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Directional Distributions of Wind Resource Potential in Mandara Mountains Region, Nigeria

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ABSTRACT

This study analyzed the speed and direction of the wind and its power available at Mubi and Gwoza, North-eastern Nigeria; and Guider and Mokolo, Far North Cameroon stations selected in the Mandara Mountains. Daily wind speeds and directions data covering the period from 2011 to 2016 were used to analyze directional distribution using windrose xls software. The record of highest number Wind Rose Distribution with 432, 411, 395, and 376 days, dominant directions, were observed for Gwoza, Guider, Mubi, and Mokolo respectively. The highest frequencies of daily wind directions are at the averages of South West (SW) with 21.6%, South (S) with 21.0%, South South-East (SSE) with 22.5%, and South (S) with 23.7% for Mubi, Mokolo, Guider, and Gwoza respectively. The highest distributions of wind speed classes for daily average events with 48.0%, 50.1%, 45.6%, and 51.1% were respectively observed for Mubi, Mokolo, Guider, and Gwoza. The result shows that the wind speed was directed predominantly to SW, S, SSE, and S respectively for Mubi, Mokolo, Guider, and Gwoza describing the roughness of the terrain in different directions from prospective stations. Therefore, it is recommended that this research is applicable for building positioning, weather prediction, landscaping, and control of wind erosion, and wind energy exploitation on a small scale.

INTRODUCTION

Wind flow is a rapidly changing situation with its local topographic disturbances. Usually, it does not flow in a defined direction. It varies with geographical locations, time of day, the season in a year, height above the earth's surface, weather conditions, and local landforms. Hills and many other topographic features alter air flows. The changes in air flows can increase, decrease, or even reverse and intensify turbulence. Also, uneven ground features can cause a wide range of local wind flow effects (Tin and Robert, 2015). With the flow moving to the top hill, the blockage effect will decrease gradually and finally disappear when the flow moves on to the top hill. At the same time, the speed-up effect will increase continuously and reach maximum (Tian et al, 2015).

Mountains cover 25% of the world's land surface and are home to about 10% of its population, most of whom depend on mountain resources for their livelihoods (ARCOS Network, 2017). Mean and peak wind speed can be increased considerably by natural and man-made topography in the forms of escarpments, ridges, cliffs, and hills (Zeng-wei and Alex, 2013). Highest wind velocities are found on hilltops, exposed coasts, and sea (Enibe, 1987). Wind turbines and wind farms are being deployed in areas of increasing topographic complexity (Parvu, 2013). The understanding of the wind characteristic will help optimize wind turbines design, develop wind measuring techniques, and select wind farms sites (Wei, 2010). A steady supply of reasonably strong wind is a requirement for utilizing the power in the wind (Chaudhry, 2007).

A wind rose depicts the frequency of incidence winds in each of the particular wind direction sectors and wind speed modules for a specified site and period. A wind resource map usually shows the variation over an area of the mean wind speed or direction for a given height above the ground level and knowing the prevailing wind directions is essential to determine the impact of obstacles and landforms when seeking the best site location and estimation of the wind resource at that location. To help this process, wind roses were used to show the directional distributions of wind of a particular area. The wind rose divides a compass into sectors, usually 8 or 16, and indicates the average wind speed, average percentage of times that the wind blows from each direction, and/or the percentage of energy in the wind by sector (Wei, 2010). Unfortunately, wind maps lack critical information such as wind speed distribution, direction, and turbulence intensity, which is necessary for making an accurate adjustment to account for the local site's features (Tin and Robert, 2015). Therefore, the

overall potential of wind depends heavily on the accurate mapping of wind resources (IEA, 2009).

This study is aimed at determining the directional distribution of wind resource potential in the Mandara mountains region with the emphasis on mapping out (wind rose) mean wind direction and speed.

MATERIALS AND METHODS

Source of Data

The Mandara Mountains has a geographic coordinate of $13^0$45'00"N and $10^0$40'00"E with an elevation of 901m. Daily mean wind speed and direction data used for this analysis were captured at Mubi, Gwoza, Mokolo, and Guider stations by satellite covering the period between 2011 to 2016 and was obtained from meteoblue AG. Basel, Schweiz/ Switzerland to analyzed the mean wind speed and direction at 10m height above the earth's surface.

Table No. 1: List of some selected stations for evaluations

Stations	Longitude	Latitude	Elevation (m)
Mubi	13.2670	10.2686	582
Gwoza	13.6959	11.0831	418
Mokolo	13.8023	10.7424	813
Guider	13.9467	9.9333	346

Method of Data Analysis

The wind rose is a circular frequency distribution of how wind speed and direction at a given location for a certain period is blowing. Also to indicate the dominant wind direction and the direction of the strongest wind speed. The wind rose for respective years were constructed based on the available data to show the frequency of occurrence of the wind blowing through 16 different coordinate direction and 6 wind speed classes. The frequency of each wind speed category was calculated (as a percentage of the total number of observations) and then represented on each concentric circle, emanating from zero at the center to the outer circles. The total number of events and the corresponding percentage for each direction and wind speed classes were computed automatically by windrose.xis software.

