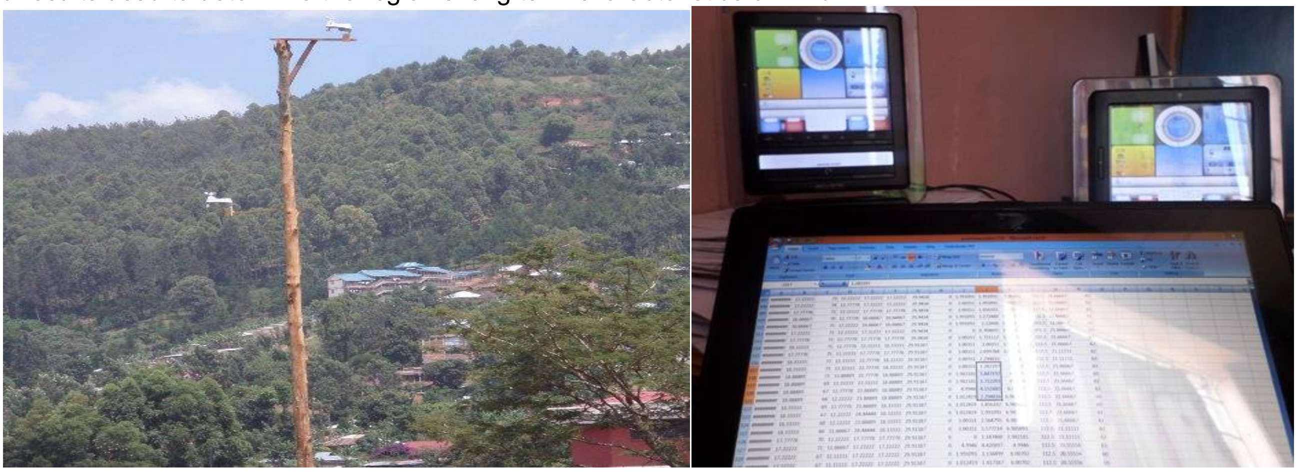

FIGURE 1: ACURITE wind senosrs, display boards and PC at Kisii University

2.2. Governing equations and principles

2.2.1. Energy on the Wind

The energy that wind transfers to the rotor of a wind turbine is proportional to the density of the air, the rotor area, and the cube of the wind speed (Akpinar et.al, 2005).

$$P = \frac{1}{2}\rho A v^3 \qquad 1$$

Where

P-Power in the wind (W), ρ-Density of the air (at normal atmospheric pressure and at 15° Celsius air weigh some 1.225 kilograms per cubic meter), A- Rotor Area (A typical 1,000 kW wind turbine has a rotor diameter of 54 meters). (Danish wind, 2008), V - The wind speed (m/s)

2.2.2. Weibull probability density function

The Weibull probability density function (pdf) is given by equation 1(Manwell, 2002).

$$f(v) = \begin{Bmatrix} \frac{k}{C}\left(\frac{v}{C}\right)^{k-1} \exp\left\{-\left(\frac{V}{C}\right)^{k}\right\} & \forall\, v \geq o \\ 0 & v < 0 \end{Bmatrix} \qquad 2$$

And Weibull power output is calculated by use of the power density formula shown below. (Choge,et.al 2013)

$$P_w = \frac{1}{2}\rho C^3 \Gamma\left(1 + \frac{3}{k}\right) \qquad 3$$

Where Γ is the gamma function, k shape parameter and c Weibull scale parameter (m/s), ρ - Air density (kg/m^3)

2.2.3. Weibull factors.

Shape factor k

$$k = \left(\frac{0.9874}{\frac{\sigma}{\overline{\overline{V}}}}\right)^{1.0983} \qquad 4$$

Where δ -is the weibull distribution variance and $\vec{v}$ is mean wind speed at height z

Weibull scale factor C

The Weibull factor can be calculated as;

$$C = \vec{V}\left(0.568 + \frac{0.433}{k}\right)^{\frac{-1}{k}} \qquad 5$$

With area under the curve is always unity.

2.2.4. Methods of extrapolating Weibull parameters

Weibull phase factor k and scale factor C for given know heights can be extrapolated to other hub heights by using the following formulas (Kidm D. K. et al. 2014);

$$C_z = C_{10} \times \left(\frac{z}{z_{10}}\right)^{\propto} \qquad 6$$

$$k_z = \frac{k_{10}}{1 - 0.008811 ln\left(\frac{z}{10}\right)} \qquad 7$$

Where

$$n = 0.37 - 0.088\ln(C_{10}) \qquad 8$$

2.2.5. The Rayleigh Density Function

For $k = 2$ the Weibull pdf is commonly known as the Rayleigh density function in which case Equation 2 may be rewritten as in Equation.9.

$$\mathrm{f(v)} = \frac{2\mathrm{V}}{\mathrm{C}^2}\exp\left\{-\left(\frac{\mathrm{V}}{\mathrm{C}}\right)^2\right\} \qquad 9$$

For Rayleigh distribution, power density is calculated using equation 10;

$$P_R = \frac{3}{\pi}\rho C^3\left(\frac{\pi}{4}\right)^{\frac{3}{2}} \qquad 10$$

Where P represents wind power density, ρ is the density of wind of the region under study

2.2.6. The Power Exponent Function

$$\frac{V_z}{V_{10}} = \left(\frac{Z_y}{Z_{10}}\right)^{\alpha} \qquad 11$$

Where α is the wind shear exponent of the region which depends on the roughness of the terrain and can be calculated using equation 12. (Bekele. G., Palm B., 2009b)

$$\alpha = \frac{1}{ln\frac{Z}{Z_0}} \qquad 12$$

2.2.7. The Logarithmic Function

$$\vec{\mathrm{V_z}} = \mathrm{V}_{10}\frac{\ln\frac{\vec{\mathrm{Z_y}}}{\mathrm{Z}_{10}}}{\ln\frac{\mathrm{Z}_{10}}{\mathrm{Z}_0}} \qquad 13$$

Where;

Z_y- Height above the ground,
Z_o - Roughness parameter,
$\vec{\mathbf{v}}_{\mathbf{z}}$ – Mean wind speeds at heightZ_y.

3.0. RESULTS AND DISCUSSIONS

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3.1. Diurnal Variation

Graphs of the averages of hourly wind speeds against time of the day were plot to give diurnal wind speed distribution pattern as presented in the figure 2 and 3.

