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The Impact of Climate on Flood Disasters in Indonesia

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Abstract – Weather changes that are quite extreme at this time are considered quite disturbing to the community. Extreme weather certainly opens up opportunities for disasters such as floods and so on. The occurrence of flooding certainly causes huge losses in an area. The purpose of this study was to determine the effect of climate on household flooding. The data used in this study is sourced from the 2018 National Socio-Economic Survey (SUSENAS) data, with a total of 293,651 households covering all provinces in Indonesia. The data analysis method used is Ordinary Least Square (OLS). The results of this study indicate that rainfall and air humidity have a positive effect of 0.0003% and 0.11%, respectively, on the occurrence of flooding. Another climate element, namely solar radiation, has a negative effect of 0.04% on floods that occur in Indonesia in general. If it is divided into rural and urban areas, the rainfall value in urban areas is higher but air humidity is lower than in rural areas. Meanwhile, solar radiation is relatively the same in urban and rural areas.

Keywords – Climate, Flood, rainfall, Indonesia, Ordinary Least Square (OLS)

I. INTRODUCTION

Climate is the average weather condition in a relatively long time and covers a large area. The process of occurrence of weather and climate is a combination of the same atmospheric variables called climate elements. Climate and its elements are important things to pay attention to, study, and anticipate its effects, because its effects often cause problems for humans and other living things (Faradiba, F., & Zet 2020; Miftahuddin 2018). Some of the climatic elements/factors that have been mentioned previously are certainly an important concern in anticipating disasters that may occur. Climate is a natural phenomenon that is driven by a combination of several elements, namely solar radiation, temperature, humidity, clouds, rain, evaporation, air pressure, and wind (Tjasyono 2004).

Rain is part of the water cycle to maintain the balance of water in the universe. On the other hand, rain has the potential for disaster if the amount and distribution is not controlled. Rainfall intensity is the amount of rainfall expressed in rain height or rainfall volume per unit time, which occurs during a period of concentrated rainwater (Tambunan 2017). The amount of rainfall intensity varies depending on the duration of rainfall and the frequency of occurrence (Juleha 2016). Rainfall An increase in the intensity of extreme rainfall can result in quite a bad situation, among which the most frequent is flooding. Not only floods, several conditions that have a high chance of appearing are wind storms, tsunami waves and many other negative impacts that can be caused (Faradiba 2020).

In addition to rainfall, the element of air humidity also takes part in contributing to the occurrence of floods. Air humidity is the content of water vapor in the air. The amount of water vapor in the air is actually only a small part of the entire atmosphere. Roughly about 2 percent of the total mass (Sherwood et al. 2010). However, the water vapor is one of the most important air components, in terms of weather and climate. The air humidity is large enough in an area, giving an indication that the air in that area contains a lot of water vapor or the air is wet (Pierrehumbert, Brogniez, and Roca 2007). The high percentage of air humidity is in line with the increase in rainfall intensity. The high and low humidity in a place really depends on several factors, namely temperature, air pressure, wind movement, quantity and quality of radiation.

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Sunlight affects the rise and fall of the earth's surface temperature and affects other weather elements. Apart from controlling climate and weather, the sun is an important source of energy for life. The potential of solar energy can be utilized for the human environment (Sari, Yulkifli, and Kamus 2015). Solar radiation duration (LPM) is one of several elements of climatology. The duration of solar radiation or the duration of solar radiation (periodicity) is the length of time the sun shines brightly on the earth's surface which is calculated from sunrise to sunset (Matuszko and Węglarczyk 2015). The amount of solar radiation is written in units of hours, the value of tenths, or in units of percent of the maximum day length (Pujiastuti and Harjoko 2016).

Climate change that occurs has a very broad impact on people's lives. The increase in the earth's temperature does not only have an impact on increasing the temperature of the earth but also changes the climate system which affects various aspects of changes in nature and human life, one of which is the quantity of water. An increase in the quantity of water caused by extreme climate change will trigger a flood disaster (Van Aalst 2006; Faradiba 2021).

