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Impact of Tropical Cyclone Seroja on Rainfall and Wind Speed in East Nusa Tenggara Province

Astried Valentine Kaha[1]*, Winardi Tjahyo Baskoro[1*], Kadek Sumaja[2*], I Ketut Sukarasa[1], Ida Bagus Alit Paramarta[1], I Nengah Sandi[1]

[1]*Departement of Physics, Faculty of Mathematics and Natural Sciences, Udayana University, Bukit Jimbaran Campus, Badung, Bali, Indonesia 80361*
[2]*Meteorological Station Class I I Gusti Ngurah Rai, GOI Building 2nd floor Ngurah Rai Airport, Tuban, South Kuta, Badung, Bali, 80361*

Corresponding Authors E-mail: valentineastried@gmail.com, winardi@unud.ac.id, kadek.sumaja@gmail.com.

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Abstract

Tropical cyclone phenomenon can give impacts such as heavy rain, strong winds, and high waves around its growth area. One of the tropical cyclones that has occurred is Seroja Tropical Cyclone which formed in the Sawu Sea on April 3, 2021. Therefore, this study aims to determine the effect of Seroja Tropical Cyclone on rainfall and surface wind speed in East Nusa Tenggara Province and the percentage comparison of rainfall and wind speed during the Seroja tropical cyclone event with the normal value of rainfall and surface wind speed over a 10-year period. The data used are daily rainfall and surface wind speed data during the Seroja tropical cyclone event, namely April 3 to 12, 2021 and daily average rainfall and wind speed data in April for 10 years in several affected districts in East Nusa Tenggara Province. Data processing is done by calculating the percentage comparison of rainfall and wind speed during the Seroja Tropical Cyclone event with normal rainfall and wind speed in several regions in East Nusa Tenggara. Based on the analysis, heavy to extreme rainfall and strong winds were found in several districts at a radius of about 400 km from the center of the cyclone. Although the category of this tropical cyclone is low, it is able to give impacts in the form of heavy to extreme rainfall and strong winds in the surrounding area. So it can be concluded that the tropical cyclone category does not directly affect rainfall and wind speed in an area, but the distance between the area and the center of the tropical cyclone is more influential in increasing rainfall and wind speed in an area. This is also proven by Sumaja's research in the case of tropical cyclones LUA and Narelle.

Introduction

Tropical cyclones are strong storms characterized by swirling wind vortices, formed over warm waters with areas of convective clouds (clouds that grow vertically) and wind speeds

that reach 34 knots or more [1]. The tropical cyclone phenomenon has great potential to cause damage in the areas it passes through. Tropical cyclones occur over large bodies of water, with swirling winds and heavy rain [2]. The impacts caused by tropical cyclones are extensive, not only on the areas through which they pass, but also on the areas around the location of the tropical cyclone [4]. One of the areas often affected by tropical cyclones is Indonesia. Based on data for 42 years, tropical cyclones in the southern part of Indonesia most often occur in February, namely 122 events for 42 years, with an average of 2.9 events per year. In this month, the most tropical cyclone events were experienced in 1968 where at that time there were 7 (seven) tropical cyclone events. [5]

In general, the occurrence of tropical cyclones can also cause increased rainfall, strong winds and trigger the occurrence of high waves around the formation area [6]. According to research conducted by Hidayat and Efendi in 2017, it is said that the occurrence of strong winds occurred consecutively for 6 days due to the influence of Tropical Cyclone Yvette [7]. Then, based on research conducted by Muhammad Najib in 2018, Cempaka Tropical Cyclone affects rain intensity. This is characterized by an increase in daily rain intensity and rain intensity will be higher in areas closer to the center of the cyclone [8]. In addition, based on the results of research conducted by Haryani in 2012, it is said that in 2010 in general tropical cyclones in the southern region of Indonesia or in the Indian Ocean and its surroundings often occur in January, partly in March and December [9].

Based on data from the Meteorology, Climatology and Geophysics Agency, it is said that since 2008 until now there have been 3 Tropical Cyclone events that grew around the East Nusa Tenggara Province, namely Kirrily, Lili and Seroja Tropical Cyclones. Two of the tropical cyclone events occurred in April, namely Kirrily and Seroja Tropical Cyclones while Lili Tropical Cyclone occurred in May. In addition, based on research conducted by Kholidatul Islamiyah in 2021, East Nusa Tenggara was also affected by Tropical Cyclone Claudia that crossed Sulawesi, Bali, and the Nusa Tenggara islands, which had an impact on increasing sea wave heights to more than two meters [10].

Tropical Cyclone Seroja occurred in April 2021, which initially began to form in the South of East Nusa Tenggara Province, especially in the Sawu Sea on April 3, 2021. The storm had wind vortex speeds of up to 75 km/h that caused severe flooding on several islands in the provinces of NTT and Timor Leste. The impacts caused by this cyclone include casualties, material/physical damage to buildings, gardens, public facilities and some non-physical impacts such as trauma, stress and sadness [10]. Based on research conducted by Sumaja et al in 2021, it is said that this is because the closer the position of a tropical cyclone is to an area, the greater the impact [5]. Based on data from the National Disaster Management Agency, Seroja Tropical Cyclone is a tropical cyclone that gives the biggest impact on the East Nusa Tenggara Province. Considering the impact caused by tropical cyclones is very large, this is the background for the author to analyze the impact of Tropical Cyclone Seroja on rainfall and wind speed with a case study in East Nusa Tenggara Province. This is because East Nusa Tenggara Province is the closest area of Indonesia to the growth location and trajectory of Tropical Cyclone Seroja. Therefore, this study aims to determine the effect of category and center distance of Seroja Tropical Cyclone on rainfall and wind speed as well as the percentage comparison of rainfall during the occurrence of Seroja Tropical Cyclone with normal rainfall and wind speed in several districts in East Nusa Tenggara Province.

Theory and Calculation

Tropical Cyclones

A tropical cyclone is a strong storm characterized by a swirling vortex of winds, formed over a large body of water with warm sea surface temperatures of more than 26.5°C and the presence of convective cloud areas (vertically growing clouds) and wind speeds reaching 34 knots or more and has an average radius of about 150 to 200 km and an average lifespan ranging from 3 to 18 days [11, 12, 13]. Tropical Cyclones weaken or die when they enter cold waters or when they reach land, as their energy comes from warm waters. There are several requirements for the formation of Tropical Cyclones, namely sea surface temperature of at least 26.5°C to a depth of 60 meters, unstable atmospheric conditions that allow the formation of cumulonimbus clouds (these clouds are thunderclouds that indicate the presence of strong convective areas, which play an important role in the development of Tropical Cyclones), relatively moist atmosphere at an altitude of about 5 km (at this altitude, if it is dry, it cannot support the development of thunderstorm activity within the cyclone), being at a distance of about 500 km from the equator (although possible, cyclones rarely form near the equator), the presence of atmospheric disturbances near the earth's surface in the form of rotating winds and accompanied by wind swells (convergence) [11].

