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Research Article

How Central Sulawesi Province's Natural Disasters Affect Economic Growth?

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Abstract: Historically, Indonesia is an area prone to natural disasters. Potential losses caused by natural disasters can be death, injury, illness, threatened life, sense of security, displacement, damage or loss of objects, and disruption of daily activities. The impact of natural disasters will indirectly affect output, income, demand for labor, and economic growth. This study aims to calculate the impact of natural disasters in Central Sulawesi Province (which occurred in 2018) on the regional and national economies. The method used is the Interregional Input-Output model measuring 17 sectors and 34 provinces. The findings show that Central Sulawesi Province's Gross Regional Domestic Product is IDR.114.01 trillion, decreased-12.93 percent to IDR.99.27 trillion due to natural disasters. Labor demand decreased by -9.68 percent, and income decreased by -9.58 percent. Natural disasters in Central Sulawesi Province also impacted the decline in National GDP by -0.16 percent. Disaster mitigation programs are essential for anticipating direct and indirect losses caused by natural disasters. Consequently, the government must consider the impact of inflation and economic growth when implementing disaster mitigation programs on the public agenda.

Keywords: natural disasters, economic growth, income, unemployment

JEL Classification: F43, O44, Q54

Abstrak: Secara historis, Indonesia merupakan wilayah yang rawan bencana alam. Potensi kerugian yang ditimbulkan bencana alam secara langsung dapat berupa kematian, luka, sakit, jiwa yang terancam, rasa aman, pengungsian, kerusakan atau kehilangan benda, dan terganggunya aktivitas sehari hari. Dampak bencana alam secara tidak langsung akan mempengaruhi output, pendapatan, permintaan tenaga kerja dan pertumbuhan ekonomi. Penelitian ini bertujuan untuk menghitung dampak bencana alam yang terjadi di Provinsi Sulawesi Tengah (yang terjadi pada Tahun 2018) terhadap perekonomian daerah dan nasional. Metode yang digunakan adalah model Interregional Input-Output berukuran 17 sektor dan 34 provinsi. Hasil analisis menunjukkan bahwa Produk Domestik Regional Bruto Provinsi Sulawesi Tengah adalah Rp.114,01 triliun, turun -12,93 persen menjadi Rp.99,27 triliun akibat bencana alam. Permintaan tenaga kerja turun sebesar -9.68 persen dan pendapatan turun sebesar -9.58 persen. Kejadian bencana alam di Provinsi Sulawesi Tengah juga berdampak pada penurunan PDB Nasional sebesar -0,16 persen. Program mitigasi bencana menjadi suatu keniscayaan, untuk mengantisipasi kerugian baik kerugian langsung maupun tidak langsung akibat bencana alam. Jadi, pemerintah perlu memperhitungkan dampak inflasi dan pertumbuhan ekonomi dalam mengimplementasikan program mitigasi bencana kedalam agenda publik.

Kata Kunci: bencana alam, pertumbuhan ekonomi, pendapatan, pengangguran

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1. INTRODUCTION

The territory of Indonesia occupies a highly active tectonic zone because three of the world's most enormous plates and nine smaller plates collide and form complex plate-meeting lanes on Indonesian soil. Due to the interactions between these plates, the Indonesian region is highly susceptible to natural disasters, especially earthquakes (Hutchings & Mooney, 2021). The primary problem with natural disasters such as earthquakes is that they have the potential to cause enormous losses. They are natural events that cannot be accurately calculated and predicted. Their occurrence, location, and magnitude cannot be foreseen, and they cannot be prevented (Utomo & Marta, 2022). Because it cannot be prevented and cannot be accurately predicted, it is customary to avoid areas with faults or faults, the possibility of tsunamis and landslides, and earthquake-resistant buildings must be planned and constructed. Disaster risk is the potential loss caused by a disaster in a defined location and specific time, including death, injury, illness, threatened life, loss of security, displacement, damage or loss of property, and disruption of community activities (Avelino & Dall'erba, 2019). According to Cardona et al. (2012), areas with a high propensity for human activity could have a high level of vulnerability. Vulnerability refers to humans' tendency, livelihoods, and property rights to suffer adverse effects when exposed to hazards.