The graphs demonstrate a smooth and predictable diurnal wind speed distribution patterns with high wind speeds prevailing from approximately 1100 hours to around 1600 hours for stations of Ikobe and Nyamecheo with kisii showing a different pattern with prevailing winds appearring approximately between the 0300hrs and 0800hrs. This implies that, for the stations of Ikobe and Nyamecheo, the wind speed is heigh during the mid-day approching evenings when the temperature is heigh. While on the other hand, wind speed is heigh after mid-night approaching down for the Kisii station when the temperature are low and are in reducing trend. Kisii at the prevailing wind recorded high wind speeds as compared to Ikobe and Nyamecheo. This varriation patterns can be associated to the differential heating of the earth's surface during the daily radiation cycle depending on the nature of the topegraphical feature of the place (Maduako E. O. et al. 2017)

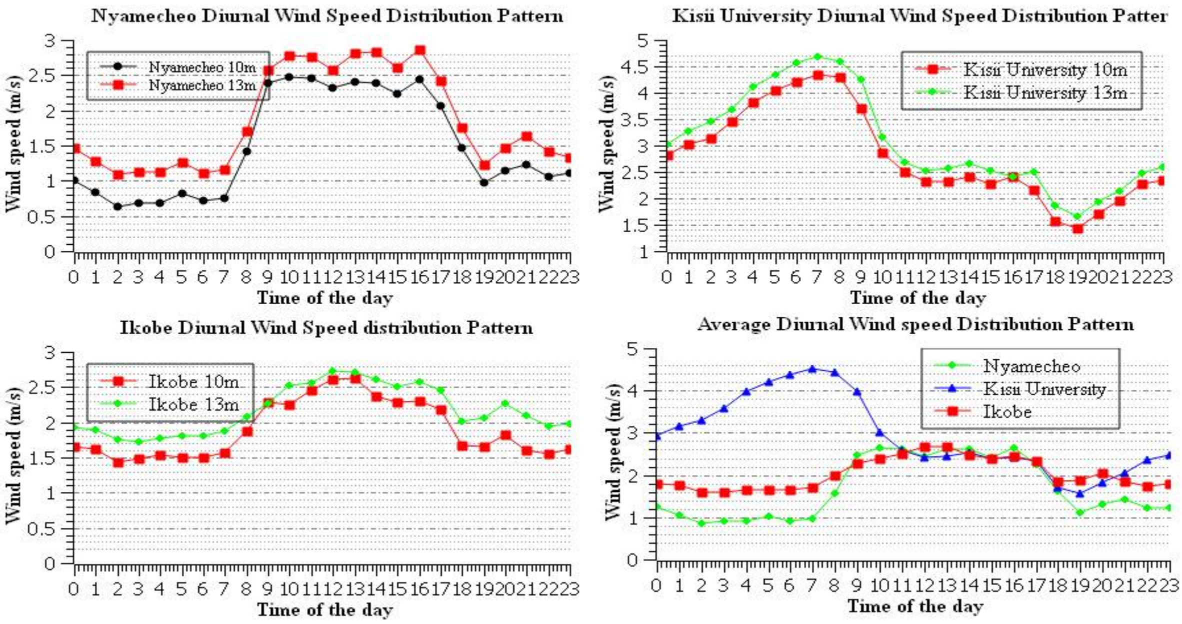

FIGURE 2: Diurnal Wind Speed Distribution pattern for the Month of February.

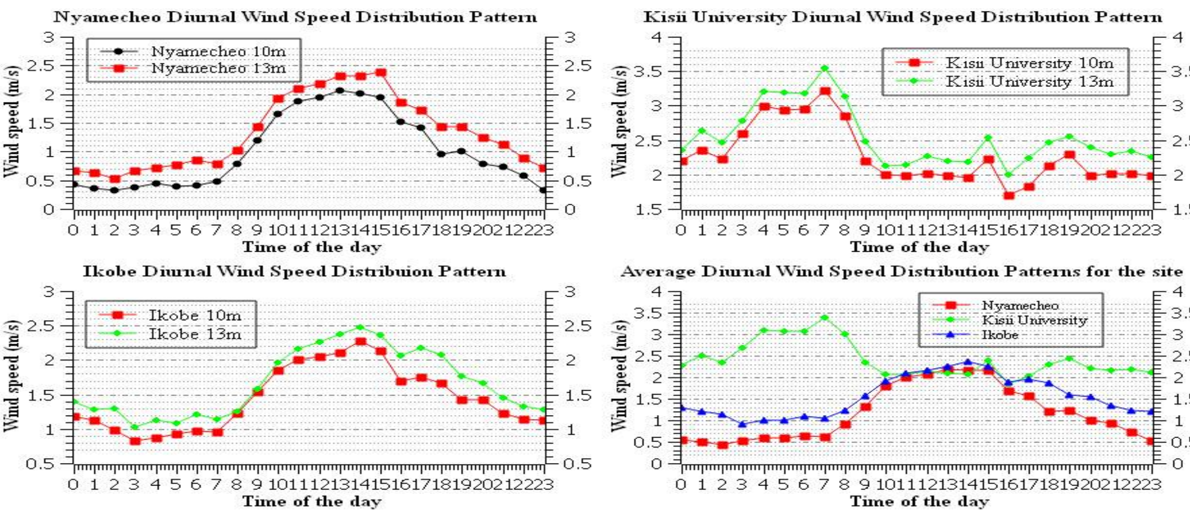

FIGURE 3: Diurnal Wind Speed Distribution pattern for the month of March

3.2. Daily Variations

Figure 4 and 5, represents the average wind speeds of the three stations for the two months which were also found to vary from day to day. As can be seen from the figures, the variation of wind speed takes same pattern for the three stations but different from month to month. This can be associated to monthly solar radiation pattern that renders wind speeds to exhibit a particular pattern although many of the factors that affect wind speeds have a unique daily and not a monthly temporal pattern (Lysen, 1983).

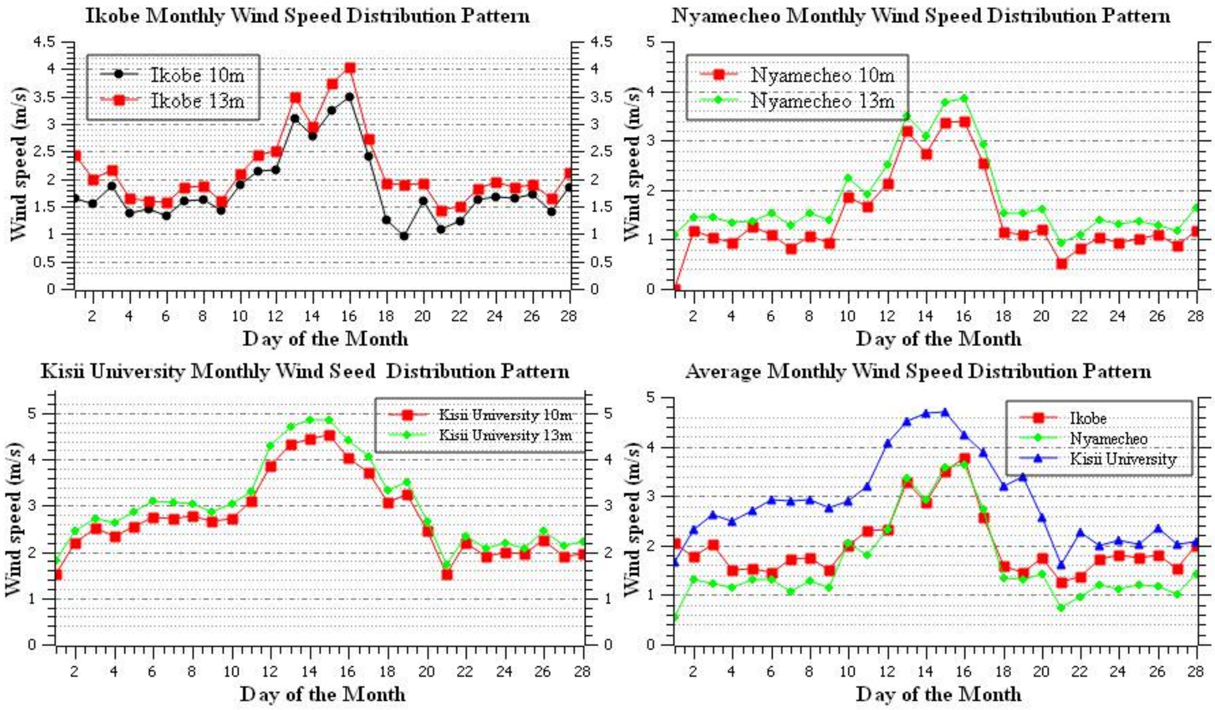

FIGURE 4: Ikobe Monthly Wind Speed Distribution.

