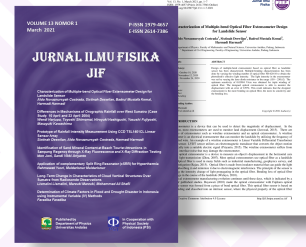


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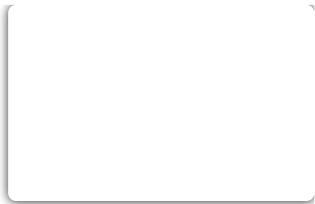
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Determination of Climate Factors in Flood and Drought Disaster in Indonesia using Instrumental Variable (IV) Methods

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ABSTRACT

Located in the Southeast Asia region, Indonesia has rainy and dry seasons. In the rainy and dry seasons that occur in Indonesia, often causes many problems in various business sectors and community activities, including floods and droughts. It is known that the disaster will have an impact on material and non-material losses. This study uses climate data and disaster data at the village level to determine the effect of rainfall on disasters. This study uses the instrumental variable method because the model has endogeneity problems. The study results concluded that increased rainfall had a positive impact on flood disasters with a coefficient of 0.003038. Simultaneously, rainfall also impacted drought with a coefficient of -0.000377. Variables in the regression model that are formed can explain 1.74 percent of the flood disaster and 0.59 percent of the drought disaster. These results indicate that most of the other variables can influence flooding and drought. Through this research, it is known that rainfall for floods and droughts is quite significant. Therefore, government and community efforts are needed to anticipate similar disasters.

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1. INTRODUCTION

Flanked by two oceans, namely the Pacific Ocean and the Indian Ocean, Indonesia has two climates every year. The rainy season ranges from October to March, and the dry season from April to September (Mau, 2018). Indonesia's geographical conditions significantly affect the climate conditions that occur, especially with global warming (Faradiba, 2018; Laksmana, 2011; Marfai & King, 2008).

In Indonesia, extreme climatic conditions often disrupt community activities, thus impacting government programs (Faradiba & Zet, 2020). Disasters that occur due to extreme weather during the rainy season include floods. Meanwhile, during the dry season, drought often occurs (McSweeney & Coomes, 2011; Mitchell et al., 2010; Rahman, 2013). The two disasters were affected by the rain that occurred and were opposites.

Flood disasters can be triggered by several natural factors, including prolonged heavy rains, silting rivers, and high tides (Chatterjee, 2010; Manawi et al., 2020; Trysnyuk et al., 2018). In addition, flood disasters can also be triggered by human actions, such as littering into waterways. In a short time, this may not cause significant harm, but the behavior of littering carried out by many people and carried out continuously will cause disaster.

In contrast to floods, during the dry season, Indonesia is often hit by drought. Drought is caused by a lack of rain intensity that flushes an area (Potts, 2003; Rouault & Richard, 2003). In addition, drought disasters can also be prevented through “loving the environment” behavior by creating greenery around the house (Ryan, 2011). When the whole community carries out this behavior, the natural ecosystem will tend to be better preserved.

Flood and drought disasters are frequent disasters in Indonesia, directly caused by the intensity of rainfall (Asy'ari, 2018; Pratiwi & Nugraha, 2016). Disasters that occur will cause material and non-material losses, such as damage to houses, casualties, wounded victims; even a few disasters will cause poverty and disrupt regional development (Cherniack, 2008; Panwar & Sen, 2019; Toya & Skidmore, 2007).

Based on previous research, it is known that climate affects natural disasters (Banholzer et al., 2014; Benevolenza & DeRigne, 2019; Van Aalst, 2006). Previous research has used data at both the state and provincial levels. This study used data at the village level. From this research, the effect of rainfall on floods and drought in Indonesia will be known.

2. METHOD

The data used in this study is the raw data from PODES 2018 data collection, which describes the conditions of flood and drought disasters at the village level from 2015 to 2017. PODES data collection is organized by BPS and is specifically designed to collect data that can describe conditions in rural areas and urban villages, and prepare the upcoming census through the collected data and information.

