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ANALYSIS OF SUSTAINABLE ECONOMICS IN DISASTER-PRONE AREAS OF LEMBANG FAULT

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Abstract
The geographical condition of Indonesia, which is at the confluence of three tectonic plates, causes the formation of faults that are spread in several regions in Indonesia, one of which is the Lembang Fault. This condition causes most of the Lembang Fault area and its surroundings to be disaster-prone areas, so the issue of economic resilience in disaster-prone areas becomes critical. The study area of this research covers the villages traversed by the Lembang Fault. Over the past ten years, the economic growth in the region has been relatively rapid, especially on eco and green tourism. This research was done to obtain a map of the level of economic activity and a map of recommendation areas for economic development in the Lembang Fault area. The methodology used is literature study and data collection in hotel, restaurant and tourism data. The outputs obtained from this study are a thematic map of economic activity and a thematic map of regional recommendations for economic development in the Lembang Fault area. The study results show that areas in the east (Bandung Barat Regency and Bandung Regency) are the areas that allow for sustainable economic development. As for overlay areas with very high risk, further review on the preparation of mitigation and optimal community suppression is needed in an earthquake disaster due to the Lembang Fault.

Keyword :
Bandung Basin, Earthquake, Lembang Fault, Tourism

1. Introduction

The geographical condition of Indonesia, which is located between two continents and two oceans, and its geological location at the confluence of 3 tectonic plates, causes plate faults to form, forming faults that are spread across several regions in Indonesia. Indonesia is categorised as a country with a high level of disaster risk (World Risk Report (2016) in (BNPB, 2020)). This is due to the high level of exposure and vulnerability to disasters. Nearly 75% of Indonesia's industrial infrastructure and basic connectivity, including supporting facilities, are built-in disaster-prone zones (BNPB, 2020).

Indonesia's location is right on the path of the source of a large earthquake from the megathrust-plate subduction zone and active faults on the mainland (BNPB, 2020). Dynamic fault segments that can produce earthquakes above 6.5 magnitudes have been identified as reaching 295 faults (BNPB, 2020). The occurrence of natural disasters, especially earthquakes due to fault movements, will undoubtedly impact objects above the earth's surface. Figure 1 compares the impact of earthquakes and ground displacement on buildings and houses, which shows that in the

last two decades, regions in Indonesia have become increasingly vulnerable to natural disasters.

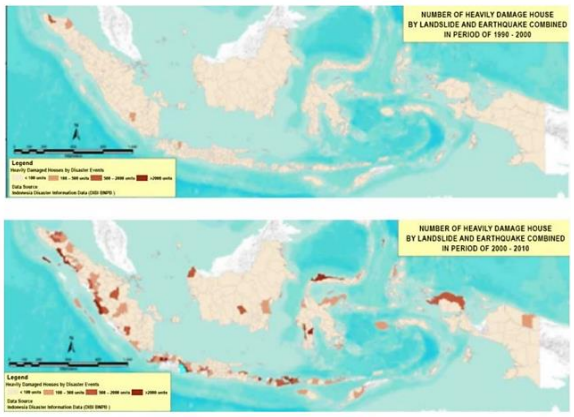


Figure 1. Comparison of disaster-impacted buildings and houses over the past two decades (Gunawan et al., 2015)

Referring to BNPB National Disaster Management Plan 2015-2019, West Java is the province that ranks first in the National Priority Location for Earthquake Disasters with 33,015,075 people exposed and the National Priority Location for Land Movement Disasters with 983,857 inhabitants. This national priority location becomes a reference for disaster management within five years (2015-2019), determined based on the number and lives of exposed infrastructure, probability of occurrence for the next five years, and events impacting more than two provinces (BNPB, 2014).

One of the active faults that can produce earthquakes above 6.5 magnitudes is the Lembang Fault, which stretches 29 kilometres from Padalarang in West Bandung to Cilengkrang in East Bandung. The rate of shift of the Lembang Fault per year is 1.95 – 3.45 millimeters, with the potential for a large earthquake of 6.5 – 7.0 magnitude (Daryono et al., 2019). This condition certainly causes the area traversed by the Lembang Fault to become a disaster-prone area due to the fault's movement.

