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Analysis of Potential Destructive Earthquakes in the Seulimeum Fault – North

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\textbf{Abstract.} Earthquake activities in Aceh Province are caused by the Sumatran Fault Zone and the West Coast Subduction Zone. Recent Research suggested that there are 13 Active Fault Segments in the Aceh region. Since 1938 – 2018 there were 21 destructive earthquakes occurred in Aceh. Destructive earthquakes were dominated by the source of active fault segment in the Aceh region, one of the active faults with destructive earthquakes is the Seulimeum Fault – North. This research aims to determine the level of seismicity in the Seulimeum Fault - North area using the Gutenberg Richter ($\log = a - bM$) method. Then it is used to calculate surface density and earthquake recurrence times. The results are then used to model the worst scenario of a destructive earthquake along Seulimeum Fault – North, so that the level of earthquake hazard potential risk can be determined. The data used in the research based on the priority of the sources Sumatran Fault epicenter as earthquake catalog in the Aceh region from 2010 to 2021 with geographical boundaries of $1^\circ$ - $6^\circ$ Latitude and 94.0$^\circ$ - 99.0$^\circ$ Longitude and magnitude \textgreater{} 1, depth less than 30 km. The results of the analysis figure that the Seulimeum Fault – North has a surface density (B-value) around 0.2 – 0.6. It was assumed that the area has a high concentration of fault stress or currently accumulating energy and has the potential to generate a severe earthquake in the future. The recurrence times of destructive earthquakes in the Seulimeum Fault – North with a time span of 47.66 - 59.12 years and the maximum magnitude release is estimated to be $M \leq 8$ implying a high level of potential hazard risk.

\textbf{INTRODUCTION}

The Province of Aceh in seismic activities perspective was classified as an active earthquake area. Earthquake activities is caused by the Sumatran Fault Zone and the Subduction Zone on the West coast of Aceh Province. According to [1] there are 19 Sumatran Fault Zone Segments and 6 fault segments of which are in the Aceh Province. The six fault segments include the Segment Fault of Aceh, Seulimeum, Batee, Tripa, Renun and Angkola. In 2019, Muksin Umar stated in his work that Aceh Region has 13 Active Faults Segments [2]. The destructive earthquake is dominated by the source of the Active Fault Segment in the Aceh region. From the destructive earthquake, Aceh is an area that has a high-level risk of earthquake disasters.

An understanding sources of destructive earthquakes of the potential hazard analysis along the active Aceh fault has not yet become one of the important indicators in the hazard component of a disaster risk assessment. The results of the earthquake potential hazard analysis in the study area are modeled with a destructive earthquake scenario in the affected area. The scenario model obtained the scale of damage or intensity of earthquake shake [3]. The intensity of the shaking is categorized into a scale of input values for the risk level indicator as a hazard component based on the classification [4]. Hazard values include aspects of earthquake potential analysis such as validation of seismic
parameter results, stress change models as the basis for strong motion earthquakes and scenario models of shaking level and earthquake intensity as a determination of the hazard area for destructive earthquakes.

![Active fault sources in Aceh region](image)

**FIGURE 1.** Active fault sources in Aceh region [2]

The important elements in the hazards value component which are includes aspects of earthquake potential analysis. The basis for the causes of destructive earthquakes as well as a scenario model of the level of shaking and intensity of earthquakes to determine the hazards area for destructive earthquakes in Aceh Province. In addition, previous studies used parameters of vulnerability and capacity components that have not been updated according to the latest geological and demographic conditions. The study of the hazard and risk of destructive earthquakes along the active Aceh Fault is a disaster mitigation step and a recommendation for the preparation of a disaster risk assessment document as an effort to Disaster Risk Reduction (DRR) in Aceh Province.

