Available online at http://www.iorajournal.org/index.php/ijgor/index

International Journal of Global Operations Research

e-ISSN: 2722-1016
p-ISSN: 2723-1739

Vol. 2, No. 4, pp. 162-167, 2021

Determination of the Contribution of the Reserve Fund for Flood Natural Disaster Management in the DKI Jakarta Region

Dwita Safira Nugraha[1*], Dwi Susanti[2], Sukono[3]

[1,*]*Mathematics Undergraduate Study Program, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*

[3]*Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jatinangor, Indonesia*

**Corresponding author email: dwita18003@mail.unpad.ac.id*

Abstract

Floods are natural disasters that are quite difficult to predict. As a result, there are many losses both materially, morally and even to the point of taking lives. In Indonesia, one of the areas that experience flooding the most is DKI Jakarta. In early 2020, flooding was the biggest cause of loss in the region. The role of the people of DKI Jakarta is very important in collecting contributions to the reserve fund for disaster emergency response. Therefore, this study aims to estimate the amount of reserve fund contributions for community-based flood disaster management in the DKI Jakarta area based on the Collective Risk Model method approach, using Poisson and Log-Normal distributions, including parameter estimates λ and (μ,σ) , resulting in an estimate of the expected magnitude of the risk of loss. Based on these expectations, the contribution amount can be calculated using the Individual and Collective Risk Model. The result of this research is the contribution of funds which is calculated based on the principle of expected value

Keywords: Flood disaster, losses, Poisson distribution, Log-Normal distribution, risk model, estimated contribution amount.

1. Introduction

DKI Jakarta is one of the areas in Indonesia that makes flooding a major problem in the disasters experienced. It is proven that at the beginning of 2020 until February 2020 it had happened six times (Puspitasari, 2020) with 12.611 people affected (BPBD DKI Jakarta). In addition, the damage to infrastructures and rising inflation is the most felt consequence (Ari, 2020). Thus, the community preparedness plays a very important role in dealing with the risk of loss due to disasters. Therefore, determining the contribution of reserve funds of community-based flood mitigation is a strategy that is considered very effective (Ali et al., 2019; Flanagan et al., 2011; O'Keefe & Ufier, 2017).

In Ali et al.'s research (2019), they are said that in the last ten years, significant natural disasters in Indonesia are volcanic eruptions, tsunamis, earthquakes, floods and social conflicts. The implementation of PPBM is carried out by increasing the capacity of preparation and response by encouraging full participation of all elements. According to Hapsari and Zenurianto (2016), at the post-disaster stage, community prevention and preparedness are still lacking so that continuous action is needed to overcome these problems. In evaluating the economic analysis of the short-term and long-term effects on disaster safety projects, according to Heo et al. (2019) that disaster prevention and damage reduction projects, both in the short and long term, were very effective.

Based on the description above, it is not explained how the community's involvement in preparing for disaster management is in collecting fund contributions, so this research is aimed at applying the collective risk model in determining the contribution of reserve funds of community-based natural disaster management in the DKI Jakarta area.

2. Literature Review

Natural Disasters

Disaster is an event that threatens and disrupts people's lives, usually caused by natural or human factors, thus causing a loss. Natural disaster is a disaster caused by an event or series of events caused by nature (Law No. 24 of 2007).

Flood

in research by Schwab et al. (1981) floods are overflows or puddles of water caused by high rainfall or melting snow or even due to tidal waves that inundate most of the land.

Community-based Disaster Mitigation

Mitigation is an effort to reduce disaster risk, either through physical development or increasing the ability to deal with disaster threats (Law Number 24 of 2007). In the last few years, the concept of community-based disaster management has been promoted in several program categories.

The Poisson Distribution

When a random variable *N* has a Poisson distribution with parameter $\lambda > 0$, its probability function is given by

$$P(N = x) = e^{-\lambda}\frac{\lambda^x}{x!}, \tag{1}$$

where $x = 0,1,2,\ldots$ and for the expectation and variance of the Poisson distribution are the derivatives of the probability function equations, so we get the following:

$$E(N) = \lambda, \tag{2}$$

$$Var(N) = \lambda. \tag{3}$$

We use the notation $P(\lambda)$ to denote a Poisson with parameter λ (David, 2005).

The Lognormal Distribution

When a random variable X has a Lognormal distribution with parameters μ and σ, where $-\infty < \mu < \infty$ and $\sigma > 0$, its density function is given by

$$f(x) = \frac{1}{x\sigma\sqrt{2\pi}}\exp\left\{-\frac{(\ln x - \mu)^2}{2\sigma^2}\right\}, \tag{4}$$

for $x > 0$.