The current trend in natural disaster research in Indonesia is to focus on community preparation to respond to catastrophes as well as technical readiness to assist community resilience in disaster situations. Research on the regional economic impact of catastrophes, particularly in Indonesia, remains sparse. However, research employing a regional economic strategy in the field of natural disasters is actually quite prospective in the future in order to better prepare important stakeholders for natural catastrophe events. Numerous earlier researchers, including Fomby et al. (2013), have reviewed empirical studies regarding the impact of natural disasters on the economy. Using data from 84 countries between 1960 to 2007, he discovered that while the effect of natural disasters on economic growth varied depending on the type of disaster, in developed countries the impact was negligible. The greatest negative influence on economic growth is caused by climate disasters in developing nations (Klomp & Valckx, 2014). Disasters have an impact on the economy both nationally and regionally. For example, damage from environmental shocks lowers the GDP growth rate of economic cities in the state of Ceará, Brazil (De Oliveira, 2019).

Diverse frameworks for economic modelling have been created to estimate the direct and indirect impacts or higher-order effects of a disaster. The IO Model is the most widely used modelling framework. Several researchers who have applied the Input-Output Model as an impact analysis tool assess the impact of natural disasters on economic performance, such as Cochrane (1997); Ishiwata & Yokomatsu (2018), Kawashima et. al. (1991); Yokomatsu et al. (2014); Sahin & Yavuz (2015), Boisvert (1992); Gordon & Richardson (2001); Okuyama (2007); Rose & Liao (2005); Rose & Benavides (1998); Santos et al. (2013); Okuyama & Santos (2014); Avelino & Dall'erba (2018); and Aurangzeb & Stengos (2012).

The SAM model is an extension of the IO model, which depicts the economy at a particular time. The SAM model has an advantage over the IO model in that it can describe the flow of income distribution and the redistribution of income and consumption among groups of households in the economy. Studies using the SAM model such as Cole (1995, 1998, and 2004); Okuyama & Sahin (2009); Mbanda & Bonga-Bonga (2018). Like the IO model, the SAM approach has a rigid coefficient and tends to provide an upper bound on estimates (because it uses SAM multiplier analysis). However, the MAS framework can derive the distributional impact of disasters from evaluating equity considerations for public policies on catastrophe.

Their SAM model, however, is unable to account for the indirect effects of catastrophic events, such as the financial effects on neighboring regions. As was done by Rahmawan & Angraini (2021) in Lampung Province, Hidayah & Sunarjo (2021) in West Sumatra Province, and Taufiqqurrachman, (2022) in East Java by using the 2016 IRIO Table, this research fills this gap by using the Interregional Input Output (IRIO) model to capture this. Puspita and Ningsih (2021) also used the 2016 IRIO Table in their research to examine the impact of changes in final demand on the regional economy during Indonesia's economic recovery from the COVID-19 pandemic. Given these considerations, this study employs the 2016 IRIO model to determine the impact of natural disasters in Central Sulawesi on national economic performance, both internally in Central Sulawesi and other provinces.

2. RESEARCH METHODS

This research employs the Interregional Input-Output (IRIO) model as its methodology. In simple terms, Table 1 displays the IRIO Table for two sectors and two regions. Central Bureau of Statistics does not regularly publish the IRIO Table; instead, it is more incidental, sometimes appearing more than once every ten years. This study makes use of the 2016 IRIO Table since it is the most recent version that is currently accessible. As shown in Table 1 below, the IRIO model is not only data but also a concept when represented as a 2 x 2 matrix with two regions:

Table 1. Summary Table of Indonesia's IRIO 2016, Size of 2 Sectors and 2 Provinces