Based on research conducted by the LIPI Geotechnology Research Center team, it is known that there were two major earthquakes in 2000 years ago and in the 15th century with a strength of more than Mw 6 in the Lembang Fault area. The LIPI Geotechnology Research Center team also confirmed that a fault has a period or recurrence of earthquakes. The period of the earthquake caused by the movement of the Lembang Fault itself is 170 – 670 years, and it is estimated that the Lembang Fault has entered the final period of energy release. It can be interpreted that the Lembang Fault is at the end of the earthquake cycle (Yulianto, 2016).

Based on Presidential Decree 45/2018 in (Rismawati, 2019), the Bandung Basin Urban Area is designated as a National Strategic Area from an economic point of view, which later forms a Metropolitan Area. The Metropolitan Area is divided into Core Urban Areas (Bandung City and Cimahi City) and Surrounding Urban Areas (West Bandung Regency, Bandung Regency and Sumedang Regency). On the other hand, referring to the Regulation of the Minister of Agrarian Affairs and Spatial Planning No. 24 of 2020 concerning the Management of Urban Areas in the Bandung Basin, the area traversed by the Lembang Fault (chapter II article 4) will be used as a cultural centre, a tourism center, as well as a center for service activities and the creative economy (Peraturan Menteri Agraria Dan Tata Ruang / Kepala Badan Pertanahan Nasional Republik Indonesia No 24 Tahun 2020 Tentang Pengelolaan Kawasan Perkotaan Cekungan Bandung, 2020). With the enactment of the ministerial regulation, the area traversed by the Lembang Fault will become the center of various actions, especially as a center of economic activity.

Economic activities in the Lembang Fault area include the plantation, tourism, and livestock sectors as the primary sources of income in the region. These sectors are related to land use and land ownership, so economic activity will also impact economic value and land value. Given that the Lembang Fault area is a disaster-prone area, spatial planning in the Lembang Fault area needs to be reviewed for the suitability of spatial planning for disaster management efforts which will undoubtedly affect economic resilience. In this way, economic resilience in the disaster-prone Lembang Fault area becomes a somewhat important issue. Economic resilience itself can be interpreted as a condition in which specific levels

of production and consumption can be maintained for a long time (Perrels, 2005).

This research seeks to analyse and study economic activities in disaster-prone areas (Lembang Fault). In the end, this can be used as an illustration and input in management, which includes planning, implementation, control activities, and spatial planning in accordance with disaster management and mitigation efforts. Based on the background, the formulation of the problem that will be discussed in this research is how is the distribution of the density level of economic activity in the Lembang Fault prone area.

2. Literature Review

Economic resilience in disaster-prone areas never runs out for review. Two indicators important for measuring economic resilience include the ability of urban economic systems to deal with disaster risks and restore development after disasters. Economic recovery in the short term focuses on sensitive sectors (i.e., government finance, social finance, transportation, and social welfare). In contrast, the long-term focuses on stable sectors (the pull of investment and financial support). To improve economic resilience in disaster-prone areas, it is necessary to reflect on changes in economic structure based on data before and after disasters and the need for integration of economic sectors and matching economic activities in the area (Zhou et al., 2019).

In his research entitled "*Damage Assessment In Tourism Caused by an Earthquake Disaster*", (Nishimura et al., 2012) wrote that earthquake disasters could reduce the number of tourists even though the area suffered minor damage. This is believed to be due to psychological reasons such as people's uncertainty regarding service levels, so they prefer to avoid travelling to these areas. This decrease in the number of tourists occurred in an area with a radius of 50 km from the center of the site that suffered severe damage. But regions with a longer radius also experienced a decrease in tourists, although not as much as areas with a radius of 50km. One of the reasons for such cases is geographic location, economic blocks, and traffic networks (Nishimura et al., 2013).

Based on the research, economic resilience is an issue that needs to be followed up. There needs to be adequate preparation and management to create a region with safe economic activity, even in disaster-prone areas. Creating a disaster-resilient area will increase tourist confidence about the safe level of service for disaster risk. It can also reduce and reduce economic losses incurred due to a disaster (Nishimura et al., 2013).