RESULTS AND DISCUSSION

Table No. 2: Frequency distribution of Mubi wind directions

Directions	0-1 (m/s)	1-2 (m/s)	2-3 (m/s)	3-4 (m/s)	4-5 (m/s)	>5 (m/s)	No. of days	Event (%)
N	0	3	24	14	2	0	43	2.3
NNE	0	13	51	27	5	0	96	5.2
NE	0	11	32	10	2	0	55	3.0
ENE	1	15	35	17	1	0	69	3.8
E	1	18	38	9	1	0	67	3.7
ESE	3	23	49	11	1	0	87	4.8
SE	2	34	63	14	0	0	113	6.2
SSE	1	70	83	25	0	0	179	9.8
S	1	79	124	34	4	0	242	13.2
SSW	1	87	140	50	10	4	292	15.9
SW	3	68	164	111	37	12	395	21.6
WSW	2	35	54	28	14	0	133	7.3
W	1	19	17	5	1	0	43	2.3
WNW	1	5	4	1	0	0	11	0.6
NW	1	4	1	0	0	0	6	0.3
NNW	0	0	0	0	0	0	0	0.0
No. of days	18	484	879	356	78	16	1830	
Event (%)	1.0	26.4	48.0	19.4	4.3	0.9		100%

Table No. 3: Frequency distribution of Mokolo wind directions

Directions	0-1 (m/s)	1-2 (m/s)	2-3 (m/s)	3-4 (m/s)	4-5 (m/s)	>5 (m/s)	No. of days	Event (%)
N	0	1	3	1	0	0	5	0.3
NNE	0	0	4	13	1	0	18	1.0
NE	1	1	7	3	0	0	12	0.7
ENE	0	7	6	6	0	0	19	1.1
E	1	6	18	15	0	0	40	2.2
ESE	1	34	40	14	0	0	89	5.0
SE	2	61	86	21	0	0	170	9.5
SSE	1	130	171	3	0	0	305	17.1
S	3	122	230	20	1	0	376	21.0
SSW	3	109	122	25	1	0	260	15.1
SW	3	99	125	37	10	1	275	15.8
WSW	2	53	59	24	15	4	157	8.0
W	2	17	18	3	6	0	46	2.4
WNW	0	6	6	2	0	0	14	0.9
NW	0	2	0	0	0	0	2	0.1
NNW	0	0	0	0	0	0	0	0.0
No. of days	19	648	895	187	34	5	1830	
Event (%)	1.1	36.2	50.1	10.5	1.9	0.3		100%

Table No. 4: Frequency distribution of Guider wind directions

Directions	**0-1 (m/s)**	**1-2 (m/s)**	**2-3 (m/s)**	**3-4 (m/s)**	**4-5 (m/s)**	**>5 (m/s)**	**No. of days**	**Event (%)**
N	0	0	0	11	6	0	17	0.9
NNE	0	0	0	13	6	0	19	1.0
NE	0	0	1	13	8	0	22	1.2
ENE	0	0	1	12	0	0	13	0.7
E	0	3	6	24	3	0	36	2.0
ESE	4	6	41	27	3	0	77	4.4
SE	5	38	130	39	0	0	212	11.6
SSE	5	108	216	80	2	0	411	22.5
S	4	93	192	64	6	0	359	19.6
SSW	1	62	124	66	20	1	277	15.0
SW	0	29	112	116	54	21	337	18.1
WSW	1	9	9	18	6	0	42	2.3
W	0	2	2	5	0	0	9	0.5
WNW	0	0	1	1	0	0	2	0.1
NW	0	0	0	0	0	0	0	0.0
NNW	0	0	0	0	0	0	0	0.0
No. of days	20	350	835	489	114	22	1830	
Event (%)	1.1	19.1	45.6	26.7	6.2	1.2		100%

Table No. 5: Frequency distribution of Gwoza wind directions

Directions	0-1 (m/s)	1-2 (m/s)	2-3 (m/s)	3-4 (m/s)	4-5 (m/s)	>5 (m/s)	No. of days	Event (%)
N	0	0	0	0	0	0	0	0.0
NNE	0	2	0	5	0	0	10	0.4
NE	0	6	8	3	0	0	17	0.9
ENE	0	7	10	4	0	0	21	1.2
E	0	11	16	9	0	0	36	2.0
ESE	2	24	30	14	0	0	70	3.8
SE	1	40	69	9	0	0	119	6.5
SSE	0	126	164	15	0	0	305	16.8
S	2	154	254	21	1	0	432	23.7
SSW	3	135	148	27	6	0	319	17.5
SW	3	95	156	47	14	1	315	17.4
WSW	1	43	56	24	2	0	126	6.8
W	0	22	18	4	0	0	44	2.4
WNW	0	6	4	0	0	0	10	0.5
NW	0	0	0	0	0	0	0	0.0
NNW	0	0	0	0	0	0	0	0.0
No. of days	13	672	933	182	23	1	1830	
Event (%)	0.7	36.8	51.1	10.0	1.3	0.1		100%