		W₁		W₂		F₁	F₂	X
		1	2	1	2			
W₁	1	x_{11}^{11}	x_{12}^{11}	x_{11}^{12}	x_{12}^{12}	F_1^{11}	F_1^{21}	X_{11}
	2	x_{21}^{11}	x_{22}^{11}	x_{21}^{12}	x_{22}^{12}	F_2^{11}	F_2^{21}	X_{12}
W₂	1	x_{11}^{21}	x_{12}^{21}	x_{11}^{22}	x_{12}^{22}	F_1^{12}	F_1^{22}	X_{21}
	2	x_{21}^{21}	x_{22}^{21}	x_{21}^{22}	x_{22}^{22}	F_2^{12}	F_2^{22}	X_{22}
V		V_{11}	V_{12}	V_{21}	V_{22}			
I		X_{11}	X_{12}	X_{21}	X_{22}			

Generally, the information presented in Table 1 can be reorganized into the following 17 sectors and 34 provinces:

$$\sum_{j=1}^{578} x_{ij}^{w} + \sum_{j=1}^{170} F_{ij}^{w} = X_j^{w} \tag{1}$$

where, w defines 1,2,3, ... , 34. $X_j^w$is the amount of sector i output used as input by sector j in province w,; F_{iw} explains total final demand for each sector i in region w, X_{iw} is total output of sector i in region w.

In the same way, if read columnwise, it can be seen that the total input for sector 1 of X_{11} is allocated for x_{11}^{11}, x_{21}^{11}, x_{11}^{21}, x_{21}^{21} as an intermediate input and primary input of v_{11}. Overall input allocation from Table 1. can be reformulated as:

$$\sum_{i=1}^{578} x_{ij}^{w} + \sum_{i=1}^{6} V_j^{w} = X_j^{w} \qquad \text{for } j = 1,2,3,\ldots,n \tag{2}$$

where, V_j^w is the amount of primary input (gross value-added) from sector j in province *w*, X_j^wexplains the number of input sectors *j* in province *w*. By knowing the value x_{ij}^w and X_j^w a technical coefficient can be calculated, a_{ij}^w, following:

$$a_{ij}^{11} = \frac{z_{ij}^{11}}{X_j^A} \tag{3}$$

$$a_{ij}^{22} = \frac{z_{ij}^{22}}{X_j^B} \tag{4}$$

Equations (3), and (4) are referred to as technical coefficients, also known as input-output coefficients or direct input coefficients Miller & Blair (1985). The coefficient a_{ij} indicates the amount of sector i input needed to produce one unit of sector j output. Within the IRIO framework, equations (3) and (4) are referred to as Intra-regional Input Coefficients. In addition to the interregional input coefficients, in the IRIO model, we will also recognize the Inter-Regional input coefficients shown in equations (5) and (6) below:

$$a_{ij}^{12} = \frac{z_{ij}^{12}}{X_j^1} \quad (5)$$

$$a_{ij}^{21} = \frac{z_{ij}^{21}}{X_j^2} \quad (6)$$

Generally, technical can be written in equation (7) as follows:

$$a_{ij} = \frac{z_{ij}}{X_j} \quad (7)$$

The aforementioned equation can be simplified in the form of the following equation (8):

$$(I - A)\,X = F \text{ or } X = (I - A)^{-1}\,F \quad (8)$$

where, $(I - A)$ is Leontief matrix; $(I - A)^{-1}$ is Leontief's inverse matrix (*multiplier output$_t$*); F is exogenous final request, X is total output determined by inputting various final demand values of F.

Due to the relationship between the level of final demand and the production level, the inverse matrix of Leontief's Input-Output analysis is a fundamental tool in economic analysis. The inverse matrix of Leontief is also known as the matrix multiplier or output multiplier. This study utilized both qualitative and quantitative primary and secondary data. Primary data were obtained from interviews with National Development Planning Agency. The secondary data was obtained from related agencies, especially National Development Planning Agency (Bappenas), National Agency for Disaster Countermeasure (BNPB), and the Central Statistics Agency (BPS) at the national and provincial levels.