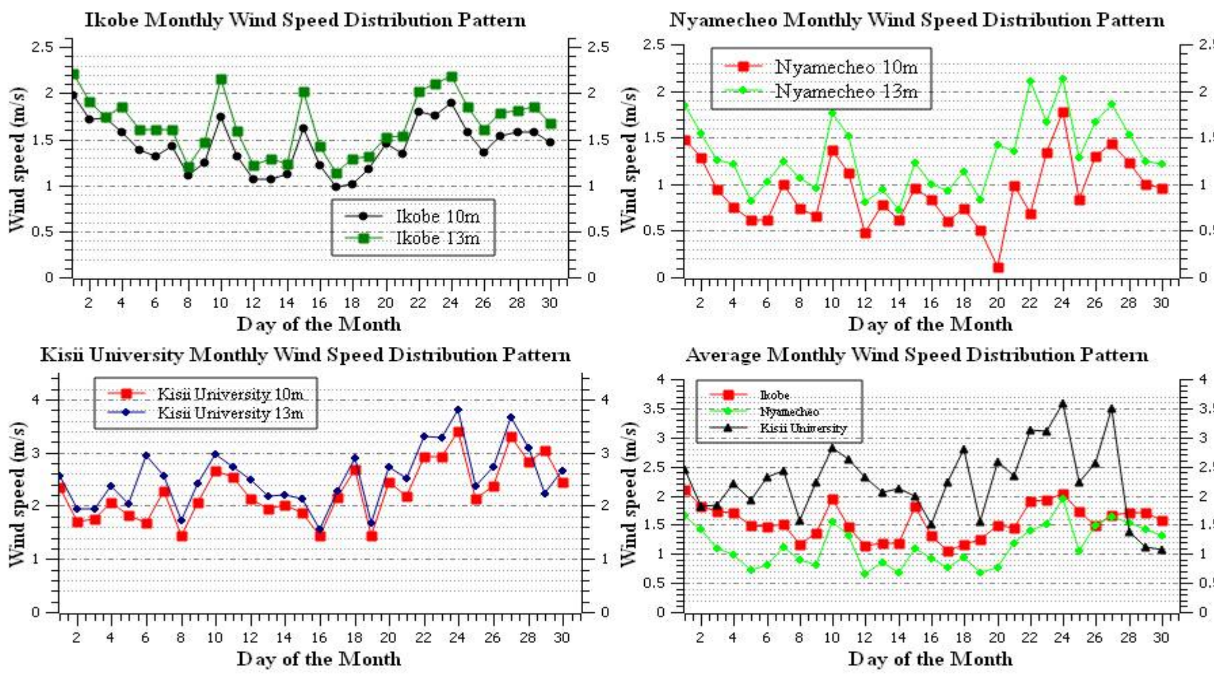

FIGURE 5: Ikobe monthly Wind Speed Distribution for the month of March.

3.3. Long term characterization

Table 1 is a record of computed estimations of normal wind speed, standard deviation, shape factor and scale factor parameters of the kisii locale for the period 2004-2013. As it can be seen from the table, the most astounding average wind speed is 3.84m/s and the least 1.95m/s with standard deviations of 1.61m/s and 1.12m/s respectively. Likewise from the table, it can be noticed that the estimations of shape factor ranges from 2.53 to 1.62 while the scale factor extends between 4.23m/s and 2.18m/s. The shape factor k indicates how peaked the wind conveyance is at a place. From the estimations of k recorded in table 1, we can state that wind speed is highly peaked.

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Table 1: Yearly averages of wind speed of the Kisii region.

Parameter	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Whole yr
$V(m/s)$	3.60	3.84	3.37	3.19	2.90	2.83	2.67	2.36	2.12	1.95	2.88
$\sigma\ (m/s)$	1.58	1.61	1.82	1.79	1.66	1.67	1.57	1.47	1.25	1.24	1.56
$k(-)$	2.44	2.56	1.94	1.86	1.82	1.76	1.77	1.66	1.76	1.62	1.91
$C(m/c)$	4.06	4.23	3.80	3.59	3.27	3.18	3.00	2.64	2.38	2.18	3.25

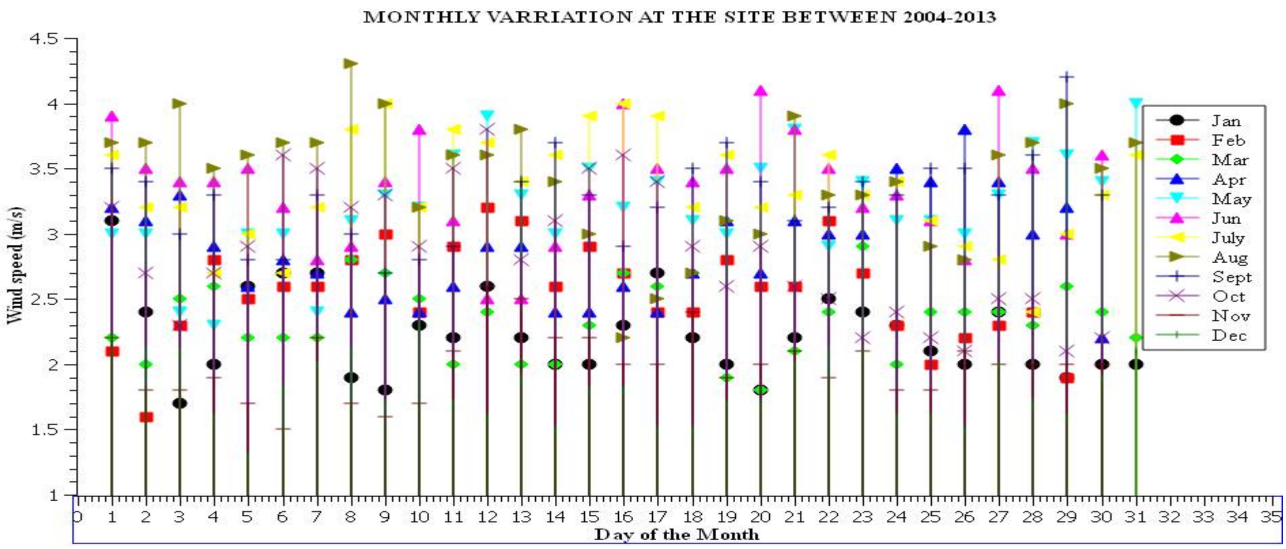

FIGURE 3: Monthly variation of wind speed for the period 2004-2013

3.4. Weibull and Reighleigh distribution

Weibull and Rayleigh probability distribution graphs are usually used to describe how wind varies over a given period of time at a particular site. Figure 7 shows a distribution plot for the Kisii wind speed data based on wind speed measured for ten years (2004–2013) at the Kisii meteorological station. When compared to the actual frequency distribution, both the weibull and Rayleigh probability curves gives a good fit for the data and provides the probability of obtaining a given wind speed at the site at any given time.