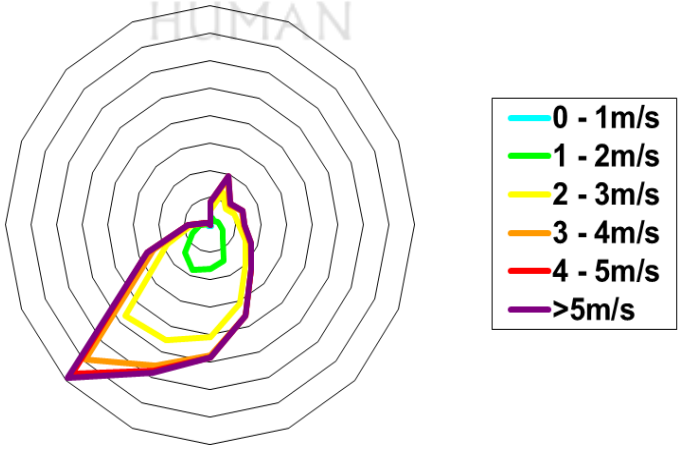

Figure No. 1: Daily five years (2011-2015) wind rose distribution of Mubi

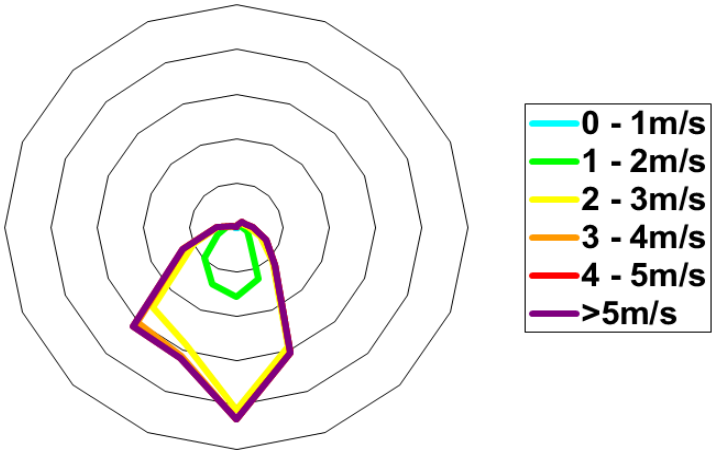

Figure No. 2: Daily five years (2011-2015) wind rose distribution of Mokolo

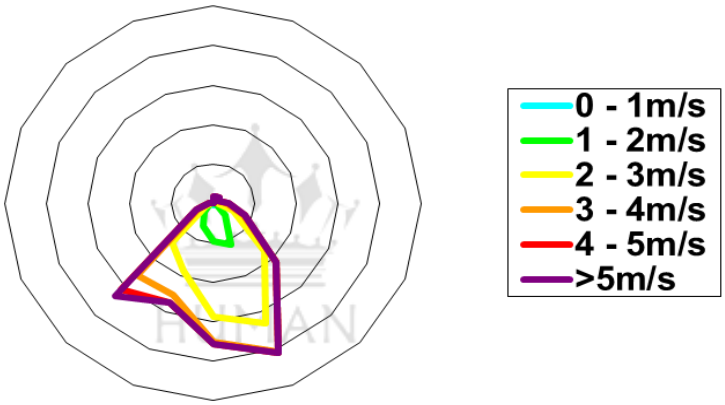

Figure No. 3: Daily five years (2011-2015) wind rose distribution of Guider

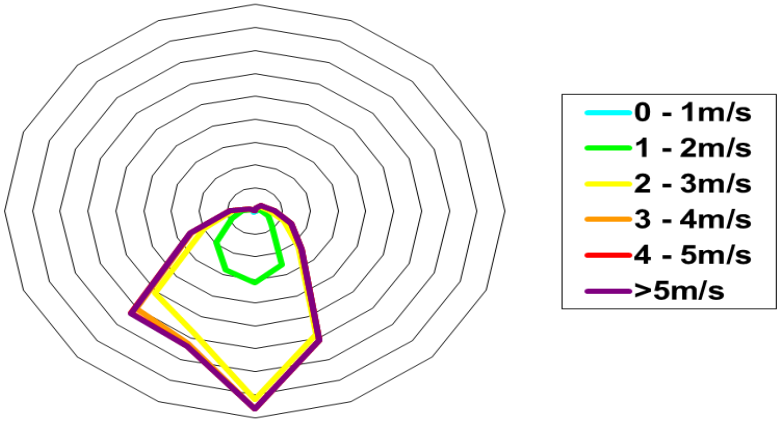

Figure No. 4: Daily five years (2011-2015) wind rose distribution of Gwoza

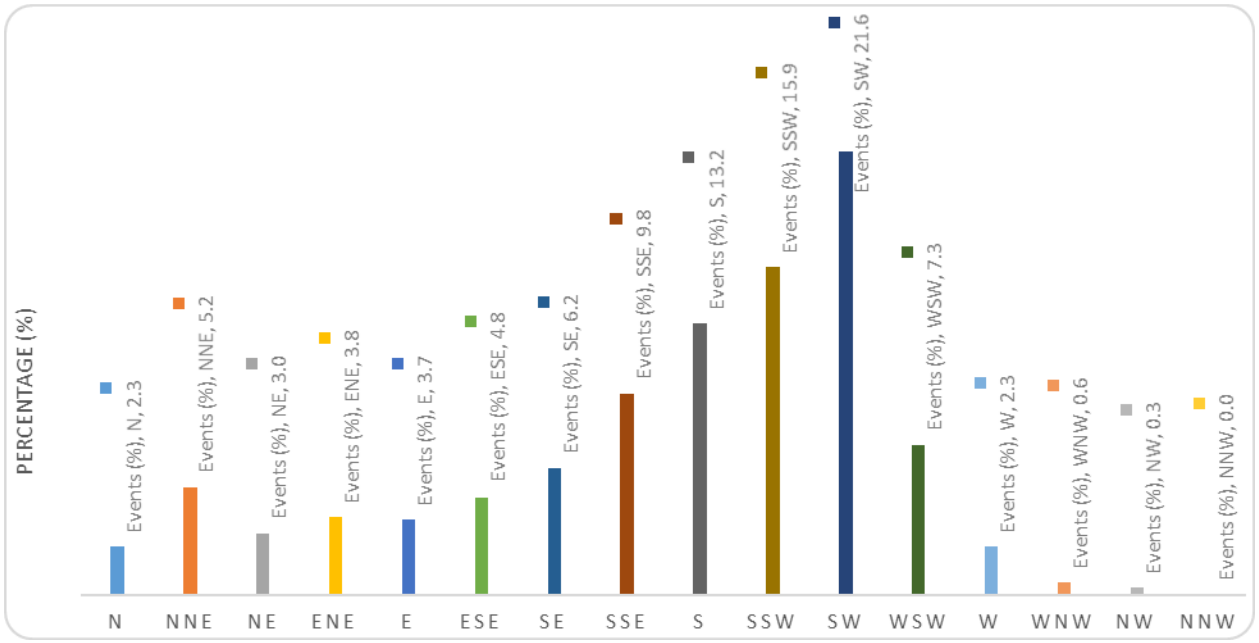

Figure No. 5: Percentage distribution of Mubi wind directions

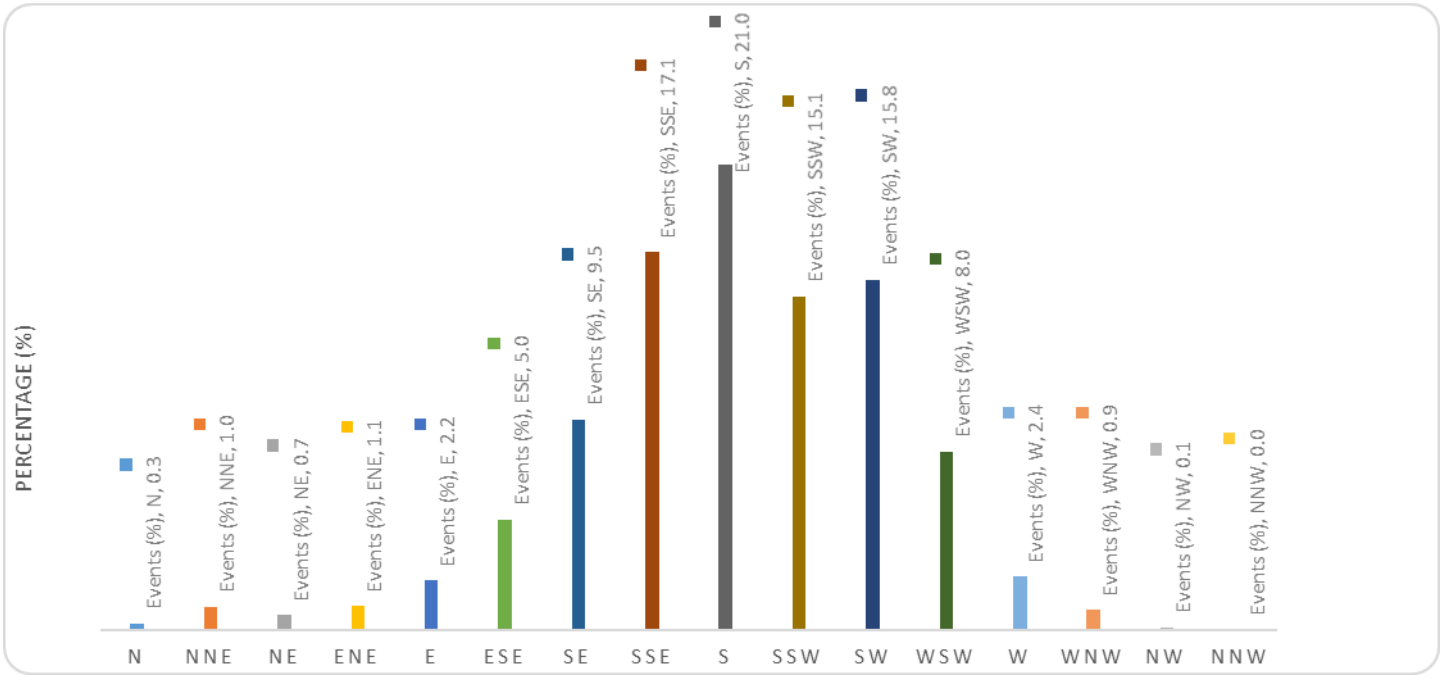

Figure No. 6: Percentage distribution of Mokolo wind directions

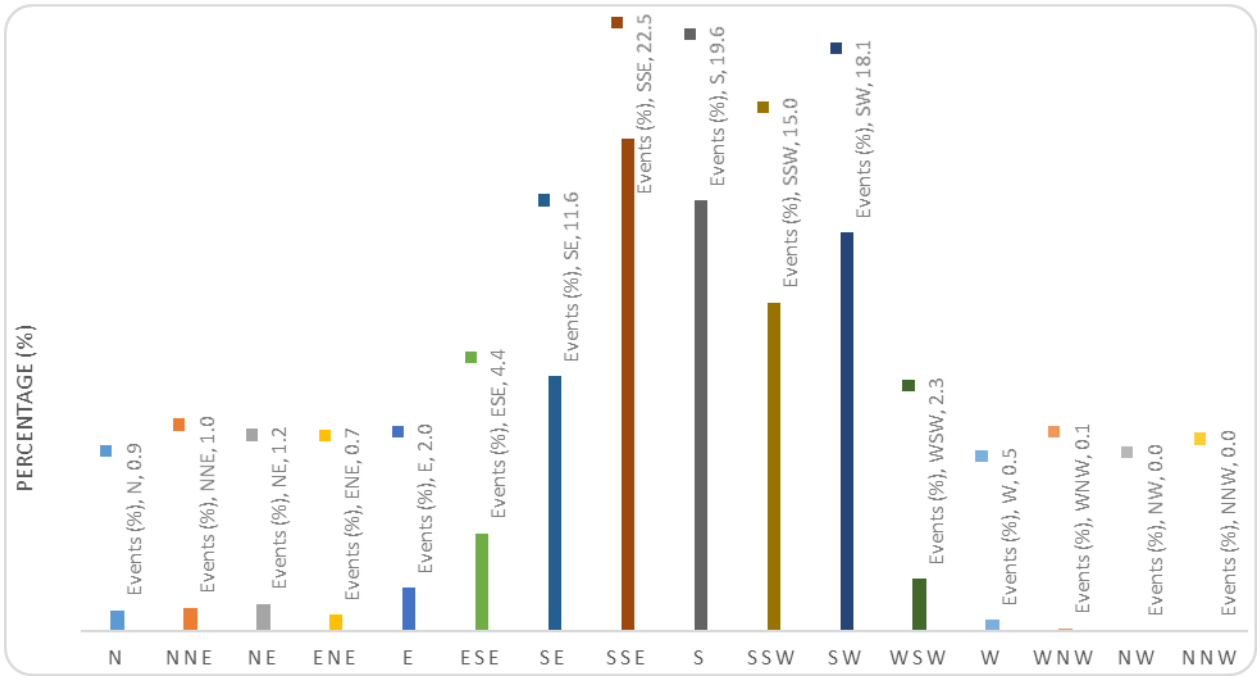

Figure No. 7: Percentage distribution of Guider wind directions

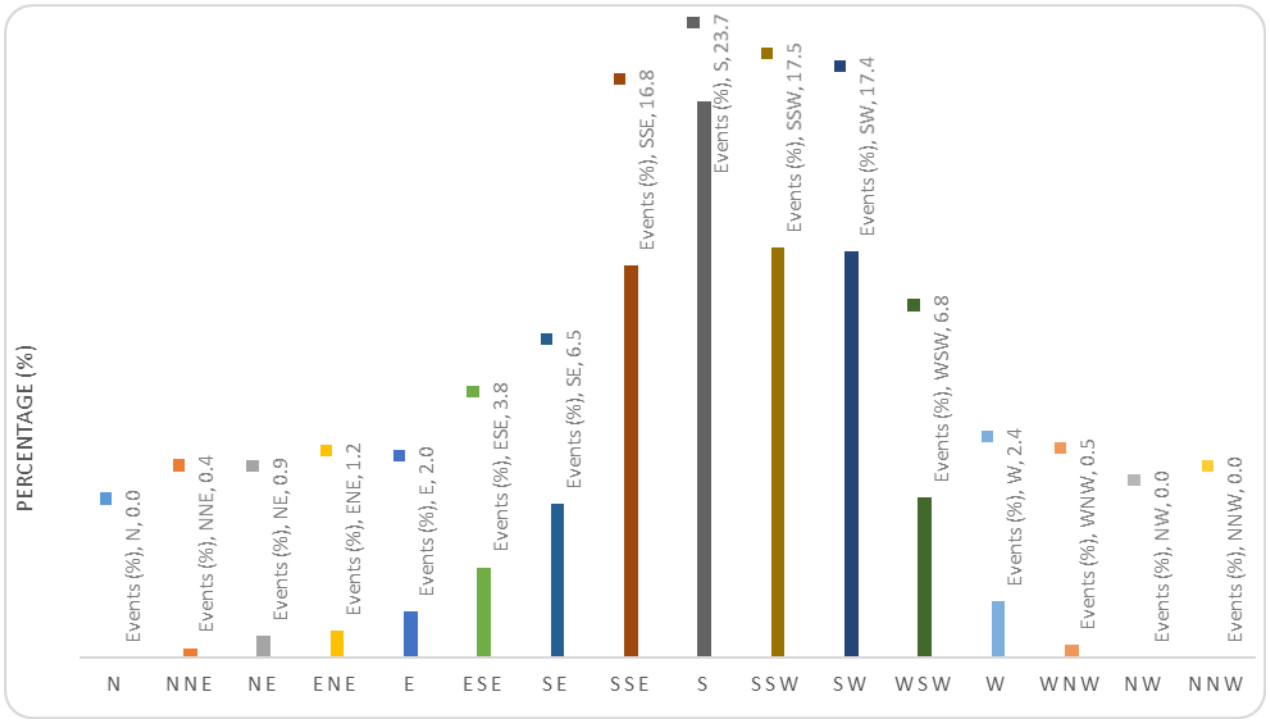

Figure No. 8: Percentage distribution of Gwoza wind directions