**METHODS**

The data are used to relocating earthquake parameters in the Aceh region from January 2010 - December 2021 with a range (1° - 6° and 94° - 99°) and magnitude (M) of 1 > 9, a depth of 0 > 100 km. Total of 3281 earthquake events were used from the BMKG earthquake catalog. Relocation of parameters using with hypodd has results is 3242 earthquake events. Earthquake data is collected according to the parameters that are limited in the data processing process. The process of processing BMKG catalog data sourced from the catalog data obtained is carried out by improving the parameters by relocating using the Double Difference method. This method uses the Hypodd software application as a systematic step to relocated an earthquake parameters as described [5,6]. Then the Double-Difference equation for each station can be written as an empiric result:

\[ \mathbf{WGm} = \mathbf{Wd} \]  

(1)

Where \( \mathbf{G} \) is a matrix with dimension \( \mathbf{M} \times 4\mathbf{N} \), \( \mathbf{M} \) is the number of Double-Difference observations and \( \mathbf{N} \) is the number of earthquakes; \( \mathbf{d} \) is the data matrix \( \mathbf{d} \) with dimension \( \mathbf{M} \times 1 \), \( \mathbf{m} \) is the earthquake hypocenter change parameter \( (\Delta \mathbf{m}) = (\Delta x, \Delta y, z) \) while \( \mathbf{W} \) is the weighting applied in the diagonal matrix. The equation for the relative hypocenter parameters between the two earthquakes by taking the difference for the earthquake pairs is as follows.

\[ \frac{\partial \mathbf{t}^i}{\partial \mathbf{m}} \Delta \mathbf{m}^{ij} = \Delta \mathbf{r}^j \]  

(2)

where \( \Delta \mathbf{m}^{ij} = (\Delta x^i, \Delta y^i, \Delta z^i, \Delta \tau^i) \) is the relative change in the hypocenter parameters between the two earthquakes, and the partial derivatives from \( \mathbf{t} \) to \( \mathbf{m} \) is the component of the slowness vector of the wave connecting the source and the measured station at the source. After processing with hypodd, the earthquake relocation parameters
Seismicity parameters in the form of (a-value) and (b-value) are determined by using the relationship between Magnitude and frequency. This relationship is better known as Gutenberg-Richter or Frequency-Magnitude Distribution [7,8] as follows:

$$\log N(M \geq M) = a - bM$$

(3)

Where $N(M \geq M)$ is the cumulative number of earthquakes with a higher magnitude than or equal to $M$, while $a$ and $b$ are constants referred to as seismicity parameters. The increased the (a-value) could be high level of seismicity in the area. The Decreased (b-value) indicates that the stress level in the area is high. Surface density (b-value) was determined by the maximum likelihood method. The maximum likelihood method uses the following equation:

$$b = \frac{\log e}{M - M_{\text{min}}} = \frac{0.4343}{M - M_{\text{min}}}$$

(4)

The Value of $M$ is the average magnitude and $M_{\text{min}}$ is the minimum magnitude. If given the probability for 95%, the upper and lower limits of the b-value obtained, then the equation can be written:

$$\bar{b} = b \left(1 + \frac{1.960}{\sqrt{n}}\right) \text{dan} \quad b = \bar{b} \left(1 - \frac{1.960}{\sqrt{n}}\right)$$

(5)

Corresponding to the a-value calculated from the cumulative frequency relationship for $M \geq M_0$ using the equation:

$$a = \log N(M \geq M_0) + \log(b \ln 10) + M_0 b$$

(6)

An important parameter in determining the b-value is Magnitude Completeness (Mc), which is the minimum magnitude. The relationship between the number of earthquakes meets equation (2,3), so an accurate description of the local (Mc) is needed because the (Mc) in the research area is very dominant in determining the b-value. Declustering is the separation of earthquake data based on the preliminary earthquake (foreshock), the main earthquake (mainshock) and earthquake (aftershock). These criteria are used by referring to the windowing principle (classification of boundaries) as described [9] with the approach method [10]. Declustering analysis and (a-value and b-value) analysis using the ZMAP software application [11,12] to calculate the spatial variation (a-value and b-value) with the maximum-likelihood method and calculate the magnitude of completeness (Mc). The results of seismic parameters are calculated to see the relationship between seismic frequency and magnitude so that the seismicity level (a-value) and surface density (b-value) was estimated. The results of the seismicity level and surface density analysis are preliminary in determining the potential for destructive earthquakes at the source in the Aceh Region as a scenario for earthquake hazard areas.

