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Lembang Fault Deformation Study Using Sentinel-1A Image with PS-Insar Method

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ABSTRACT

The National Disaster Management Agency (BNPB) stated that the number of earthquakes that occurred in Indonesian territory during 2018 was 11,418. Nearly 95 percent of earthquakes occur in fault areas and plate boundaries. The methodology of this study has four main stages of data processing, namely the differential interferogram stack stage and coregistered stack formation using SNAP software. The results of the study concluded that the average deformation along the Lembang Fault was 2,485 mm, with a graph that tended to rise. The area most affected by deformation is Cisarua District, with a Line-of-Sight deformation speed of 28.4 – 48.9 mm/year. The most minor deformation occurred in Lembang Regency with a Line-of-Sight deformation speed of -2.3 – 19.2 mm/year. Conclusion The PS-InSAR method has proven to be effective in mapping the speed of Line-Of-Sight (LOS) deformation along the fault path. PS-InSAR data shows that deformation in the Lembang Fault ranges from an average of 2,485 mm, with an increasing trend from January 2018 to March 2019. The area most often affected by deformation is Cisarua District, West Bandung Regency, with the LOS deformation rate reaching 28.4 to 48.9 mm per year.

Introduction

The Lembang Fault is one of the faults that is estimated to be an active fault that will trigger earthquakes in West Java, especially in the Bandung area (Aji, Prasetyo, & Awaluddin, 2018). The Lembang fault depicts the topography as a gawir that extends west-east and is located north of Bandung City in West Java (Y Prasetyo & Firdaus, 2019). This fault is a canal from the northern end of the Cimandiri fault (PSGN, 2017). The activity level of the Lembang Fault is not well known, so more integrated research is needed from several methods, including seismic methods, gravity methods, and deformation methods (Rasmid, 2014).

Deformation can be an essential parameter to determine the presence and impact of an earthquake (Arintalofa, Yulianto, & Harmoko, 2020). Deformation is a change in position, absolute or relative movement of the position of a material, or a change in position in linear dimensions (Andreas, 2001 in Jamel, 2013). The amount of deformation can be analyzed through SAR image data using the InSAR, DinSAR, and PS-InSAR methods (Yudo Prasetyo & Subiyanto, 2014). The PS-InSAR technique is a development of conventional techniques InSAR and DInSAR (Lesniak, 2008). The main principle of the PS-InSAR technique is utilizing multitemporal SAR image observation data over long time spans to detect potential points of coherence. These points are then analyzed over some time to see their displacement (Maghsoudi, van der Meer, Hecker, Perissin, & Saepuloh, 2018).

Sentinel-1A satellite imagery is imagery produced by the Sentinel-1A satellite designed and developed by the European Space Agency (ESA) in 2014. Citra Sentinel 1 has three product types, consisting of SLC (Single Look Complex), GRD (Ground Range Detected), and OCN (Level-2 Ocean) (RoseGIS, 2018). SLC products consist of focused radar data, geo-referenced using orbit and altitude data from satellites, and are available on slant-range geometry (Syahputri, Anjasmara, & Hayati, 2023). Sentinel-1A can observe the Earth's surface during the day and night with a repeat cycle every 12 days. There are four acquisition modes owned by Sentinel-1A, namely Stripmap (SM), Interferometric Wide Swath (IW), Extra Wide Swath (EW), and Wave (WV). IW is the main recording that focuses on land where the recording area is 250 km2 and has a spatial resolution of 5 m to 20 m (single look).

Method

This research methodology has four main stages of data processing, namely the differential interferogram stack and coregistered stack formation stages using SNAP software, StaMPS processing to analyze the selection and calculation of PS point deformation using Matlab software, spatial subsetting stage or limiting deformation results according to the Lembang Fault path using RStudio software, layouts using QGIS software, and calculating the average LOS deformation using Microsoft Excel software. The research methodology can be seen in Figure 1. The study began by forming eight images into differential interferograms and coregistrated stacks. These two stacks are each exported using the StaMPS export operator in the SNAP software in the form of a folder structure required by the StaMPS program and then used the mt_prep_snap command on the Ubuntu terminal to calculate the stability of the amplitude by entering the dispersion threshold of 0.4. Furthermore, the Matlab software uses StaMPS scripts to identify Permanent Scatterers (PS) and estimate deformation. After obtaining the results as a time series Line-Of-Sight velocity of deformation, extraction is carried out as a CSV table to limit or spatial subset according to the Lembang Fault path area. The PS points are then laid out using QGIS software, which produces a map depicting the deformation of the Lembang Fault.