The unit of analysis in this research is definitive villages and urban village according to the following provisions: (i) there is a village/urban village area with clear boundaries, (ii) there are residents who live in the village/urban village area, (iii) There is a village/urban village government (BPS, 2018). The number of observations used in the study was 83,931 villages.

This study uses rainfall data as a variable of interest. The instrument variables in this study were wind speed, humidity, and temperature. This study also uses several control variables, namely villages bordering the sea, villages in forest areas, water pollution, soil pollution, and air pollution.

This study uses the Instrumental Variable (IV) method because built model has an endogeneity problem. Wooldridge (2016) states that instrumental variable analysis is used to overcome the problem of endogeneity. The Ordinary Least Square (OLS) estimator will be biased and inconsistent if a critical variable is not included in the model. Coefficients IV and OLS will be compared in this study. According to the theory, the IV coefficient will be greater than OLS. Suppose there is a simple regression equation like the following:

$$y = \beta_0 + \beta_i x + u \tag{1}$$

where x and u correlated or $Cov(x, u) \neq 0$, hence the OLS method cannot be used. This is known as endogeneity. Order an estimator β_0 and β_1 consistent when x and u correlated, then additional information is needed by adding new variables that fulfill certain properties. The new variable (say z) must meet two assumptions, namely: (i) Variable z uncorrelated with u $Cov(z, u) = 0$. This assumption is called the exogeneity instrument; and (ii) Variable z correlated with x or $Cov(z, x) \neq 0$. This assumption is called the relevance instrument. The variable z is called the instrumental variable for the variable x or the instrument for the variable x . Furthermore, the variable x , which is said to be an endogenous variable, raises the following regression equation:

$$x = \pi_0 + \pi_i x + z + v \tag{2}$$

Table 1. OLS and IV estimation results on the number of floods and droughts during the 2015-2017 period

Description	Floods		Droughts	
	OLS	IV	OLS	IV
Rainfall	-0.000084	0.003038***	-0.000369***	-0.000377***
Control Variable	Yes			
Instrument Variable	No	Yes	No	Yes
R^2	0.0205	0.0174	0.0059	0.0059
Observation	83,931			

Note: Notation level of significance *** $p < 1\%$.