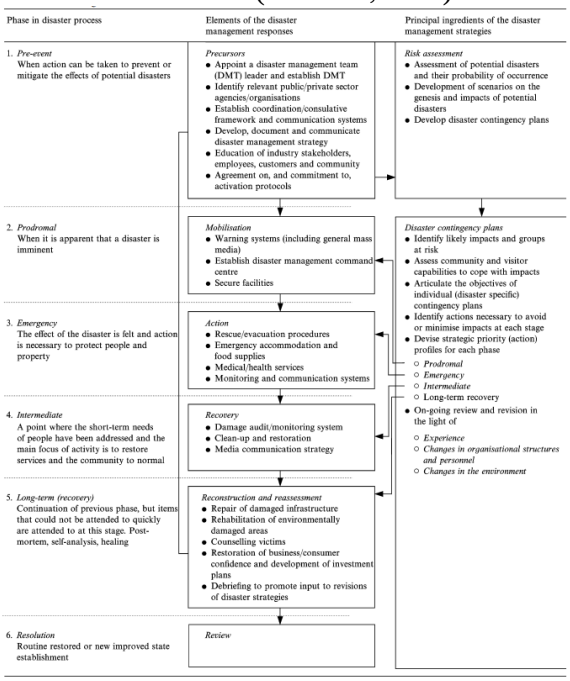
It is always fascinating to learn how tourism businesses can persist in rural areas prone to disasters. Undoubtedly, the tourism sector has become one of the significant contributors to development. It is an agent of change for many parts of the world. The strengths of tourism are described in various forms as a tool in economic and physical development and to enhance social and human capital development and conserve our natural environment. In rural areas, especially in developing countries, tourism development has been eagerly embraced as a panacea for revitalizing the rural economy. Ever since the concept of sustainable development came into the development and conservation debate, many government agencies, particularly tourism-related bodies, have invested heavily to promote more sustainable forms of tourism in rural areas (Kamarudin et al., 2019).

Based on the evidence from the analysis performed by Kamarudin, the essential ingredients for business resilience in disaster-prone areas are closely related to the respondents' positive attitude and, in this case, high self-esteem and internal belief that they will succeed in their tourism businesses despite facing many challenges and uncertainties from time to time. To reinforce their resilience, other influential factors such as kinship and family support, the possession of practical skills and the ability to conduct self-maintenance of homestays are also necessary (Kamarudin et al., 2019).

Natural and human-induced disasters alike are neither predictable nor avoidable. Furthermore, while disasters are, fortunately, relatively rare occurrences and they are to some extent random, it is also true that no destination is immune from such events. In response to the near certainty of experiencing a disaster of some type eventually, tourism organizations can devise means for minimizing the damage of, and accelerating the recovery from, such events through the development of disaster management strategies. By studying past events, the responses of those affected, the adopted recovery measures, and

retrospectively evaluating the activeness of these responses, we can develop strategies for coping with similar events in the future. A distinction has been drawn between crises and disasters (Faulkner, 2001).

Table 1 Tourism disaster management framework (Faulkner, 2001)



Two overarching results were found related to the vulnerability and resiliency of tourism-based economies before and after a natural disaster. First, as expected, natural disaster damage related to physical damage and human loss influenced regional economies. This negative relationship suggests that more disaster losses lead to lower regional economic levels. Second, more significant economic development before the disaster occurs contributed to lower disaster losses. This finding indicates that a region with a more robust economic condition without considering natural disaster insurance before a cataclysm will experience more minor disaster losses than a weaker financial situation. Smaller economies with less industry diversity (i.e., primarily, or largely dependent on tourism) are more deeply impacted by disaster events than more significant and more economically robust economies (Kim & Marcouiller, 2015).

Currently, small, and medium-sized community businesses are growing in disaster-prone areas of The Lembang Fault. But, according to Aini, the increasing numbers of natural disasters slow down the development of the economy in developing countries in Asia. To reduce the impact of disasters, it becomes mandatory for the business operator in disaster-prone areas to form a business continuity plan. A business continuity plan is a process whereby the business operator or company creates the prevention and recovery systems specifically to deal with potential threats of a disaster. Having a business continuity plan, in the long run, can improve business protection from disruption to protect the business assets and prevent losses (Aini et al., 2020).

In the future, the number of people and infrastructure will be in disaster-prone areas as the population and economy grow. Hence, disasters in these areas tend to be more costly. In addition, economic impacts such as damage to infrastructure and assets can be felt due to the disaster itself or from events in the aftermath of a disaster. Disaster will be lowering the capital stock of an area, and the indirect impacts include reduced economic productivity, interruption of commercial operations and public services, and the multiplier effect on reduced economic activity. Thus, there is a solid economic case for investing in disaster risk reduction, alongside the social and environmental reasons for undertaking these investments. So, to support economic sustainability in disaster-prone areas, there needs to be an analytical framework of benefit-cost analysis for improving decision-making about investments in disaster risk reduction. Decision-makers will make more informed decisions if the economic costs and benefits are visible (Vorhies, 2012).