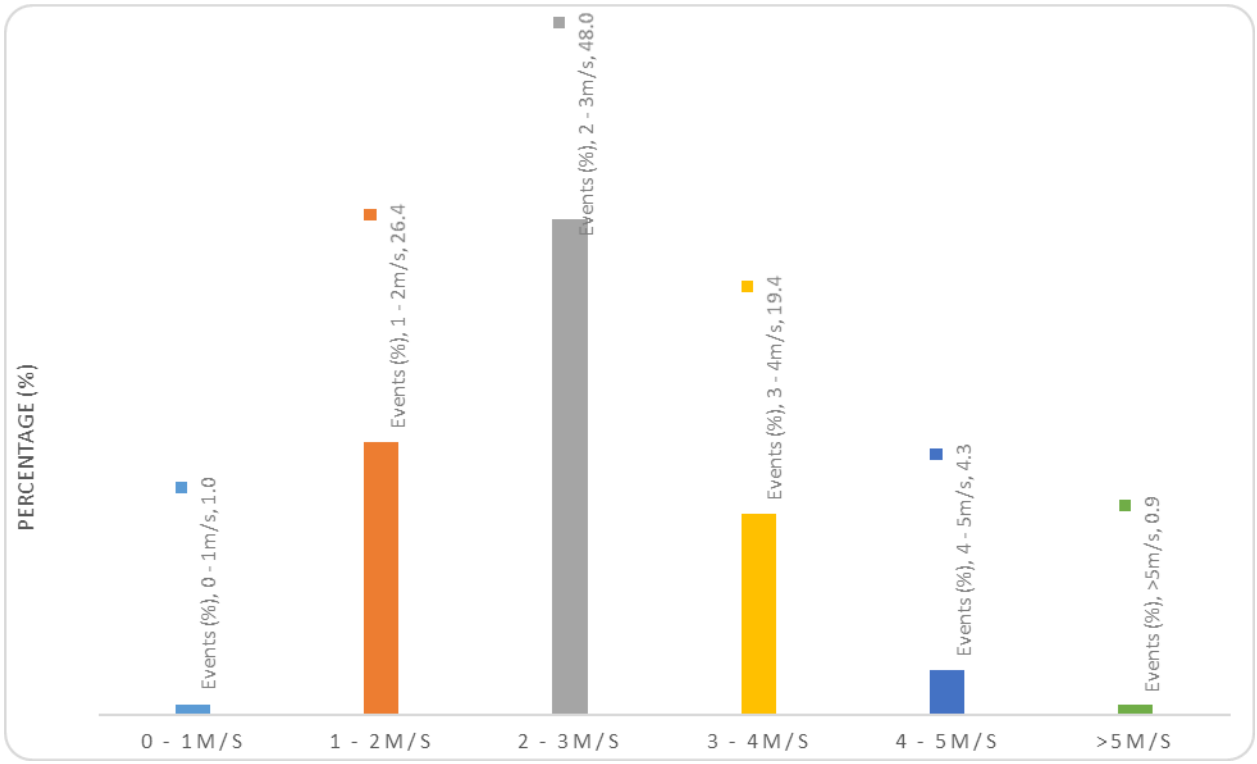

Figure No. 9: Percentage distribution of Mubi wind speed classes

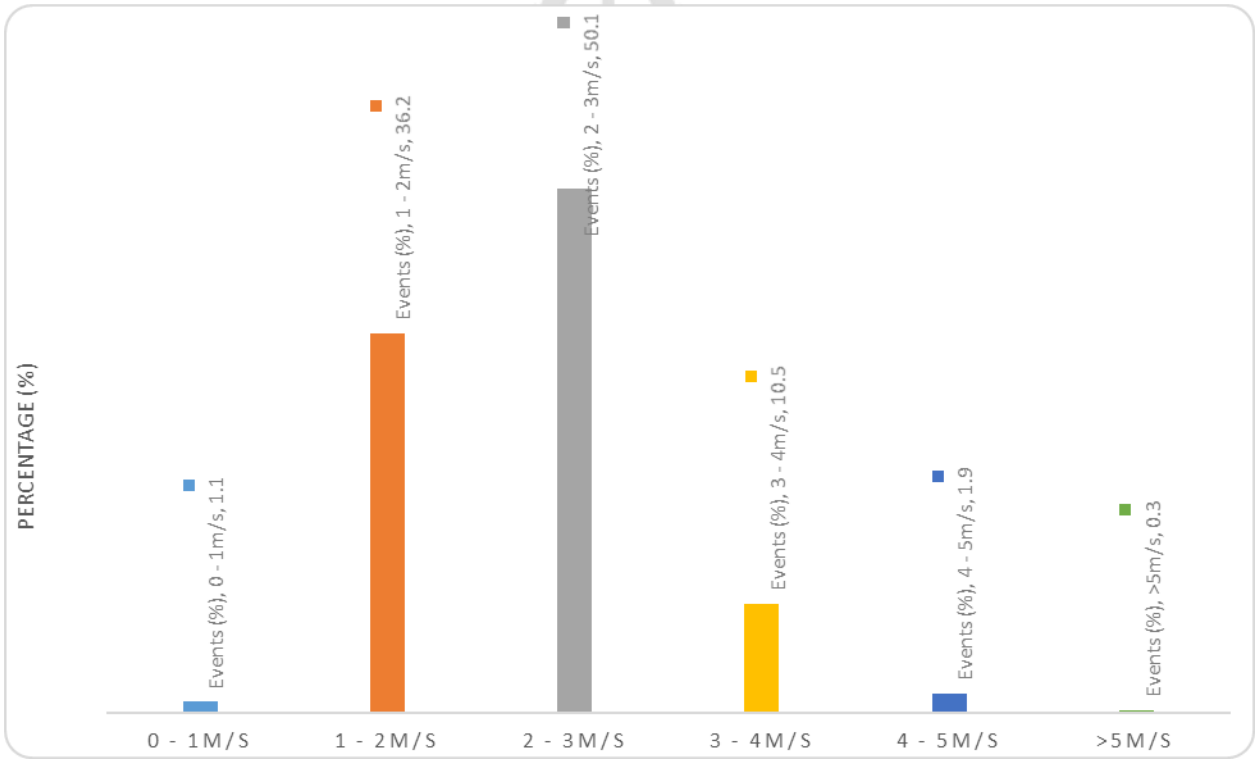

Figure No. 10: Percentage distribution of Mokolo wind speed classes

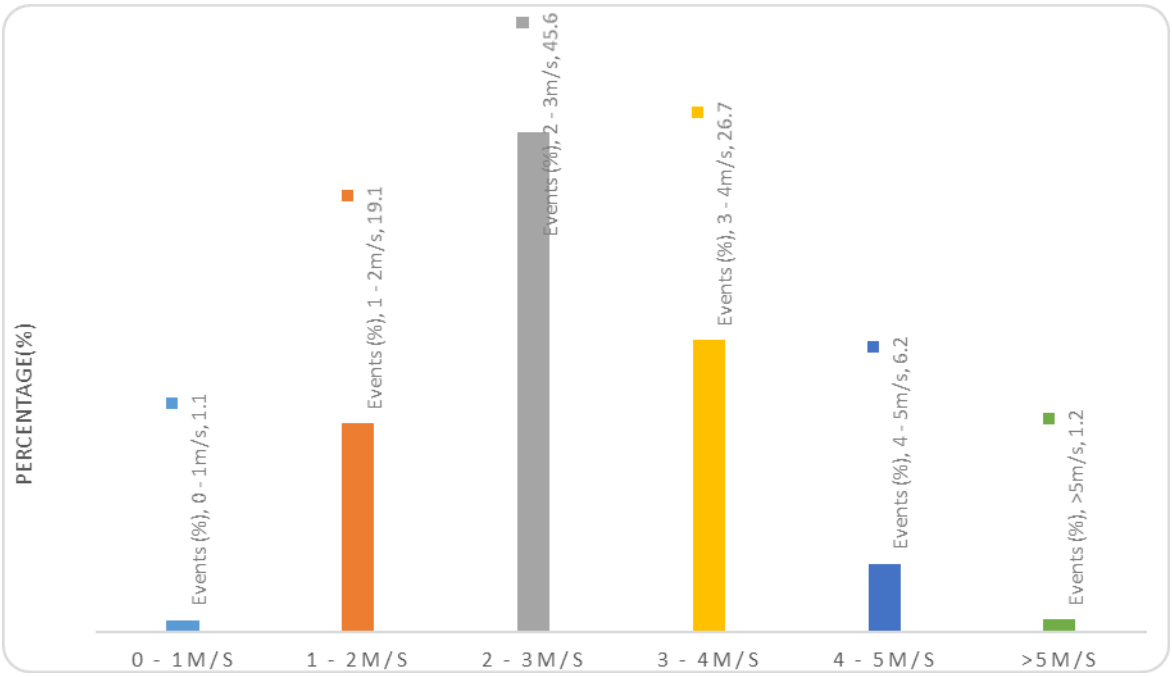

Figure No. 11: Percentage distribution of Guider wind speed

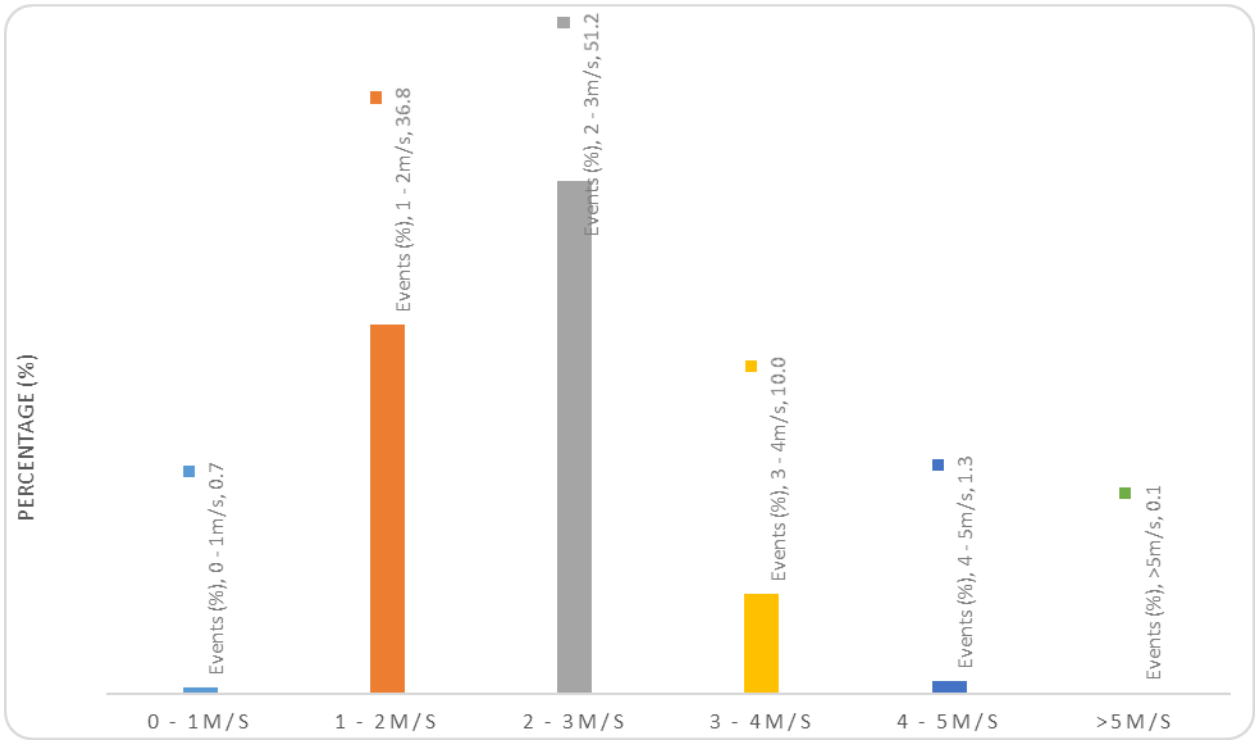

Figure No. 12: Percentage distribution of Gwoza wind speed classes

Wind Rose Distributions

From Fig. 1, 2, 3, and 4 plotted respectively from Tables 2, 3, 4 and 5, all wind roses evolved here use 16 basic directions, such as north (N), (NNE), etc. were plotted clockwise (0) from

North (N). The wind roses revealed the occurrence of wind directions spinning to each axis and is broken down into separate frequency categorizing the number of times (days) wind blows within 1830 days (observed for five years from 2011 to 2016). The