We use the notation $LN(\mu,\sigma)$ to denote a Lognormal distribution with parameters μ and σ. From the argument it follows that if $X \sim LN(\mu,\sigma)$, then $\ln X \sim N(\mu,\sigma^2)$ (David, 2005). For the expectation and variance of the Log-Normal distribution, the function is given by:

$$E(X) = \exp\left(\mu + \frac{1}{2}\sigma^2\right), \tag{5}$$

$$Var(X) = \exp(2\mu + \sigma^2)\,(\exp(\sigma^2) - 1). \tag{6}$$

Maximum Likelihood Estimation

Maximum likelihood estimation used to estimate a particular point by maximizing the likelihood function. The density function of the random variables $X_1, X_2, X_3, \ldots, X_n$, namely $f(x_1, x_2, x_3, \ldots, x_n)$ is called the likelihood function, so it is given by:

$$L(\theta|x) = \prod_{i=1}^{n} f(x_i; \theta). \tag{7}$$

Goodness of Fit Test

Goodness of fit test is a statistical hypothesis test to see how well sample data fit to a distribution from a population. This test shows if your sample data represents the data you would expect to find the actual population. There are multiple methods for determining goodness of fit test. Some of the most popular methods used in statistics include the chi-sqare, the kolmogorov-smirnov test, Anderson-darling test, etc.

Individual Risk Model

Individual risk model is mostly used in case of group insurance, it is alson more common in health and life insurance. The aggregate (or total) claim amount can be calculated as

$$S = Y_1 + Y_2 \ldots + Y_n. \tag{8}$$

The calculation of expectation and variance for S is obviout due to construction(Kaarik, 2013):

$$ES = EY_1 + EY_2 \ldots + EY_n, \tag{9}$$

$$VarS = VarY_1 + VarY_2 \ldots + VarY_n. \tag{10}$$

Collective Risk Model

The aims of collective risk model are:

- To describe the distribution of total claim amount with some known distribution;
- To include only the policies that actually caused claims (in order to reduce the amoun of work)

To calculate expectations and variance o aggregate claim amount by (Kaarik, 2013):

$$ES = EN \cdot EX, \tag{11}$$

$$VarS = (EX)^2 \cdot VarN + EN \cdot VarX. \tag{12}$$

Premium

Premium is the payment of a sum of money to compensate for a loss due to the emergence of a role for the transfer of risk (Amrin, 2011). The principle of expected value is used in calculating the premium value, namely using the following equation:

$$\prod X = (1 + \theta)E[X], \tag{13}$$

where $\theta > 0$ as loading factpr or risk aversion coefficient at premium $\theta E[X]$.

3. Materials and Methods

Materials in this study is data on the amount of house damage and data on loss of house damage due to floods that occurred in the DKI Jakarta area in 2020. Data was obtained through the Badan Perencanaan Pembangunan Nasional

(Bappenas) and Badan Penanggulangan Bencana Daerah (BPBD) DKI Jakarta. After getting the information related to the required data, then a simulation data of 100 data was formed.

The data is divided into three categories, namely missing house data, heavy damage data, and light damage data. The existing data has a Poisson distribution (for data on the number of house damage) and a lognormal distribution (for data on the number of house damage losses), so that it is obtained as follows:

Table 1 : Information Data on the Amount of Damage to Houses and the Large Loss

	Number of Houses	**Loss (in millions)**
Lost House	150	10
Heavy House Damage	225	20
Minor House Damage	1.125	5

4. Result and Discussion

From the data, then the distribution suitability test with easyfit, so that it is obtained the rank goodness of fit test as given in Table 2.

Table 2 : Rank Goodness of Fit Test

	Poisson Distribution	**Lognormal Distribution**
Lost House	1 (Kolmogorov-Smirnov)	18 (Anderson-Darling)
Heavy House Damage	2 (Anderson-Darling)	7 (Anderson-Darling)
Minor House Damage	2 (Kolmogorov-Smirnov)	19 (Anderson-Darling)

Then, the amount of damage and the amount of loss parameters estimated using Maximum Likelihood Estimation and Easyfit. The estimated parameters are parameter λ for the amount of damage to the house and (μ, σ) parameters for the amount of loss that occurred. So the results obtained are as follows:

$$\hat{\lambda}_{MLE} = \frac{\sum x_i}{n}, \tag{14}$$

$$\hat{\mu} = E(X) = \exp\left(\frac{\sum_{i=1}^{n} \ln x_i}{n} + \frac{\beta}{2n}\right), \tag{15}$$

$$\widehat{\sigma^2} = \exp\left(2\left(\frac{\sum_{i=1}^{n} \ln x_i}{n}\right) + \frac{\beta}{2n}\right)\left(\exp\left(\frac{\beta}{2n}\right) - 1\right), \tag{16}$$

with $\beta = \sum_{i=1}^{n} \ln {x_i}^2 - \frac{(\sum_{i=1}^{n} \ln x_i)^2}{n}$

Based on the data given in Table 1, and the calculations performed using equations (14), (15) and (16), the parameter values given in Table 3.