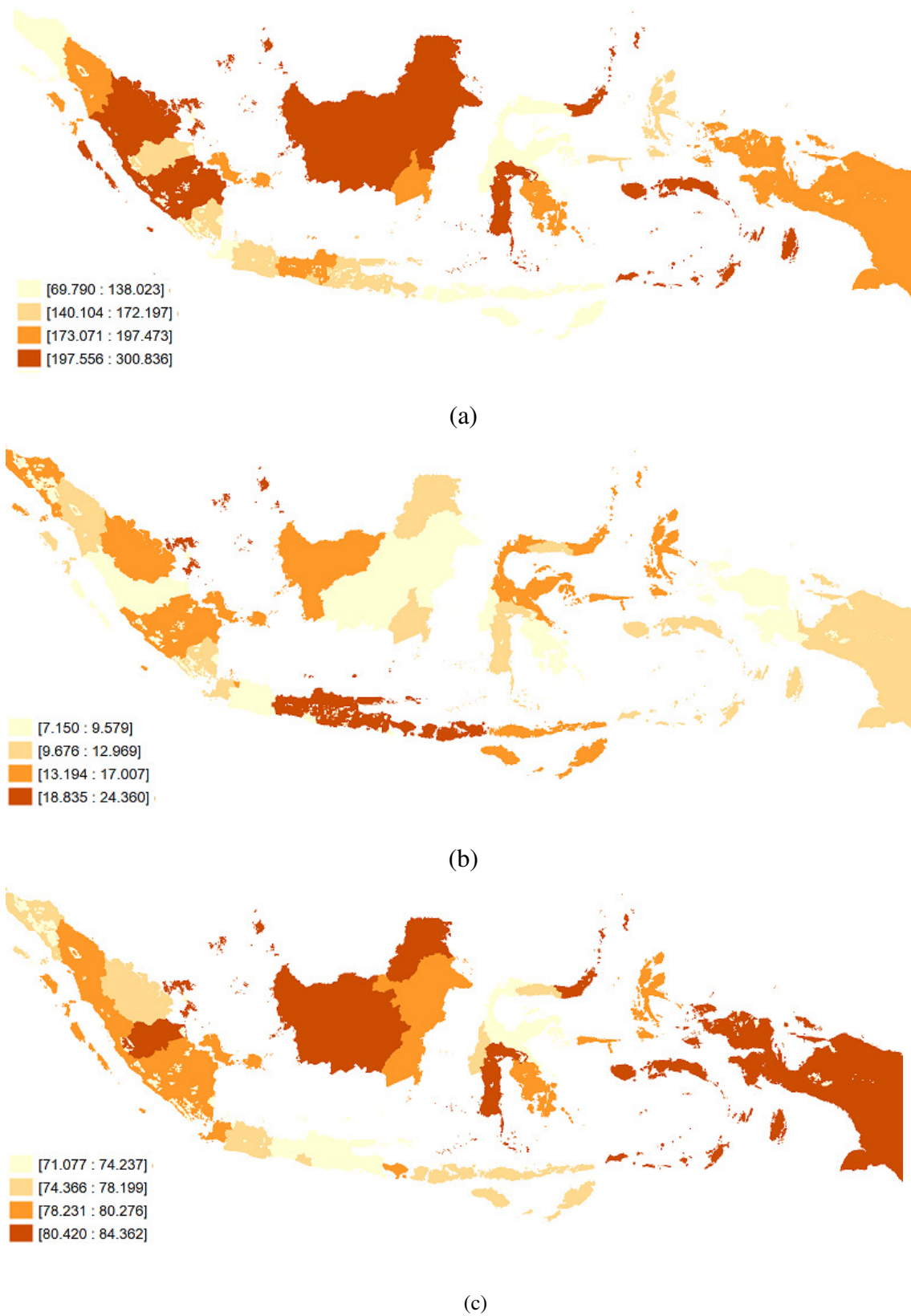
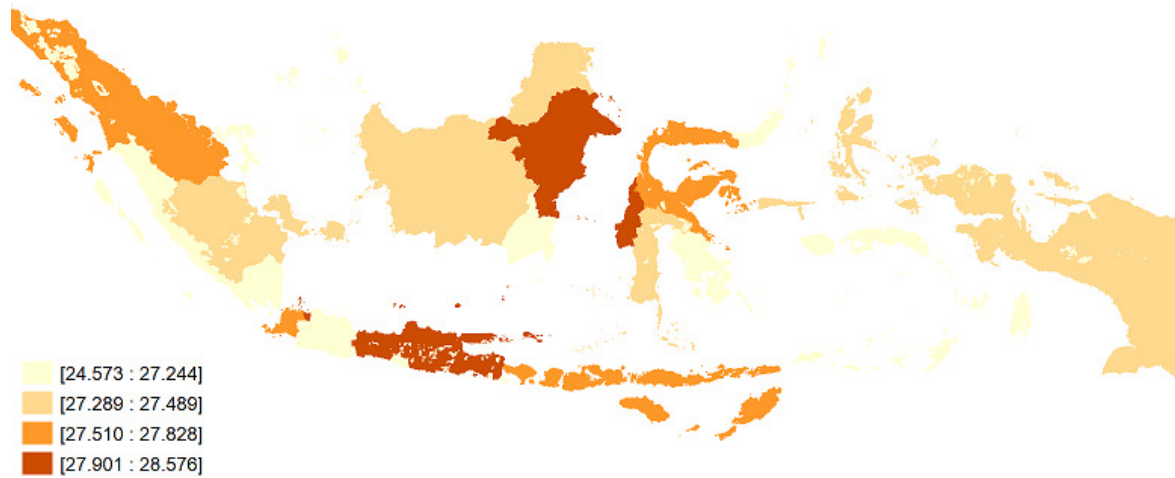