Tropical Cyclone Strength Scale

In order to give an idea of the strength and impact that a tropical cyclone can have, a guideline of Tropical Cyclone strength scale is made. The commonly used scale is the Saffir-Simpson scale, which is divided into five categories as described in Table 1 below:

Table 1. Saffir-Simpson scale for tropical cyclones [1]

Type	Category	Damage	Max. wind speed (km/h)	Min. air pressure (mb)	Wave height
Depression	TD	-	<34		
Tropical strom	TS	-	34 - 63		
Hurricane/typhoon	1	Minimal	64-83	≥980	3-5
Huttycace/Typhoon	2	Moderate	84-96	979 - 965	6-8
Huttycace/Typhoon	3	Extent	97-113	964 - 945	9-12
Huttycace/Typhoon	4	Extreme	114-135	944 - 920	13-18
Huttycace/Typhoon	5	Catastrophic	> 135	< 920 mb	> 18

Rainfall

Rainfall is defined as the height of rainwater that falls on a flat place with the assumption that it does not evaporate, does not seep and does not flow [14]. Rainfall is always expressed in millimeters or inches. However, in Indonesia the unit of rainfall used is millimeters (mm). Rainfall of 1 mm means that in a unit area of one square meter on a flat surface, there is a water reservoir as high as 1 mm or a volume of water as much as 1 liter [15].

Rainfall in Indonesia has a high level of diversity based on space and time [16]. This is due to differences in latitude, solar apparent motion, geographical location, topology and the interaction of various kinds of air circulation both locally, regionally and globally [17].

According to Meteorology, Climatology and Geophysics Agency regulation no: KEP.009 Year 2010, the definition of heavy rain is rain with an intensity of at least 50 mm/day and/or 20 mm/hour. The threshold values used to determine rain intensity are shown in Table 2 below.

Table 2. Rainfall intensity categories.

Rain intensity (mm/day)	Color on the map	Rain category
0	Gray	Cloudy
0.5 - 20	Green	Light rain
21 - 50	Yellow	Moderate rain
51 - 100	Orange	Heavy rain
101 - 150	Red	Very heavy rain
>150	Purple	Extreme rain

Wind

Wind is the horizontal flow of air masses expressed in direction and speed. Wind occurs because air moves due to differences in air pressure with the direction of wind flow from a place of high pressure to a place of low pressure. If there is a difference in air pressure between two locations horizontally, there will be movement of air masses from areas with higher air pressure to areas with lower air pressure. This movement of air masses in the horizontal direction is known as wind [17].

Wind speed is the speed at which the wind moves and is expressed in knots or kilometers per hour or meters per second. However, in general, wind speed is always expressed in knots where 1 knot is 0.5144 m/s. Based on Meteorology, Climatology and Geophysics Agency Regulation No. Kep.009/2010, it is stated that the category of strong wind is wind with a speed of more than or equal to 25 knots or 45 km/hour. In addition, weather conditions such as rain, wind direction and speed, temperature and surface pressure in a region are influenced by Tropical Cyclones [18]. A collection of thick and widespread convective clouds (Cumulonimbus) is one of the factors causing strong winds. Cumulonimbus (Cb) cloud conditions can cause thunder, lightning, hailstones, heavy rain along with strong winds [19]. According to Nugroho (2018) revealed that large cumulus clouds or called Cumulonimbus clouds (Cb) can cause rain with strong winds and even lightning [20].

Experimental Method

This study was conducted in the Sawu Sea as the growth area of Tropical Cyclone Seroja and East Nusa Tenggara Province as the affected area. The data used are the track and category of Tropical Cyclone Seroja, rainfall, and surface wind speed as well as the average daily rainfall and surface wind speed in April for 10 years (2011-2020) in several districts in East Nusa Tenggara Province. The type of data used is reanalysis data downloaded from the website https://cds.climate.copernicus.eu/. Data processing is carried out by determining the rainfall category based on the Meteorology, Climatology and Geophysics Agency category and in each district in East Nusa Tenggara Province. In addition, a grouping of strong wind categories (wind speed greater than or equal to 21 Knots) and extreme wind (wind speed greater than or equal to 25 Knots) was also carried out. Then, the percentage comparison of daily rainfall and average wind speed during the Seroja Tropical Cyclone event with normal rainfall and wind speed in each district was calculated. Furthermore, an analysis was conducted to determine the influence of Tropical Cyclone Seroja on rainfall and wind speed in East Nusa Tenggara Province. In summary, the location of the research method carried out is interpreted in the form of a flow chart as in the following figure.