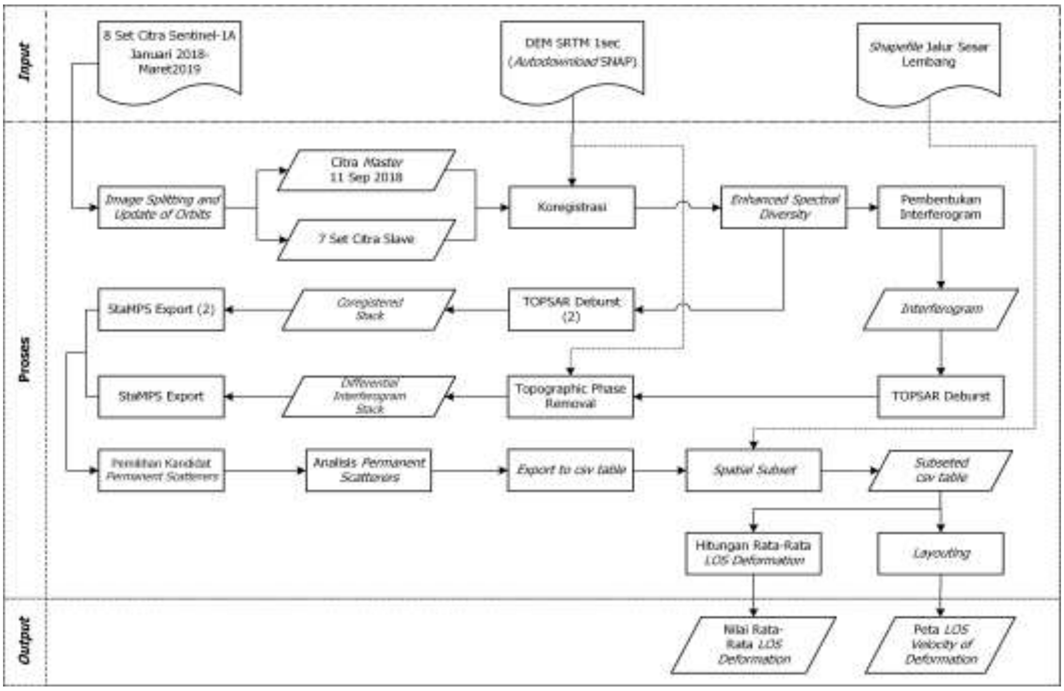


Figure 1
Research Methodology

Results and Discussion

The Lembang Fault deformation study results in the form of the LOS Velocity of Deformation Map in time series (mm/year) from 2018 to 2019. The velocity of the deformation value can be harmful, which means that the study area is down, or it can be positive, which means the research area is up (Rohmah, 2017). These results can be seen in Figure 2. According to the results of the study, it can be explained that the Lembang Fault experiences LOS velocity of deformation represented by color points, ranging from the smallest value of -2.3 mm/year marked with yellow color to the most significant value with purple color, which is 48.9 mm/year. The research area along ± 29 km processed from observations from January 2018 to March 2019 produced 15,542 PS points and obtained an average deformation LOS value of 2,485 mm (Muvid, 2018).