Indonesia's environmental conditions are very diverse and dynamic, both according to time and space. Indonesia is one of the countries that have been hit by many disasters (Rosyidie 2013). The National Disaster Management Agency (BNPB) reported that there were 2,203 natural disasters that occurred in Indonesia in the last 10 months or starting from January 1, 2021 to October 30, 2021. The most frequent natural disaster events were floods, then tornadoes, landslides, and so on. forest and land fires. The majority of these natural disasters occurred in West Java, East Java, Central Java, and Aceh. Based on BNPB data, there were 891 flood events, 587 tornadoes, 406 landslides, and 258 forest and land fires (BNPB 2021).

For Indonesia, the most frequent disasters occur, especially during the rainy season. The water level can reach 30 cm or even more. Floods not only inundate rural areas but also urban areas. Flood disasters that occur can destroy people's houses, houses of worship, bridges, airports, public and other social facilities.

II. Methods

The data used in this study was sourced from the 2018 National Socio-Economic Survey (SUSENAS) data, with a total of 293,651 household observations covering all provinces in Indonesia. In this study, several climatic factors were analyzed such as rainfall, air humidity and solar radiation. The method of analysis uses Ordinary Least Square (OLS) with climate factors as the independent variable and flood disaster as the dependent variable. The flood concept used is that it has been inundated by more than 30 cm of water after 2 hours of stopping the rain. The influence between variables can be seen from the coefficient value of the independent variable. In this study, it will also be disaggregated by urban and rural areas for flood cases that occurred in Indonesia. To what extent are the impacts different for urban and rural areas affected by flooding.

III. Result And Discussions

The results of this study obtained several forms of relationship patterns related to flood disasters. The first relationship is related to rain and floods in Indonesia in general; The second relationship is related to air humidity to flood disasters in the territory of Indonesia in general; The third relationship is related to solar radiation to flood disasters in Indonesia in general; In addition, the analysis is also carried out by dividing the specific urban and rural areas in relation to the flood disaster that occurred.

Table 1. The Effect of Rainfall on Flood Disasters in Indonesia

```
. reg r1520 hujan,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =      15.04
                                                Prob > F          =     0.0001
                                                R-squared         =     0.0001
                                                Root MSE          =     .18309

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hujan |   .0000287   7.41e-06     3.88   0.000     .0000142    .0000432
       _cons |    .029385   .001407     20.89   0.000     .0266274    .0321426
------------------------------------------------------------------------------
```

Rainfall is one of the elements that influence climate change. High rainfall intensity is an indicator that contributes greatly to the occurrence of floods. Based on table 1 the coefficient value of the rainfall variable is 0.00000287. From the results it means that an increase in the value of rainfall by 1 unit (mm) has a positive impact of 0.003% on the flood disaster that occurred. So if there is an increase in the intensity of extreme rainfall, of course, the percentage of flooding is very large.

Based on data analysis of rain and the nature of rain in September 2021 from the Meteorology, Climatology and Geophysics Agency (BMKG), namely high-very high rainfall (>300 mm / month) occurs in parts of North Sumatra, Parts of West Sumatra, Parts of Riau, Jambi Bagan eastern part of Bengkulu, eastern part of Lampung, part of Banten, part of West Kalimantan, part of Central Kalimantan, northern part of North Kalimantan, part of East Kalimantan, eastern part of South Kalimantan, Part of North Sulawesi, part of northern Gorontalo, part of Central Sulawesi, part of southern Sulawesi north, northern Southeast Sulawesi, parts of Maluku, parts of northern Maluku, parts of West Papua and western and central Papua. The nature of the rain in September 2021 in general is above normal (BMKG 2021).

The number of areas that include high – very high rainfall certainly opens up a huge opportunity for floods to occur in the area. As the results in table 1 show that an increase in the intensity of rainfall has a positive impact on the occurrence of floods.

Table 2. Effect of Air Humidity on Flood Disasters in Indonesian Territory

```
. reg r1520 lembab,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =      74.34
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0003
                                                Root MSE          =     .18307

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lembab |   .0011359   .0001317     8.62   0.000     .0008777    .0013941
       _cons |   -.053095   .0101643    -5.22   0.000    -.0730167   -.0331732
------------------------------------------------------------------------------
```

In addition to rainfall, another climatic element is air humidity. Based on table 2 the coefficient value of the air humidity variable is 0.0011359. From the results it means that an increase in the value of air humidity by 1 unit (^{o}C) has a positive impact of 0.11% on the flood disaster that occurred.