From the Weibull and Rayleigh probability density distribution graphs shown in figure 8, it is clear that the two models gives a good fitting to the wind speeds of three stations used in the study. The area under the curves is one since the probability that wind of a certain speed (zero included) will blow at any given time at the sites is 100 per cent. As can be seen, the graph in fig 7 is skewed and peaks at a mean wind speed of about 2.5 m/s which is the most probable wind speed at the region. High speeds to a tune of 9.5m/s also can be obtained at the site although with a low probability hence rare.

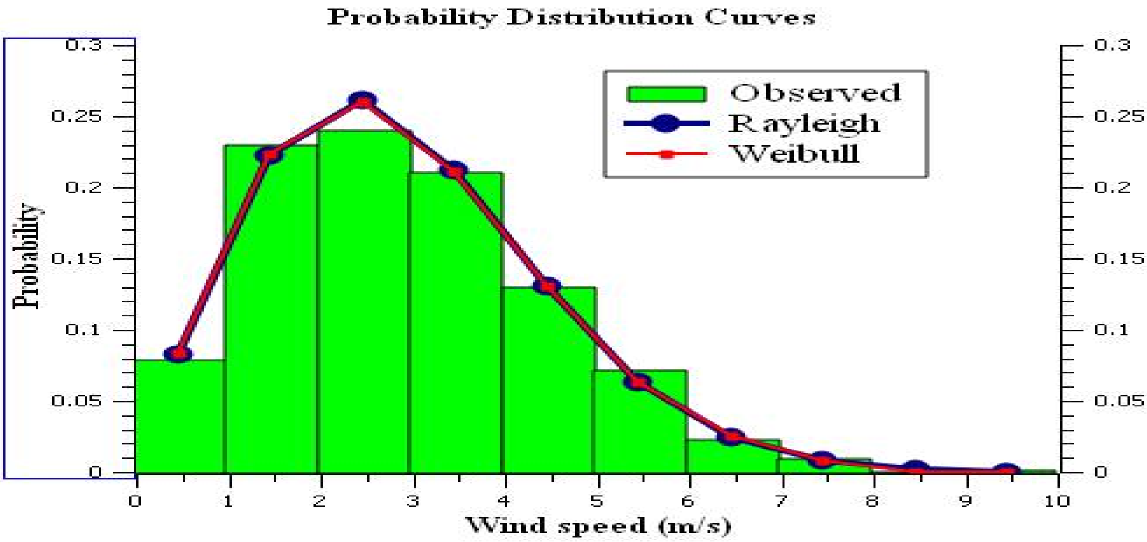

FIGURE 7: Weibull/Rayleigh probability distribution curve of the wind speeds

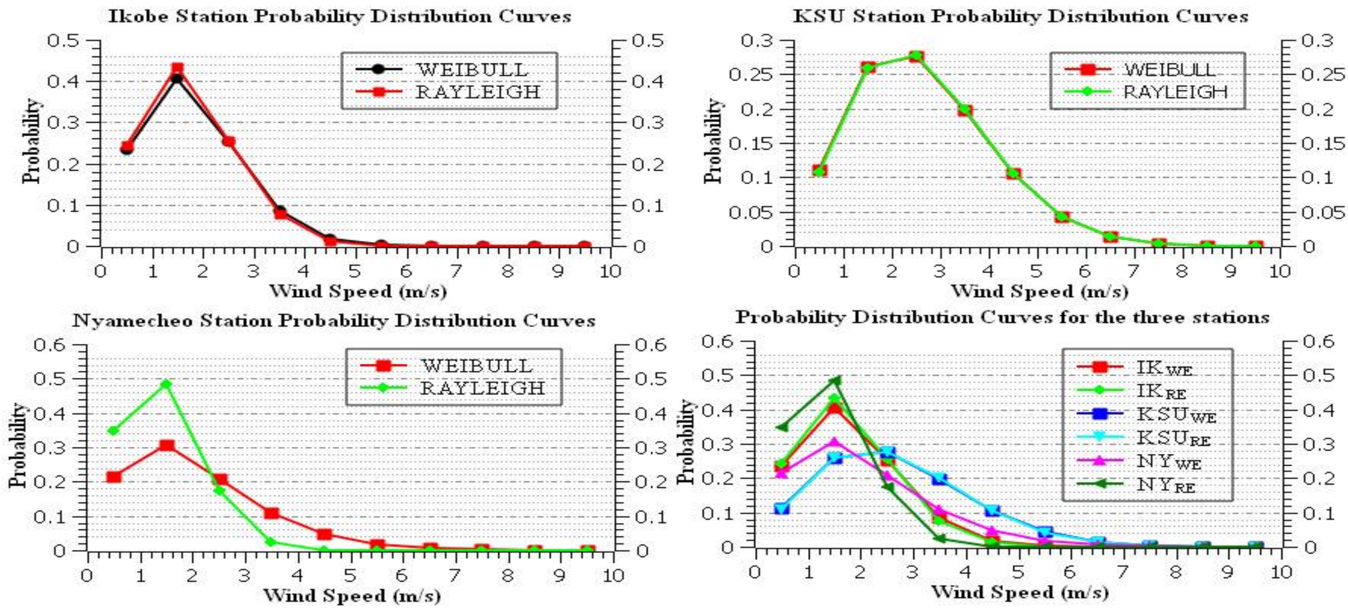

FIGURE 8: Weibull/Rayleigh probability distribution curves of the wind speeds at 10m

To find the average wind speed at the site, each wind speed in the category is multiplied with the probability of obtaining the individual speed and results added.

It is important also to know the probability that wind speed will be smaller than or equal to a given wind speed. And to show this, a weibull and Rayleigh cumulative frequency curves are plotted. As can be seen from the curves in figure 9 below, about 60% of the Kisii wind speeds lies below 3m/s. The curve is very important more so when analyzing the percentiles of wind speeds in a given site.