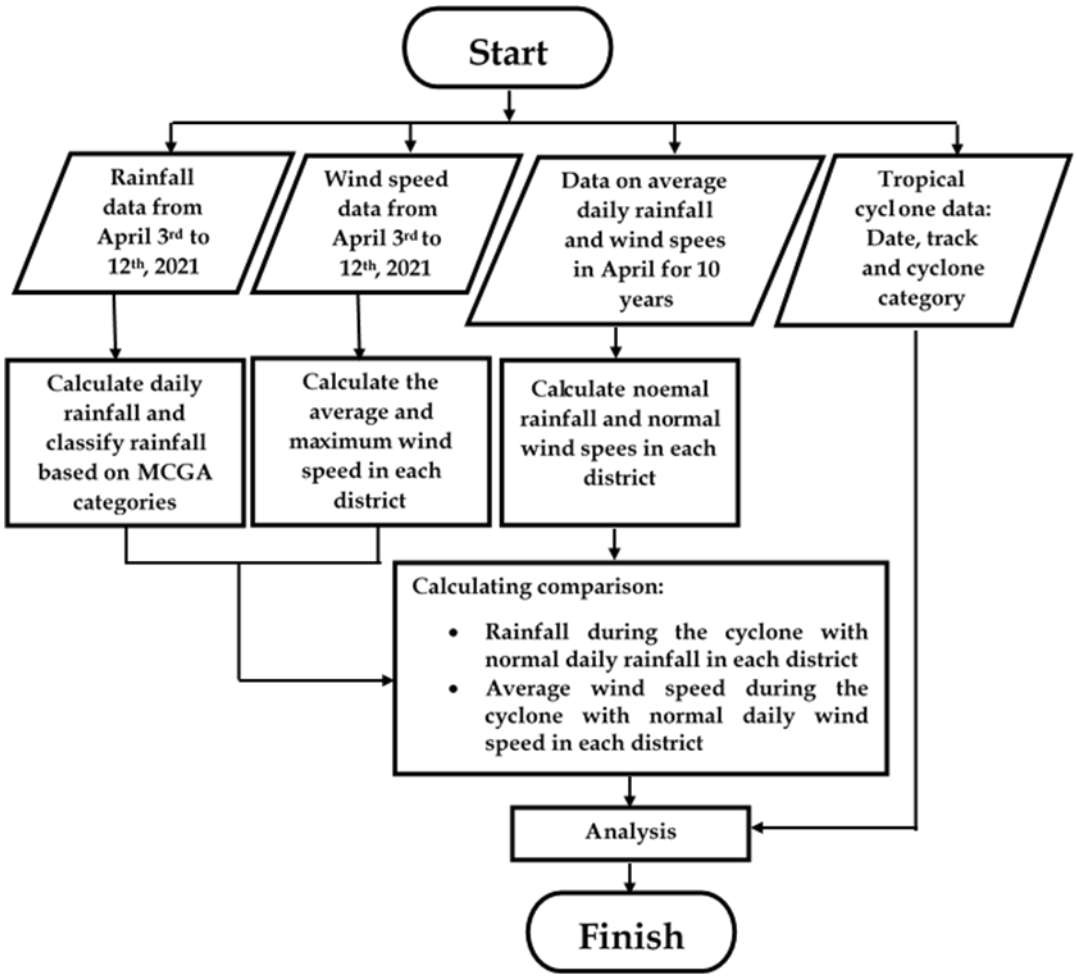


Figure 1. Research flow chart

Result and Discussion

In this study, rainfall and wind speed data in East Nusa Tenggara Province were processed during the Seroja Tropical Cyclone event, namely April 3 to 12, 2021. In addition, normal rainfall and wind speed data were also processed, namely the average rainfall and wind speed in April for 10 years (2011-2020). Data processing was conducted in 15 districts in East Nusa Tenggara Province, namely Lembata, Malacca, Ngada, Sabu Raijua, South Central Timor, Kupang, Rote Ndao, North Central Timor, West Sumba, Sikka, Manggarai, Alor, East Flores, East Sumba and Ende. These districts generally represent all other regions in East Nusa Tenggara Province. Then, the daily rainfall data during the Seroja Tropical Cyclone event can be grouped based on Meteorology, Climatology and Geophysics Agency categories in Table 3. Furthermore, the percentage comparison of the average daily rainfall during the Seroja Tropical Cyclone event with the average daily rainfall in each district is calculated. As for wind speed data, the daily average and maximum are calculated. Then the percentage comparison with the average daily wind speed in each district is calculated.

Based on the data in Figure 3 and 4, it is known that Seroja started to grow as a low category tropical cyclone on April 3, 2021 and moved slowly near Rote Island, East Nusa Tenggara

Province with wind speed reaching 30 knots. On April 4 to 5, Seroja continued to intensify into a category 2 tropical cyclone with wind speeds increasing to 50 knots and moving westward. On April 6 and 7, Seroja weakened again to a low category with wind speeds decreasing to 40 knots and moved southwestward and began to move away from East Nusa Tenggara Province. On April 8 and 9, Seroja interacted with Tropical Cyclone Odette through the Fujiwara Effect for a period of about 36 to 48 hours [10]. Fujiwara Effect or also called Fujiwara Interaction is a phenomenon that occurs when two cyclonic storm vortex centers move closer to each other and reduce the distance between each cyclonic storm low pressure vortex center. Then on April 10, Seroja turned southeast towards the Western Australian Coast and steadily intensified to a category 3 tropical cyclone on April 11. Seroja continued to move inland with rapid motion and finally weakened below tropical cyclone intensity on the morning of April 12 near Dalwallinu Town. The track of Tropical Cyclone Seroja is shown in Figure 2.