Based on data analysis and prediction of surface relative humidity in October 2021 from the Meteorology, Climatology and Geophysics Agency (BMKG), the relative humidity in the surface layer is generally above 80%. The relative humidity of the surface is predicted to generally range from 60-80% and will occur until the First Basis of November 2021 (BMKG 2021).

Tabel 3. The Effect of Sunlight on Flood Disasters in Indonesian Territory

```
. reg r1520 sinar,r

Linear regression                               Number of obs     =    293,651
                                                F(1, 293649)      =     122.88
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0004
                                                Root MSE          =     .18306

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       sinar |  -.0003919   .0000354   -11.08   0.000    -.0004611   -.0003226
       _cons |   .0581193   .0021718    26.76   0.000     .0538625     .062376
------------------------------------------------------------------------------
```

The results of the analysis for the climate element, namely solar radiation related to the occurrence of flood disasters, based on table 3 obtained a coefficient value of -0.0003919. From the results it means that an increase in the value of solar radiation by 1 unit (%) has a negative impact of 0.04% on the flood disaster that occurred. So if the increase in the percentage of sunlight is high, the chances of a flood disaster are small.

Furthermore, the analysis is carried out by adding control variables, namely flood disasters in urban and rural areas. This control variable serves to see the influence of climate elements, especially rainfall which is divided into two regions.

Tabel 4. The Effect of Rainfall on Flood Disasters in Urban and Rural Areas

```
. reg r1520 hujan if r105 ==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =      17.36
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0001
                                                Root MSE          =     .19745

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hujan |   .0000535   .0000128     4.17   0.000     .0000283    .0000787
       _cons |   .0307444   .0024103    12.76   0.000     .0260202    .0354686
------------------------------------------------------------------------------
```

a. Urban Areas

```
. reg r1520 hujan if r105 ==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =       3.67
                                                Prob > F          =     0.0555
                                                R-squared         =     0.0000
                                                Root MSE          =     .17135

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hujan |   .0000173   9.02e-06     1.91   0.056    -4.10e-07    .000035
       _cons |   .0270503   .0017267    15.67   0.000      .023666    .0304345
------------------------------------------------------------------------------
```

b. Rural Areas

Based on table 4a. obtained a coefficient value of 0.00000535. From the results it means that an increase in the intensity of rainfall in urban areas has a positive impact of 0.005% on the flood disaster that occurred. based on table 4b. obtained a coefficient value of 0.0000173. From the results it means that an increase in the intensity of rainfall in rural areas has a positive impact of 0.002% on the flood disaster that occurred.

Rain has a significant impact on flood disasters in rural and urban areas. The results of the addition of control variables can be seen in tables 4 and 5. From these results it can be seen that the rainfall coefficient value in urban areas is greater than in rural areas..

Flood is a complex problem, there are many factors that cause it, starting from the geological and geomorphological aspects of an area (Prabawadhani et al. 2016). In urban areas, green open spaces and urban parks are still a lot below the ideal area for a city, now less pressured by settlements and other uses that are considered capable of providing higher economic benefits. As a result of the reduced green open space (RTH) of the city, the infiltration rate in the area decreases while the velocity and runoff rate increase (Rafiq et al. 2016). When it rains heavily for a long time, most of the rainwater will flow over the land surface with great speed and volume and then accumulates into floods.

The causes of flood disasters in urban areas include: Development that is not environmentally sound, the absence of a clean lifestyle of the community, the absence of planning and maintenance of a good drainage system, the absence of consistency of the authorities in the Regional Spatial Plan (RTRW). the absence of conservation efforts to balance the water environment, the occurrence of land subsidence and very high rainfall (Asiedu 2020; Rahardjo 2014).

Tabel 5. The Effect of Air Humidity on Flood Disasters in Urban and Rural Areas

```
. reg r1520 lembab if r105 ==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =       6.98
                                                Prob > F          =     0.0082
                                                R-squared         =     0.0001
                                                Root MSE          =     .19746

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lembab |   .0005469    .000207     2.64   0.008     .0001411    .0009526
       _cons |  -.0014633   .0159291    -0.09   0.927     -.032684    .0297574
------------------------------------------------------------------------------
```

a. Urban Areas

```
. reg r1520 lembab if r105 ==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =     149.10
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0009
                                                Root MSE          =     .17127

------------------------------------------------------------------------------
             |               Robust
       r1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lembab |   .0020524   .0001681    12.21   0.000      .001723    .0023818
       _cons |  -.1288991   .0129743    -9.93   0.000     -.1543284   -.1034698
------------------------------------------------------------------------------
```

b. Rural Areas

Humidity has a significant positive impact on household flooding, both in rural areas and in urban areas. based on table 5a. obtained a coefficient value of 0.0005469. From the results it means that the level of air humidity in urban areas has a positive impact of 0.055% on the flood disaster that occurred. Meanwhile, based on table 5b. obtained a coefficient value of 0.0020524. From the results it means that the level of air humidity in rural areas has a positive impact of 0.21% on the flood disaster that occurred.

