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The Impact of Natural Disasters on Income Inequality in Indonesia

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ABSTRACT

Introduction: The purpose of this study is to investigate the relationship between natural disasters and income inequality in Indonesia, a developing country with a high risk of natural hazards and high population densities in disaster-prone regions.

Methods: This paper used cross-province panel data during the period between 2010 and 2016. Natural disasters data were obtained from Indonesia National Agency for Disaster Management (BNPB), while Gini index data as an indicator of income inequality were obtained from Indonesia Central Bureau of Statistics (BPS). To estimate the impact of natural disasters on income inequality, this paper used a fixed effect regression model.

Results: It was found that the lagged variable of natural disasters positively affected the Gini index. The coefficient of this variable was 0.0093 at a significance level of 5%. It indicated that natural disasters worsen income inequality. This study also showed that natural disasters that negatively affected the Gini index were hydrological disasters in year *t* (between -0.0179 and -0.0199 at a significance level of 0.1%). Meanwhile, meteorological disasters tended to increase income inequality in the subsequent years. The coefficients were 0.0282 and 0.0187, and were statistically significant at least 5%. In addition, meteorological disasters consistently affected income distribution in all Western Indonesia (Sumatra, Java, and Bali) and other islands. The coefficients were 0.0205 and 0.0510 at a significance level of 5% indicating that meteorological disasters tended to increase inequality in income distribution.

But these climatological disasters had a negative impact on income distribution in other islands in years *t* and *t-1* (-0.0192 and -0.0680 at the significance level of 1% and 5%, respectively).

Conclusion: The findings of this study imply that designing policies to deal with inequality at the regional level should also concern the different influences of various natural disasters on income inequality.

Key words: Natural Disasters, Income Inequality, Gini Index, Cross-Province, Indonesia

Introduction

The socio-economic impacts of natural disasters have increased over the past decades (1). Some of the biggest natural disasters in these decades are the 2005 landfall of Katrina in New Orleans, the 2004 Indian Ocean, the 2010 earthquake in Haiti, the earthquake in Japan in March 2011, and the landfall of Superstorm Sandy in 2012 in New York City. These natural shocks raise our concern regarding the implications of natural disasters on various aspects of human life since the disasters. Therefore, natural disasters have also become an important topic of debate in social science (1, 2, 3).

The impacts of natural disasters on economic growth, human development, and poverty have been intensively investigated (4, 5, 6, 7). Another aspect that can be affected by natural disasters, but is rarely investigated is income distribution (2, 8, 9). Natural disasters can affect a wide range of communities, but poor people are more affected than rich people. It is also known that in contrast to rich people, the low-income communities have limited access to insurance or other social security programs. The poor group can also experience a reduction in their income due to being unable to work, after they are injured by a natural disaster. Furthermore, the recovery process can provide more benefits to the rich group, since this group has better access to various resources, including the decision for allocating recovery programs. As a result, income inequality between these two groups tends to widen in the wake of natural disasters. Therefore, it can be hypothesized that the occurrence of natural disasters increases the inequality in income distribution (2, 9).

Studies indicate that the impact of natural disasters on income inequality is still debatable. A cross-country study revealed that there was a short-term impact of natural disasters on income inequality. (2) Another study at the county level in the United States, found a substantial heterogeneity regarding the effects of natural disasters on incomes, in particular, in damaging the middle incomes (8). In Vietnam, natural disasters worsened the inequality issues among households (10). Meanwhile, a study using data at the district level of Sri Lanka demonstrated that contemporaneous natural disasters and their immediate lags decreased income inequality among the households, but there is no evidence that natural disasters affected expenditure inequality (11).

Also, other studies focusing on the impact of a specific natural disaster on income inequality showed different results. A study in the United States found an increase in income inequality over time, in the hurricane states (12). In India, climate-related events aggravate inequality in rural India, since poor farming households suffer the largest percentage of losses (13). Meanwhile, tropical Cyclone Nargis reduced inequality between regions of Myanmar, but economic inequality within the affected regions increased (14). Another study in Bangladesh, also, indicated that Cyclone Alila has improved income equality among households (15).

Despite the growing interest in the impact of natural disasters on income inequality, there is little research on this issue in Indonesia. One study included a disaster variable in explaining income inequality in Indonesia, but it only focused on West Sumatra, and the included natural disaster was a dummy variable of earthquakes at the district level (16). Nevertheless, they found that income distribution inequality would increase in regions affected by earthquakes.

