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Wind Speed Regression Model in Forecasting Wave Height in the Shipping Channel Zone

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ABSTRAK

Dewasa ini, sering terjadi kecelakaan seperti tenggelamnya kapal laut di wilayah perairan yang disebabkan oleh faktor cuaca, salah satunya adalah kecepatan angina yang ekstrim. Kecepatan angin dan kuat hempasan ombak di laut saling berkaitan, sebab faktor yang mempengaruhi kuat hempasan ombak adalah kecepatan angin. Penelitian ini bertujuan untuk memberikan informasi tentang model regresi kecepatan angin sebagai upaya untuk mengetahui ketinggian gelombang di pelabuhan penyeberangan laut. Penelitian ini merupakan penelitian kuantitatif. Data yang digunakan berupa data kecepatan angin yang diambil pada koordinat Pelabuhan Lembar dan Labuan Bajo dari website NASA sub-agroclimatology mulai 1 Januari 2012 hingga 31 Desember 2021 (selama 10 tahun). Pada studi kasus ini menggunakan analisis regresi linear dan dioperasikan menggunakan software SPSS. Data tersebut menunjukkan bahwa di Pelabuhan Lembar memiliki fluktasi kecepatan angin paling ekstrim di tahun ke-6 dan ke-7. Sedangkan fluktasi kecepatan angin di Labuan Bajo konsisten, namun sedikit ekstrim di tahun ke-7 melampaui tahun ke-1. Hasil penelitian menunjukan bahwa R-Square pelabuhan Lembar sebesar 15,4% sedangkan R-Square pelabuhan Labuan Bajo sebesar 16,2%. Hasil penelitian ini dapat digunakan dalam menyusun kebijakan keselamatan transportasi laut di kedua wilayah tersebut.

ABSTRACT

Nowadays, there are often accidents such as the sinking of ships in water areas that are caused by weather factors, one of which is the extreme wind speed. Wind speed and strong waves in the sea are interrelated because the factor that affects the strength of the wave blow is wind speed. This study aims to provide information about the angina speed regression model to find out the wave height at the sea crossing port. This research is a quantitative research. The data used is in the form of wind speed data taken at the coordinates of Lembar Port and Labuan Bajo Port from the NASA sub-agroclimatology website from January 1, 2012, to December 31, 2021 (for 10 years). This case study uses linear regression analysis and is operated using SPSS software. The data shows that in Lembar Port has the most extreme wind speed fluctuations in the 6th and 7th years. While the wind speed fluctuations in Labuan Bajo are consistent, but slightly extreme in the 7th year surpassing the 1st year. The results showed that the R-Square of Lembar port was 15.4% while the R-Square of Labuan Bajo port was 16.2%. The results of this study can be used in formulating marine transportation safety policies in both regions.

1. INTRODUCTION

Indonesia is a maritime country with two-thirds of its area being territorial waters. Indonesia is an archipelagic country with 18.306 islands and a land area of islands of about 1.92 million km^2 with a coastline length of 81.000 km (Ngurah et al., 2021; Brotosusilo et al., 2016). As the largest archipelagic country, Indonesia has maritime potential in various fields not only as biotechnology and marine tourism area, deep sea waters, and marine minerals but also in the shipping and defence industry and the world maritime industry (Al Syahrin, 2018). The sea in Indonesia has a very large potential so as a maritime country with the existence of sea transportation can facilitate public relations from island to island (Purwendah, 2020). This makes it an important facility that dominates and has a positive impact on the people in areas that have ports. As the largest archipelagic country, Indonesia has maritime potential in various fields not only in biotechnology and marine tourism area, deep sea waters, and marine minerals but also in the shipping and defence industry as well as the world's maritime industry. The port is a place of stop (terminal) for ships after sailing (Zhang et al., 2021; Rodrigue & Notteboom, 2012). Lembar Port is a port located in Lembar West Lombok, West Nusa Tenggara province while Labuan Bajo port is located in Komodo District, West Manggarai Regency, East Nusa Tenggara Province. Lembar and Bajo are one of the ports that become the entrance of large ships and are visited by foreign tourist ships from abroad. Sea