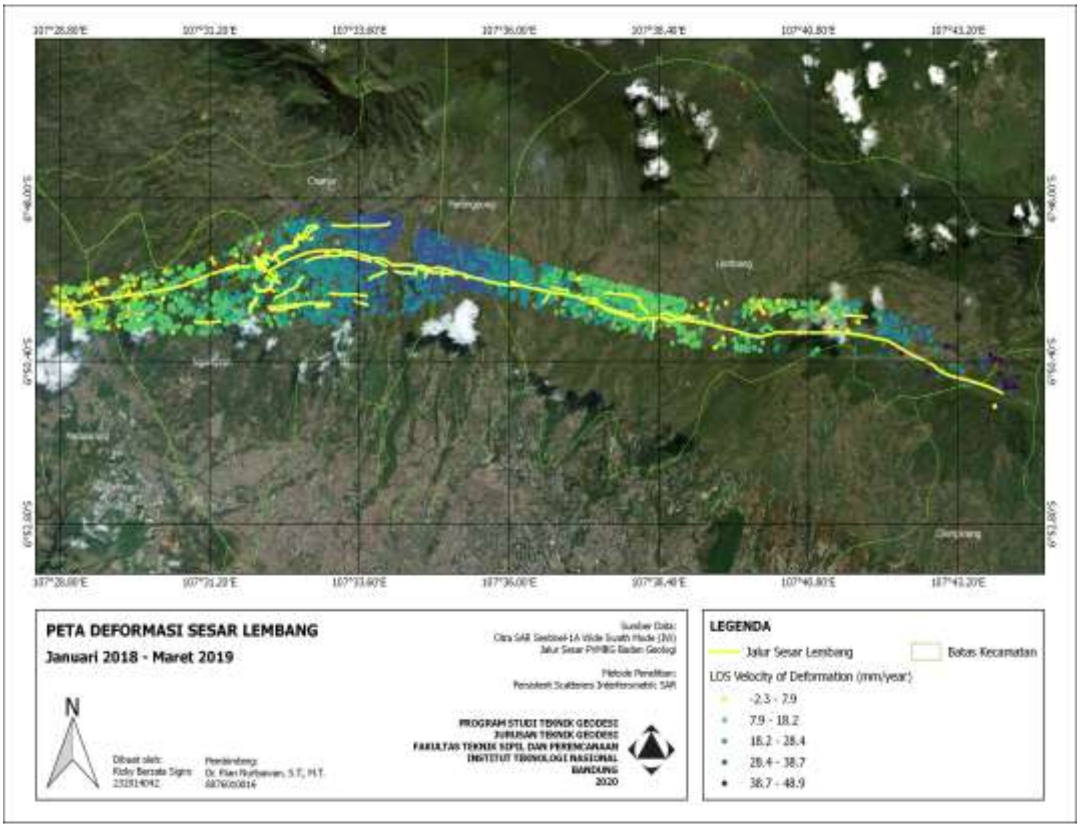


Figure 2. Lembang Fault Deformation Map

Deformation Trend Analysis

Based on the study's process and results, the Lembang Fault experiences deformation that varies uplift and subsidence. The resulting deformation values are positive and negative. The average value of LOS deformation can be summarized in one graph. The graph, as shown in Figure 3, illustrates the deformation trend in the Lembang Fault from January 2018 to March 2019.

In the future, the number of generations will move according to the human life cycle; of course, the existence of technology will be beneficial and more accessible. The results and discussions in the multi-finance industry, which is divided into three asset categories, have their challenges, where those included in the 10 T > assets will maintain and, if possible, will move to become leaders. Likewise, for multifinance companies with assets of 5-10 T and 1 -5 T, whether they decide to be aggressive or survive. For companies that are still in the asset category between 5 -10 T and 1 - 5 T, of course, they will expect to be able to have a more significant amount of assets, which will undoubtedly be attractive to investors who will invest their funds which have an impact on the low cost of funds so that the segment of financed debtors will be lower risk so that the portion of technology spending can be increased.

The initial mapping of organizational conditions, especially for IT and Digital departments or directorates, will make it easier for a company to determine organizational goals in the next 3-5 years. The latest opportunities and innovations will always emerge; by using PASTEL analysis SWOT in the use of technology through website media in the multifinance industry, every multifinance company has an overview of a company's strategy in information technology and digitalization. By also paying attention to the opportunities and threats of each category of asset-based finance companies, you can see how a company applies technology in supporting business and the process of adapting to technology and digitalization by using applications such as digital signatures, third-party data to see the credit history of prospective debtors.