The aim of this paper, then, is to investigate the relationship between natural disasters and income inequality across the provinces in Indonesia. Regarding income inequality, this paper used the Gini index. This index is widely used as a measure of income distribution in a population, and the data are available from the Indonesia Central Bureau of Statistics (BPS). The value of this index ranges from 0 (or 0%, representing perfect equality) to 1 (or 100%, representing perfect inequality). It should be noted that the Gini index provided by the BPS is based on expenditure data. Figure 1 shows that the Gini index in Indonesia is still relatively high, indicating inequality in income distribution.

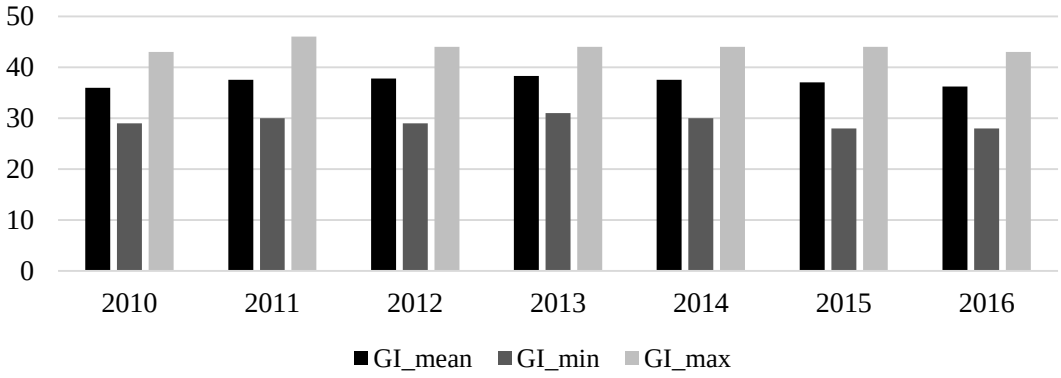

Figure 1. Gini Index in Indonesia (Provincial Average in the Scale of 100)

Materials and Methods

Indonesia is located in Southeast Asia and Oceania, between the Indian and Pacific oceans. It has more than 17,000 islands, including Sumatra, Kalimantan, Sulawesi, Java, and Papua. It is the world's largest island country at 1,904,569 km^2, with about 270 million people. Java is home to more than half of the country's population. This country lies along the equator, and has two seasons—a wet season and a dry season. The climate is dominated by tropical rainforest climate (Figure 2).

Indonesia is also known as a developing country that has a high risk of natural hazards, with high population densities in disaster-prone regions. Figure 3 shows the number of natural occurrences at the provincial level. The natural disasters data from Indonesia National Agency for Disaster Management (BNPB) have been classified into four groups: hydrological disasters cover floods, floods and landslides, and tidal waves/abrasions; meteorological disasters include strong wind; climatological disasters include drought and forest fires; and geological disasters cover earthquakes, tsunamis, and volcanic eruption (17, 18).