Table 3 : Parameters Estimated

	λ	**μ**	**σ**
Lost House	150.73	9.9787	0.09875
Heavy House Damage	225.01	19.999	0.10096
Minor House Damage	1123.7	5.0177	0.08733

After that, determine the individual risk model by determining the expected and variance of the amount of house damage that occurs with the parameter λ due to flood natural disasters with a Poisson distribution, $EN = VarN = \lambda$, so the results obtained are as Table 4.

Tabel 4 : Individual Risk Model

	EN	***VarN***
Lost House	150.73	150.73
Heavy House Damage	225.01	225.01
Minor House Damage	1123.7	1123.7

Furthermore, a collective risk model is obtained by determining the expected and variance of the individual risk model with the amount of damage caused by flooding, with the equation:

$$ES = EN \cdot EX = \lambda \cdot \exp\left(\mu + \frac{1}{2}\sigma^2\right), \tag{17}$$

$$VarS = (EX)^2 \cdot VarN + EN \cdot VarX = \left(\exp\left(\mu + \frac{1}{2}\sigma^2\right)\right)^2 \cdot \lambda + \lambda \cdot \exp(2\mu + \sigma^2)\,(\exp(\sigma^2) - 1), \tag{18}$$

so that the results using equations (17) and (18) above are obtained the parameter values as given in Table 5.

Table 5 : Collective Risk Model

	$\boldsymbol{ES}$	$\boldsymbol{VarS}$
Lost House	4,8757,007.286	86,047,454,654
Heavy House Damage	4,501.122	$119482e^{19}$
Minor House Damage	5,642.674	4,959,546.643

After obtaining the collective risk model for each category, it can be determined how much premium is collected as a reserve fund of a flood natural disaster in the DKI Jakarta area using the expectation principle with a loading factor 2% or $\theta = 0.02$, jadi dengan menggunakan persamaan (13) diperoleh besar premi (iuran) untuk masing-masing golongan adalah sebagai berikut:

Category I (Lost House) = IDR 4.972.507.431.000,00

Category II (Heavy House Damage) = IDR 45.191.144.180,00

Category III (Minor House Damage) = IDR 5.755.527.944,00

5. Conclussion

From the results, parameter estimates are obtained so that they can determine the expectation and variance of the individual risk model. Furthermore, the results of the collective risk model are obtained which are used in calculating the reserve fund premium. Then, with these results, we can also conclude that the people of DKI Jakarta can participate in tackling the flood natural disasters that occur in their area by preparing reserve funds in the form of contributions that are shared together to prepare for future disaster management.

References

Ali, M.S.S., Arsyad, M., Kamaluddin, A., N Busthanul, N., & Dirpan, A. (2019). Community Based Disaster Management: Indonesian Experience. *IOP Conf. Series: Earth and Environmental Science*, 235 (2019) 012012, 1-10.

Dickson, & David C. M. (2005). *Insurance Risk and Ruin.* Cambridge : Cambridge University Press.

Fikhri, M. Yanuar, F. & Asdi, Y. (2014). *Pendugaan Parameter dari Distribusi Poisson dengan Menggunakan Metode Maximum Likelihood Estimation (MLE) dan Metode Bayes. Jurnal Matematika Unand, 3 (4)*, 152-159.

Flanagan, B.E., Gregory, E.W., Hallisey, E.J., Heitgerd, J.L., & Lewis, B. (2011). A Social Vulnerability Index for Disaster Management. *ournal of Homeland Security and Emergency Management*, Volume 8, Issue 1, Article 3, 1-24.

Hogg, R. V., McKean, J. W., & Craig, A. T. (2013). *Introduction to Mathematical Statistics (7th edition)*. Boston: Pearson Education, Inc.

Käärik, & Meelis. (2013). *Non-Life Insurance Mathematics.* Tartu: University of Tartu. Tersedia dalam DSpace Universitas Tartuensis.

Neonisa, O. (2021). *Estimasi Parameter Distribusi Log-Normal Menggunakan Metode Maksimum Likelihood dan Metode Bayes*. Diakses pada 5 Oktober 2021, dari http://skripsi.undana.ac.id/index.php?p=show_detail&id=1468&keywords=.

O'Keefe, J.P. & Ufier, A.B. (2017). Determining the Target Deposit Insurance Fund: Practical Approaches for Data-Poor Deposit Insurers. *Working Paper Series, Federal Deposit Insurance Corporation,* FDIC CFR WP 2017-04, 1-37.