Calculation of stress changes using the Coulomb stress change method includes several stages, including determining the study area, creating a fault plane simulation, and calculating the change in coulomb stress. Analysis of changes in seismic stress (Coulomb Stress) was also carried out to analyze the characteristics of the surface density in the area triggered by the main earthquake at the fault source. Earthquake events that occur are capable of triggering earthquakes around other fault sources with considerable strength or damage within a certain period of time, based on the elasticity of the surface density along the fault line. This calculation is carried out as one of the validation tests as a correlation of seismic parameter calculations. The results of seismic stress calculations are a supporting indicator for determining scenarios for destructive earthquakes in active fault segments in the Aceh region, especially the Seulimeum – North active fault. The calculation of the area of the fault plane is assumed to be an isotropic homogeneous rectangular area. In performing calculations and further analysis of earthquake parameters into seismic stress changes using Coulomb 3.3.01 software designed by [13] to calculate static displacement, strain and stress at depth caused by slip of a fault, magma intrusion or dike expansion. Seismic stress change modeling using fault length and width data. The modeling can interpret in general the direction of radiation and the assumed value of the characteristics of the surface from the magnitude of the earthquake. The correspondence of the empirical formula as described in "New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement" by [14] According to Coulomb (1733) in [15], the shear strength of the surface is equal to the original strength of the surface plus a constant. Coulomb formulates the strength of surface at fracture or fracture which is written as the following equation.
| $\tau|_{\text{failure}} = C + \mu \sigma n$  

Where $\tau$ is the pressure required to break the rock (bar or Pa) and $C$ is the cohesion coefficient of the surface’s strength, $i$ is the constant coefficient of internal friction of the rock, and $\sigma_n$ is the normal stress or normal stress (bar or Pa). The explanation that the shear strength of the surface is equal to the homogenous surface strength plus a Lay constant. This change in stress is known as the Coulomb stress change. The distribution pattern of Coulomb stress changes is influenced by fault geometry, magnitude, and friction coefficient ($\mu$). The basic Coulomb equation is then widely referenced and developed in the analysis of stress changes in a fault plane caused by an earthquake. The intensity of the shaking at the ground surface was estimated from the results of the scenario of making a shake map with reference to the prediction of the earthquake that will occur. The scenario of making a destructive earthquake shake map is based on the results of regional selection based on calculations (a and b-value) which have been analyzed with the ZMAP program according to the regional boundaries described in the previous sub-chapter and the results of the Coulomb stress analysis using the Coulomb 3.3 program based on destructive earthquake in the zone along the active fault in the Aceh region.

Earthquake shake map modeling used to earthquake parameters as described above, by simulating earthquake sources based on characteristics and ground motion calculation models in the Seulimeum - North and surrounding active fault segments. In addition to the ground motion calculation model, a deterministic seismic hazard analysis approach is needed (Deterministic Seismic Hazard Analytic) by paying attention to historical seismic factors, theoretical earthquake sources and local factors.

One of the stages of shake map work is the determination of Ground Motion Prediction Equations (GMPE), namely empirical regression of recorded accelerograph data. The calculation principle of GMPE is to estimate ground vibration parameters ($pga, pgv$, spectral acceleration or velocity response). In addition, other factors that influence the determination of GMPE are the type of earthquake (subduction or fault) and the source mechanism (strike-slip, normal, reverse). Shake map describes a map of the distribution of earthquake intensity in MMI scale due to an earthquake. The hazard component is adjusted to the potential source of seismicity in the active fault zone with administrative area boundaries. It is intended to see and calculate the level of disaster risk with the hazard index parameter and the exposed population index based on the hazard level matrix. The exposure population index is determined by determining the hazard area. The exposed population data includes administrative location boundaries selected by the demographics of the Aceh Province which are sourced from the data [16]. The results of the classification of the impact of damage based on administrative boundaries are correlated with the demographics impacted of the area. This demographic includes the number of people exposed to the level of damage caused. So that the exposed population could be calculated based on weighting of impact from the determining calculation the hazards level [17].

