ESTIMATING ECONOMIC LOSSES FROM SINABANG EARTHQUAKE USING AN EMPIRICAL APPROACH

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ABSTRACT

The empirical approach is a potential candidate along with other engineering-based loss models within the Prompt Assessment of Global Earthquakes for Response (PAGER) system for rapid social and economic loss estimation. In this study, we focused to evaluate the Sinabang earthquake on 7 January 2020 with Magnitude 6.3. The result of this study shown the green alert for shaking related fatalities and economic losses in 65 % from the estimated fatalities and losses in Sinabang.

Keywords: Empirical Approach, Fatalities and Economic Loss, Earthquake, PAGER, Sinabang.

ABSTRAK

Pendekatan empiris adalah kandidat potensial bersama dengan model kerugian berbasis teknik lainnya dalam sistem Penilaian Cepat Gempa Bumi Global untuk Respons (PAGER) untuk estimasi kerugian sosial dan ekonomi yang cepat. Dalam studi ini, fokus kami adalah mengevaluasi gempa Sinabang pada 7 Januari 2020 dengan Magnitudo 6.3. Hasil penelitian ini menunjukkan peringatan hijau untuk korban jiwa dan kerugian ekonomi akibat guncangan sebesar 65% dari perkiraan kematian dan kerugian di Sinabang.

Kata Kunci: Pendekatan Empiris, Kerugian Ekonomi, Gempa Bumi, PAGER, Sinabang.

INTRODUCTION

Earthquakes generate a variety of financial impacts. To reap a steady measure, the authentic harm country ought to be linked to the greenback losses of the capital inventory and then translated into direct commercial employer interruption losses and the ensuing ripple consequences that take area at some stage in the economy. The Earthquake Loss Estimation with the aid of Prompt Assessment of Global Earthquakes for Response (PAGER) empirical fatality estimation methodology proposed with the aid of (Jaiswal & Wald, 2011) to unexpectedly estimate financial losses after big earthquakes. The requisite model inputs are shaking depth estimates made with the aid of way of the Shake Map system, the spatial distribution of population reachable from the Land Scan database, present-day and ancient united states or sub-country populace and Gross Domestic Product (GDP) data, and economic loss data from historic earthquakes catalog. The process consists of the use of a country-specific multiplicative issue to accommodate the disparity between financial exposure and the annual per capita GDP, and it has confirmed successful in hindcasting previous losses. Although loss, population, shaking estimates, and financial statistics used in the calibration technique are uncertain, approximate ranges of losses can be estimated for the essential motive of gauging the overall scope of the disaster and coordinating response (USGS, 2009).

Estimating practical financial influence due to a large-scale earthquake catastrophe can be a daunting undertaking (Rahayu & Purwoko, 2020). Due to the inherent complexity of estimating infrastructural and institutional influences (in terms of direct and indirect losses), the actual cost of monetary impact from such failures would possibly also only be about acknowledged (Ratti, 2017), (Okuyama & Chang, 2004).

This paper describes a procedure for swiftly estimating the monetary penalties in the aftermath of a giant Sinabang earthquake disaster. First, an estimate is made of the country- or region-specific financial loss ratio (defined right here as total direct economic loss normalized via the use of the complete financial exposure), which varies as a characteristic of shaking intensity and is calibrated towards historic earthquakes losses. The monetary price of all the bodily belongings exposed at great locations in a given location is regularly not recognized and can be notably tough to bring together at a regional scale, let on my own on an worldwide scale. In the absence of such a dataset, we estimate the whole gross home product (GDP) uncovered at every shaking depth with the aid of multiplying the per-capita GDP of the Sinabang Earthquake, Indonesia in January 2020 with the aid of the complete populace uncovered at that shaking depth level. We then scale the whole GDP estimated at each depth by means of a publicity adjustment multiplier to account for the disparity between wealth and/or monetary assets and the annual GDP (Osberg & Sharpe, 2001), (Dynan & Sheiner, 2018).

Simeluae regency with its capital Sinabang positioned southwest of Aceh province, located one hundred and five miles north Meulaboh, Aceh Barat regency, or 105 mils from Tapak Tuan, Aceh Selatan Regency. Simelue regency is a cluster island that consists of 147 giant and small islands. The GDP of Simelues from 2017 to 2019 continually increasing, and also the population in Simeluae between 1.19 to 1.23 percent every year (BPS Simeulue, 2016). Sinabang earthquake is a one major earthquake on 7 January 2020, with magnitude 6.3, 14 km S of Sinabang, Indonesia (BMKG). The earthquake location un-close to the land with 2.348°N 96.358°E. the intensity of the Sinabang earthquake show in Fig. 1

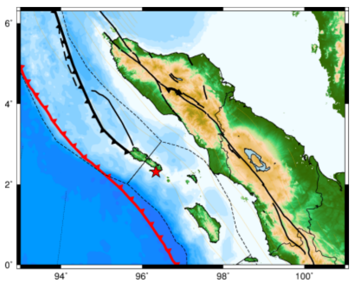


Fig. 1 Map intensity of Sinabang Earthquake, 7 January 2020

Fig. 1 show the severity of the earthquake in terms of its effects on Sinabang and on humans and their structures. In this case, the damages of the earthquake are strong in Sinabang and Labuhan Bajau city and moderate shaking in Lauke city.