In line with table 4 regarding rainfall, of course, if the intensity of rainfall is high, the humidity level will also be high. However, when compared to urban and rural areas, the humidity in hot areas is much higher than in urban areas (Hage 1975). This is caused by the poor air quality in urban areas. The presence of pollutants produced by factory waste, infrastructure development, motor fuel and so on causes the air temperature in urban areas to increase which has an impact on the low level of air humidity. In contrast to conditions in rural areas that have good air quality (Manisalidis et al. 2020).

Tabel 6. The Effect of Sunlight on Flood Disasters in Urban and Rural Areas

```
. reg r1520 sinar if r105 ==1,r

Linear regression                               Number of obs     =    126,070
                                                F(1, 126068)      =      44.17
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0003
                                                Root MSE          =     .19743

------------------------------------------------------------------------------
             |               Robust
      r1520  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       sinar |  -.0004176   .0000628    -6.65   0.000    -.0005408   -.0002944
       _cons |    .065601   .0038441    17.07   0.000     .0580666    .0731354
------------------------------------------------------------------------------
```

a. Urban Areas

```
. reg r1520 sinar if r105 ==2,r

Linear regression                               Number of obs     =    167,581
                                                F(1, 167579)      =      87.52
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0004
                                                Root MSE          =     .17132

------------------------------------------------------------------------------
             |               Robust
      r1520  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       sinar |  -.0003805   .0000407    -9.36   0.000    -.0004602   -.0003008
       _cons |   .0529712   .0025135    21.07   0.000     .0480448    .0578977
------------------------------------------------------------------------------
```

b. Rural Areas

Solar radiation has a significant negative impact on household flooding in both urban and rural areas. based on table 6a. obtained a coefficient value of -0.0004176. From the results it means that the level of solar radiation in urban areas has a negative impact of 0.042% on the flood disaster that occurred. Meanwhile, based on table 6b. obtained a coefficient value of -0.0003805. From the results it means that the level of air irradiation in rural areas has a negative impact of 0.041% on the flood disaster that occurred.

The level of sunlight will certainly decrease if the value of rainfall is high and humidity is high. Low sunlight causes the air temperature to drop (Mekhilef, Saidur, and Kamalisarvestani 2012). If the level of sunlight is high, of course, it will reduce the chance of flooding.

IV. CONCLUSIONS

The conclusion in this study is that the intensity of rainfall and air humidity have a positive effect of 0.0003% and 0.11%, respectively, on the occurrence of floods. Another climate element, namely solar radiation, has a negative effect of 0.04% on floods that occur in Indonesia in general. When differentiated into rural and urban areas, the rainfall value in urban areas is higher but air humidity is lower than in rural areas. Meanwhile, solar radiation is relatively similar in urban and rural areas.

REFERENCES

[1] Van Aalst, Maarten K. 2006. "The Impacts of Climate Change on the Risk of Natural Disasters." *Disasters* 30(1):5–18.

[2] Asiedu, Joel Bernard. 2020. "REVIEWING THE ARGUMENT ON FLOODS IN URBAN AREAS: A LOOK AT THE CAUSES." *Theoretical and Empirical Researches in Urban Management* 15(1):24–41.

[3] BMKG. 2021. *Analisis Dinamika Atmosfer 11 Oktober 2021*.

[4] BNPB. 2021. *Banjir Melanda Beberapa Wilayah*.

[5] Faradiba, F., & Zet, L. 2020. "The Impact of Climate Factors, Disaster, and Social Community in Rural Development." *The Journal of Asian Finance, Economics and Business* 7(9):707–17. doi: https://doi.org/10.13106/jafeb.2020.vol7.no9.707.