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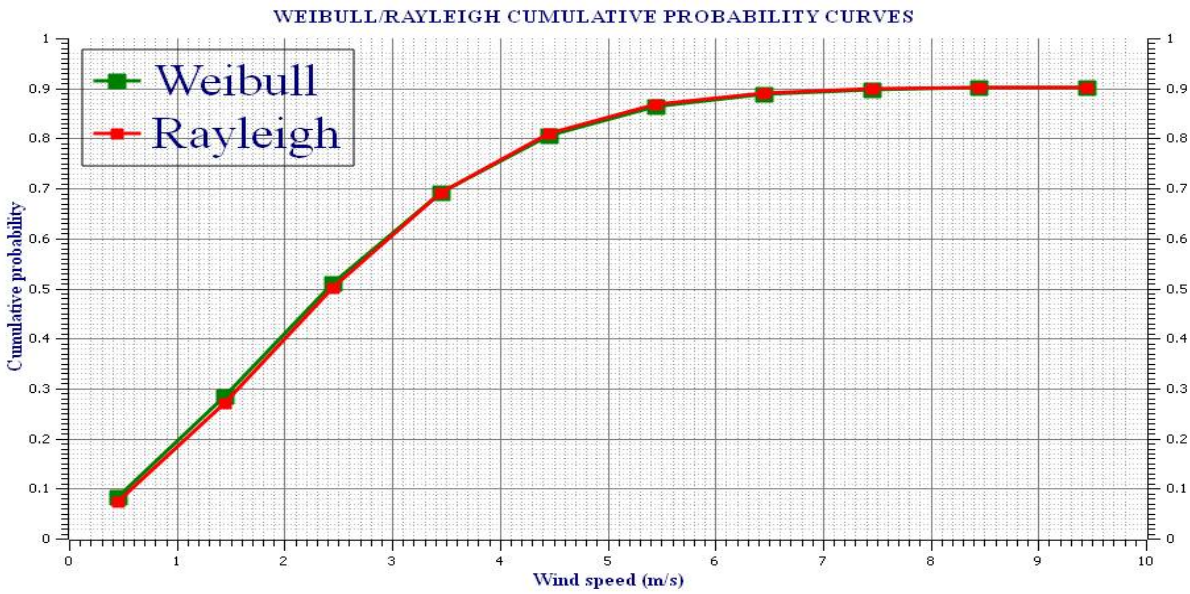

FIGURE 9: The Weibull cumulative frequency curve

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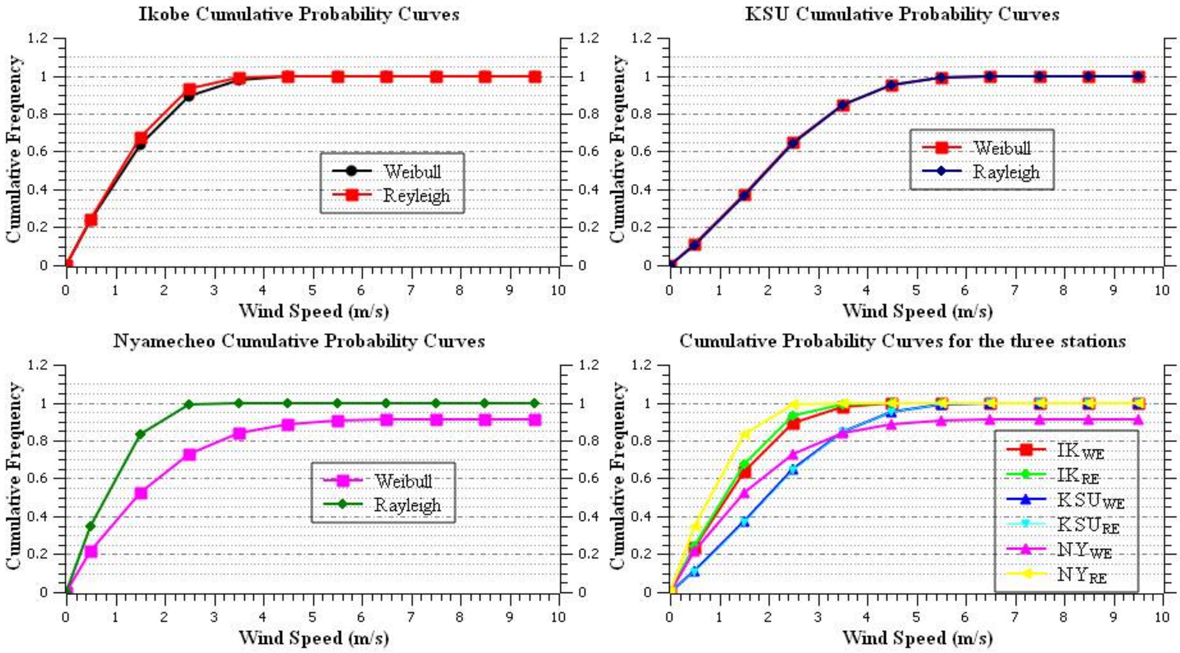

FIGURE 10: The Weibull cumulative frequency curves for the sites

Table 2: Region's Estimated Wind Power Density

Power (w/m²)	MONTH OF THE YEAR											
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Max	35.58	38.72	29.80	65.50	76.45	82.33	76.45	95.00	88.50	65.50	21.00	14.50
Min	5.87	4.90	7.00	12.70	14.50	18.70	16.50	12.70	21.00	11.06	4.00	2.60
Ave.	12.70	18.70	14.50	29.13	39.14	63.87	42.93	47.00	42.93	29.13	9.56	9.48

From table 2, it is clear that mid months of the year recorded high wind power as compared to earlier and last months of the year. From this study, the month of August recorded the highest wind power in average of 47.00W/m^2 for the entire period with least power of 9.56W/m^2, 9.45W/m2 and 12.70W/m^2 recorded in the months of November, December and January respectively. When the months of the site are classified into periods of cold and worm seasons based on the temperatures, mid months of the year are cold seasons while earlier and end months of the year fall under worm seasons. This therefore implies that, in Kisii region, cold seasons (May, June, July, August, and September) have high wind power than worm seasons.

According to Abul, K. A. et al 2014, wind power can be classified into seven classes as shown in table 4. Considering this power classes, Kisii region has a poor wind power at a height of 10m, marginal wind power at height of 30m and moderate at 50m. This implies that the kisii winds can be best harvested for wind power at higher hub heights since they improve to better classes with increase in height. Maximum and minimum wind speeds and wind power ware observed in the months of August and November with values of 9.3 m/s, 4.96 m/s and 797.53W/m^2, 120.99W/m^2 respectively at height 50m.

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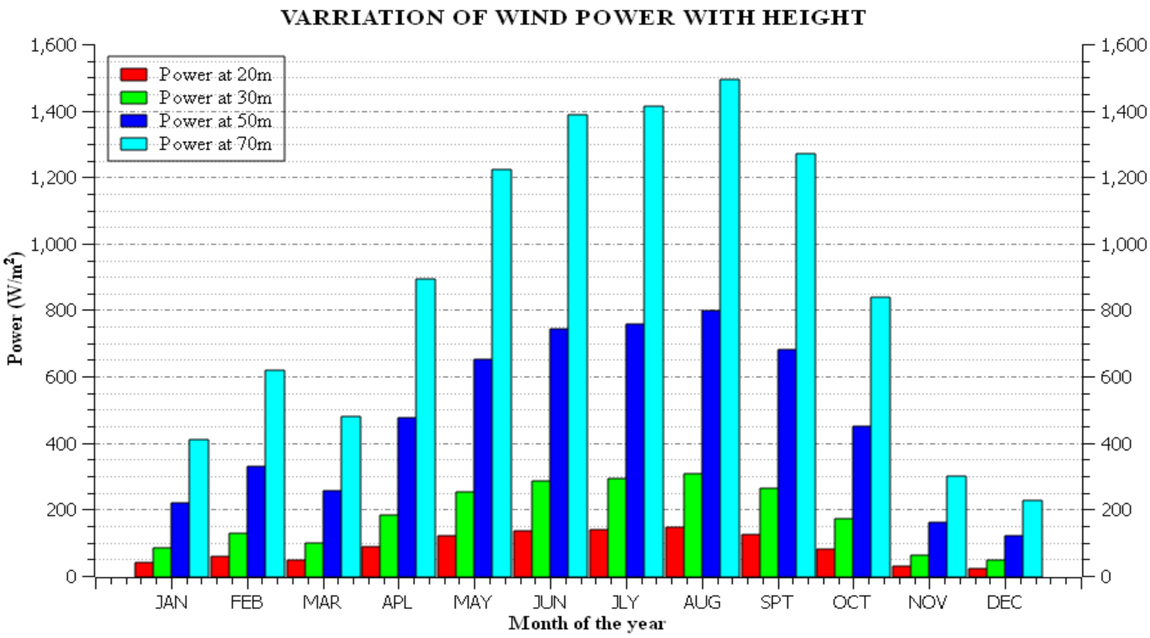