3. RESULTS AND DISCUSSION

Geographically, Indonesia is situated in the exact centre of the ring of fire disaster zone. This disaster zone encompasses the waters and landmass of Japan, turning clockwise to encompass Australia, Papua New Guinea, Timor Leste, the Indonesian Archipelago, and mainland Asia before returning to Japan. As the regional epicentre, Indonesia is susceptible to almost all potential natural disasters, including landslides, floods, tornadoes, desert storms, snowstorms, forest fires, volcanic eruptions, and tsunamis. It is evident that Indonesia's territory is a disaster-prone region with the potential to occur in nearly all provinces.

Indonesia's land is situated on the ring of fire in terms of geography. The ring of fire, also known as the Circum-Pacific Belt, is a band of volcanoes and seismically active areas that stretches 40,000 kilometers across the Pacific Ocean. According to a National Geographic report, the Pacific Plate is surrounded by a larger plate called the ring of fire, which is the meeting point of several tectonic plates, including those of Eurasia, North America, Juan de Fuca, Cocos, Caribbean, Nazca, Antarctica, India, Australia, and the Philippines. The plates are continually moving underneath, over, or colliding with one another. The fault lines—the boundaries where plates meet—are the sites of earthquake epicenters, deep ocean trenches, and volcanic eruptions as a result of this movement. The following Figure 1 can be viewed for more clarity.

As the regional epicentre, Indonesia is susceptible to almost all potential natural disasters, including landslides, floods, tornadoes, desert storms, snowstorms, forest fires, volcanic eruptions, and tsunamis. It is evident that Indonesia's territory is a disaster-prone region with the potential to occur in nearly all provinces. Since early 2021, natural disasters have persisted in several Indonesian regions. There are thousands of them. From January 1 to April 5, 2021, the National Disaster Management Agency (BNPB) recorded 1,045 natural disasters. Starting with forest and land fires

(Karhutla), Mount Merapi eruptions, floods, earthquakes, and droughts, landslides are Indonesia's most common natural disasters.

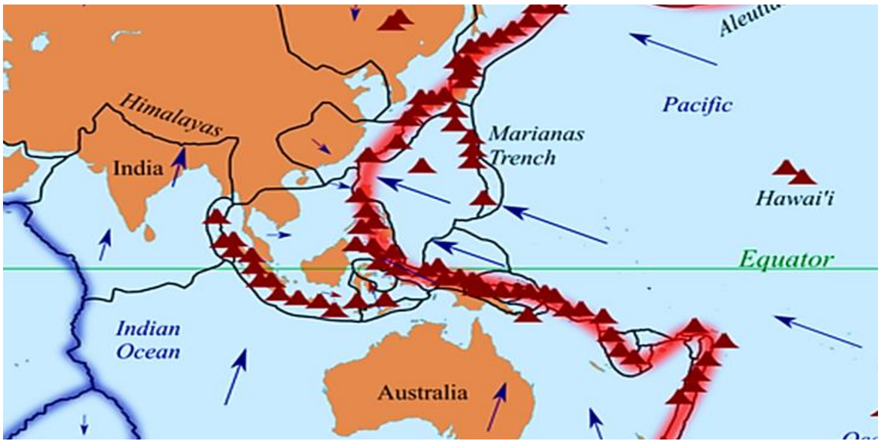

Figure 1. The map of Indonesia’s ring of fire
Source: commons.wikimedia.org (2018)

The natural catastrophe displaced 4,362,537 people, killed 337, injured 12,463, and left 55 unaccounted for. In 2018, losses and damages in the form of Rupiah values had a significant impact amounting to IDR.46,73 Trillion (Figure 2). At the end of 2018, Indonesia closed the year of the worst disaster in the last decade (BNPB). Table 2 shows the magnitude of the value of damage and losses due to natural disasters that occurred in 2018 by province.