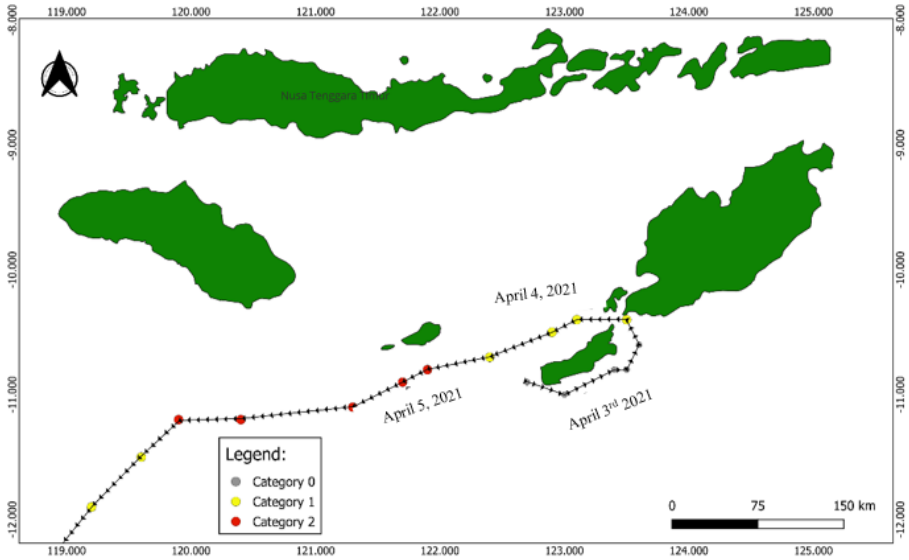


Figure 2. Trajectory of Seroja Tropical Cyclone

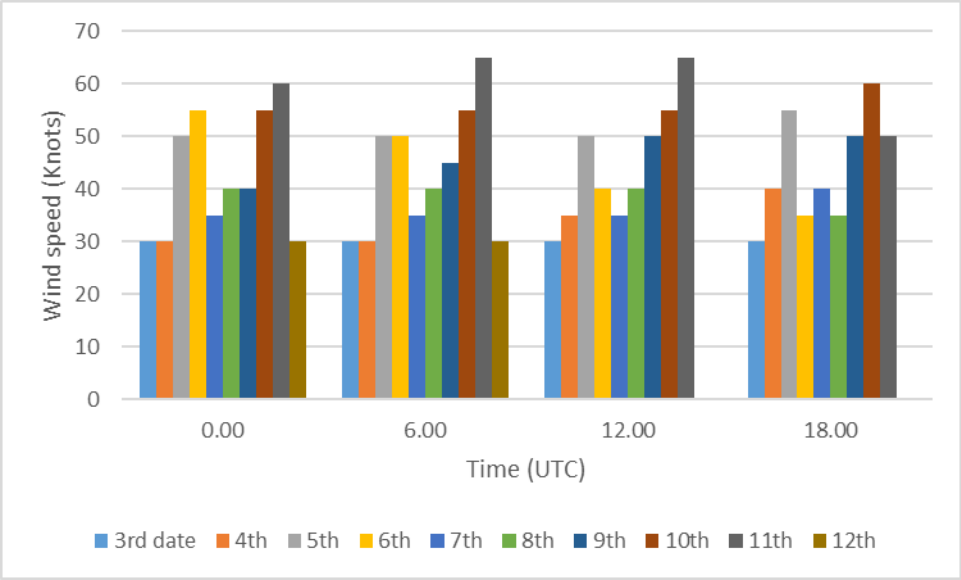


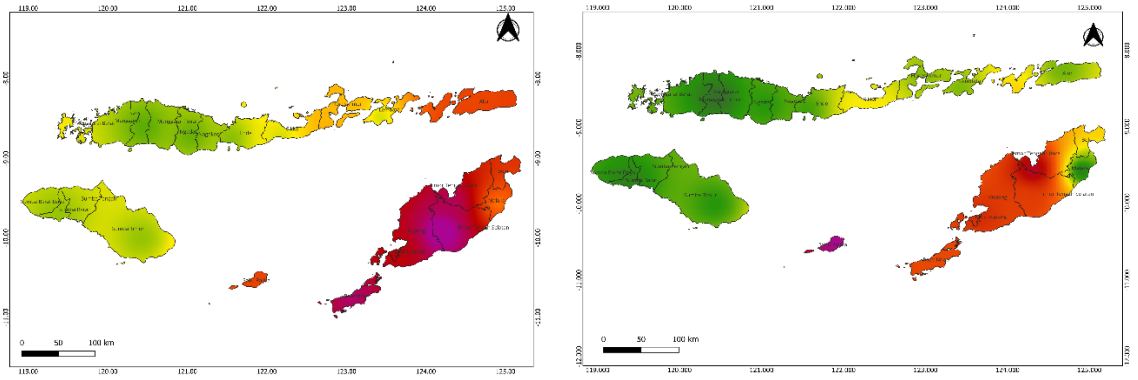
Figure 3. Wind speed around the center of Tropical Cyclone Seroja

Furthermore, data processing was carried out for rainfall and wind speed parameters in several affected districts in East Nusa Tenggara Province. In this study, the data used are rainfall data in several districts affected by Tropical Cyclone Seroja on April 3 to 12, 2021 and average daily rainfall data in April for 10 years (2011 – 2020) in each of these districts. The type of data used is reanalysis data downloaded at one coordinate point in each district. Based on the rainfall data during the Seroja Tropical Cyclone event, the daily rainfall in each district is shown in Table 3.

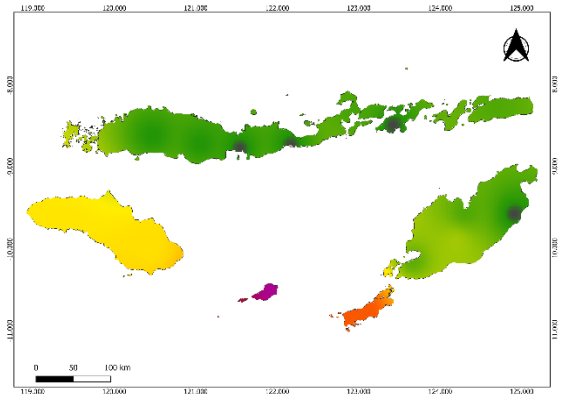
Table 3. Daily rainfall during the Seroja Tropical Cyclone event

District	Rainfall intensity (mm/day) on the date:									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Lembata	17	33	0	2	0	1	0	0	0	0
Malacca	46	15	0	0	8	4	0	0	0	0
Ngada	7	20	1	8	7	12	5	1	0	1
Sabu Raijua	64	225	173	4	0	0	1	0	0	0
South Central Timor	166	119	12	0	10	1	0	0	0	0
Kupang	103	128	6	0	7	17	0	0	1	0
Rote Ndao	135	112	52	0	1	1	0	0	0	0
North Central Timor	129	164	5	0	0	0	0	0	0	0
West Sumba	11	15	22	11	7	1	1	0	0	0
Sikka	17	50	0	0	2	0	0	0	0	0
Manggarai	6	10	1	17	11	19	1	3	0	0
Alor	63	31	5	3	26	15	0	0	1	4
East Flores	30	34	4	6	9	12	8	0	0	0
East Sumba	11	20	23	2	10	12	4	4	1	0
Ende	10	24	0	3	1	0	4	0	0	0

Based on the table above, the rainfall data can be interpreted in the form of a map as shown in the following figure.



(a) (b)



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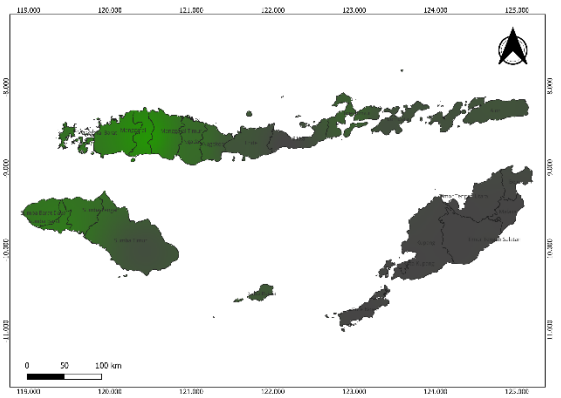

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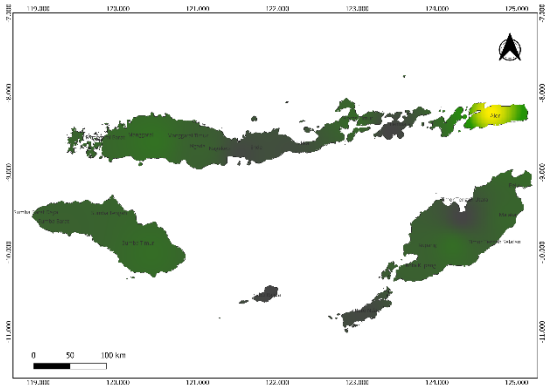

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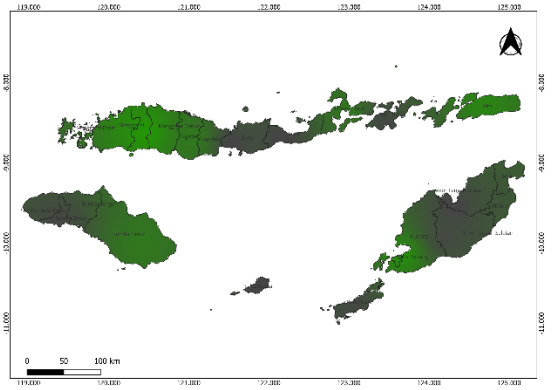