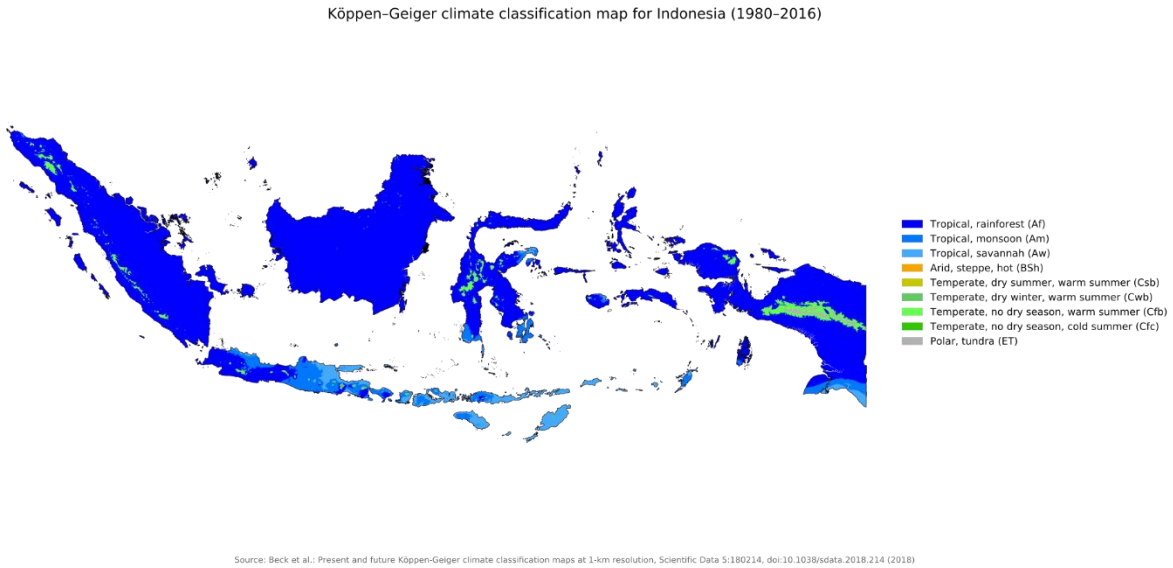

Figure 2. Indonesia's Climate Classification Map
Source: https://en.wikipedia.org/wiki/Indonesia#/media/File:Koppen-Geiger_Map_IDN_present.svg

This figure also shows that hydrological and meteorological disasters dominate natural disasters in Indonesia. At the provincial level, the figure shows that provinces in Java, especially

West Java, Central Java, and East Java, experienced more natural disasters than any other province. These three provinces also contributed to a large number of hydrological and meteorological disasters. In terms of climatological disaster, East Kalimantan lies in the top rank.

This study used panel data at provincial level. Panel data is the data that contains observations about different cross-sections over time. There are 33 provinces in this dataset. These provinces are the cross-sections or the panels. We used annual data covering the period from 2010 to 2016 (7 years). Therefore, in this panel data, we had 231 observations, in which the number of panels (33 provinces) was larger than time periods (7 years).