The goal of this study to estimating the economic losses from impact and earthquake damage in Sinabang by using empirical approach in PAGER.

DATA AND METHOD

The Sinabang earthquake on 7 January 2020 had been held at 13:05:19 at local time, with the Magnitude 6.3 at the 2.348°N 96.358°E. We used the Sinabang earthquake to evaluate the impact to economic loss and earthquake damage. In this case, we had been collected the waveforms (Fig. 2) from the sensor which BMKG Network (Table 1) deployed and use the PAGER from USGS.

Table 1. Sensor recorded the waveform of the Sinabang earthquake 7 January 2020T06:05:19

Id_Station	Sensor	Latitude	Longitude	Stream
IA	GSI	1.30	97.58	BH*
IA	SNSI	2.41	96.33	BH*
IA	TSI	3.50	98.56	BH*

PAGER (Prompt Assessment of Global Earthquakes for Response) is a computerized gadget that produces content material concerning the have an have an effect on on of giant earthquakes, informing emergency responders, authorities and aid agencies, and the media of the scope of the viable disaster. PAGER all of sudden assesses earthquake impacts via way of comparing the populace uncovered to every stage of shaking depth with fashions of financial and fatality losses especially based on previous earthquakes in each united states of america or location of the world. Earthquake indicators which had been formerly sent notably based totally only on match magnitude and vicinity or population publicity to shaking now will additionally be generated based totally definitely on the estimated variety of fatalities and economic losses (Jaiswal & Wald, 2011).

Simple thresholds, derived from the systematic evaluation of the preceding earthquake have an affect on and associated response levels, flip out to be quite top notch in communicating expected influence and response wanted after and event characterized by means of signals of inexperienced (little or no impact), yellow (regional have an impact on and response), orange (national-scale have an affect on and response), and crimson (international response).

Corresponding fatality thresholds for yellow, orange and purple alert ranges are 1, 100, and 1,000, respectively. For harm impact, yellow, orange, and crimson thresholds are caused by using way of estimated losses achieving $1 million, $100 million, and $1 billion respectively (Jaiswal & Wald, 2011).

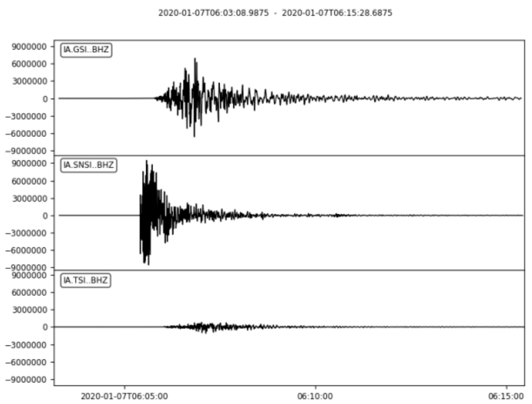


Fig. 2. The waveforms recorded from the BMKG Seismic Network

We define the economic loss ratio, r, as the entire direct financial loss (which consists of structural, non-structural and content material losses) normalized by way of way of the total economic publicity as eq. 1 (Jaiswal & Wald, 2011).

$$Loss\ Ratio\ r = \frac{Direct\ Economic\ Loss}{Total\ Economic\ Exposure} \quad \ldots(1)$$

The time period Damage Ratio (DR) used in earthquake loss estimation research are used to characterize earthquake injury to a precise structure. DR is described as repair fee divided with the aid of alternative (or total) cost. At any given populace center, we might additionally find out about single or countless sorts of buildings such as wooden frame, concrete, metal frame, and masonry buildings. In order to compute shaking-induced financial losses to these developing types, we choose to establish the floor motion-damage relationships for each form type. Such analyses are possible solely at places the place each the building stock and vulnerability data for every structure form exist. In order to sidestep this, we strive to signify the total direct economic loss (which can be a mixed assessment of losses from wonderful shape types) the use of a single time period r, and extra importantly, now not be structured upon the laborious requirement of developing stock inventory and vulnerability information (Jaiswal & Wald, 2011).