Another thing that is no less important is to improve people's perspectives. It is because the development of the disaster-prone area always lacks sustainability. So, in terms of the construction of centralized resettlement areas, integrating relocation policies to avoid geological disasters, which is essential for poverty alleviation, and ensuring that they live in good houses is necessary. The economy in the region will not be sustainable if the rich infrastructure does not match the economic system used in the area (Tang et al., 2021).

Botzen reviewed those natural disasters have significant negative direct economic consequences. Policies need to address the significant distributional effects of disasters. So,

policymakers must have information about local natural disaster risks and effective risk mitigation measures and procedures. Policymakers should also strive to promote economic resilience by maintaining a vibrant, flexible, and diversified economy that can cope with shocks (Botzen et al., 2019).

3. Methodology

The planned methodology in the implementation of this research is as follows:

A. Literature study

This stage is the initial stage carried out to collect and understand the problems raised. The implementation of this stage is to conduct a study of some literature on disaster resilience in urban communities, especially from an economic perspective, and a sustainable economy in disaster-prone areas of the Lembang Fault. The result of this stage is the collection of related reference sources that can be used as a basis and reference for writers.

B. Data collection

At this stage, the data used is data on the distribution of economic activities, including hotels (accommodation), restaurants, and tourism in the Lembang Fault area. Data collection of distribution of economic activities is carried out using the Openstreetmap turbo overpass platform. And used a map of the risk of earthquake disaster due to the Lembang Fault studied by Tsasalatsa, 2021.

C. Data processing

This stage is the stage for processing the data obtained to produce information and research products that can be analyzed. The data processing in this final project research was carried out using ArcGIS software for making thematic maps of economic activities and thematic maps of regional recommendations for economic development in the Lembang Fault area. The map obtained will then be overlaid with a map of the earthquake disaster risk due to the Lembang Fault.

The earthquake risk map used in this study is a map made by a team of members of the Applied Geology and Cadaster Surveying research team, one of which is Tsasalatsa (2021), which writes the results of earthquake risk mapping in its final project using three main criteria, namely hazard, vulnerability, and exposure. The variables used for each criterion are the peak acceleration value in bedrock for the hazard criteria, the implication factor, fault density, distance from the fault, soil movement susceptibility, building density and social index for vulnerability assessment, and building assets and residents for exposure assessment. The method used is MCDM (multi-criteria decision making), which involves the consideration of many criteria (Mulliner in Tsasalatsa, 2021). The MCDM method used includes the *Analytical Hierarchy Process* (AHP) and *Vlsekriterijumska Optimizacija I Kompromisno Resenje* (Multi-criteria optimization and compromise solution / VIKOR). The AHP method is used to calculate the weights of the criteria to be considered. The weighting is carried out following the rules of comparative judgment on the three criteria set to give a priority order of the existing variables. After the weighting is done, an assessment is carried out using the VIKOR method by entering criteria based on the variable's value with a decision matrix. The decision matrix is a matrix that contains the arrangement of each criterion and alternative. The alternative levels chosen were 1 (very low), 2 (low), 3 (medium), 4 (high), and 5 (very high). Then the value is presented in the form of a risk map which is then used to overlay with a map of the distribution of economic activity.

D. Analysis of the results

The analysis process was carried out on both thematic maps, which were overlaid with disaster risk maps related to economic sustainability in the disaster-prone area of the Lembang Fault. The analysis includes how the map of the density level of economic activity in the disaster-prone region of the Lembang Fault represents the density of economic activity. And what are the recommendations for areas suitable for sustainable economic development in disaster-prone areas of the Lembang Fault.

E. Conclusions and suggestions

The last stage contains conclusions drawn based on the research results that have been carried out. This conclusion stage is the answer to the main problem formulated previously. From the

findings obtained, it is necessary to have suggestions for the development of further research.