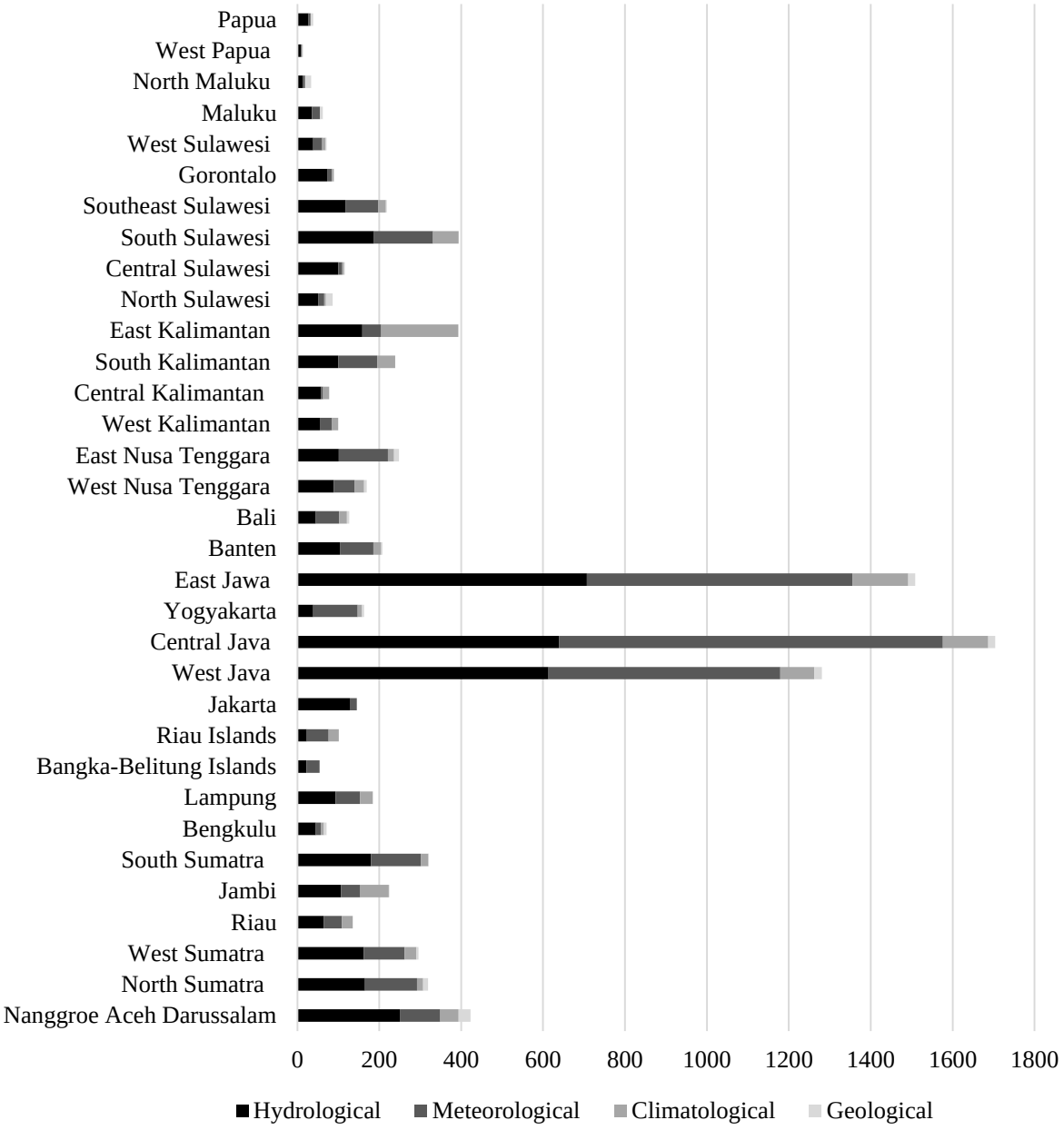

Figure 3. Number of Natural Disaster Occurrences in Indonesia at the Provincial Level (2010-2016)
Source: BNPB (processed)

The natural disasters data was taken from the BNPB. Like other developing countries, BNPB also provides data on disasters using the DesInventar method. This data can be accessed at http://bnpb.cloud/. Meanwhile, economic data was taken from the Indonesia Central Bureau of Statistics (BPS). This data consists of Gross Domestic Product(GDP), population density, Gini index, and democracy index. Summary statistics of these variables is provided in Table 1.

Table 1. Summary Statistics of Relevant Variables

Variables	Description	Mean	Std. Dev
Gini	Gini index (ranging from 0 to 100)	37.1865	3.8168
Disasters	Number of natural disasters occurrence	41.6364	61.7992
-Hydrological	Number of hydrological disasters occurrence	19.9178	30.8676
-Meteorological	Number of meteorological disasters occurrence	16.3377	31.0632
-Climatological	Number of climatological disasters occurrence	4.5498	12.4162
-Geological	Number of geological disasters occurrence	0.8312	1.5157
ln(GRDP per capita)	Gross Regional Domestic Product per capita (in Rupiah, constant price)	17.1617	0.5583
Democracy	Democracy index (ranging from 0-100)	68.5176	6.8746
Population density	Population per km square	71.5515	2559.9200

The estimated model in this research was adopted from a cross-country study (e.g. 2). Income inequality was measured by the Gini index (*Gini*). The disaster variable reflects the number of events or frequency of natural disasters (*Natdes*) in year *t*. Lagged variables of this disaster variable were also included to test the subsequent impact of the disaster on income distribution. Other independent variables are the log form of Gross Regional Domestic Product per capita (*ln(GDRPper capita*) , representing the level of economic development, democracy index (*Demi*), and the population density per km square (*Popden*). The model is:

$Gini_{i,t} = \alpha_1 Natdes_{i,t} + \alpha_2 Natdes_{i,t-1} + \alpha_3 Natdes_{i,t-2} + \alpha_4 ln(GDRPper\ capita)_{i,t} + \alpha_5 Demi_{i,t} + \alpha_6 Popden_{i,t} + u_i + k_t + \varepsilon_{i,t}$,

Estimation was conducted in three versions. First, the study estimated the impact of the number of events of natural disasters on the Gini index (Table 2). It was, then, followed by estimating four types of natural disasters (Table 3). Finally, the study separated the data into two groups of islands (Table 4). The first group consisted of provinces in Sumatra, Java, and Bali; and the second group covered the rest of the provinces. Sumatra, Java, and Bali represented Western Indonesia, while the rest was for the Eastern part. This paper used Stata 15 software. Following a previous study (2), the authors estimated a fixed-effect model. Since the number of the panels was larger than the number of periods, they did not conduct additional time-series tests (19).