Figure 1. Climate Conditions in Indonesia (a) Rainfall, (b) Wind velocity, and (c) Humidity



(d)

Figure 1. (continued) (d) Temperature

Gujarati & Porter (2009) said that the IV method is carried out in two stages. The first stage is to regress equation (2) and predict the value of the variable x which is denoted by \hat{x} . The second stage is to enter the variable value \hat{x} into equation (1) and perform regression using OLS. This second stage estimate is an estimator from IV method, which is consistent and unbiased. The models to be built in this study are:

First stage model

$$\text{rainfall} = \alpha + \beta_1 \text{wind}_{\text{velocity}} + \beta_2 \text{humidity} + \beta_3 \text{sunshine} + \beta_4 \text{temperature} + \beta_5 \text{air}_{\text{pressure}} + \beta_i X_i + \varepsilon \quad (3)$$

Floods OLS model

$$\text{Floods} = \alpha + \text{rainfall} + \beta_1 \text{sea}_{\text{border}} + \beta_2 \text{forest}_{\text{area}} + \beta_3 \text{water}_{\text{pollution}} + \beta_4 \text{soil}_{\text{pollution}} + \beta_5 \text{air}_{\text{pollution}} + \beta_i X_i + \varepsilon \quad (4)$$

Floods IV model

$$\text{Floods} = \alpha + \widehat{\text{rainfall}} + \beta_1 \text{sea}_{\text{border}} + \beta_2 \text{forest}_{\text{area}} + \beta_3 \text{water}_{\text{pollution}} + \beta_4 \text{soil}_{\text{pollution}} + \beta_5 \text{air}_{\text{pollution}} + \beta_i X_i + \varepsilon \quad (5)$$

Droughts OLS model

$$\text{Droughts} = \alpha + \text{rainfall} + \beta_1 \text{sea}_{\text{border}} + \beta_2 \text{forest}_{\text{area}} + \beta_3 \text{water}_{\text{pollution}} + \beta_4 \text{soil}_{\text{pollution}} + \beta_5 \text{air}_{\text{pollution}} + \beta_i X_i + \varepsilon \quad (6)$$

Droughts IV model

$$\text{Droughts} = \alpha + \widehat{\text{rainfall}} + \beta_1 \text{sea}_{\text{border}} + \beta_2 \text{forest}_{\text{area}} + \beta_3 \text{water}_{\text{pollution}} + \beta_4 \text{soil}_{\text{pollution}} + \beta_5 \text{air}_{\text{pollution}} + \beta_i X_i + \varepsilon \quad (7)$$