record of the highest number with 432, 411, 395, and 376 days (dominant directions) was observed for Gwoza, Guider, Mubi, and Mokolo respectively. It was also observed from all the figures, that prevailing wind directions fall within East to West (i.e second and third quadrants) which is more than 80% of all the times and no wind speed and direction measurement were observed on North-North West (NNW) direction for all stations. The extent of each spoke represented in colors around the circle is associated with five (5) wind speeds class intervals. Therefore, for this observation, almost all resulted in wind speed was directed to a similar pattern.

Percentage Distributions Wind Directions

From Fig. 5, 6, 7 and 8 plotted respectively from Tables 2, 3, 4 and 5, show the highest frequencies of daily wind directions are at the averages of South West (SW) with 21.6% (395 days), South (S) with 21.0% (376 days), South South-East (SSE) with 22.5% (411 days) and South (S) with 23.7% (432 days) for Mubi, Mokolo, Guider and Gwoza.

Percentage Distributions of Wind Speed Classes

From Fig. 9, 10, 11 and 12 plotted respectively from Tables 2, 3, 4 and 5, show the highest distributions of wind speed classes for daily average events with 48.0% (879 days), 50.1% (895 days), 45.6% (835 days) and 51.1% (933 days) for Mubi, Mokolo, Guider and Gwoza. These percentages values (48.0 to 51.1%) are all within 2 to 3 m/s of wind speed class interval.

CONCLUSION

The wind was found to be predominantly directed to SW, S, SSE and S directions. This is not, but due to the topographic effects, resulting from uneven distribution of terrains (i.e roughness of hills, cliffs, ridges, escarpments, feet, and valleys) causes wind flow obstacles in the mountains range. Therefore, the result obtained