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traffic is inseparable from accidents, in 2018 to be precise, on July 20, two ships that were about to sail in the port of Lembar collided with each other. Meanwhile, in Labuan Bajo, a tourist boat sank in the waters of Bidadari island on January 4, 2020. the accidents at the two ports were allegedly due to bad weather, high waves, and strong winds. Climate variability such as rainfall and water conditions with high waves and strong winds affect fishermen's activities at sea in carrying out fishing operations (Samah et al., 2019). The wind is a large amount of airflow due to the rotation of the earth and also due to the difference in air pressure around it (Yang, Xue, Zhang, & Sun, 2017). The magnitude of the wind pressure is affected by the wind speed that occurs (Stathopoulos, Zisis, & Xypnitou, 2014). The Western Season occurs in December, January, and February. While the Eastern Season occurs in June, July, and August. The wind that blows in Indonesia is influenced by the seasons so this wind system is called the Monsoon wind or Monsoon wind (Nababan, Rosyadi, Manurung, Natih, & Hakim, 2016). The movement of wind will affect the characteristics of water masses in the sea, one of which is the occurrence of changes in the direction of surface currents. Strong wind movements can also affect the mixing of water masses in the upper layers which results in a homogeneous temperature distribution (Stanev et al., 2019; Abbasi et al., 2016).

The speed of the sea breeze and the strong impact of sea waves have a very close relationship because the factor that affects the strong impact of the wave is wind speed (Young & Ribal, 2019). Therefore, this research is carried out as an information medium that can be used by fishermen to find out the condition of the sea waves before they sail. Because the height of a wave can be influenced by the factor of the wind season where large winds tend to respond to produce large waves (Marino, Giusti, & Manuel, 2017). The regression analysis has long been developed to study patterns and measure statistical relationships between two or more variables (Fikri, 2013). An analytical technique that tries to explain the form of the relationship between two or more variables or more specifically the relationship between changes that contain causation is called regression analysis (Lowry P B & J, 2014). Its analysis procedure is based on the distribution of probabilities along with its variables. If this relationship can be expressed in mathematical equations, it can be used in daily needs, for example, to make predictions, fortune-telling, and so on. Regression analysis is one of the data mining techniques with a statistical basis for data modelling with the concept of linear line equations (Saigal & Mehrotra, 2012). The modeling method that most commonly used by researchers is linear regression model (Permai & Tanty, 2018) . Regression analysis process is carried out by analyzing the relationship of two or more independent variables or called free variables or predictor variables (Williams, Gomez Grajales, & Kurkiewicz, 2013). The free variable is used to determine the value of a free variable or called a dependent variable. This variable is generally notated with x. The free variable is used to determine the value of a free variable or called a dependent variable. Regression analysis that has one free variable is often referred to as simple linear regression (Luthfiarta, Febriyanto, Lestiawan, & Wicaksono, 2020). (Baroya, 2018)

Several studies related to weather prediction have been carried out using regression analysis (De Giorgi, Congedo, & Malvoni, 2014; Hendra Jaya, Rudi Gunawan, 2019; Jhonson Arizona Saragih et al., 2020; Nalina, Prema, Smitha, & Rao, 2014; Ngurah et al., 2021; Putri, Syafrialdi, & Mustakim, 2017; Riyandiarto & Fadjrin, 2020; A. Q. Sari, Sukestiyarno, & Agoestanto, 2017; Sarwat, Amini, Domijan, Damnjanovic, & Kaleem, 2016; Sulistyono & Sulistiyowati, 2017). The research was conducted using the linear regression analysis method: The highest waves in the southern Makassar Strait in 2005-2015 occurred in January, June, and September, while the lowest occurred in November and April (Rahmaniar, Arsyad, & Tiwow, 2020). The data used is secondary data for 2005-2015. The simulation of the prediction of monthly total rain in 2009 in the study area obtained an average RMSE = 98 mm / month using air temperature predictors, RMSE = 7 mm / month using air humidity predictors, and RMSE = 69 mm / month using air temperature predictors and air humidity at the same time. The results of (Saragih, Mulyono, & Santoso, 2018) showed that the NACA 4412 windmill produces more electricity when placed in a place that has a wind speed above 5.380859 m/s. research by (Jamdade & Jamdade, 2012) using a linear regression model of the Weibull distribution of two parameters used to analyze variations in wind speed patterns showed that Irish coastal sites such as Malin Head, Dublin Airport, and Belmullet had good wind power potential.