Results

Table 2 shows that there is no evidence that natural disasters directly affected the Gini index. Natural disaster (*t-2*) was the only indicator of natural disasters, which was statistically significant in affecting the Gini index. Its coefficient was 0.0093 at a significance level of 5%. This indicated that natural disasters do not have a short-term impact on income inequality, but it has an influence on income inequality two years after the disaster occurred. Since its coefficient was positive, it suggested that natural disaster (*t-2*) had worsened income inequality across provinces in Indonesia. The results generally indicate that the impact of natural disasters on income inequality is relatively small. Another variable that significantly affected income distribution at a significance level of 0.1% was population density. The coefficients in estimation (2) and (3) are relatively large, 0.0037 and 0.0032, respectively.

Table 2. Fixed Effects: Natural Disasters (Total Occurrence)

	(1)	(2)	(3)
Natural disasters (t)	-0.0030	-0.0032	0.0002
	(0.0067)	(0.0068)	(0.0079)
Natural disasters (t-1)			0.0115
			(0.0058)
Natural disasters (t-2)			0.0093*
			(0.0044)
ln GDRP per capita)		0.4016	0.3376
		(1.7927)	(1.8016)
Democracy index		-0.0297	-0.0310
		(0.0307)	(0.0300)
Population density		0.0037***	0.0032***
		(0.0010)	(0.0009)
Constant	37.3121***	29.7777	30.3982
	(0.2781)	(30.6025)	(30.3939)
Observations	231	231	231

Notes: Robust standard errors are in parentheses (clustered by province). * p<0.05, ** p<0.01, *** p<0.001

Estimations in Table 3 represent the impact of various types of natural disasters on income distribution. Hydrological disaster in year *t* ,negatively and significantly, affected the Gini index in all estimations, meaning that this type of disaster tended to decrease income inequality. The coefficients of this variable were between -0.0179 and -0.0199 at a significance level of 0.1% . But, this disaster had no impact in the long term. Meanwhile, meteorological disasters had no direct impact on the Gini index, but they, then, influenced income distribution one or two years later. In estimation (6), the coefficient of meteorological (*t-1*) and (*t-2*) were 0.0282 and 0.0187, and statistically significant at 1% and 5%. These results suggested that meteorological disasters tended to increase income inequality, not in the short term.

Meanwhile, geological disasters had no statistically significant impact on the Gini index. Therefore, it can be concluded that different disasters had different impacts on income distribution. Another variable which had a statistically significant positive influence on Gini index, was population density. Coefficients of this variable were more than 0.0040, and were statistically significant at a significance level of 0.1%. The impact of population density was consistent with the results in Table 2.

Classifying provinces into two groups gave interesting results (Table 4). Meteorological disaster (*t-1*) in estimations (7) and (8), consistently affected the Gini index in Western Indonesia provinces (Sumatra, Java, and Bali), as well as in other islands. Its coefficient was positive (0.0205 and 0.0510) at a significance level of 5% ,indicating that meteorological disasters tended to increase inequality regarding income distribution. Meanwhile, climatological disasters in years *t* and *t-1* had a negative impact on income inequality in the other islands (Kalimantan, Sulawesi, Maluku, Nusa Tenggara, and Papua). The coefficients were -0.0192 and -0.0680 at the significance level of 1% and 5%, respectively. It should also be noted that the impact of climatological disasters (*t-1*) was larger than climatological disasters (*t*), meaning that in the long-term, climatological disasters corrected income inequality.

Table 3. Fixeds Effects: Natural Disasters (Classified into 4 Types)

	(4)	(5)	(6)
Hydrological	-0.0179***	-0.0199***	-0.0181**
	(0.0042)	(0.0041)	(0.0061)
Hydrological (t-1)			-0.0050
			(0.0066)
Hydrological (t-2)			-0.0016
			(0.0093)
Meteorological (t)	0.0269	0.0290	0.0241
	(0.0178)	(0.0182)	(0.0164)
Meteorological (t-1)			0.0282**
			(0.0086)
Meteorological (t-2)			0.0187*
			(0.0075)
Climatological (t)	-0.0117	-0.0132	-0.0132
	(0.0094)	(0.0091)	(0.0099)
Climatological (t-1)			-0.0067
			(0.0216)
Climatological (t-2)			0.0188
			(0.0151)
Geological (t)	-0.0964	-0.0790	-0.0480
	(0.1247)	(0.1267)	(0.1520)
Geological (t-1)			0.0068
			(0.0705)
Geological (t-2)			0.0904
			(0.0648)
ln(GDRP per capita)		-1.0002	-2.2826
		(1.8585)	(2.0227)
Democracy index		-0.0270	-0.0327
		(0.0255)	(0.0242)
Population density		0.0043***	0.0042***
		(0.0008)	(0.0008)
Constant	37.2368***	53.2030	74.9915*
	(0.3451)	(31.2340)	(33.9538)
Observations	231	231	231