from this research is applicable for building positioning, weather prediction, landscaping, control of wind erosion, and wind energy exploitation on a small scale.

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REFERENCES

1. ARCOS Network, (2017): African mountain: Water towers in need of attention. *Society and science of sustainable mountains development.* Available at; www.arcosnetwork.org. 2017).
2. Chaudhry, Q. Z. (2007): An investigation on wind power potential of Ghoro-Sindh, *Pakistan journal of meteorology*. Vol. 6(2)
3. Ebibe, S. O. (1987): A method of assessing wind energy potential in Nigeria locations. *Nig. Journal of Solar Energy*. Vol.6: 14.
4. IEA, (2009): IEA wind: 2009 annual report. IEA wind energy system.
5. Tian, W., Ozbay, A. and Hu, H. (2015): Terrain effects on characteristic of surface Swind and wind turbines wakes. 7th International Conference on Fluid Mechanics, ICFM7. *Procedia Engineering*. Vol. 126: 542-548. Available at www. Sciencedirect.com.
6. Tin, O. and Robert, P. (2015): Small wind site assessment guidelines. Technical report. *National Renewable Energy Laboratory (NREL).* Available at www.nrel.gov/publications.
7. Parvu, D. S. (2013): Experimental modeling of wind form topography and canopy. Electronic thesis at Department of Civil and Environmental Engineering. University of Western Ontario, Canada. Available at: http://ir.lib.uwo.ca/etd.
8. Wei, T. (2010): Wind power generation and wind turbines design. WIT Transaction on state of the art in science and Engineering. *WIT Press*. ISSN: 1755-8336 PP. 4. Available at; www.witpress.com.
9. Zeng-wei, Z. and Alex P. T. (2013): Recommendation on topographic effect correction factor for applying of Chines national wind load code. *Research publisher, Singapore*. Pp. 522-628.