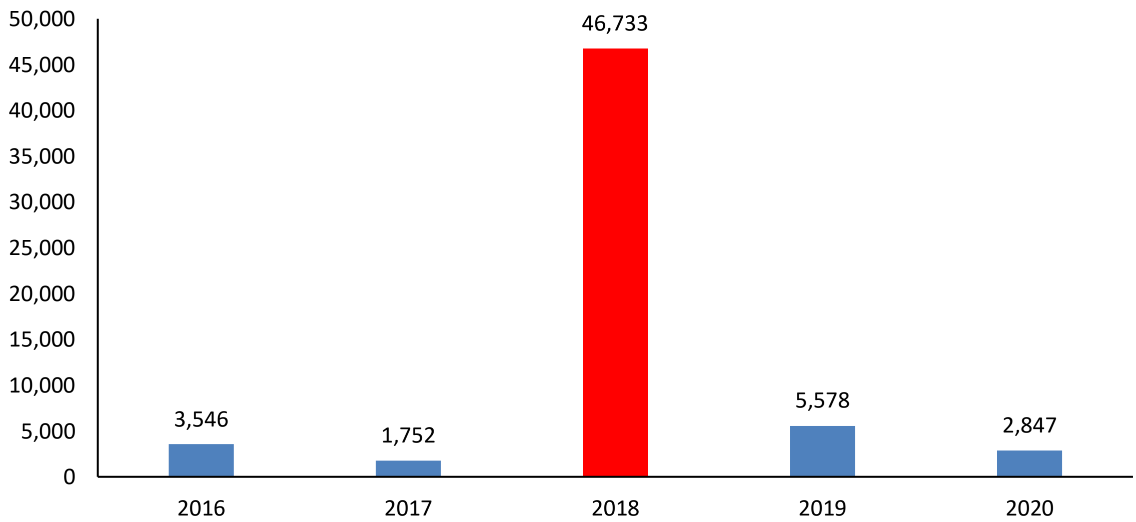

Figure 2. Total damage and losses due to natural disasters in Indonesia, 2016-2020 (IDR Billion)
Source: National Agency for Disaster Countermeasure (2022)

According to these statistics, at least thirteen provinces have been affected by natural disasters, with Central Sulawesi accounting for 51.86 percent of the total damage and losses. It is one of the criteria for determining the indirect impact of natural disasters on the region and national economic performance. Several significant earthquakes have occurred in the last few decades in Indonesia, such as the 2000 Bengkulu Earthquake, the 2004 Aceh-Andaman Tsunami, the 2005 Nias-Simeulue Earthquake, the 2006 Yogyakarta Earthquake, the 2006 South Java Earthquake followed by the 2006 tsunami, and The Padang earthquake was in September 2009, the last one in 2018 was an earthquake on Lombok Island and an earthquake in Central Sulawesi which caused thousands of victims. The following is data on Disaster Events and Casualties shown in Figure 2.

Table 2. Total Damage and Disadvantage Due to Natural Disasters by Province in Indonesia 2018 (IDR Billion)

No.	Provinces	Damage	Disadvantage	Total	%
1.	Aceh	119.29	30.82	150.11	0.32
2.	North Sumatera	120.64	109.93	230.57	0.49
3.	South Sumatera	170.74	200.70	371.44	0.79
4.	Lampung	167.12	149.23	316.35	0.68
5.	Central Java	1.74	0.22	1.96	0.00
6.	Special Region of Yogyakarta	1,359.06	845.22	2,204.28	4.72
7.	Banten	115.28	276.94	392.21	0.84
8.	West Nusa Tenggara	12,315.39	5,922.85	18,238.24	39.03
9.	South Kalimantan	127.39	89.20	216.59	0.46
10.	North Sulawesi	11.46	20.65	32.11	0.07
11.	Central Sulawesi	19,341.90	4,893.77	24,235.67	51.86
12.	West Sulawesi	44.32	41.92	86.24	0.18
13.	South Sulawesi	139.27	118.09	257.36	0.55
		34,033.61	12,699.53	46,733.14	100.00

Source: National Development Planning Agency (2021)

In 2015 the frequency of disaster events that occurred in various regions of Indonesia reached 68,351 incidents with a loss of life of 7,948 people. The most famous case in 2015 was the flood disaster, reaching 25,200 incidents. Natural disaster events in 2016 tended to decrease by 67,518 incidents, but the number of fatalities was higher than in 2015. In 2017, natural disaster events again increased to 74,314 incidents with a total fatality of 9,111 people. The most significant disaster cases in 2017 were floods, with 26,921 incidents, followed by earthquakes, with 18,080 incidents. If observed further in Figure 3, the most significant frequency of natural disaster events occurred in 2019, namely 94,041 incidents, with the most prominent types of natural disasters being contributed by floods and earthquakes.