Notes: Robust standard errors are in parentheses (clustered by province). * p<0.05, ** p<0.01, *** p<0.001

Table 4. Fixed Effects: Natural Disasters (Provinces Are Classified into 2 Groups of Islands)

	(7) (Sumatra, Java, Bali)	(8) (Other islands)
Hydrological	-0.0105	-0.0173
	(0.0101)	(0.0168)
Hydrological (t-1)	-0.0038	-0.0148
	(0.0061)	(0.0142)
Hydrological (t-2)	0.0025	-0.0138
	(0.0117)	(0.0126)
Meteorological (t)	0.0231	0.0153
	(0.0193)	(0.0272)
Meteorological (t-1)	0.0205*	0.0510*
	(0.0085)	(0.0186)
Meteorological (t-2)	0.0128	0.0144
	(0.0102)	(0.0144)
Climatological (t)	0.0197	-0.0192**
	(0.0438)	(0.0056)
Climatological (t-1)	0.0084	-0.0680*

	(7) (Sumatra, Java, Bali)	(8) (Other islands)
	(0.0264)	(0.0277)
Climatological (t-2)	0.0170	0.0070
	(0.0261)	(0.0179)
Geological (t)	0.0768	-0.2287
	(0.2089)	(0.2277)
Geological (t-1)	0.0528	-0.1903
	(0.0643)	(0.3053)
Geological (t-2)	0.0930	-0.0176
	(0.0610)	(0.2191)
ln(GDRP per capita)	1.7658	-2.3315
	(3.7664)	(3.2436)
Democracy index	-0.0024	-0.0405
	(0.0292)	(0.0327)
Population density	0.0026	-0.0825
	(0.0013)	(0.0734)
Constant	1.2776	87.1472
	(63.6017)	(51.1921)
Observations	119	112

Notes: Robust standard errors are in parentheses (clustered by province). * p<0.05, ** p<0.01, *** p<0.001

Discussion

The findings in this study were in line with a study that covered 88 countries from 1965 to 2004. It found that natural disasters affect income inequality (2). To be precise, this study demonstrated that natural disasters do not immediately affect income inequality in Indonesia, but it has a medium-term impact of inequality. The difference between this study and the previous cross country study is in the length of the short and long term period. The cross-country study defines the short term as a 5 years period and the long term as a 10 years period, while in this study, they are 1 year and 3 years (maximum), respectively. Accordingly, this research basically confirmed that there is only a short-term impact of natural disasters on income inequality as found in the previous study.

The results were also in line with another study at the county level in the United States, in which natural disasters increased income inequality, and the frequency of multiple and severe disasters, also, magnified the effects of natural disasters on incomes (8). The finding of the Indonesia case also confirmed a study based on the Vietnam Household Living Standard Survey in 2008 .It revealed that natural disasters worsen income inequality (10). In contrast, this study did not support the findings of a study in Sri Lanka, suggesting there was no evidence that natural disasters affected expenditure inequality (11). As already stated in the introduction, the indicator of income inequality in Indonesia is based on the expenditure data due to the availability of the data.

With regards to the impacts of different types of natural disasters, this study indicated that each type of natural disaster influenced the Gini index differently. In general, there was no evidence of the impact of geological and climatological disasters on income inequality, but there were evidences that hydrological and meteorological disasters affected income inequality.

The results of this study were not in line with a study in West Sumatra, which found regions affected by earthquakes experienced an increase in the inequality of income distribution (16). However, it should be noted that these two studies used a different level of data. This study employed provincial data, while the second one used data at the district level. Besides, the number of geological disasters in this analysis was relatively small, which were only concentrated in a few provinces. This implied that a study across locations in a single province could find a stronger socio-

economic impact of geological disasters, such as the earthquake and tsunami in Aceh, in 2004 (20).