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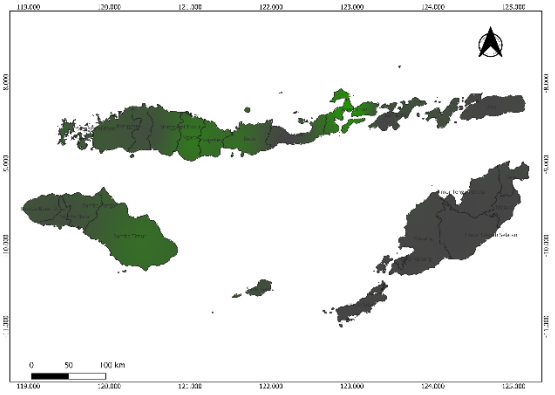

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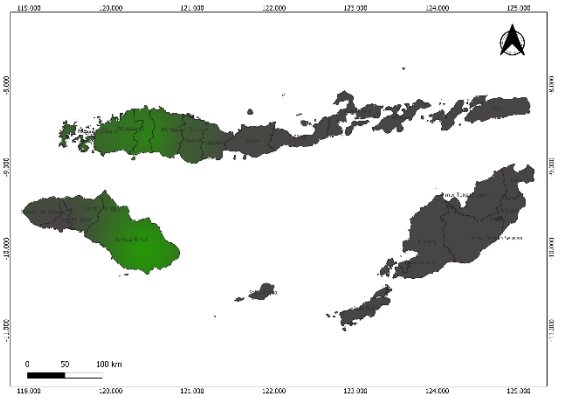

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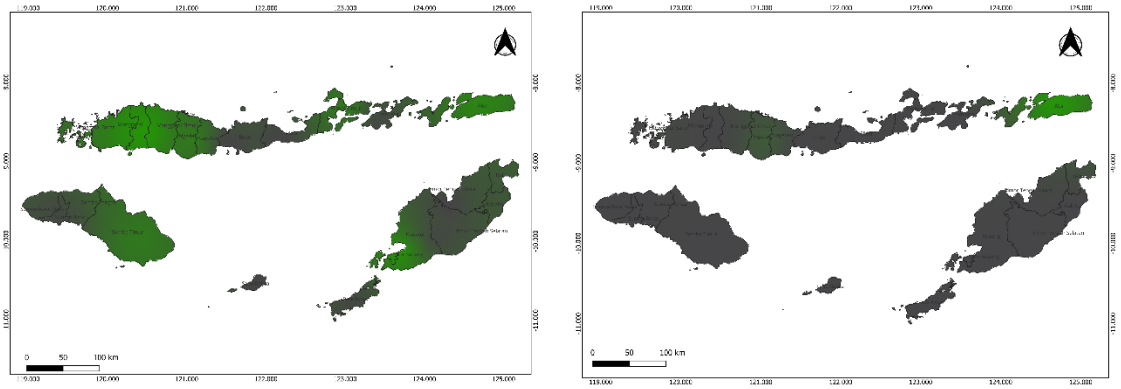

(i) (j)

Figure 4. Rainfall map during the consecutive occurrence of Tropical Cyclone Seroja on April 3 to 12, 2021

Based on Table 4, it can be seen that several districts in East Nusa Tenggara Province only experienced high rainfall on April 3 to 5, 2021. The district with the highest rainfall is Sabu Raijua, which reached 225 mm/day on April 4, 2021. In addition, it can be seen that on April 3, many districts experienced rainfall in the categories of heavy, very heavy and extreme rain. These districts are Sabu Raijua, Alor, South Central Timor, Kupang, Rote Ndao, and North Central Timor. Then on April 4, rainfall in these districts is still in the category of heavy to extreme rain except in Alor District which has decreased to the category of moderate rain. Furthermore, on April 5, in general, rainfall in all districts was already under the category of heavy rain. However, Sabu Raijua and Rote Ndao Regencies are still in the extreme rain and heavy rain categories. Meanwhile, from April 6 to 12, rainfall conditions in East Nusa Tenggara Province were already under the category of heavy rain as shown in Table 3.
Furthermore, the normal daily rainfall data in each district is processed. The data processing aims to compare rainfall that occurs especially during the Seroja Tropical Cyclone period with normal rainfall in several districts in East Nusa Tenggara Province. Processing was done by calculating the average daily rainfall for 10 years (2011 - 2020) in April in each district using the following equation:

$$Normal\ rainfall = \frac{\sum Average\ daily\ rainfall\ 2011-2020}{Many\ data}$$

$$= \frac{Daily\ rainfall\ in\ 2011+\cdots+\cdots+daily\ rainfall\ in\ 2020}{10} \qquad (1)$$

Then the percentage comparison of average daily rainfall during the Seroja Tropical Cyclone event with normal rainfall in each district was calculated. The results obtained are shown in Table 4 and Table 5 below.

Table 4. Normal daily rainfall in several districts in East Nusa Tenggara Province on 2011-2020

District	Normal daily rainfall (mm/day)
Lembata	2.40
Malacca	4.40
Ngada	6.90
Sabu	2.60
South Central Timor	3.60
Kupang	3.60
Rote	2.30
North Central Timor	4.40
West Sumba	6.50
Sikka	2.90
Manggarai	9.10
Alor	9.80
East Flores	6.00
Lembata	2.40
Ende	4.40

Table 5. Percentage comparison of daily rainfall during the Seroja Tropical Cyclone event with normal daily rainfall in each district in East Nusa Tenggara Province

District	**Percentage comparison (%) on the date:**									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Lembata	708	1375	0	83	0	42	0	0	0	0
Malacca	1045	341	0	0	182	91	0	0	0	0
Ngada	101	290	14	116	101	174	72	14	0	14
Sabu	2231	8654	5692	154	0	0	38	0	0	0
South Central Timor	1972	1528	0	0	278	28	0	0	0	0
Kupang	2861	3556	167	0	194	472	0	0	28	0
Rote	5870	4870	2261	0	43	43	0	0	0	0
North Central Timor	2932	3727	114	0	0	0	0	0	0	0
West Sumba	169	231	338	169	108	15	15	0	0	0
Sikka	586	1724	0	0	69	0	0	0	0	0
Manggarai	66	110	11	187	121	209	11	33	0	0
Alor	643	316	51	31	265	153	0	0	10	41
East Flores	500	567	67	100	150	200	133	0	0	0
East Sumba	234	426	489	43	213	255	85	85	21	0
Ende	238	571	0	71	24	0	95	0	0	0

Based on the table above, the maximum percentage value can be interpreted in the following figure.