Table 3. Direct Losses Due to Natural Disasters in the Provinces of Banten, West Nusa Tenggara and Central Sulawesi, 2018

Province/Sector	Losses (IDR Million)
Banten	392,213
Information and Communication	3,485
Construction	303,873
Agriculture, Forestry and Fisheries	84,855
West Nusa Tenggara	18,238,240
Processing Industry	902
Financial Services and Insurance	8,330
Construction	17,937,932
Water Supply & Waste Management	219,230
Agriculture, Forestry and Fisheries	71,846
Central Sulawesi	24,235,674
Processing Industry	56,257
Information and Communication	4,232
Other Services	73
Construction	22,792,861
Water Supply & Waste Management	181,768
Wholesale, Retail	2,306
Agriculture, Forestry and Fisheries	1,197,242
Total Loss	**42,866,126**

Source: National Development Planning Agency (2021)

However, the number of victims was relatively small, namely 6,891 people. It is different from the events in 2020, where the frequency of occurrence was only 33,685 times, with a total of 6,531 fatalities. This implies that the most widespread type of natural disaster in 2020 was flooding, while in 2019, apart from flooding, the most frequent occurrence was an earthquake. An earthquake struck North Sulawesi at the beginning of 2019. According to the Meteorology, Climatology, and Geophysical Agency (BMKG) version was damaged on August 3 by the South Banten, Banyuwangi, and the foot of Mount Salak Earthquake.

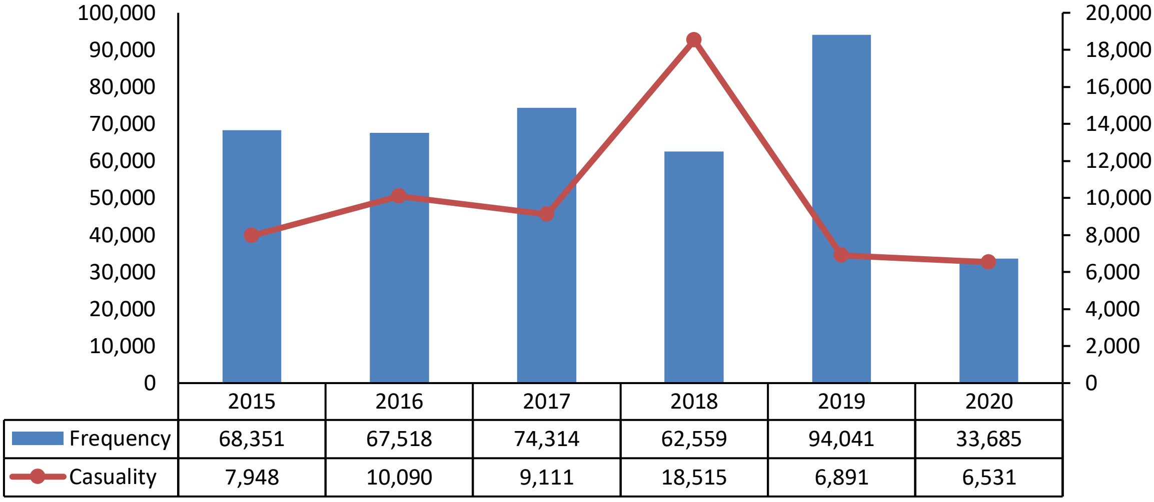

Figure 3. Frequency and Casualties of Natural Disasters in Indonesia, 2015-2020
Source: Central Bureau of Statistics (2021)