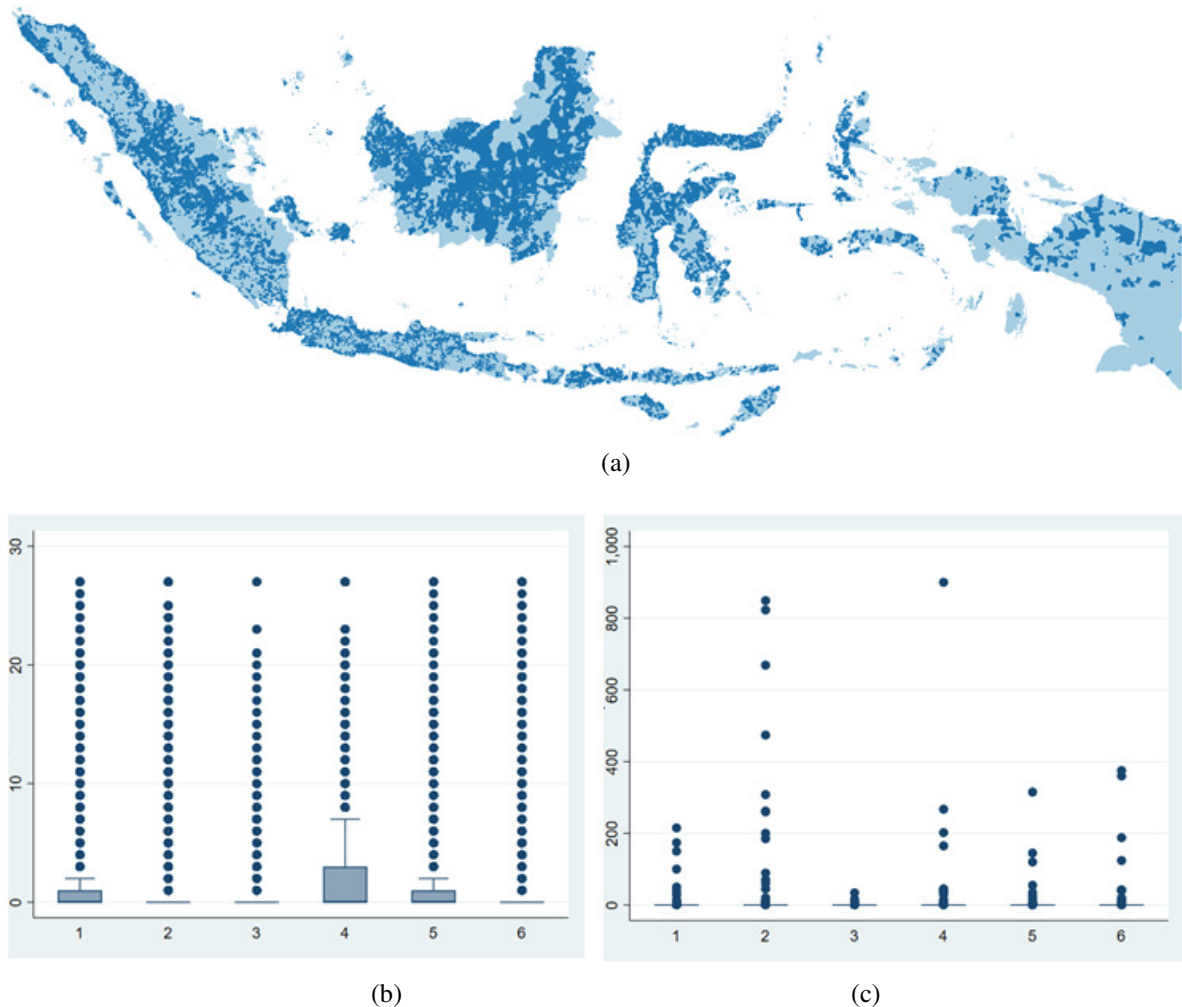


Figure 2. Flood Disaster Condition in Indonesia (a) The existence of a flood disaster, (b) Range of number of flood disasters experienced by the and (c) The range of the number of deaths due to flood experienced by the village

3. RESULTS AND DISCUSSION

There are differences in geography position, causing differences in climate in Indonesia. From Figure 1, it is known that the rainfall on Kalimantan Island is the highest, while Java Island has the highest wind speed. In addition, Kalimantan Island is an island with high humidity, and Java Island has a high temperature. Apart from different geographical positions, regional characteristics (such as population density, regional economy, and the main source of income for the community) can also influence climate conditions that occur in an area.

From the results of regression calculations using the instrumental variable method, in Table 1, it is known that rainfall has a positive effect on flood disasters as well as a negative effect on drought disasters. These results are in line with the previous study (Ralph et al., 2003; Verschuren et al., 2000). This indicates that the variable of rainfall, such as two blades. In the dry season, high rainfall is needed for the source of life for the community. The existence of a prolonged dry season causes people to get clean water. This business can take the form of fetching water that is located further away or paying for water. This condition must be done because water is a basic need for households.