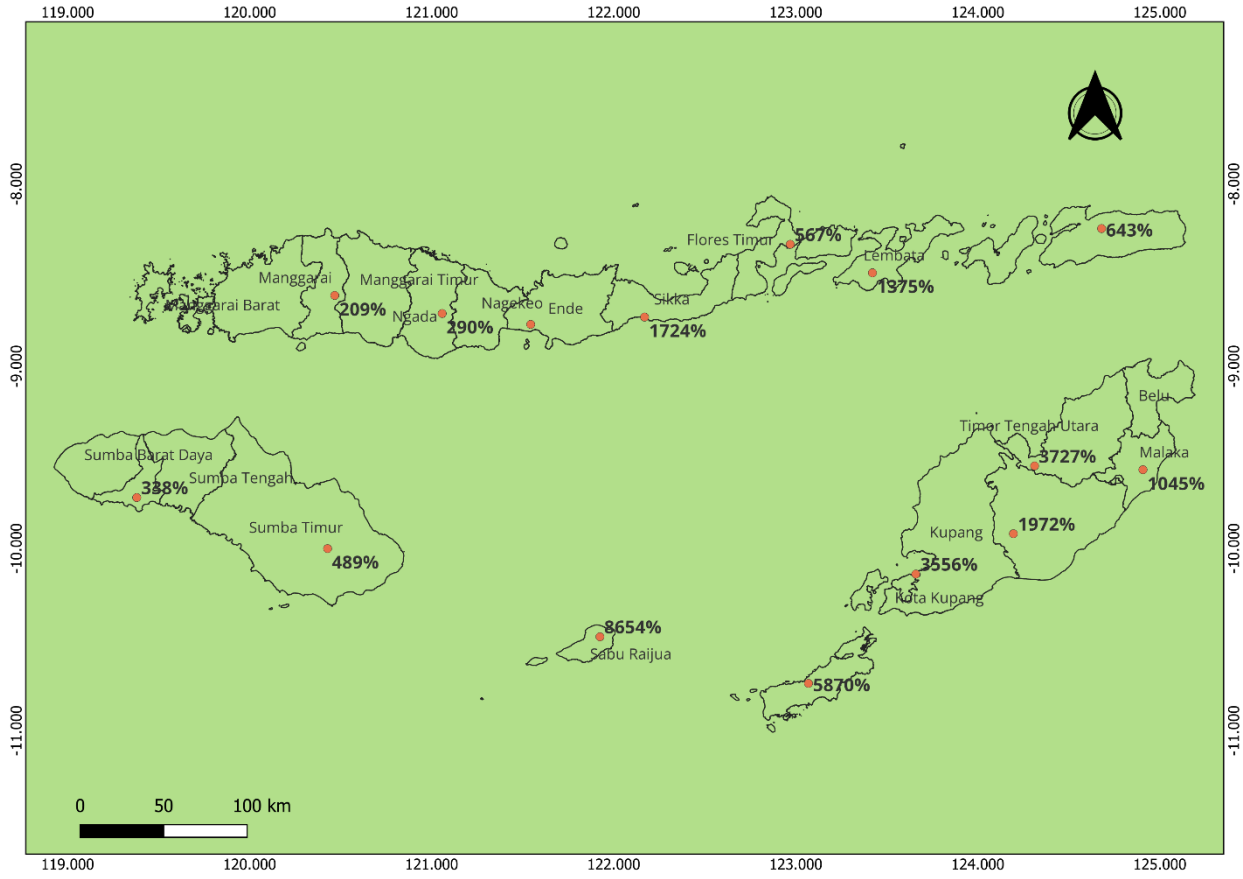

Figure 5. Maximum percentage value in each district [Personal references].

Table 5 shows the percentage comparison of daily rainfall during the Seroja Tropical Cyclone event with normal daily rainfall in each district. Based on Table 4.3, on April 3 and 4, 2021, it can be seen that the percentage of comparison in almost all districts in East Nusa Tenggara Province is more than 100%, which means that the accumulation of rainfall for 1 day during the Seroja Tropical Cyclone event has increased from the normal daily rainfall in the district. On April 3 to 5, 2021, the comparison percentage value in some districts even reached more than 1000% percent with the highest value of 8654% on April 4, 2021 in Sabu Raijua Regency which means that the rainfall for 1 day during the Seroja Tropical Cyclone event was equal to 8 times the normal daily rainfall in the district. In addition, on April 5 to 12, the percentage value is generally 0% which means that during the Seroja Tropical Cyclone event, there was no rainfall in the district.

One of the impacts of tropical cyclones is an increase in rainfall around the cyclone growth area. In the case of Tropical Cyclone Seroja, the affected area in Indonesia is East Nusa Tenggara Province. Extreme rainfall can be influenced by several factors, such as air humidity and cloud temperature conditions. According to research conducted by Nugroho et al (2021), the relative air humidity in East Nusa Tenggara Province during the Seroja event reached 90% and the cloud top temperature was very low, reaching -80°C [21]. The conditions of air humidity and cloud temperature indicate the growth of convective clouds. The growth of convective clouds can cause rainfall to reach the extreme rainfall category. This is also proven in research conducted by Sa'adah and Sugihartati (2017) which states that air humidity in the

range of 75% to 95% indicates the growth of convective clouds that cause extreme rainfall during the Yvette Tropical Cyclone event [22].

The distribution of rainfall in East Nusa Tenggara Province during Tropical Cyclones is generally uneven. Some areas experienced high intensity rain while other areas only experienced low intensity rain. Based on the results obtained in this study, it can be seen that the areas that experienced high rainfall to reach the extreme rain category during the Seroja Tropical Cyclone event were Alor, Sabu Raijua, South Central Timor, Kupang, Rote Ndao, and North Central Timor. While other districts only experienced light to moderate rain. When viewed based on the location and trajectory of Tropical Cyclone Seroja, it can be seen that the districts with high rainfall are areas with close proximity to the cyclone trajectory as shown in Figure 1. On April 3, the center of Tropical Cyclone Seroja was very close to several districts such as Rote Ndao District with a distance ranging from 11 km to 26 km. In addition, other districts with close proximity are Kupang, South Central Timor, and North Central Timor Districts with distances ranging from 28 km to 136 km. Rainfall in these districts is in the very heavy to extreme category. Then on April 4, rainfall in these areas increased. This occurred due to the trajectory of Tropical Cyclone Seroja which moved closer to these areas. Then on April 5, rainfall began to decrease drastically to reach the category of light rain. However, in Sabu Raijua and Rote Ndao Regencies, rainfall conditions are still in the extreme rain and heavy rain categories. This occurred because on April 5, Tropical Cyclone Seroja began to move away from the East Nusa Tenggara Province area but still passed through the waters between Sabu Raijua and Rote Ndao Regencies with the closest distance of 38 km from Sabu Raijua Regency and 300 km from Rote Ndao Regency. Therefore, the impact only occurred in these two regencies. Whereas on April 6, Tropical Cyclone Seroja had moved away from the East Nusa Tenggara region completely so that rainfall conditions in all regions in East Nusa Tenggara were only in the category of light rain to moderate rain.