FIGURE 11: Wind Power variation with height at the region

Figure 11 shows vertical varriation of wind power for the period of 10 years. Mid months of the year have higher wind speed than mid months of the year. This site wind profiles have been categorized into two seasons; cold and hot season. Mid months were found to be cateractirized by low temperatures hence were classified as cold seasons while earlier months and end months of the year were found to have higher temperatures hence classfied under hot seasons. This therefore implies that, cold seasons are rich in wind power than cold seasons at the site. Also from the figure, it is noted that wind power at the site improved to much better classes as you move from one hub height to the other. This can be associated to surface roughness parameter, wind fetching characteristics and teperature stratification at the site (Monim H. al., 2010).

If we consider the effect of the Beltz limit whose value is 0.593, then the maximum extractable power is in pproximate equal to 59.3% of the theoretical power density. For this site, the maximum extractable power by a windmill of unit area operating at its optimum efficiency are etimated in table 3 below;

Table 3; Beltz limit effect on theoretically estimated wind power with height

Month of the Year	20m		30m		50m		70m	
	V (m/s)	P (w/m^2)	V (m/s)	P (w/m^2)	V (m/s)	P (w/m^2)	V (m/s)	P (w/m^2)
January	3.43	23.68	4.41	48.95	6.04	129.59	7.45	243.01
February	3.93	35.76	5.06	76.06	6.94	196.12	8.55	367.13
March	3.61	27.75	4.64	58.78	6.37	151.85	7.85	284.14
April	4.44	51.37	5.71	109.62	7.84	283.18	9.66	530.52
May	4.93	70.60	6.34	149.96	8.70	386.87	10.73	725.54
June	5.15	80.13	6.62	170.29	9.09	441.24	11.19	823.08
July	5.18	81.79	6.66	173.74	9.14	449.03	11.26	838.80
August	5.27	86.06	6.78	182.90	9.30	472.94	11.46	885.17
September	4.99	72.90	6.42	155.69	8.82	403.66	10.86	752.81
October	4.35	48.36	5.59	102.64	7.68	266.25	9.46	497.68
November	3.09	17.37	3.97	36.74	5.45	95.03	6.72	178,63
December	2.81	13.02	3.62	27.95	4.96	77.75	6.12	134.79
Average	4.27	50.73	5.49	107.78	7.53	278.96	9.28	521.78

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Table 4: Classification of wind power with height (source: Abul 2014)

Power class	Potential	10m(33ft)		30(98ft)		50m(164ft)	
		Power (W/m^2)	Speed (m/s)	Power (W/m^2)	Speed (m/s)	Power (W/m^2)	Speed (m/s)
Class-I	Poor	$P_{10} \le 100$	≤ 4.4	$P_{30} \le 160$	≤ 5.1	$P_{50} \le 200$	≤ 5.6
Class-II	Marginal	$P_{10} \le 150$	≤ 5.1	$P_{30} \le 240$	≤ 6.0	$P_{50} \le 300$	≤ 6.0
Class-III	Moderate	$P_{10} \le 200$	≤ 5.6	$P_{30} \le 320$	≤ 6.5	$P_{50} \le 400$	≤ 7.0
Class-IV	Good	$P_{10} \le 250$	≤ 6.0	$P_{30} \le 400$	≤ 7.0	$P_{50} \le 500$	≤ 7.5
Class-V	Very good	$P_{10} \le 300$	≤ 6.4	$P_{30} \le 480$	≤ 7.5	$P_{50} \le 600$	≤ 8.0
Class-VI	Excellent	$P_{10} \le 400$	≤ 7.0	$P_{30} \le 640$	≤ 8.2	$P_{50} \le 800$	≤ 8.8
Class-VII	Excellent	$P_{10} \le 1000$	≤ 9.4	$P_{30} \le 1600$	≤ 11.0	$P_{50} \le 2000$	≤ 11.9

3.5. Yearly variation of wind power

From figure 12, the general trend in yearly mean wind speed seems to be decreasing gradually from 2004 to 2013. This can be associated with several Processes on local, regional and global scales which are likely contributing to this decrease. According to Ayush, 2016, this can be as a result of variation of forest density and global climatic change.

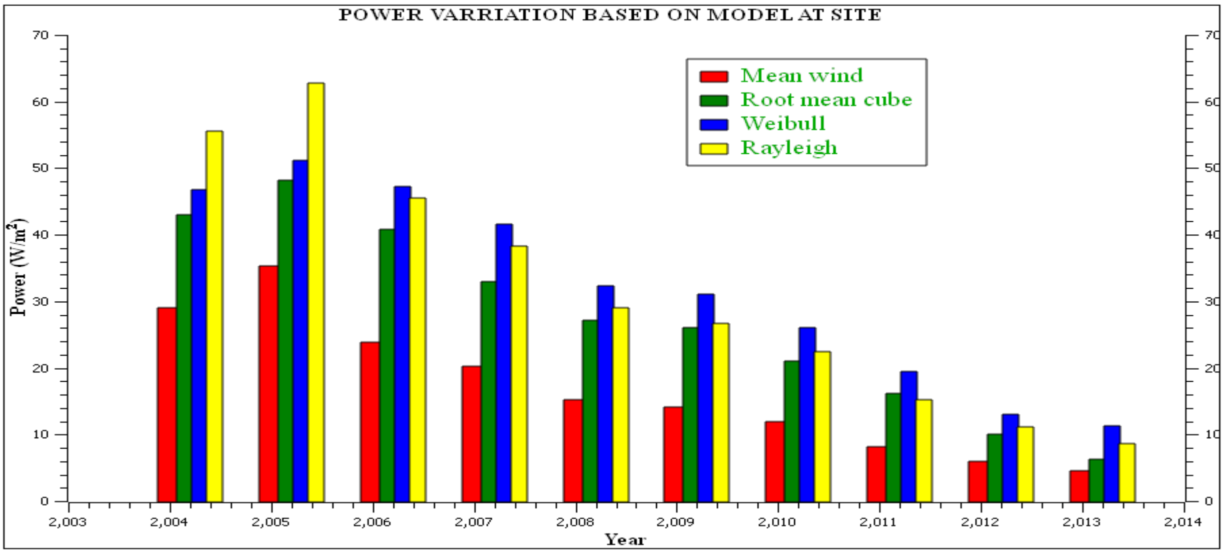

FIGURE 12: Wind Power variation based on model at the site.