Similar to DR, the loss ratio r varies with Modified Mercalli (MMI) shaking intensity s. By definition, as the shaking depth increases, the susceptibility to earthquake damage and losses increases. Similarly, the loss ratio r (defined right here as the ratio of complete direct monetary loss to entire economic exposure) can assume any rate between zero and 1 at a given depth s. These criteria, in addition to giant historic priority (based on earthquake harm and loss evaluation in the past), we pick out a two-parameter lognormal cumulative distribution characteristic of shaking depth s to outline the loss ratio characteristic (Jaiswal & Wald, 2011).

$$r(s) = \emptyset\ [\tfrac{1}{\beta} \ln \tfrac{s}{\theta}] \quad \ldots(2)$$

The place ϕ is the trendy everyday cumulative distribution function. The parameter θ represents the recommend of the natural logarithm of shaking intensity s and the parameter β represents the fashionable deviation of ln (s). In the existing application, the shaking intensity s ranges from 5.0 to 9.0, the place complete exposure at MMI IX and above is aggregated and assigned to IX. Unfortunately, for the last thirty years, per capita, GDP estimates are unavailable at a resolution higher than the country level. Using per capita GDP at the year of an earthquake and complete populace subjected to a precise shaking depth level, one can compute the complete GDP uncovered to the shaking depth level at the time of the earthquake. We use country-level estimates to apportion the complete GDP of the country into the region's GDP below the assumption that per capita GDP estimates are uniform within a country (The World Bank, 1994).

$$Total\ GDP_{(region,intensity=s)} = Per\ Capita\ GDP_{(country)} x\ Population_{(region,intensity=s)} \quad \ldots(3)$$

The complete economic publicity at a given intensity can be computed the usage of whole GDP uncovered to that intensity elevated with the aid of the country- or region-specific exposure correction issue α as shown beneath.

$$Eco.Exposure_{intensity=s} = \alpha_{region} x\ Total\ GDP_{(region,intensity)} \quad \ldots(4)$$

The publicity correction element is definitely the ratio of per capita wealth to per capita GDP estimate of the country. The records on per capita wealth is at as soon as taken from the (The World Bank, 1994) study.

$$E(L) = \textstyle\sum_s r(s) x\ Eco.Exposure_{(intensity=s)} \quad \ldots(5)$$

The loss ratio attribute r(s) relies upon on the two free parameters, θ, and β for each united states or geographic region k. If we think about that Oi is the recorded monetary loss for earthquake i, and there are N such earthquakes for that country, then we can decide the parameters of the loss ratio function in such a way that the total error ε between expected loss E(L) (also termed as model estimated loss abbreviated as E_i and recorded losses Oi is minimized using the following norm proposed via (Jaiswal & Wald, 2011).

$$\varepsilon = \ln\left[\sqrt{\frac{1}{N}\sum_i^N [E_i - O_i]^2}\right] + \sqrt{\frac{1}{N}\sum_i^N [\ln(\frac{E_i}{O_i})]^2} \quad \ldots(6)$$

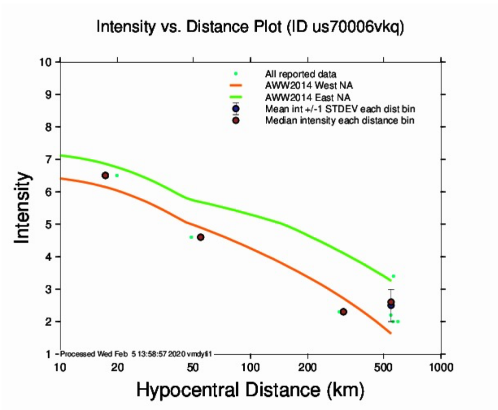
The desire of the above norm is based totally on our confined analysis. For a given country, the catalog has many earthquakes with a lower cost of economic losses and few earthquakes that have a tremendous price of financial losses. The aim is to search for the parameters that first-class hind cast the losses in the bulk of these historic earthquakes, each at high and low ends of economic loss. It is potential to use another, maybe statistically robust, and efficient norm that may want to gain the equal motive discussed above.

From the PAGER (USGS, 2009), operational device point of view, on account, that we do no longer have all the facts that might also be crucial to systematically quantify the complete variability associated with acceptable economic impacts from any given earthquake, we can only use the model's predictability to hind cast preceding earthquake losses as a measure to infer the uncertainty that may additionally moreover be related with future losses. In order to depict such uncertainty in an ahead sense, we estimate the modern-day deviation ζ of the herbal logarithm of authentic or catalog-recorded loss, that is, $\ln(O_i)$ gave the natural logarithm of model-estimated loss $\ln(E_i)$ in eq.7.