Based on the above analysis, it can be said that the closer the location of the Cyclone to an area, the greater the influence on the increase in rainfall. This is also evidenced in research conducted by Najib (2018) with the case study of Cempaka Tropical Cyclone which states that the closer an area is to the center of the tropical cyclone, the higher the rainfall increase and the rain intensity experiences a maximum increase when the center of the tropical cyclone is in the closest position to the study area.

Then, if reviewed based on the Seroja Tropical Cyclone category, on April 3 to 4, Seroja Tropical Cyclone was still in the low category. However, rainfall in several districts such as South Central East, Kupang, Rote Ndao, and North Central East was in the very heavy to extreme rain category. On April 5, Seroja increased to category 2 but the affected areas were only Sabu Raijua and Rote Ndao districts where the two districts were the closest to Seroja's location at the time. Based on this, it can be concluded that the cyclone category does not directly impact rainfall but the distance of an area to the center of the cyclone is more influential in increasing rainfall.

In addition to rainfall, another weather parameter that can be affected by the tropical cyclone phenomenon is wind speed. Therefore, in this research, wind speed data processing is also carried out. The data used is surface wind speed reanalysis data. The results of wind data processing provide average and maximum wind speed values in 15 districts on April 3 to 12, 2021 and average wind speed data in April for 10 years (2011 - 2020) in several districts in East

Nusa Tenggara Province. The average wind speed data during the Seroja Tropical Cyclone event is shown in Table 6 below.

Table 6. Wind speed average during the Seroja Tropical Cyclone event in East Nusa Tenggara Province on April 2021

District	Wind Speed Average (Knots) on Dates:									
	3	4	5	6	7	8	9	10	11	12
Lembata	17.87	17.07	13.87	9.87	5.84	4.41	7.60	9.79	9.92	6.98
Malacca	8.63	9.64	6.88	4.49	2.99	1.93	2.85	2.59	2.56	2.73
Ngada	4.42	3.91	4.02	1.79	0.92	1.18	1.57	2.13	1.91	1.50
Sabu Raijua	17.62	31.05	31.20	12.96	5.86	3.95	5.16	6.41	7.30	4.73
South Central Timor	5.00	9.66	4.76	3.02	2.05	2.30	3.01	2.81	3.05	2.81
Kupang	10.68	15.36	7.87	4.63	2.07	2.40	3.17	3.36	3.06	3.16
Rote Ndao	14.00	15.49	17.65	8.83	4.03	4.47	5.33	6.56	5.81	5.42
North Central Timor	21.51	30.29	15.74	13.88	5.42	2.96	6.36	8.62	8.02	5.90
West Sumba	8.61	6.32	9.79	10.86	3.53	3.27	2.45	2.94	3.31	2.12
Sikka	8.69	12.75	8.54	10.00	4.99	2.99	4.56	7.25	7.33	5.37
Manggarai	6.03	5.94	5.02	3.63	1.51	1.78	2.14	1.81	1.40	1.16
Alor	7.64	7.37	4.92	2.53	2.05	2.88	3.56	2.57	2.77	1.80
East Flores	11.19	10.44	8.13	5.05	4.08	3.88	3.50	3.50	3.27	2.54
East Sumba	8.67	8.37	13.34	8.00	2.73	3.21	1.82	1.65	1.33	2.03
Ende	3.49	4.35	4.96	7.81	3.57	2.58	2.85	4.36	4.37	3.09

Based on Table 6, there are two districts in Nusa Tenggara Timur experiencing large wind speeds that reach the strong wind category, namely Sabu Raijua and Timor Tengah Utara. On April 3, the wind speed in Timor Tengah Utara District reached the strong wind category with a wind speed of 21.51 Knots. Then, on the 4th, it increased to reach the extreme wind category with a wind speed of 30.29 Knots. While on April 5 to 12, it decreased again to below the strong wind category. Sabu Raijua Regency experienced extreme winds on April 4 and 5. On the 4th, the wind speed in Sabu Raijua District was 31.05 Knots and increased to 31.20 Knots on April 5th. Then on April 6 to 12, the wind speed in Sabu Raijua District was under the strong wind category. Based on this, it can be said that Tropical Cyclone Seroja has an impact on strong winds only on April 3 to 5, 2021.

In addition, wind speed conditions in East Nusa Tenggara can also be reviewed based on the maximum wind speed. This needs to be done because the greater the wind speed in an area, the greater the impact. Table 7 below shows the maximum wind speed during the Seroja Tropical Cyclone event in each district.

Table 7 shows the maximum wind speed in several districts during the Seroja Tropical Cyclone Event. Based on the data, it can be seen that the wind speed in Nusa Tenggara Timur Province on April 3 to 5 was generally in the category of strong winds to extreme winds. Regencies with wind speeds reaching strong to extreme winds are Lembata, Sabu Raijua, Kupang, Rote Ndao, and Timor Tengah Utara.

Table 7. Maximum wind speed during Tropical Cyclone Seroja event

District	Maximum Wind Speed (Knots) on Date:									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Lembata	25.58	23.42	17.84	13.99	9.71	5.89	12.27	11.33	12.56	10.89
Malacca	13.88	13.10	10.46	6.84	3.97	3.59	6.83	5.59	5.00	5.80
Ngada	6.38	5.04	6.02	3.61	1.61	1.87	2.79	3.34	3.74	2.80
Sabu	28.09	39.35	43.90	18.04	11.17	5.79	7.02	7.89	9.94	6.72
South Central Timor	8.30	13.16	7.82	4.24	3.96	4.49	7.15	5.77	5.88	4.88
Kupang	13.90	23.44	14.05	8.20	3.45	4.51	6.44	5.77	6.09	5.11
Rote	19.62	35.84	26.36	12.41	6.64	7.35	7.50	7.20	8.75	7.00
North Central Timor	27.96	33.33	22.34	17.27	11.57	6.63	9.16	10.20	10.35	8.84
West Sumba	11.24	10.71	15.06	16.50	6.89	5.34	4.64	5.02	5.54	3.78
Sikka	13.86	16.98	11.65	12.42	8.22	5.17	7.19	8.11	9.10	8.45
Manggarai	8.81	8.13	8.45	7.21	3.95	3.59	3.12	2.64	2.06	1.91
Alor	11.06	11.86	8.29	5.78	4.30	4.53	5.51	3.40	3.70	2.49
East Flores	15.81	15.22	11.28	7.12	6.38	5.61	4.27	5.22	4.92	3.67
East Sumba	12.33	10.52	18.83	13.99	6.96	5.98	2.93	2.61	2.56	2.78
Ende	5.03	8.45	8.15	11.01	6.46	4.00	5.63	5.60	6.13	5.07