This further validates Indonesia's location on the Pacific Ring of Fire based on its precise geographical location (a region with a lot of tectonic activity, Table 1). This position classifies Indonesia as one of the countries most susceptible to natural disasters, making it susceptible to volcanic eruptions, earthquakes, floods, and tsunamis. Figure 3 depicts the overall frequency and number of fatalities caused by natural disasters. At 18:02 WITA on September 28, 2018, a 7.4-magnitude earthquake struck Donggala, Central Sulawesi. West Sulawesi, from Palu and Sigi to Mamuju, experienced tremors. The BMKG reports that the earthquake has the potential to cause a tsunami. The tsunami finally struck Palu on the same date at 18:22 WITA with a height of between 0.5 and 1.5 meters. In addition, there was liquefaction in Petobo Village, Balaroa Village, Biromaru, and Jonooge Village, Sigi Regency. In October 2018, the BNPB recorded 2,079 deaths, 4,438 injuries, and 1,330 missing persons. In the meantime, 68,451 homes were damaged, and the estimated total loss is IDR.13,82 trillion National Development Planning Agency estimates that natural disasters have caused damages and losses totaling IDR.24.23 trillion in the province of Central Sulawesi.

Table 4. Multiplier Output of Central Sulawesi Province

Economic Sectors	**Forward**			**Backward**		
	Intra	**Inter**	**Total**	**Intra**	**Inter**	**Total**
Agriculture, Forestry and Fisheries	1.558	0.495	2.052	1.152	0.176	1.328
Mining and Excavation	1.499	0.470	1.969	1.192	0.311	1.502
Processing industry	1.407	0.499	1.906	1.481	0.373	1.854
Procurement of Electricity and Gas	2.314	0.034	2.348	2.184	0.735	2.919
Water Supply, Waste Management and Recycling	1.035	0.007	1.042	1.200	0.375	1.574
Construction	1.235	0.019	1.254	1.288	0.469	1.757
Wholesale and Retail Trade; Car & Motorcycle Repair	1.540	0.166	1.707	1.194	0.374	1.568
Transportation and Warehousing	1.320	0.099	1.419	1.293	0.602	1.896
Provision of accommodation and food and drink	1.178	0.031	1.209	1.463	0.411	1.874
Information and Communication	1.566	0.067	1.633	1.410	0.338	1.747
Financial Services and Insurance	1.439	0.040	1.479	1.167	0.197	1.364
Real Estate	1.179	0.017	1.196	1.194	0.186	1.380
Company Services	1.108	0.011	1.119	1.289	0.383	1.671
Adm. Government, Defense & Mandatory Social Security	1.131	0.007	1.138	1.298	0.471	1.769
Education Services	1.031	0.001	1.032	1.203	0.321	1.524
Health Services and Social Activities	1.032	0.002	1.034	1.294	0.490	1.784
Other Services	1.083	0.014	1.097	1.355	0.383	1.737

Source: IRIO 2016 model (processed by researchers)

The impact of natural disasters on the economic performance of the Central Sulawesi region is calculated by the research using the IRIO model. Matrix multipliers, also known as output multipliers, are the outcomes of the Leontief inverse matrix, an economic analysis tool that reveals the relationships between industries and between regions, as Table 4 illustrates. Based on the aforementioned research findings, it can be analyzed how a sector is linked to its upstream and downstream sectors conceptually using backward and forward linkages. Forward linkages are links to sales of completed goods and are calculated based on columns, whereas backward linkages are links to input raw materials (input providers) and are based on rows. If the final demand for the agricultural sector in Central Sulawesi province increases by IDR.1 million, output in the Central Sulawesi region will rise by 1,328, while output in other regions will rise by 0.176 million (Saban et al., 2023). Table 4 also shows that Central Sulawesi Province's leading sector is the Electricity and Gas Processing and Procurement Industry.