**RESULTS AND DISCUSSION**

**Results**

The results of the seismicity level (a-value) and surface density (b-value) are more consistent based on seismic activity at the seismic source. The results of seismic parameters are calculated using the Maximum Likelihood method to see the relationship between seismic frequency and magnitude so that the seismicity level (a-value) and surface density (b-value) are obtained. The results of the seismicity level and surface density analysis are preliminary in determining the potential for destructive earthquakes at the earthquake source in the Aceh Region as a scenario for earthquake hazard areas. Seismic parameters and magnitude of completeness (Mc) were calculated using earthquake data after relocation and separation according to the main and subsequent earthquake events (decluster). The determination of the magnitude of completeness (Mc) used by the highest frequency of earthquake occurrences in a certain magnitude range. Based on the calculation that the average magnitude of completeness (Mc) is magnitude 3.7 with a maximum seismicity limit of magnitude 8.0 is shown in Figure 2(a).

In this study, the estimation of seismic recurrence times using data from the latest destructive earthquake, that event was the Pidie Jaya earthquake (07/12/2016) with a magnitude of M = 6.5 because it come from an active fault segment. This is derived the determination of seismic parameters better interprets the level of surface fragility in active fault sources in the Aceh region. Based on these estimation calculations, it can be assumed that the recurrence period of an earthquake from an active fault with a maximum magnitude of M 6 (15.48 Years), M 7 (47.66 Years), M 8 (39.12 Years), M 9 (146.7 Years) as shown in Figure 2(b).
FIGURE 2. (a) Results of determining the magnitude of completeness (mc) for the Aceh region for the 2017-2021 period using the maximum likelihood method (b) estimation graph of the calculation of potentially destructive earthquakes with a certain period using the maximum likelihood method.

The level of seismicity is nearly related to the level of surface fragility that was the relationship between the characteristics and the potential for recurrence of destructive earthquakes had have occurred in an area can be determined. The above results could be used as an indicator for determining the level of earthquake risk in Aceh Province. Surface characteristics and seismic activity should be interpreted based on modeling.

The result of modeling changes in seismic stress (Coulomb Stress) in the Pidie Jaya earthquake (06/12/2016) is a positive change in seismic stress, which means that the main fault during an earthquake pushes the fault plane to increase stress, so that increases the probability of failure in the second fault as shown figure 3 (b). Changes in seismic stress with a negative value indicate that the area of the surface is attracted has experienced density relaxation which causes the chances of failure. So, it could be concluded that the coefficient of friction (cf) or the value of the of rigidity coefficient in the surface plane that experiences density relaxation is an area of asperities. The asperities areas include the active Seulimeum – North Fault Segment, the Aceh Segment Fault, the Tangse-Beutong Fault, the Nisam Fault and the Lhokseumawe Fault. These appear to be based on a coefficient of friction (CF) of around 0.40 CF. The coefficient value obtained in the analysis of changes in seismic stress is in accordance with the explanation of [18] that the coefficient of friction in bedrock sediment in general is 0.40.

FIGURE 3. (a) Seismic parameter model showing surface density (b-value) in the 2010-2021 earthquake with a depth of < 30 km in the Aceh region using the maximum likelihood method. (b) changes in seismic stress of the Pidie Jaya earthquake (06/12/2016) at a centroid depth of 17.5 km using the coulomb method.
Figure 3. (a) shows the distribution of seismicity levels (a-value) and surface density (b-value) at the source of the earthquake in the Aceh Region including the Seulimum Segment Fault, Aceh Segment Fault, Tangse-Beutong Fault, Tripa Segment Fault, Fault Kuta Cane-Blangkejeren Fault, Trienggadeng Fault, Lampahan Segment Fault, Samalanga Fault, Batee Fault, Nisam Fault, Lhokseumawe Fault, Pining Fault, Lokop Segment Fault. In general, the interpretation can be explained that the level of seismicity (a-value) initiate in this study is between 2.86 to 5.56, it is assumed that the area with a high (a-value) is an area experiencing passive slip, it is assumed that the level of seismicity is low and slightly accumulate stress (creeping zone). While the results of surface density (b-value) estimated values between 0.437 to 0.896, it is assumed that areas with low (b-value) are interpreted as bedrock sediment areas (asperities zone), areas that have high stress concentrations, then have the potential to release large amounts of energy or releasing the destructive power of earthquakes.