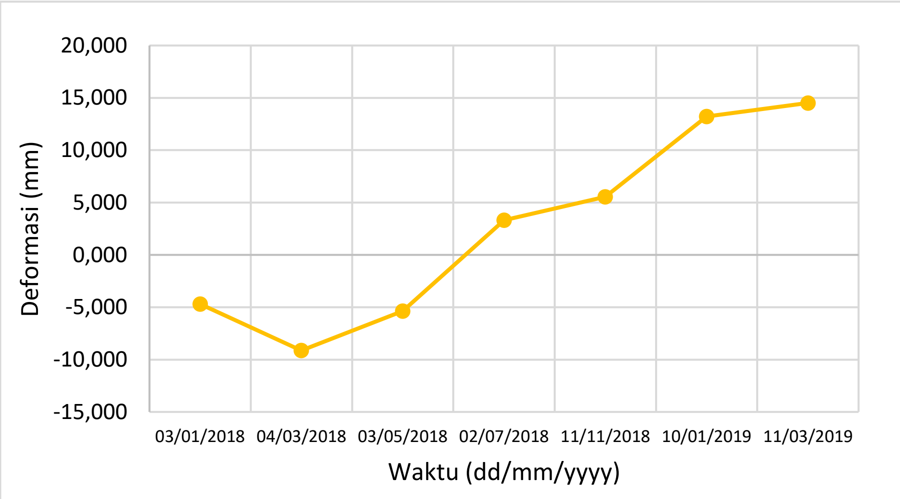


Figure 3. LOS Tren Deformation

In January 2018, the average deformation LOS was -4,703 mm. It decreased in March 2018 to -9,133 mm and rose sequentially from May 2018 to March 2019 with a value of -5,381 mm, 3,309 mm, 5,559 mm, 13,230 mm, and 14,513 mm. Overall, the deformation trend in the Lembang Fault tended to rise or uplift from January 2018 to March 2019. However, there was also a decrease or subsidence in March 2018.

Largest Deformation Analysis

The largest categorized LOS Velocity of Deformation value is 28.4 and 48.9 mm/year. After analysis per sub-district, it can be concluded that the most considerable deformation on the Lembang Fault occurred in the Cisarua District, West Bandung Regency. The area consists mainly of settlements, which shows that the risk of deformation impact on the Cisarua District is higher. The results of this analysis can be seen in Figure 4.