4. Discussions and Analysis

Map of economic activity (figure 2) is compiled based on the number of economic activities from the hotel, restaurant and tourism sector in each village in the Lembang Fault area. Data on the number of hotels, restaurants, and tourism are then classified using natural spatial breaks to obtain a map, as shown in figure 2. While the earthquake risk map (figure 3) was obtained from Tsasalatsa (2021) research with the title "Earthquake Risk Assessment Due to the Lembang Fault in Bandung and Surrounding Areas, West Java." Figure 4 is a map resulting from the overlay of the risk map earthquake disaster and economic activity in the Lembang Fault Area.

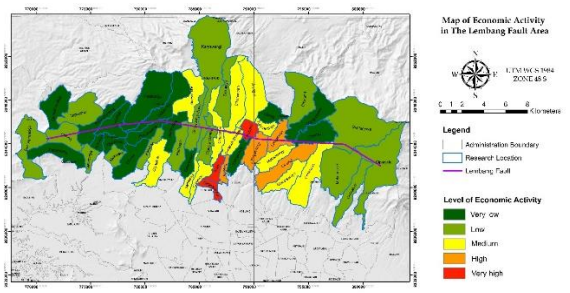


Figure 2. Map of economic activities in the Lembang Fault Area (Source: Authors' Analysis)

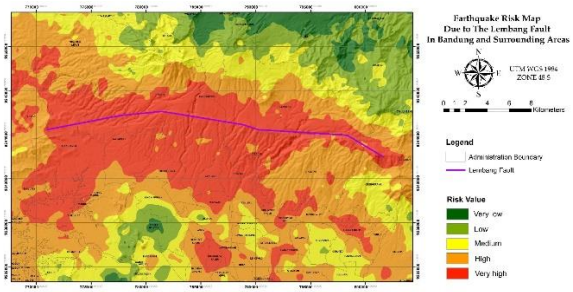


Figure 3. Map of earthquake disaster risk due to the Lembang Fault (Source: (Tsasalatsa, 2021))

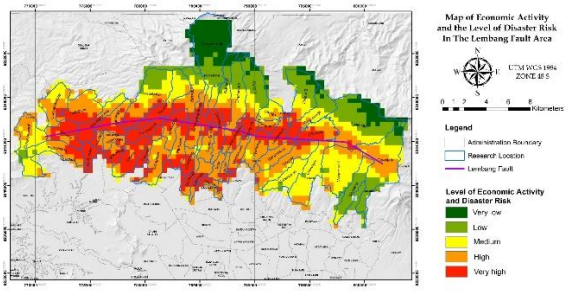


Figure 4. Map of economic activities and disaster risk levels in the Lembang Fault Area (Source: Authors' Analysis)

Map of Economic Activities and Disaster Risk Levels in the Lembang Fault Area shows the relationship between economic activity density and earthquake disaster risk in the Lembang Fault Area. The results of displaying the two maps produce new data distributions related to the density level of economic activity in earthquake-prone areas due to the Lembang Fault. Areas in red (very high class) indicate that the site is located in a room with a very high risk of earthquake disaster with a density of economic activity that varies from very high to low. From the map in figure 4, it can be seen that there has been a decrease in one level of earthquake risk with the density of economic activity in the low classes. Note that the area is located relatively long from the Lembang Fault line. Meanwhile, for areas reasonably close to the Lembang Fault, it shows that the results of the patching of the two maps are in the very high to high class. However, if we look further, areas with a density of middle to high-class economic activity that overlaps with regions with high and very high earthquake risk classes do not show a decline in class.

From this description, it can be found that the two maps patching results give varied results. Besides being influenced by the parameters of economic activity and earthquake risk, the variation in question is also influenced by the distance of the area from the Lembang Fault. On the earthquake risk map, areas relatively close to the Lembang Fault have a higher risk of an earthquake disaster than areas farther from the Lembang Fault. The economic activity map shows the distribution of hotels, restaurants, and tourism in each village without considering the distance of the town from the Lembang Fault. So, when overlaid, the area relatively close to the Lembang Fault indicates

that the site is in a very high class and a high class. For areas not too close to the Lembang Fault, the new type formed will depend on calculating the density level of economic activity with the level of earthquake risk in the area. These areas are relatively experiencing a decrease of one class level from the earthquake risk class.