Figure 3. (b) shows a change in the value of this earthquake stress forming 4 (four) directions of the movement plane, with 2 (two) blue or negative directions of radiation distribution in the East to West direction and North to South direction from the fault plane indicating that region had has released tension or tensile forces on the surface plane with values ranging from – 0.01 to – 0.2 Bar. Meanwhile, 2 (two) red or positive directions of radiation distribution in the Southeast to Northwest and North east to Southwest directions are seen to experience an increase in stress marked by the release of energy or a push force occurs on the surface with values ranging from 0.03 to 0.2 Bars. The area experienced an increase in stress resulting in aftershocks. The concentration of increased stress from this earthquake is more concentrated in the area near the fault plane because the movement of the earthquake source mechanism is assumed to be a shear fault.

Figure 4. (a) Map of the earthquake epicenter in the segment of seulimeum fault – north used in the shake map scenario. (b) scenario map of earthquake shaking in segmen of seulimeum fault – north.

Figure 4. (a) shows the potential hazard of a destructive earthquake is a major component of determining the level of disaster risk. In this study, the earthquake epicenter scenario data was used. The parameters used in this earthquake scenario are referring to the destructive earthquake in Banda Aceh City and its surroundings on April 2, 1964. The impact of the damage caused when it reached the MMI VII-VIII intensity scale caused many houses to be damaged with moderate to severe levels [19]. Parameter data includes magnitude M = 7.6, depth of 10 Km, location of the epicenter at 5,710 North Latitude - 95,440 East Longitude and the epicenter at sea 11 km Northeast of Banda Aceh City. The fault segment extends for 143 km from the northwest to the southeast through of Aceh Besar (Seulawah, Seulimeum, Mesjid Raya) and Sabang City and the Strike-Slip Fault type.
Figure 4. (b) shows the Scenario map of the shock generated from the earthquake source in the Seulimeum – North active fault segment with a maximum strength of magnitude M 7.6 indicated by a black asterisk, the highest ground acceleration shock scale (PGA) is seen (reddish orange color) ranges from 22-40 gal or equivalent to the impact scale of VII – VIII MMI in the Banda Aceh City area, Aceh Besar Regencies. High PGA values (orange color) ranging from 12 to 22 gal are located in the City of Sabang. Meanwhile, the medium PGA value (yellow - greenish color) ranges from 6.2 – 12 gal or equivalent to the V – VI impact scale. 0.3 – 6.2 gal or equivalent impact scale II – V MMI is in the area of Birueun, Bener Meriah, Aceh Tengah and Aceh Barat Regencies.

DISCUSSION

Based on the potential impact of the area from the spatial information scenario as described in the description above, it is possible to identify areas that have lower to severe damage. The areas identified based on the classification of damage impacts include Banda Aceh and Aceh Besar areas experiencing a shake level of 22 - 40 gal with a potential of 60 to 80 percent of severe damage can be categorized as high-level impact. The cities of Sabang and Pidie with a shake level of 12 - 22 gal with the potential for 50 - 70 percent of moderate damage can be categorized as moderate impact, while Pidie Jaya, Bireuen, Aceh Jaya, Aceh Barat and Bener Meriah experienced shake be at variance from 0.3 - 6, 2 gal with a potential of 10 - 40 percent minor damage is categorized as low-level impact. The results of the classification of the impact of damage from spatial information scenarios become a reference in calculating the components of determining disaster risk. This analysis produces an intensity scale for the area around the epicenter of the earthquake and the next step is to interpret the impact of the threat by localizing the area as carried out by researchers [20] but projected on a small scale which is limited by the study area. The description of the results of the classification of the impact of damage is as shown in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Regencies/Cities</th>
<th>Shaking of Values (gal)</th>
<th>Weighting of Damaged (%)</th>
<th>Scale (Level)</th>
<th>Level of Damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Banda Aceh</td>
<td>22 - 40</td>
<td>0.8</td>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Aceh Besar</td>
<td>22 - 40</td>
<td>0.8</td>
<td>5</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Sabang</td>
<td>12 - 22</td>
<td>0.6</td>
<td>4</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Pidie</td>
<td>6.2 - 12</td>
<td>0.5</td>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>5</td>
<td>Pidie Jaya</td>
<td>2.8 - 6.2</td>
<td>0.4</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Bireuen</td>
<td>2.8 - 6.2</td>
<td>0.3</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>7</td>
<td>Aceh Jaya</td>
<td>2.8 - 6.2</td>
<td>0.4</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>8</td>
<td>West Aceh</td>
<td>0.3 - 2.8</td>
<td>0.2</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td>9</td>
<td>Bener Meriah</td>
<td>0.3 - 2.8</td>
<td>0.2</td>
<td>1</td>
<td>Low</td>
</tr>
</tbody>
</table>