Table 5. The Impact of Natural Disasters in Central Sulawesi Province on Economic Performance

Sectors	Output (IDR Million)	Gross value-added (GVA) (IDR Million)	Income (IDR Million)	Labor Demand
Agriculture, Forestry and Fisheries	-1,956,902	-1,539,527	-615,422	-31,287
Mining and Excavation	-1,663,753	-1,072,394	-254,354	-1,726
Processing Industry	-1,150,816	-464,523	-94,666	-3,044
Procurement of Electricity and Gas	-237,790	-24,192	-10,568	-419
Water Procurement, Garbage & Waste Management	-193,502	-122,396	-17,048	-1,530
Construction	-23,050,386	-9,811,271	-2,190,449	-79,594
Wholesale and Retail Trade; Car Repair	-1,133,526	-741,646	-296,806	-13,482
Transportation and Warehousing	-451,900	-191,761	-76,136	-1,887
Provision of Accommodation & Consumption	-152,774	-65,088	-14,720	-1,928
Information and Communication	-197,030	-110,325	-30,540	-228
Financial Services and Insurance	-443,434	-337,992	-108,381	-1,254
Real Estate	-144,814	-111,140	-5,745	-24
Company Services	-165,789	-94,023	-56,545	-1,623
Adm. Government, Defense & Mandatory Social Security	-24,401	-13,560	-8,968	-263
Education Services	-9,024	-6,099	-5,300	-138
Health Services and Social Activities	-10,248	-5,404	-3,870	-109
Other Services	-63,948	-34,833	-15,168	-856
Total Impact in Central Sulawesi				
Loss	-31,050,035	-14,746,171	-3,804,687	-139,392
Basic Value	201,563,574	114,018,656	39,720,205	1,440,315
Δ%	-15.40	-12.93	-9.58	-9.68
Other Provinces	-10,987,706	-5,858,670	-2,194,456	-46,863
National Impact				
Loss	-42,037,742	-20,604,841	-5,999,143	-186,254
Basic Value	23,704,788,351	12,645,817,838	4,975,717,725	126,515,800
Δ%	-0.18	-0.16	-0.12	-0.15

Source: Analysis of the IRIO Model, 2016

The data indicate that the occurrence of natural disasters in the province of Central Sulawesi indirectly affects the national economy, not just the provincial economy. It was recorded that the gross domestic product of IDR.12,645 trillion decreased to IDR.12,625 trillion (a decrease of IDR 20.60 trillion). In other words, the national economy decreased by -0.16 percent of the total GDP. The decline in the regional economic growth rate directly influenced the demand for labour, which decreased by 139 thousand people regionally and -186 thousand people nationally. This decline will result in a decrease in sectoral income. Total revenue decreased by IDR 3.80 trillion in the province of Central Sulawesi and by IDR.5.99 trillion nationally.

4. CONCLUSIONS

Interregional Input-Output (IRIO) is the model used to calculate the impact of natural disasters on economic performance (output, economic growth, income, and unemployment). The total impact of natural disasters caused a -0.328 percent decline in national output, a -0.302 percent decline in economic growth, a -0.304 percent decline in income, and a -0.374 percent decline in labour demand. With these assumptions (especially the proportionality assumption), the IRIO model has limitations, one of which is that producers cannot adjust to changes in their inputs or alter the production process because the IRIO ratio remains constant throughout the analysis period. Changes in the quantity and price of inputs are proportional to changes in the amount and price of output under this assumption. To resolve this problem, an econometric model can be developed to predict human loss and property damage resulting from natural disasters.

The estimation results can be fed into the IRIO Model as a shock to calculate the effect on regional economic performance. The IRIO model could be dynamic in an ideal scenario by combining interregional-econometric input-output models. Consequently, not only is the model dynamic, but the impact of natural disasters varies across provinces. Nonetheless, the required model and data similarities are substantial; at least the final demand data by sector and province must be fully available. Programs for disaster mitigation are essential to preventing both direct and indirect losses from natural disasters. Therefore, the government must take into account the long-term effects on inflation and economic growth when implementing disaster mitigation programs. To guarantee the program's sustainability, preventive and mitigation actions implemented today must be proportionate to anticipated future economic growth. Fiscal stability may be impacted by shifts in the rate of inflation and economic expansion. The government must guarantee that measures aimed at mitigating disasters do not compromise fiscal stability and can be harmoniously incorporated with wider economic strategies.

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