3.6. Directional analysis

Wind direction at both sites appears to be constrained towards the same direction in the three stations and from the long term analysis of wind from the kisii meteorological data. E and SE predominates Ikobe station at 10m while ENE-E, SE and SSE predominates the station at 13m. E and WSW predominates Nyamecheo station at 10m with E predominating the station at the 13m height. E-SE pre-dominates Kisii University station both at the 10m and 13m hub heights. And in general and as per the long term data analyzed from the Kisii meteorological station, ENE-E pre-dominates the region.

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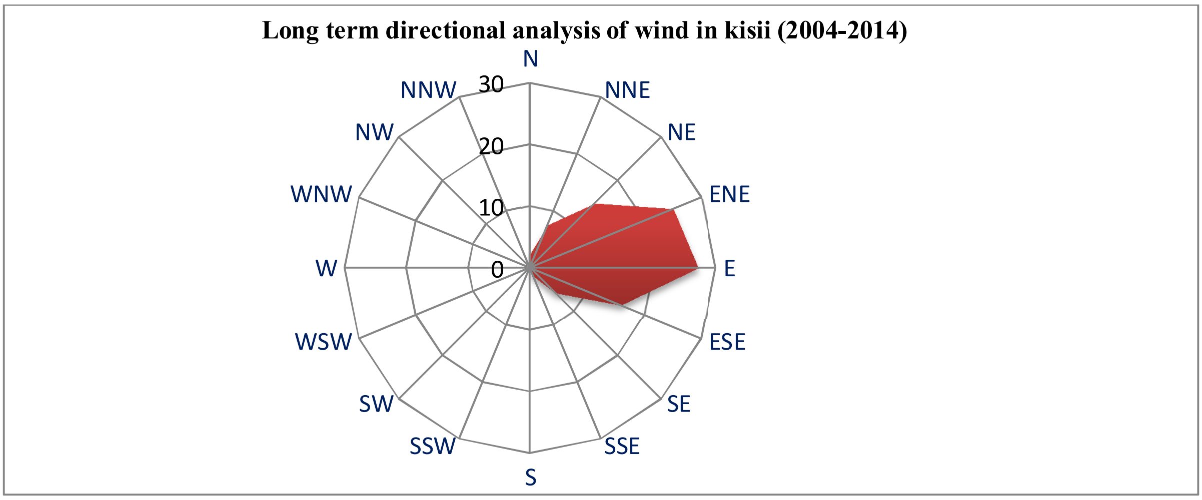

Figure 13: Long term directional analysis of wind energy

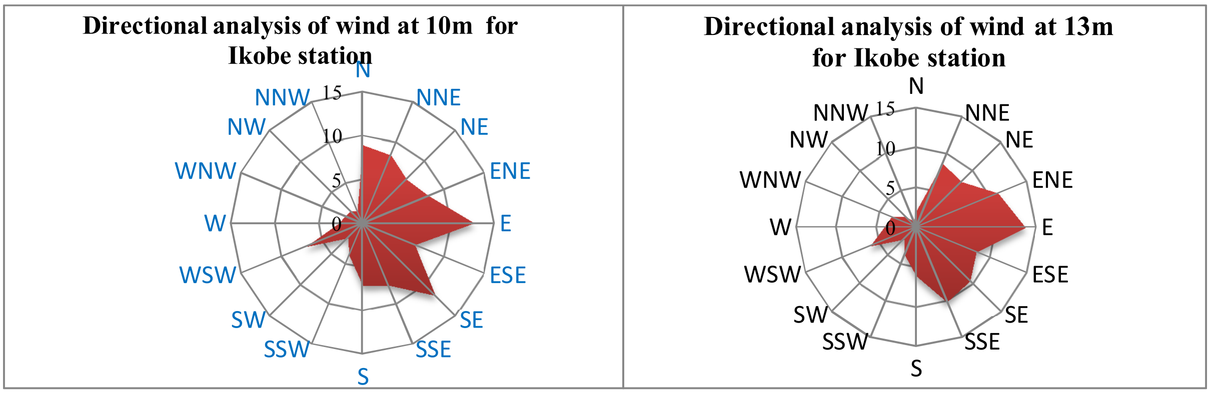

FIGURE 14: Directional analysis of wind at Ikobe station.

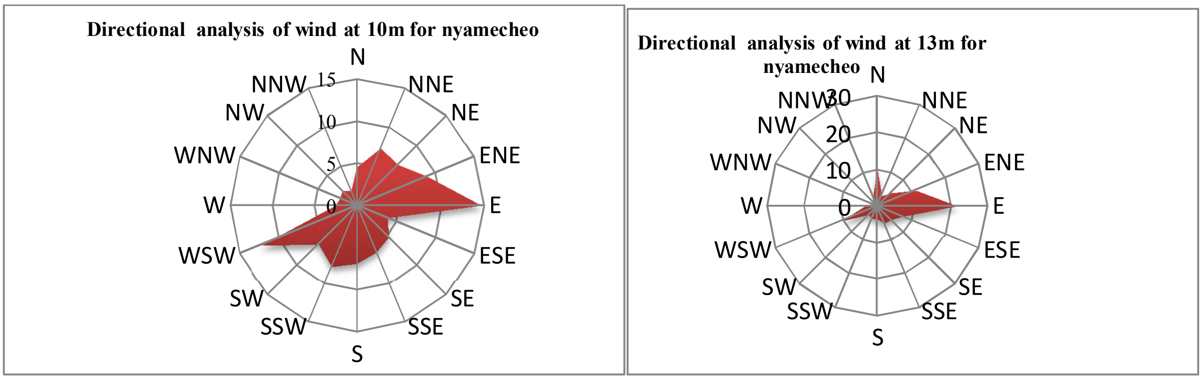

FIGURE 15: Directional analysis of wind at Nyamecheo station.

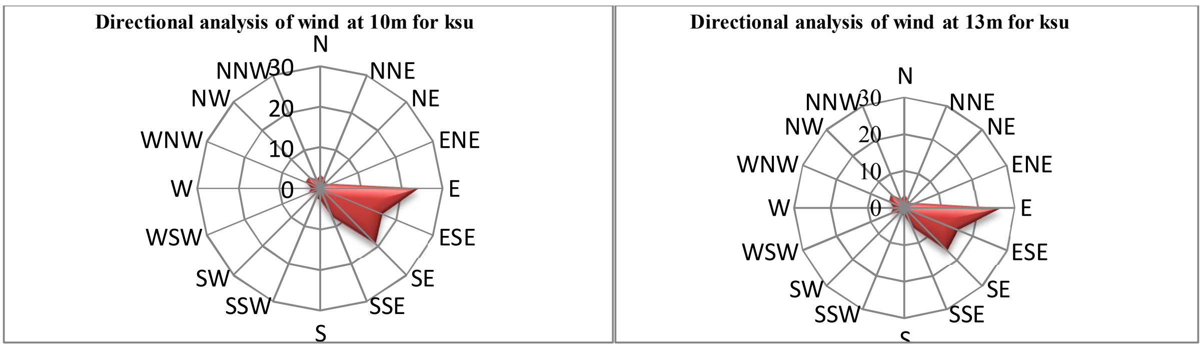

FIGURE 16: Directional analysis of wind at Kisii University station.