The results from the 9 Regencies/ Cities in Aceh Province, which are the Banda Aceh, Aceh Besar and Sabang areas with a score of 2 (two) including the high-level hazard category. Pidie regency with a score of 1 (one) is in the moderate hazard category, while the Pidie Jaya, Bireuen, Aceh Jaya, West Aceh and Bener Meriah are the area with scores ranging from 0.4 to 0.8 are in the lower hazard category. These results become a reference for calculating the vulnerability component in determining the risk of an earthquake disaster. The results of the hazard calculation based on the earthquake shake map scenario in the Active Segment Fault of Seulimeum – North can be seen in Table 2.

<table>
<thead>
<tr>
<th>No</th>
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<th>Weight</th>
<th>Score</th>
<th>Level of Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Banda Aceh</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Aceh Besar</td>
<td>2</td>
<td>0.9</td>
<td>1.9</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Sabang</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>Pidie</td>
<td>2</td>
<td>0.5</td>
<td>1</td>
<td>Moderate</td>
</tr>
<tr>
<td>5</td>
<td>Pidie Jaya</td>
<td>2</td>
<td>0.4</td>
<td>0.8</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Bireuen</td>
<td>2</td>
<td>0.3</td>
<td>0.7</td>
<td>Low</td>
</tr>
</tbody>
</table>
From the analysis of the hazards mentioned above, modeling is carried out based on the scores estimated. Mapping data analysis from component assessment results. This mapping becomes spatial information, that is a map of the hazard area according to the score and category of the result of the regional hazard level.

**FIGURE 5.** Map of earthquake hazard levels in the segment fault of Seulimeum – North.

Figure 5 shows the hazard level region of the destructive earthquake shake map scenario in the active Segment Fault Seulimeum – North. Areas with a high level of hazard include Banda Aceh City, Sabang City and most of Aceh Besar Regencies. While areas with a moderate level of hazard include most of the Pidie Regencies and some others on the West and Southeast side of Aceh Besar Regencies. For areas with low hazard levels include Regencies of Pidie Jaya, Bireuen, Aceh Jaya, West Aceh and Bener Meriah.

Based on the results of the analysis and discussion of the concept of an earthquake of hazards scenario at the Seulimeum – North active fault source in Aceh Province, spatial information is produced. Spatial information that is translated is data on the level of constructive selection of hazards. The results of this spatial category are based on the assessment obtained from matrix calculations, the results of the classification of the hazard level and the scoring assessment obtained from this study are not much different from the results of researchers [21].

**CONCLUSIONS**

The Relocated of earthquake parameters with the Double-Difference method is very influential in changing the position of the earthquake hypocenter depth. This has a relationship with analyzing seismic parameters. Calculation of seismic parameters with a maximum seismicity limit of magnitude M 8.0. Based on these estimation calculations, it can be assumed that the recurrence period of an earthquake from an active fault with a maximum magnitude of M 6 (15.48 Years), M 7 (47.66 Years), M 8 (59.12 Years), M 9 (146.7 Years). The level of seismicity obtained in this study is an area experiencing passive slip, it is assumed that the level of seismicity is low and slightly accumulate stress (creeping zone). While the results of surface density, it is assumed with interpreted as bedrock sediment is areas that have high stress concentrations. Potentially releasing large of energy or releasing the destructive of earthquakes.
The areas identified based on the classification of damage impacts include Banda Aceh and Aceh Besar with a potential of 60 to 80 percent of severe damage probability high level impact. The cities of Sabang and Pidie with a potential for 50 – 70 percent of moderate damage could be categorized as moderate impact, while Pidie Jaya, Bireuen, Aceh Jaya, West Aceh and Bener Meriah with a potential of 10 – 40 percent light damage are categorized as low-level impact.

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