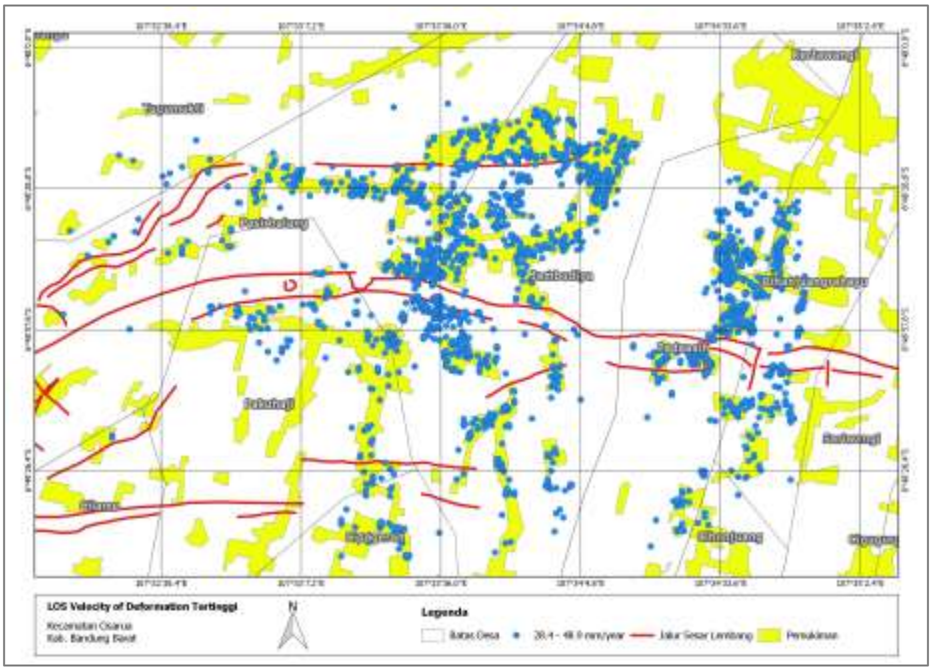


Figure 4. The Largest Deformation of the Lembang Fault

Smallest Deformation Analysis

In addition, the most minor deformation in the study area was also analyzed. The smallest category is the one that is valued between -2.3 to 18.2 mm/year. Areas with such values are located in Lembang District, West Bandung Regency. According to the results of this study, it can be concluded that this area has the lowest risk of deformation impact and is relatively safe (Awaliah, 2020). However, that does not mean this region does not need preventive measures. This is because the community settlement is very dense and is precisely on the main fault line. The results of this minor deformation analysis can be seen in Figure 5.

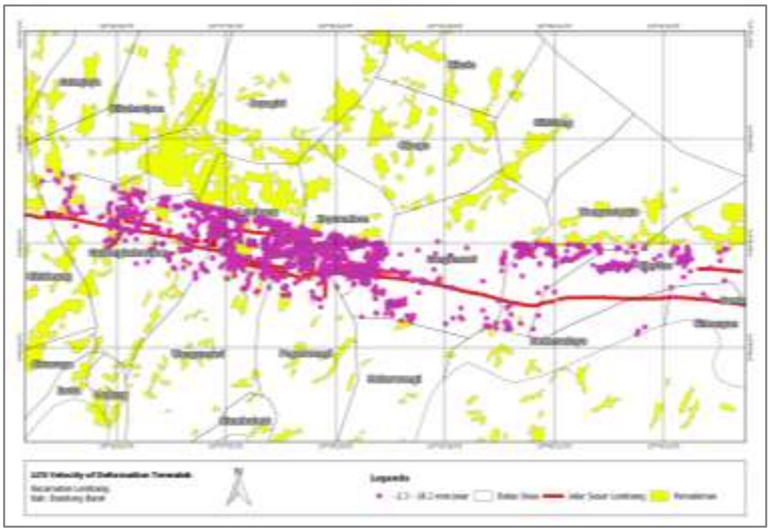
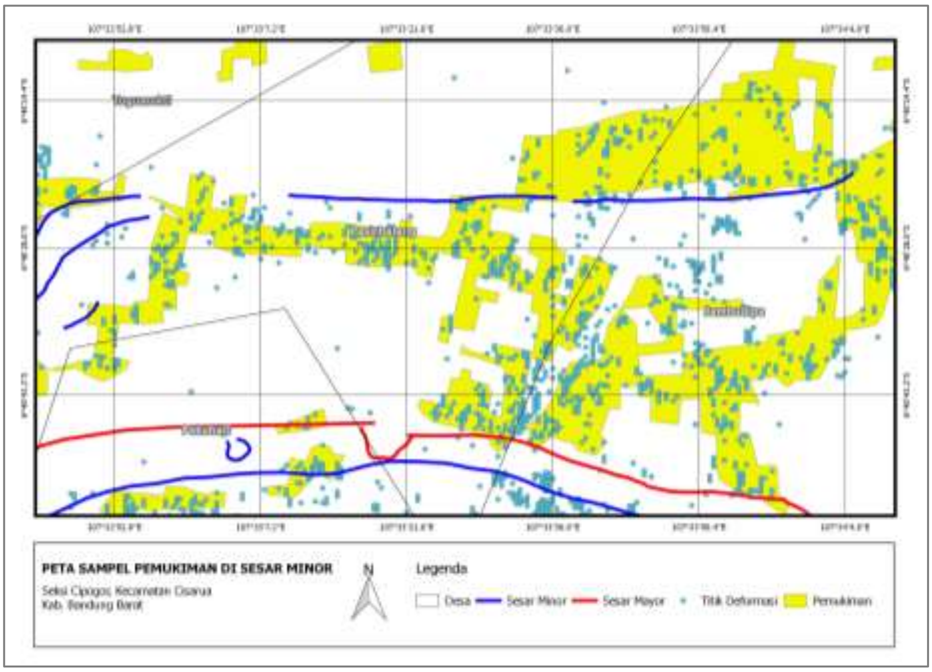


Figure 5. The most minor deformation of the Lembang fault

Analysis of minor faults

The Lembang Fault is a major fault that stretches along 29 km. In addition to significant faults, minor fault structures are of concern in this study. These minor faults are located in the south and north of the main fault. Many community settlements above it occupy this fault. Therefore, it is also necessary to analyze the existence of this settlement because settlements on the main fault line need to be considered for mitigation actions, as well as settlements on minor faults. As a sample, we can see the appearance of minor faults quite widely occupied by settlements in Figure 6.