Based on the disaster risk map due to the Lembang Fault, it is known that the area along the Lembang Fault is an area that has a very high level of disaster risk. Ironically, these areas are promising and suitable for development as centres of various economic activities. This is supported by the management of the Bandung Basin Urban Area as a cultural centre, tourism center, as well as a center for service activities and the national creative economy as stated in the Regulation of the Minister of Agrarian Affairs and Spatial Planning No. 24 of 2020 concerning Management of the Bandung Basin Urban Area. Considering the planned area allocation in the Bandung Basin area, which is full of various activities, it is necessary to build economic resilience in the context of sustainable economic development in the Lembang Fault. Sustainable economic growth in the Lembang Fault area, a disaster-prone area, needs to be considered so that disaster-prone areas can recover immediately after a disaster occurs.

Referring to (Rismawati, 2019), the West Java Provincial Government has provided specific directions regarding the potential for disasters caused by the Lembang Fault. The directives are intended to prevent or reduce the impacts caused by catastrophes and minimize disaster risks. Efforts are being made to reject applications for new permits for residential buildings, one of which is along the Lembang Fault and prohibit the construction of buildings or the addition of built-up areas. Meanwhile, efforts to improve current conditions are still limited to providing directions for determining the location, providing evacuation routes, and understanding people who are active or live along the Lembang Fault route.

Thus, in developing a sustainable economy in disaster-prone areas, it is necessary to consider various things so that economic activities can continue sustainably even in disaster-prone areas. Spatial planning in disaster-prone areas as economic management plans needs to pay attention to spatial conditions and the level of disaster risk. In relation to the obtained overlay map, the area that has the potential to be further developed is the area in West Bandung Regency (the area on the west/right side) with a relatively lower level of disaster risk compared to other areas along the Lembang Fault. However, planning for the development of this area needs to be accompanied by regulations or laws that apply to the area as described previously. The policy regarding the management of the Bandung Basin area is one of the appropriate references for developing the area.

Meanwhile, for other areas along the Lembang Fault, with a very high or high level of disaster risk and economic activity, it is necessary to monitor the economic activities that occur in the area. In addition, it is essential to educate the public about the risk of a disaster and the losses that may be caused. Educating the public also includes insurance and permits to construct buildings in disaster-prone areas to form a disaster-aware community.

On the other hand, a collaboration between government strategies and active community participation is needed in sustainable economic development in disaster-prone areas. So that the exploration of economic potential can run optimally and promotion of areas suitable for sustainable economic growth can be carried out. It is hoped that economic management planning in disaster-prone areas by considering disaster risks can create areas with strong economic resilience.

5. Conclusions

This paper describes economic activity in disaster-prone areas due to the Lembang Fault. First, this paper describes the level of disaster risk due to earthquakes in the Lembang Fault, divided into five risks. Then show the density of economic activity in the Lembang Fault area, divided into five classes with a natural breaks' classification method. In the end, the merger of the two maps resulted in a new product regarding the results of the disaster risk overlay with the density of economic activity.

From the combination of the map, it was obtained that the area in the east, with a high and medium disaster risk value bordered with a low economic activity density value, is an area that allows for sustainable economic development. The economic growth in question can begin with new tourism, which will later trigger other economic sectors such as accommodation, restaurants, souvenir centers, etc.

As for overlay areas with very high risk, further review is needed regarding mitigation preparations that economic activity actors in related areas have planned. As it is known that economic resilience is a condition in which economic activity can be maintained for a long time, as well as how society can recover after a disaster. Then it is necessary to make careful preparation that includes checking the physical condition of the building in the tourism sector, building and asset insurance, evacuation routes, and various other practices. And there needs to be optimal community suppression in the event of an earthquake disaster due to the Lembang Fault.

The preparation and review become a crucial thing to note. This is because the number of tourists can be reduced if tourist confidence in tourist services and security decreases after a disaster. To support economic sustainability in disaster-prone areas, it is necessary to do structured and sustainable planning to minimize the risks posed by disasters.

Further studies are needed to study the extent of the preparations that have been made by the parties involved in the relevant region. In addition, there are still few studies on this matter, making further studies very necessary. The thing that can be developed from this research is modelling the recovery process of economic activity in disaster-prone areas due to the Lembang Fault. In addition, it is necessary to develop in-depth interviews with businesspeople and residents living in disaster-prone regions of The Lembang Fault so that it can be done to extract the potential of the area that is suitable for economic development in more detail.

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