The calculation using the instrumental variable method is greater than the calculation using the ordinary least square method. This is in accordance with the theory presented that the instrumental variable method will solve the endogeneity problem and if traced, the coefficient formed will be greater than the ordinary least square method (Wooldridge, 2016).

From the regression results using the OLS and IV methods, it is known that, from Table 1, it can be interpreted that the variables in the regression model that are formed can explain 1.74 percent of the flood disaster and 0.59 percent of the drought disaster. These results indicate that most other variables can influence the occurrence of floods and droughts. Other things that can affect these disasters include local governments' role in controlling extreme weather and community behavior in protecting the environment (Porter et al., 2015).

Based on Figure 2a, it is known that villages in Papua Island tend to experience a few flood disasters, in contrast to other islands that experience flooding in almost all regions. This is in accordance with the condition of the land on the Papua Island, which is still natural so that water absorption can function optimally (Kurika et al., 2019; Vines, 1970). In addition, the level of population density is still relatively low, resulting in the availability of large water catchment areas.

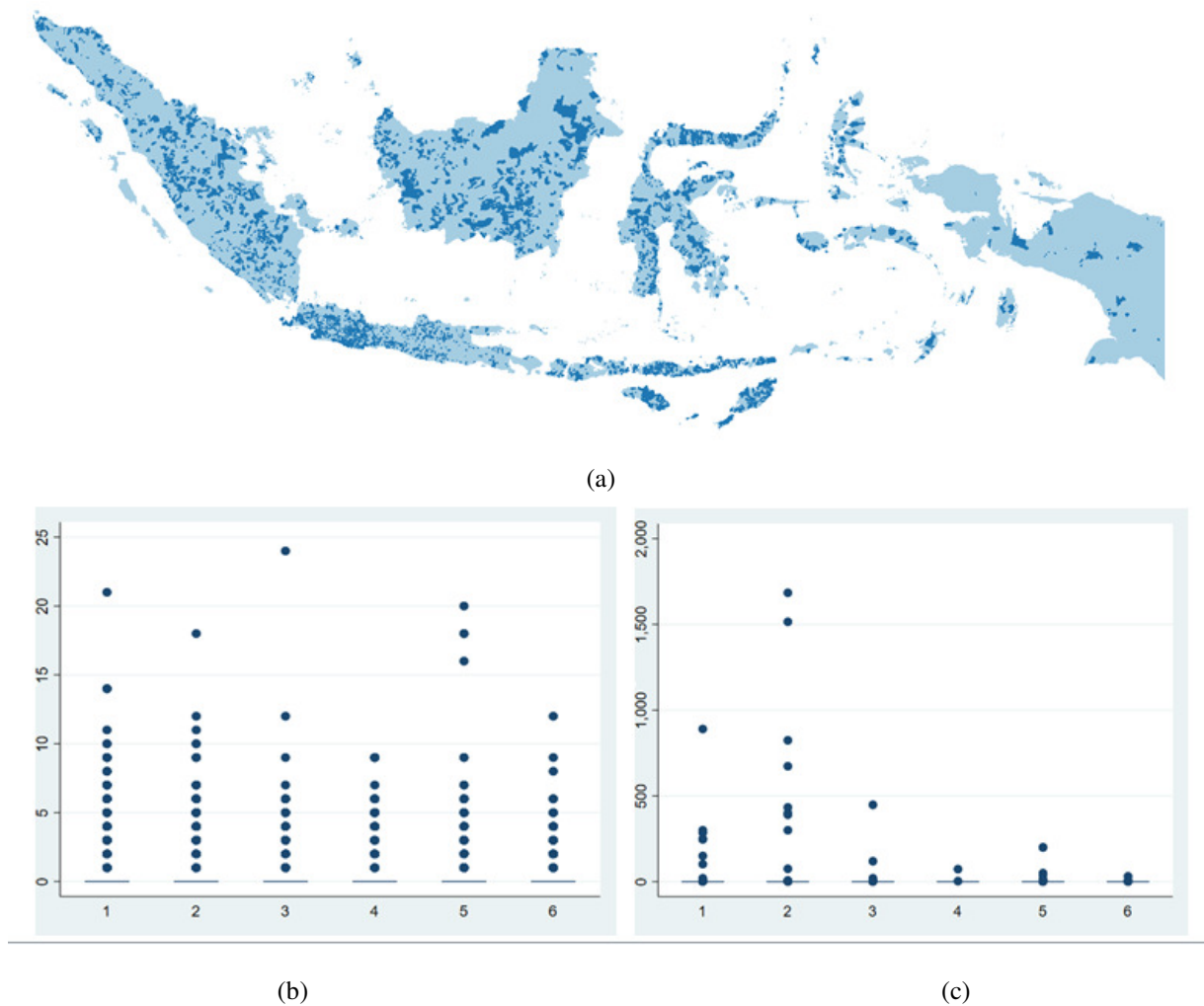


Figure 3. Drought Disaster Conditions in Indonesia (a) The existence of a drought disaster, (b) Range of number of drought disasters experienced by the village and (c) The range of the number of deaths due to drought experienced by the village

When viewed from the number of casualties, the islands of Java and Kalimantan have a record number of casualties. This can occur due to the high population density in the area so that the drought has a significant impact. Based on Figure 2b, it can also be seen that Kalimantan Island has a history of flood disasters during the last three years, mostly in the range below three events for each village

experienced it. This number is relatively evenly distributed in most of the villages in Kalimantan Island which were hit by the flood.

Based on Figure 3a, it is known that villages in Maluku and Papua islands tend to experience a few drought disasters, in contrast to other islands that experience drought in almost all regions. This is in accordance with the land condition on the island of Papua, which is still natural so that water absorption can function optimally. In addition, the level of population density is relatively low, resulting in the availability of groundwater sources that can meet the needs of local communities. When viewed from the number of casualties, Java Island has a record of many victims. This can occur due to the high population density in the area, so that the drought has a big impact. Based on Figure 3b, it can also be seen that the islands of Bali and Nusa Tenggara, Sumatra, and Sulawesi have a history of drought during the last three years, with more than 20 drought disasters.