[6] Faradiba, Faradiba. 2020. "Analisis Pola Curah Hujan Terhadap Produktifitas Tanaman Padi Sawah Di Provinsi Jawa Barat." *Jurnal EduMatSains* 4(2):139–52.

[7] Faradiba, Faradiba. 2021. "Determination of Climate Factors in Flood and Drought Disaster in Indonesia Using Instrumental Variable (IV) Methods." *Jurnal Ilmu Fisika* 13(1):54–61.

[8] Hage, K. D. 1975. "Urban-Rural Humidity Differences." *Journal of Applied Meteorology and Climatology* 14(7):1277–83.

[9] Juleha, Juleha. 2016. "Analisa Metode Intensitas Hujan Pada Stasiun Hujan Rokan IV Koto, Ujung Batu, Dan Tandun Mewakili Ketersediaan Air Di Sungai Rokan."

[10] Manisalidis, Ioannis, Elisavet Stavropoulou, Agathangelos Stavropoulos, and Eugenia Bezirtzoglou. 2020. "Environmental and Health Impacts of Air Pollution: A Review." *Frontiers in Public Health* 8:14.

[11] Matuszko, Dorota, and Stanisław Węglarczyk. 2015. "Relationship between Sunshine Duration and Air Temperature and Contemporary Global Warming." *International Journal of Climatology* 35(12):3640–53.

[12] Mekhilef, Saad, Rahman Saidur, and Masoud Kamalisarvestani. 2012. "Effect of Dust, Humidity and Air Velocity on Efficiency of Photovoltaic Cells." *Renewable and Sustainable Energy Reviews* 16(5):2920–25.

[13] Miftahuddin, Miftahuddin. 2018. "Analisis Unsur-Unsur Cuaca Dan Iklim Melalui Uji Mann-Kendall Multivariat." *Jurnal Matematika, Statistika Dan Komputasi* 13(1):26–38.

[14] Pierrehumbert, Raymond T., Hélène Brogniez, and Rémy Roca. 2007. "On the Relative Humidity of the Earth's Atmosphere." *The General Circulation* 143–85.

[15] Prabawadhani, Destianingrum Ratna, Budi Harsoyo, Tri Handoko Seto, and Bayu Rizky Prayoga. 2016. "Karakteristik Temporal Dan Spasial Curah Hujan Penyebab Banjir Di Wilayah Dki Jakarta Dan Sekitarnya." *Jurnal Sains & Teknologi Modifikasi Cuaca* 17(1):21–25.

[16] Pujiastuti, Asih, and Agus Harjoko. 2016. "Sistem Perhitungan Lama Penyinaran Matahari Dengan Metode Otsu Threshold (Studi Kasus: St. Klimatologi Barongan)." *Compiler* 5(2).

[17] Rafiq, Farhat, Sirajuddin Ahmed, Shamshad Ahmad, and Amir A. Khan. 2016. "Urban Floods in India." *International Journal of Scientific & Engineering Research* 7(1):721–34.

[18] Rahardjo, Petrus Nugro. 2014. "7 Penyebab Banjir Di Wilayah Perkotaan Yang Padat Penduduknya." *Jurnal Air Indonesia* 7(2).

[19] Rosyidie, Arief. 2013. "Banjir: Fakta Dan Dampaknya, Serta Pengaruh Dari Perubahan Guna Lahan." *Jurnal Perencanaan Wilayah Dan Kota* 24(3):241–49.

[20] Sari, Mona Berlian, Yulkifli Yulkifli, and Zulhendri Kamus. 2015. "Sistem Pengukuran Intensitas Dan Durasi Penyinaran Matahari Realtime Pc Berbasis Ldr Dan Motor Stepper." *J. Oto. Ktrl. Inst (J. Auto. Ctrl. Inst)* 7(1):37–52.

[21] Sherwood, Steven C., William Ingram, Yoko Tsushima, Masaki Satoh, Malcolm Roberts, Pier Luigi Vidale, and Paul A. O'Gorman. 2010. "Relative Humidity Changes in a Warmer Climate." *Journal of Geophysical Research: Atmospheres* 115(D9).

[22] Tambunan, Mangapul P. 2017. "The Pattern of Spatial Flood Disaster Region in DKI Jakarta." P. 12014 in *IOP Conference Series: Earth and Environmental Science*. Vol. 56. IOP Publishing.

[23] Tjasyono, Bayong. 2004. *Klimatologi*. Bandung: ITB.