Based on Table 7, it can be seen that there are 5 districts with wind speeds in the strong to extreme wind category. On April 3, the wind speed in Lembata Regency reached the extreme wind category with a wind speed of 25.58 Knots, and decreased to 23.42 Knots or in the strong wind category on April 4. Then on April 5 to 12, the wind speed in Lembata Regency was under the strong wind category. In Sabu Raijua Regency, the wind speed continued to increase and was in the extreme wind category from April 3 to 5 with wind speeds of 28.09 Knots, 39. 35 Knots, and 43.90 Knots respectively. Then on April 6 to 12, the wind speed in Sabu Raijua Regency was under the strong wind category. In Kupang Regency, the wind speed was in the strong wind category on April 4, while for the other dates the wind speed was below the strong wind category. In Rote Ndao district, wind speed reached the extreme wind category on April 4 and 5, while on the other dates, wind speed was below the strong wind category. In Timor Tengah Utara district, wind speed reached the extreme wind category on April 3 and 4, while on April 5 it was in the strong wind category. Then on April 6 to 12, the wind speed in Timor Tengah Utara district was under the strong wind category. Based on this, it can be said that the Seroja Tropical Cyclone event had an impact on wind speed in Nusa Tenggara Timur Province only on April 3 to 5, 2021.

Based on the maximum wind speed as shown in the figure above, there are several areas in Nusa Tenggara Timur Province with wind speeds that reach the category of strong winds where the maximum wind speed reaches 43.9 Knots. These strong wind events generally occurred on April 3 to 5, 2021 which were spread across four districts, namely Lembata, Sabu Raijua, Rote Ndao, and Timor Tengah Utara.

Wind speed during a tropical cyclone event can increase from the normal wind speed in an area, so it is necessary to know the comparison of wind speed during the Seroja Tropical Cyclone event with the normal wind speed in each district in Nusa Tenggara Timur Province. Normal wind speed data is obtained by calculating the average daily wind speed for 10 years (2011 - 2020) on April in each district and the results are shown in Table 8.

Table 8. Normal daily wind speed in April in several districts in Nusa Tenggara Timur Province in 2011 - 2020

District	Normal daily wind speed (knots)
Lembata	2.31
Malacca	2.44
Ngada	1.10
Sabu Raijua	7.34
South Central Timor	2.80
Kupang	4.53
Rote Ndao	6.88
North Central Timor	1.81
West Sumba	2.33
Sikka	2.35
Manggarai	0.62
Alor	0.78
East Flores	1.17
East Sumba	2.75
Ende	1.63

Based on these data, the percentage comparison of the average wind speed during the Seroja Tropical Cyclone event with the normal daily wind speed in each district was calculated, resulting in the results shown in Table 10. Based on these results, it can be seen that in almost all districts, the percentage value of the comparison exceeds 100%, which means that the wind speed during the cyclone event has increased compared to the average wind speed in each district. The highest percentage is in Timor Tengah Utara Regency with 1674% on April 4, 2021. This shows that the wind speed during the Seroja Tropical Cyclone event was greater than the normal wind speed in several districts in Nusa Tenggara Timur Province.

As in the case of rainfall, where rainfall during the Seroja Tropical Cyclone event is greater than the normal value, this is also the case for wind speed, where wind speed during the Seroja Tropical Cyclone event is greater than normal. Weather systems caused by a tropical cyclone can increase the wind speed across an area. During the Seroja event, the maximum wind speed reached 43.90 knots which occurred on April 5, 2021 in Sabu Raijua Regency.

Table 9. Percentage comparison of wind speed during the Seroja event with the average wind speed in the affected districts.

District	Percentage Comparison (%) on the date:									
	3	4	5	6	7	8	9	10	11	12
Lembata	774	739	601	428	253	191	329	424	430	302
Malacca	353	395	282	184	122	79	117	106	105	112
Ngada	403	357	366	163	84	107	143	194	174	137
Sabu	240	423	425	177	80	54	70	87	100	65
South Central Timor	179	345	170	108	73	82	107	100	109	100
Kupang	236	339	174	102	46	53	70	74	68	70
Rote	203	225	257	128	59	65	78	95	84	79
North Central Timor	1188	1674	869	767	299	164	352	476	443	326
West Sumba	369	271	419	465	151	140	105	126	142	91
Sikka	371	543	364	426	213	127	194	309	312	229
Manggarai	973	958	810	585	244	286	345	292	225	186
Alor	982	946	632	325	264	371	457	330	356	231
East Flores	954	890	694	431	348	331	299	298	279	216
East Sumba	316	305	486	291	100	117	66	60	48	74
Ende	214	267	304	478	219	158	174	267	268	189

Tropical Cyclone Seroja caused impacts in the form of strong winds based on BMKG categories only in several areas namely Lembata, Sabu Raijua, Rote Ndao, and North Central Timor Regencies. On April 3, areas that experienced strong to extreme winds were Lembata, Sabu Raijua, and Timor Tengah Utara. Then on April 4, the districts of Sabu Raijua, Kupang, Rote Ndao, and Timor Tengah Utara, while on April 5, the districts of Sabu Raijua and Rote Ndao. Based on these data, it can be seen that these areas are close to the trajectory of Tropical Cyclone Seroja.

When viewed from its category, on April 4, 2021 Tropical Cyclone Seroja was still in category 1. However, it has been able to have an impact in the form of strong winds with a maximum speed that reached 39.35 knots in Sabu Raijua Regency. Then on April 5, 2021, Seroja increased to Tropical Cyclone category 2 and in general the maximum wind speed in East Nusa Tenggara also increased to reach 43.90 knots (22.58 m/s). Furthermore, on April 6, 2021, Seroja still remained at category 2 and decreased to category 1 on the 7th to the 9th then increased again to category 2 and finally returned to category 1 before becoming extinct on April 12, 2021. However, the wind speed in East Nusa Tenggara has decreased since April 6, 2021 and did not increase again even though the category of Tropical Cyclone Seroja increased. This is because, on the 6th and onwards until it finally became extinct on April 12, 2021 Tropical Cyclone Seroja had begun to move away from the East Nusa Tenggara area. So it can be said that the tropical cyclone category does not directly influence the wind speed in an area, but the distance between the area and the center of the Tropical Cyclone has more influence on the wind speed in an area. The same thing is also proven in the research conducted by Sumaja et al (2021) with the case study of tropical cyclones LUA and Narelle.

Conclusion

As for the conclusions obtained, Seroja Tropical Cyclone affects rainfall and wind speed in East Nusa Tenggara Province up to a radius of about 400 km from the center of the cyclone. This is characterized by high rainfall and wind speed when Tropical Cyclone Seroja reaches the extreme category. In addition, it is known that the distance of an area to the cyclone center is more influential in increasing rainfall and wind speed in the area. The percentage value of the comparison of the average rainfall and wind speed during the Seroja Tropical Cyclone event with the normal rainfall and wind speed in the affected area shows that there is an increase in rainfall and wind speed during the Seroja Tropical Cyclone event from the normal values.

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