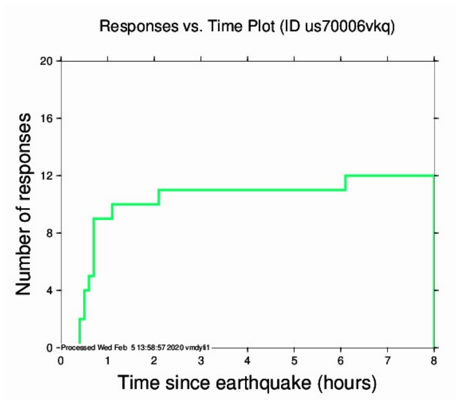
$$\zeta = \sqrt{\frac{1}{N-2}\sum_{i=1}^N [\ln Q_i - \mu_{(\ln Q_i|lnE_i)}]^2} \quad \ldots(7)$$

RESULT AND DISCUSSION

The end result of the empirical Sinabang earthquake primarily based on the intensity versus Distance proven in Fig 3 a, and based totally on the responses vs time proven in Fig.3b. The intensities in Fig. 3a is the best shut to the earthquake and decreases with distance from the earthquake and for this reason, grants a capability to locate and evaluating the dimension of shallow earthquakes.



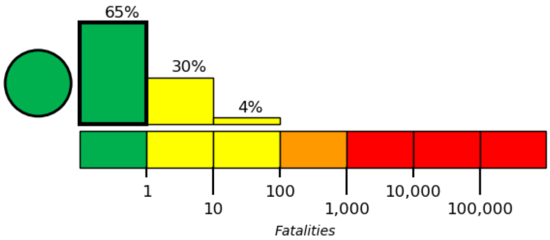
a



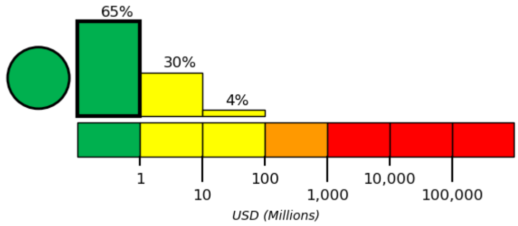
b

Fig. 3. Intensity versus Distance Map and Responses

The responses, in this case, indicated the Sinabang earthquake had been felt at the time. The design plot shows the range of responses in time is increased. The fatality alert histogram and economic alert shown in Fig. 3.



a. Fatality



b. Economy

Fig. 4. The fatality and economy alert Sinabang Earthquake, 7 January 2020

Fig. 4 are the fatality and economy alert on Sinabang earthquake 7 January 2020, the result on Fig 4, exhibit a green alert for shaking associated fatalities and monetary losses. There is a low likelihood of casualties and damage.

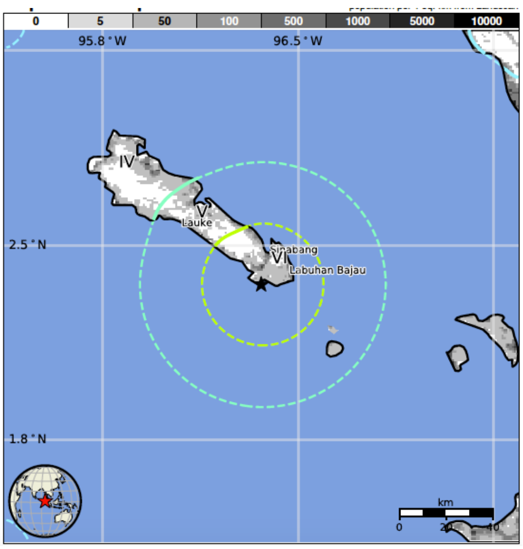


Fig. 5. Population Exposure Maps

Fig. 5 indicated the selected city exposure, the yellow circle show there are 3 cities indicated VI MMI, such us, Labuhan Baju with less than 1k population, Sinabang with 15k population, and Laun Balu with less than 1k population. The blue circle in Fig. 5 indicate V MMI in Lauke city with less than 1 k population. And out of the circle, show the III-IV MMI in Sibigo, Pulo Batal, Terbangan, and Tapaktuan city with less than 1 k population. The structures in this Sinabang region resides in buildings that are inclined to earthquake shaking, though resistant buildings exist. The predominant susceptible constructing sorts are unreinforced brick with the concrete ground and precast concrete body with wall construction. Based on the historical earthquake in this area have caused secondary hazards such as landslides that might have contributed to losses.

CONCLUSIONS

The economic loss estimates offered using the empirical mannequin are approximate and ought to only be seen interior the scope of conceivable quickly response motion and rapid decision-making in terms of alerting and useful useful resource activation. Based on the result, the green alert for shaking related fatalities and monetary losses. There is a low likelihood of casualties and damage. In this case, we estimated 65% both of the estimated fatalities (zero victim) and estimated losses from < $1 million in Sinabang Earthquake impact.

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