Some of the data predicted in the above study are wind speed, temperature, rain, and wave height using linear regression. So in this study, predictions were made using linear regression on wind speed data at two case study locations, namely Lembar port and Bajo port. Therefore, the results of this study can be used in determining marine transportation safety policies to reduce the risk of accidents. Referring to several studies that use the linear regression analysis method, it turns out that not many have used linear regression as a method to examine wind speed. Therefore, this study was conducted to describe the wind speed in forecasting the wave height in the port.

2. METHOD

This research is quantitative, because we collect time series data and analyze it quantitatively i.e. linear regression. It processes data to obtain information about the comparison of wind speeds in Lembar port and Bajo port. The research procedure is as per Figure 1.

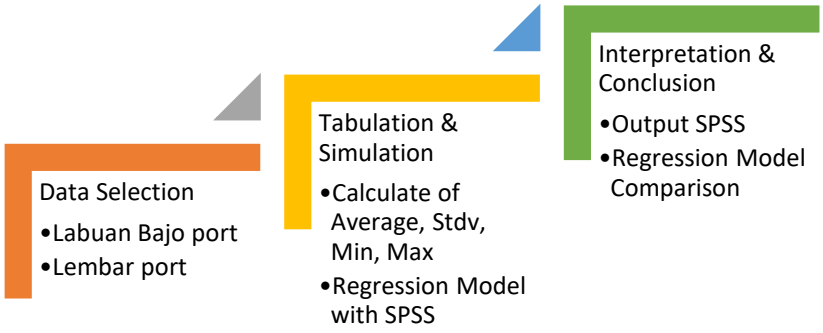

Figure 1. Procedure of Research

The design of this study began with the collection of wind speed data from January 1, 2012, to November 31, 2021 (for 10 years) on the NASA website (https://power.larc.nasa.gov/data-access-viewer/) sub agroclimatology such as Figure 2 and Figure 3. As for the data location, Labuan Bajo is located at Latitude -8.4726, Longitude 119.7578, and Lembar is located at Latitude -8.7033, Longitude 116.0606.

Figure 2. Geometric Location of Lembar Port, NTB Indonesia

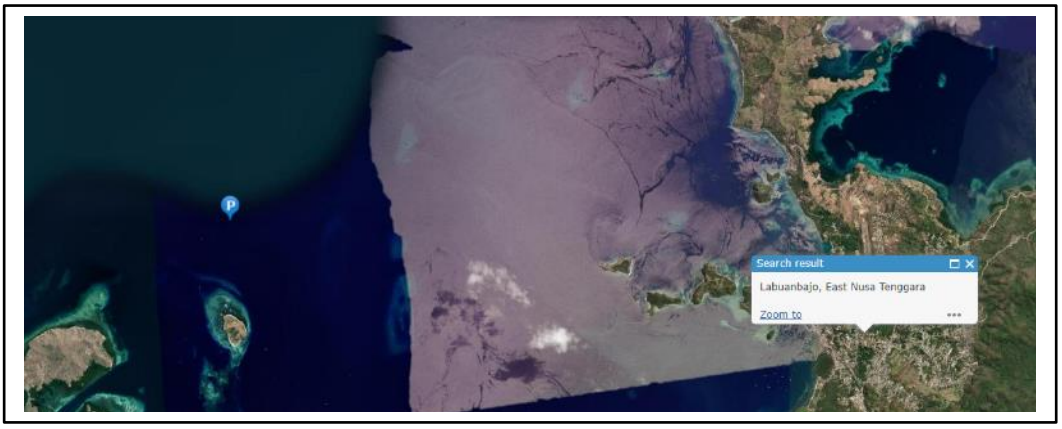

Figure 3. Geometric Location of Bajo Port, NTT Indonesia

Wind speed data is tabulated in Microsoft Excel by calculating the average, standard deviation, minimum and maximum values. The details of the datasets used are described in Table 1 and Table 2.