Gambar 6. Pemukiman pada Sesar Minor



Deformation Percentage Analysis in Settlements

Based on the data processing results using the PS-InSAR method, as many as 15,542 PS points were obtained for deformation points. Then, these points were overlaid with residential areas. The results showed 10,249 PS points, or 66%, in settlements. This shows that most of the settlement activity on the Lembang Fault caused deformation, both in the direction of uplift and subsidence. Furthermore, analysis was carried out in each sub-district on the Lembang Fault to see where the density of the deformation point was greatest. After the sub-district boundaries are plotted, as shown in Figure 7, it can be analyzed that the percentage of settlements affected by deformation is highest in Cisarua District, West Bandung Regency.

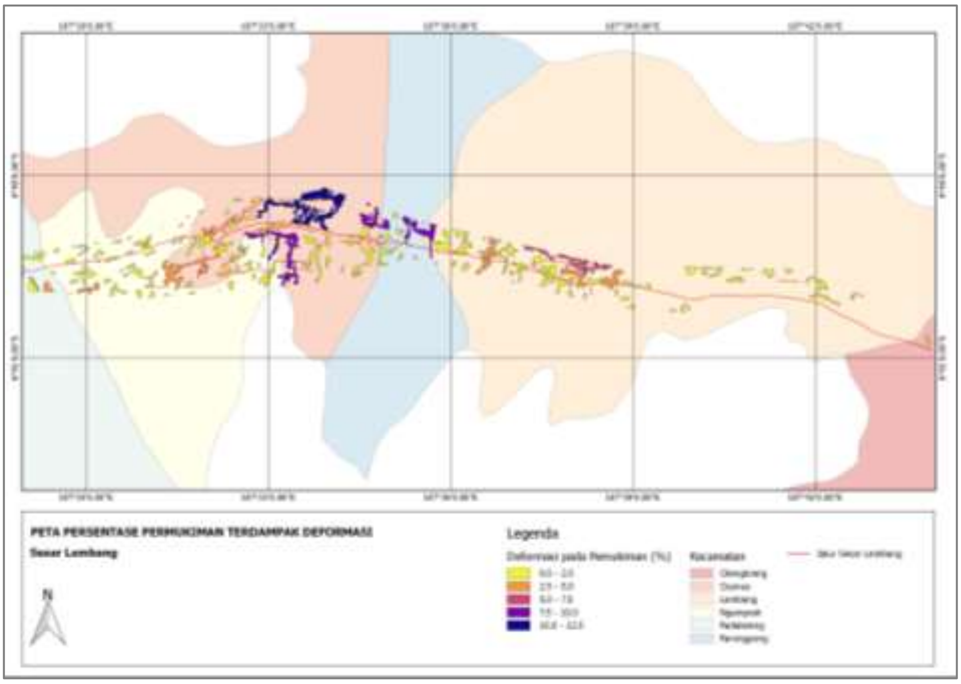


Figure 7. Percentage of Settlements Affected by Deformation

Conclusion

Based on the results of the study on the Lembang Fault, the PS-InSAR method has proven to be effective in mapping the speed of Line-Of-Sight (LOS) deformation along the fault path. PS-InSAR data shows that deformation in the Lembang Fault ranges from an average of 2,485 mm, with an increasing trend from January 2018 to March 2019. The area most often affected by deformation is Cisarua District, West Bandung Regency, with the LOS deformation rate reaching 28.4 to 48.9 mm per year. This information is important as an early warning for earthquake disaster mitigation in the region. Meanwhile, Lembang District, also in West Bandung Regency, experienced a more minor deformation with LOS speeds ranging from -2.3 to 19.2 mm per year. However, settlements in Lembang District are still at risk because they are located in the Lembang Fault Line area.

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