Efforts are needed to resolve the annual disasters that often hit villages in Indonesia. The government needs to work with local communities to reduce and even eliminate these disasters. Disasters caused by high or low rainfall cannot be regulated. However, mitigation to anticipate disasters needs to be made to minimize material and non-material casualties. Education related to the environment is also needed to increase public insight about the importance of the environment in the source of life. In the short term, the disaster may not yet be seen, but the disgraceful behavior of the community will cause a disaster in the long term (Sadiq & Noonan, 2015). Community behavior that can cause climate disruption, among others, is pollution due to business activities, burning fields, use of air conditioners, and the cessation of the culture of planting trees in the yard.

In this study, the climate variable is still used at the measurement station level, limited in number at the provincial level. It is hoped that future studies can use climate indicators at the village level, so that the analysis can be a more representative conclusion.

4. CONCLUSION

Disasters caused by natural factors often cause harm to society. This event usually occurs every year. This study indicates that areas that have high interaction, mobility, and population have a relatively high incidence of disasters. The regression results show that an increase in each unit of rainfall will provide an opportunity for a flood disaster of 0.003038. On the other hand, an increase in rainfall during the dry season will reduce the chance of a drought disaster by -0.000377. This is due to disruption of the environmental ecosystem, which results in disasters. From the results of rainfall analysis, it is known that an increase in rainfall has a positive impact on flood disasters, and simultaneously rainfall also has an impact on drought. Through this phenomenon, it can be concluded that Indonesia's climate can cause disasters, both during the rainy and dry seasons. This will become more concentrated when an area has an extremely rainy and dry season. This condition has usually been going on for the last few years. Government and community efforts are needed to anticipate similar disasters. One of the efforts that can be made to control climate is through people's behavior in carrying out their daily activities.

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