Table 1. Descriptive Statistics of Lembar Ports

Year	Average	Standard deviation	Minimum	Maximum
2012	1,72	0,33	1,23	2,27
2013	1,58	0,35	1,14	2,19
2014	1,57	0,28	1,09	1,98
2015	1,47	0,22	1,17	1,89
2016	1,33	0,19	1,02	1,69
2017	1,67	0,28	1,16	2,05
2018	1,71	0,28	1,2	2,1
2019	1,55	0,31	0,96	1,92
2020	1,57	0,27	1,15	1,96
2021	1,60	0,28	1,2	2,02

Table 1 shows that 2012 had the highest wind speed value of 1.72 with a standard deviation of 0.33. The maximum value occurred in July, which was 2.27 and the minimum was 1.23 in February. However, the highest standard deviation was in 2013, which was 0.35, and an average of 1.58. The maximum wind speed occurs a lot in July with the minimum wind speed occurring a lot in March throughout the year.

Table 2. Descriptive Statistics of Labuan Bajo Ports

Year	Average	Standard deviation	Minimum	Maximum
2012	1,3	0,29	0,98	1,85
2013	1,3	0,26	0,97	2,01
2014	1,2	0,24	0,93	1,8
2015	1,2	0,21	0,88	1,7
2016	1,1	0,24	0,85	1,77
2017	1,2	0,26	0,99	1,74
2018	1,3	0,24	0,99	1,83
2019	1,2	0,22	0,92	1,71
2020	1,2	0,25	0,88	1,64
2021	1,2	0,27	0,85	1,76

In Table 2, the average wind speed for ten years is at values between 1.3-1.2 with a standard deviation between 0.21-0.29. However, the maximum value of wind speed occurred in 2013 of 2.01. Wind speeds with maximum values in Table 2 occurred mostly in January of 2013-2015 and 2017-2020, while the minimum wind speed occurred in April and November throughout the year. Simple linear regression is a method used to measure the magnitude of the influence of independent variables on dependent variables (Rahmaniar 2020). A regression model with the following equation.

$$Y = a + bX \qquad (1)$$

Where: Y = dependent variable (year); X = independent variable (wind speed data); a = constant; b = regression coefficient

Data analysis of this study using SPSS software. Decision-making in a simple regression test can refer to two things, namely by comparing the t-count value with the t-table, or by comparing the significance value with the probability value of 0,05. Comparing the values of the t-count and t-table, (1) if the value of the t-count is greater than the value of the t-table, it means that the free variable affects the bound variable; (2) If the value of the t-count is not greater than the value of the t-table, it means that the free variable does not affect the bound variable. Comparing the significance value with the probability of 0,05, (1) If the significance value is no more than the probability value of 0,05, it means that the free variable has a significant effect on the bound variable; (2) If the significance value is more than the probability value of 0,05, it means that the free variable has no significant effect on the bound variable.

3. RESULT AND DISCUSSION

Result

Regression Model of Labuan Bajo Port

According to the research procedures that have been described, then after the data is tabulated, so that the steps determine the regression model of each data. To find out the value of the variance difference between several groups of data. Then it can be seen from the results of the ANOVA output in Table 3.

Table 3. ANOVA

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.354	1	13.354	1.545	0.249
	Residual	69.146	8	8.643		
	Total	82.500	9			

Table 3 shows the $t-count\ value = 1.545$, while the significance number $(P-value) = 0.249$. With a probability of 0.05. If the significance number $(P-value)\ is\ 0.249 > 0.05$ then the free variable has no significant effect on the bound variable. Then, the results of the Summary Model have the utility of knowing the relationship between the two or more variables in the regression equation.