Meanwhile, climatological disasters covering drought and forest fires did not have an impact on the Gini index. In Indonesia, these two natural disasters are predictable, since they normally occur during the dry seasons. They also tend to have negative influences at the local level. These characteristics probably help local people to adopt adaptation strategies in dealing with the negative impacts of the climatological disasters that limit the possible impacts of the disasters on income inequality.

This study demonstrated that the hydrological disasters negatively affected the Gini index. Meanwhile, a cross-country study found that flood, as one of the hydrological disasters, had a damaging effect on inequality (2). In this study, hydrological disasters included floods, floods and landslides, and tidal waves/abrasions. Floods tend to affect urban areas that have better resources to mitigate the impacts of the disasters that may contribute to improving income inequality. It assumes that cities have continuously improved the environmental quality of the areas and the mechanism in distributing government programs, or aid in the emergency period. Meanwhile, landslides and tidal wave/abrasions could push local people out their location, especially in rural and coastal areas, affected by disasters. It is expected that they move to other locations with better access to economic opportunities. A combination of these processes may contribute to reducing income inequality. However, these two possible reasons still need further investigation.

Since this study showed a positive impact of meteorological disasters on the Gini index in Indonesia, it indicated that this study was in line with earlier work in the United States. It suggested that catastrophic hurricane events—a type of meteorological disaster—increase income inequality over time in the hurricane states (12). It was also in line with the study on the impact of Tropical Cyclone Nargis in Myanmar, that increased economic inequality within the affected regions (14), and with another study that found climate-related events in India increased inequality, especially in rural areas (13). However, this study did not support the findings of a study in Bangladesh, in which Cyclone Alila improved income equality among households (15). Meteorological disasters can worsen income inequality, since they tend to have damaging impacts, such as destroying houses or disrupting people's economic activities.

In addition, the positive impact of meteorological disasters on income inequality in Western Indonesia was related to the Figure that showed these natural disasters contributed greatly to the total natural disaster occurrences in some provinces in Western Indonesia. In contrast, some provinces in Eastern Indonesia were more vulnerable to climatological disasters, which reduce income inequality. One of the possible explanations is that climatological disasters including drought and forest fires could force people to migrate to other areas. Migration is known as one of the important survival strategies adopted in the face of disasters (21).

Another variable that had a statistically significant impact on the Gini index was the population density in the first two tables of estimation results. The impact was positive, indicating that provinces with high population density suffered high inequality of income distribution. Provinces with high population density were mainly in Western Indonesia. Therefore, it was not surprising that this variable lost its significant impact when the authors split their estimation into two groups of islands. Meanwhile, the level of development, measured by GDRP per capita and democracy index, did not have any statistical significant impacts on the Gini index in all estimations. These results were consistent with the previous study that used cross-country data (2).

It should be noted that this study had some limitations. First, it used the Gini index based on expenditure, instead of income due to the availability of secondary data. Since expenditure data tends to give smaller inequality indices, the authors may expect that the studies that use an

income-based inequality index could provide different results. Second, this study covered all-natural disasters across the country. This choice may affect the results of the study, since different locations have different typical natural disasters. Last, this study used annual data of natural disasters and did not assess the timing of natural disasters.

Conclusions

Income distribution can be influenced by various variables from many aspects, such as economic sanctions, civil war, and natural disasters. However, there is little research on the impact of natural disasters on income inequality, especially for Indonesia, as a developing country, and vulnerable to natural disasters. The focus of this paper was to investigate the relationship between natural disasters and income inequality across provinces in Indonesia using panel data, covering 33 provinces in Indonesia for the period of 2010 until 2016.

It is suggested that natural disasters affect income inequality (measured by Gini index) only after two years, indicating that natural disasters do not immediately affect income distribution. Concerning the effect of different types of natural disasters, this study shows that the natural disasters that negatively affect the Gini index, are the hydrological disaster, while meteorological disasters tend to increase income inequality.

In addition, meteorological disasters consistently affect income distribution in all Western Indonesia (Sumatra, Java, and Bali) and other islands; but climatological disasters had a negative impact on income distribution in the other islands (Kalimantan, Sulawesi, Maluku, Nusa Tenggara, and Papua). This demonstrates that designing policies to deal with inequality at the regional level should also concern the different influences of various natural disasters on income inequality.

Conflict of interest

Authors declared no conflict of interest.

Authors Contributions

N/A

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