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3.7. Wind speeds correlation

Monthly data of wind speeds from the three stations were correlated to establish how strong the stations were correlated. As can be seen from the table 5 below, the three stations show in average a strong correlation. This implies that the method of measure, correlate and predict can be used in future to predict the long term wind distribution patterns of either of the station within the region given enough measured data of any of the stations at any instance in time.

There is a high positive correlation between the three sites (R=0.73) implying that the equations can be used if given data of at least one year to predict the general long term characteristics of wind profiles in the region. Though cheap and faster, the method will not be accurate enough in the prediction of site wind profiles as compared to the on-site measurement methods

Table 5: Correlation coefficients and prediction equations of the site's wind profiles

Month	Station	R^2	R	Correlation	Prediction equation
Feb 10m	Ikobe/Nyamecheo	0.832	0.9121	+ve strong	$V_N = 1.235V_I - 0.825$
	Ikobe/KSU	0.587	0.7662	+ve strong	$V_K = 1.038V_I + 0.861$
	Nyamecheo/ksu	0.815	0.9028	+ve strong	$V_K = 0.901V_N + 1.467$
Feb 13m	Ikobe/Nyamecheo	0.871	0.9333	+ve strong	$V_N = 1.170V_I - 0.712$
	Ikobe/KSU	0.607	0.7791	+ve strong	$V_K = 1.075V_I + 0.705$
	Nyamecheo/ksu	0.806	0.8978	+ve strong	$V_K = 0.987V_N + 1.233$
March 10m	Ikobe/Nyamecheo	0.384	0.6197	+ve moderate	$V_N = 0.829V_I - 0.256$
	Ikobe/KSU	0.193	0.4393	+ve moderate	$V_K = 0.861V_I + 1.037$
	Nyamecheo/ksu	0.282	0.5310	+ve moderate	$V_K = 0.777V_N + 1.548$
March 13m	Ikobe/Nyamecheo	0.606	0.7785	+ve strong	$V_N = 0.956V_I - 0.268$
	Ikobe/KSU	0.222	0.4712	+ve moderate	$V_K = 0.829V_I + 1.162$
	Nyamecheo/ksu	0.511	0.7148	+ve strong	$V_K = 1.022V_N + 1.190$

FIGURE 4: Correlation of Kisii winds with the Kisumu winds

Correlation between Kisii wind and Kisimu wind was also done to establish the relationship between the two sites. The correlation coefficient, $R^2 = 0.005$ obtained shows that there is a low negative correlation between Kisii region winds and those of Kisumu. This means that the winds of any one of these sites cannot be relied in the prediction of the characteristics of winds in the other region. The extracted correlating equation is given below;

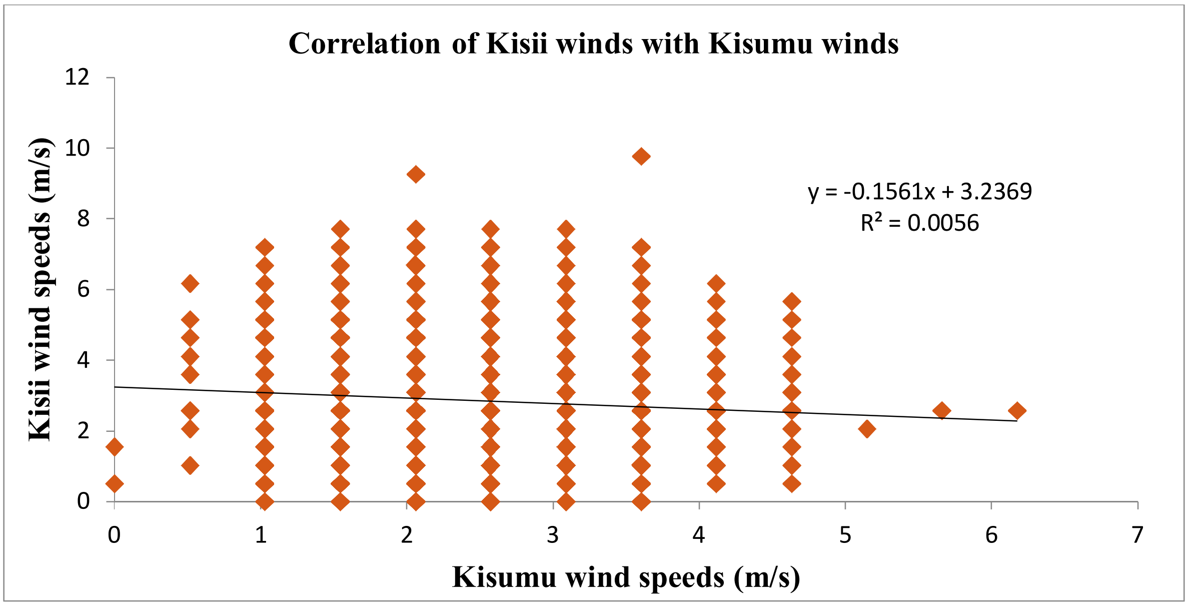

Figure 18: Correlation of Kisii wind with Kisumu winds

4.0. CONCLUSIONS

The result shows that the average wind speed for the region as per data extracted from the Kenya meteorological department is 2.9m/s. This speed represents a 10m hub height. On extrapolation, it was found to be roughly equal to 4.27m/s at 20m, 5.49m/s at 30m, 7.53m/s at 50m and 9.28m/s at 70m height. This wind speed is enough to operate modern wind turbines which require low wind speeds for domestic purposes.

Kisii can be shown as a marginal (class II) on extrapolation to 30m for wind energy generation as the region can possesses moderate wind characteristics. The determined wind power at 10m height at site is 29.00W/m^2 which on extrapolation comes to 181.75W/m^2. This means the higher the wind turbine is set at the site for wind power generation, the higher the expectation. Though the site is not suitable for electric wind application in large scale.

In general, the level of power density in Kisii region is adequate for nan-grid connected electrical and mechanical applications such as charging batteries, powering small wind generators and pumping water for domestic, industrial and agricultural use.

Both Rayleigh and Weibull distributions gives a good fitting to the measured probability distribution at the site.

From data, is seen that, mid-months of the year have maximum wind speeds with lowest mean wind speeds occurring in the earlier months and late months of the year.

The most probable wind direction(s) lies between NE and SE with East dominating implying East winds.

From the meteorological data, there is a worrying trend in yearly mean wind speed which seems to be decreasing gradually from 2004 to 2013.

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Conflict of Interest Statement

We as authors declare that there is no whatsoever any conflict of interest in this paper.

Data availability statement

The data used to support and conclude the findings of this research is available from the corresponding authors upon request. Meanwhile vital information has been included within supplementary information file.

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