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.402	0.162	0.057	2.940	0.162	1.545	1	8	0.249	0.403

Table 4, $R-Square = 0.162$ (16.2%) shows that the influence of the dependent variable (X) on the independent variable (Y) is 16.2%. While the remaining 83.8% is influenced by other variables. Next, the coefficients are used to determine the regression equation and the influence between independent variables on dependent variables partially or singly. The regression coefficient 'b' is the magnitude of the change in the value of the free variable, the greater the regression coefficient value, the greater the contribution of the change, and vice versa, the smaller it will be. The contribution of changes in the free variable (X) is also determined by the positive or negative regression coefficient.

Table 5. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-11.849	13.989		-0.847	0.422					
	Data	11.222	9.028	0.402	1.243	0.249	0.402	0.402	0.402	1.000	1.000

Table 5 produces the constant value $(a) = -11{,}849$ while the value at $(b) = 11{,}222$ so that the regression equation.

$$Y = a + bX$$
$$Y = -11.849 + 11.222X$$

From the above output, it can be determined that if the value of $t-count = 1.243$ with a signified value of $0.249 > 0.05$ then there is no significant influence of the variable (X) on the variable (Y).

Regression Model of Lembar Port

The ANOVA (Analysis of Variants) test is one of the many types of comparative tests. The Anova test also belongs to the parametric test group. Its function is to assess the difference in variance between several groups of data. The results of the F test can be seen in Table 6.

Table 6. ANOVA

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.681	1	12.681	1.453	0.262
	Residual	69.819	8	8.727		
	Total	82.500	9			

In Table 6 shows the value of $t-count = 1.453$, while the significance number $(P-value) = 0.262$. With a probability of 0.05. The significance number $(P-value)\ is\ 0.262 > 0.05$, so the free variable has no significant effect on the bound variable. Then, the coefficient of determination explains the

variation in the influence of independent variables on dependent variables. The value of the coefficient of determination can be measured by the value of R-square or Adjusted R-Square.

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.392	0.154	0.048	2.954	0.154	1.453	1	8	0.262	0.335

Table 7 of the summary model obtained $R - Square = 0.154$ (15,4 %) shows that the influence of the year variable on the wind speed variable was 15,4 percent while the remaining 84,6 percent was influenced by other variables. Next, the results of the Coefficients are used to determine the regression equation and the influence between independent variables on the dependent variable. The test results can be seen in the Coefficients table as in Table 8.

Table 8. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	28.590	19.179		1.491	0.174					
	Data	-18.927	15.701	-0.392	-1.205	0.262	-0.392	-0.039	-0.392	1.000	1.000

Table 8 shows the output of coefficients with $(a) = 28{,}590$. While the value of $(b) = -18{,}927$. so that the regression equation.

$$Y = a + bX$$
$$Y = 28.590 + (-18.927)\,X$$

From the equation above, it can be known that if the value of $t - count = -1{,}205$ with a signification value of $0.262 > 0.05$ then there is no significant influence of the variable (X) on the variable (Y).

Discussion

In solving problems related to wind speed forecasting in the ports of Lembar and Labuan Bajo, it is carried out using the linear regression method. The results showed that the *R-Square* of Lembar port was 15,4 percent while the *R-Square* of Labuan Bajo port was 16,2 percent. According to the safe sailing advice of the Meteorology and Climatology and Geophysics Agency (called BMKG) says that the early warning list for fishing boats (wind speed is more than 15 knots and wave height is above 1.25 m), barges (wind speed is more than 16 knots and wave height above 1.5 m), Ferry boats (wind speed is more than 21 knots and wave height is above 2.5 m), and large-size ships such as cargo ships/cruise ships (Wind speed over 27 knots and wave height above 4.0 m). We see the average value of wind speed from January 1, 2012, to September 31 (for ten years) in lembar and Labuan Bajo ports are 1.577 m/s and 1.2 m/s in knot parameters of 1.577 m/s = 3.0654428 knots, and 1.2 m/s = 2.33261 knots, the speed is at the safe standard wind speed from the early warning list by BMKG.

Figure 4 shows the development of the wind speed fluctuations of the Lembar and Labuan Bajo ports from the results of tabulating average data values in Microsoft excel. This shows that the port of Lembar has an extreme value, namely there was a drastic decline in the 5th year (2016) and an increase in the 6th year (2017). Meanwhile, Labuan Bajo is consistently at a value of 1,2-1,3 there has been no significant increase and decrease for 10 years. From the chart, it can be seen that the wind speed value in Lembar port is higher than the wind speed in Labuan Bajo port. The minimum wind speed both occurs in the 5th year and experiences the maximum wind speed, The sheet of the first year (2012) while Labuan Bajo occurs in two years namely the 2nd year (2013) and the 7th (2018). Wind speeds with a high return period are always related to thunderstorm outflows (Shi Zhang, Solari, Yang, & Repetto, 2018). The mixed extreme distribution asymptotically overlaps with that for thunderstorms for high return periods and always provides the highest wind speeds. Therefore, forecasting can be used as a reference to prevent the negative impact of wind and optimize the positive role of wind in human daily life (Liu, Zhang, Chen, &

Wang, 2018; V. Sari & Maulidany, 2020). But apart from that, extreme weather changes must still be watched out for considering that wind speeds can change at any time. Therefore, the results of this study can be a reference for the government to study any changes in wind speed in water areas in Indonesia, especially in the Lembar and Labuan Bajo port areas.

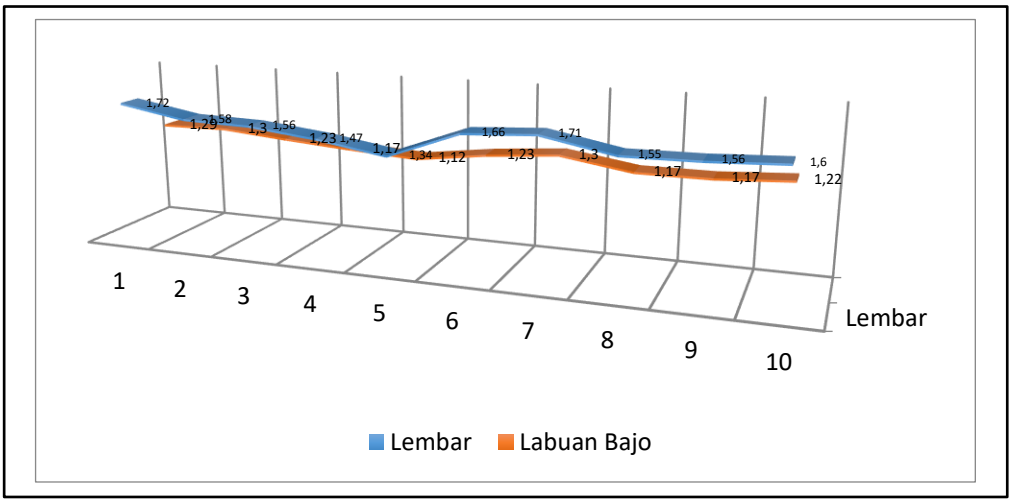

Figure 4. Wind Speed Value Graph Display

4. CONCLUSION

Based on the results and discussions that have been carried out and looking at the regression model that has been processed, it can be said that the extremity of wind speed in Labuan Bajo port is higher than lembar port, which is 16.2% and 15.4%, respectively. So with the prediction of wind speed comparison using a linear regression model, it can be an information medium for people who want to make a crossing. There are several suggestions, including the use of more data in terms of wind speed is expected to obtain a better regression output so that the prediction of a more accurate comparison. In addition to the amount of data, the use of other relevant variables that are not yet included in this regression analysis can form a clearer equation.

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