

# Methodological Study to Classification of Damage State Immediately Subsequent to the Banjarnegara Indonesia Earthquake On 2018

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**Abstract.** This paper presents a preliminary methodological study of a seismic risk assessment in a residential area to classification of damage state immediately subsequent after earthquake happen. This paper compared with difference research of a seismic risk assessment in the same area, i.e. Kertosari, Banjarnegara Indonesia. This methodological study to identified compatibility of the building vulnerability assessment with Naïve Bayes Classifier (NBC) method for determine the probability of damage that has 5 different damage statuses (slight, moderate, extensive, complete and none), where the criteria damage states in vulnerable building has additional damage parameters based on the latest building damage regulations issued in 2013, which have totally 104 data difference criteria. The results from determine the probability of damage processing using the NBC methodology in Kertosari Banjarnegara that most type of damage states is extensive damage. There is a difference with 2018 research data, where the most damage state is the moderate damage, and there is also a difference with the Banjarnegara Municipal Disaster Management Authority (BPBD Banjarnegara) data, which has the most damage state is the complete damage. The difference is caused by the criteria in determining the damage conditions are still too general and the uncertainty value is high. Therefore, it is necessary to improve and detailed the building type model and damaged condition criteria for Indonesian buildings, based on the assessment and suggestion of experts who have good and long experience in earthquake risk management and understand the state of damage to Indonesian building regulations, such as: (1) researchers/scientists; (2) small and medium-sized contractors; (3) construction supervisors; (4) government officials; (5) business leaders; (6) academics/educators; (7) non-governmental organizations, in order to obtain an assessment of damage to residential houses quickly and accurately.

## 1. Introduction

The seismic risk assessment process can be divided into two main groups namely seismic hazard and vulnerability. Seismic vulnerability depends upon model building type, and damage state effected from the hazard and seismic hazard is the event capable of causing damage while seismic vulnerability represents the degree of loss of an element resulting from hazard. It can depict in the equation  $R = H \times V / C$ , where R is a risk, H is a hazard, V is a vulnerability, and C is capacity [1,2]. It can be understood that the failure of buildings and many victims when the earthquake came one of them due to vulnerable buildings [3–5]. In seismic risk assessment, many researchers need experts to judgment an evaluation and decision-making process. The expert could have totally different opinions about the

potential earthquake vulnerability of a building if compared to the opinions of another expert, due to the differences in their knowledge and experience [6,7]. Research on the vulnerability of buildings in a developing country, is still low, including Indonesia. Contrary, information from the building vulnerability assessment can be helpful for risk mitigation and emergency response planning and important as a based guideline to build any new building for preventing of losses [5], [8–11]. In line that, this research aim to develop a simple guide to resolution building type model and the criteria of damage state for compatible Indonesian building using NBC methodology in determine the probability of damage that has 5 different damage state (slight, moderate, extensive, complete, and none).

## 2. The general background of the study

### 2.1 Banjarnegara Earthquake

The Meteorological, Climatological, and Geophysical Agency (BMKG) obtain information data as to Banjarnegara Earthquake in April 2018 [12]. Time of the incident on Tuesday, 18 April 2018 at 13:28:35 WIB, scale: 4,4 SR, Location in 7,21°LS and 109,65°BT with Depth 4 Km, earthquake shocks felt strong enough in Kertosari Villages, Banjarnegara District and surrounding areas. There were various damage states of building i.e. slight by 88 houses damage, moderate by 31 houses damage, extensive and complete by 82 houses damage [13]

### 2.2 Predicting and estimating accuracy damage state using Naïve Bayes Classifier (NBC)

Classification is one of the most important techniques in datamining for data analysis. In datamining, different classification techniques are available to predict the outcome for a given dataset. There are many classification methods for predicting and estimating accuracy; one such famous method is Naïve Bayes Classifier. Naïve Bayes is very popular as it is easy to build, however to the assumption of conditional independence among predictor's results in loss of accuracy damage states. One of the main reasons for the better performance of Naïve Bayes Classifier is the assumption of independence among predictors [6,7].

## 3. Methods

### 3.1. Naïve Bayes Classifier (NBC)

Classification is a process of grouping data based on certain characteristics into predetermined classes. The Naïve Bayes Classifier is a datamining classification method which takes probabilities of attributes belonging to class for prediction. NBC is a supervised classification approach which can be used effectively to model a predictive problem probabilistically [14]. Naïve Bayes classifier is based on Bayes' Theorem where predictors are treated as Independent. In Naïve Bayes method the overall probabilities of attributes belonging to a class are calculated by resuming that the likelihood of an attribute on a given class value is not dependent on other attributes. This presumption leads NBC to better results and is called conditional independence [14–16]. Is known  $X = \{x_1, x_2, \dots, x_k\}$  is the attribute influence the C class. Naïve Bayes theorem is described as follows:

$$P(C|X) = P(X|C) * \frac{P(C)}{P(X)} \quad (1)$$

Where:

$P(X)$  = predictor prior probability

$P(C)$  = the relative frequency of the sample C class

$P(X|C)$  =likelihood

$P(C|X)$  = posterior Probability

The conditional Independence is explained in this scenario as, the predictor (x) value on class (c) has no effect on the other predictor's values.

### 3.2 Discrete Probability

There are given free attributes (independence), the value of probability can be given as follows:

$$P(x_1, \dots, x_k|C) = P(x_1|C) * \dots * P(x_k|C) \quad (2)$$

If the attribute is to discretion, then  $P(X_i|C)$  estimated as frequeantation relative of the sample which has a value of  $x_i$ , as attribute in class  $C$ . The conditional Independence is explained in this scenario as; the predictor ( $x$ ) value on class ( $c$ ) has no effect on the other predictor's values.

#### 4. Results and Discussion

The methods of NBC are to calculate the discrete probability of damage states, there are none, slight, moderate, extensive and complete. Where, every house will get impact of all damage states, but the highest rank/the most type of damage states can be difference among them. Based on research before [8] and data additional criteria of damage states from Ministry of Public Works (PU) [17], there are 7 objects of assessment for classified of damage states [18]: 1. Building Condition, 2. Damage of column and beam, 3. Damage of wall, 4. Damage of roof, 5. Damage of plafond, 6. Damage of electrical installation and 7. Damage of door/window. The 7 criteria divide on to 104 damage states (slight, moderate, extensive, complete and none), as sample as in Table 1.

**Table 1.** Sample Object of Assessment and Damage State

No.	Object of Assessment							Damage States
	House Condition (X1)	Column and Beam (X2)	Wall (X3)	Roof (X4)	Plafond (X5)	Electrical Installation (X6)	Door/window (X7)	
1	Building still stands	Most columns, beams and/or roofs are damaged	A small part of wall is broken	Roof collapsed	Most of walls and ceiling are collapsed	Electrical installation is totally damaged	Door/window is totally damaged	Extensive (E)
2	Building still stands	Column beam partially is broken	Cracks on the plastering walls	Loose roof/tile cover	Some of ceiling coverings are broken	Some electrical installations are damaged	Door/window is partially damaged	Slight (S)
3	Building collapsed completely	Most columns, beams and/or roofs are damaged	Most of walls and ceiling are collapsed	Some of roof trusses are broken	Some ceiling coverings are damaged	Some electrical installations are damaged	Door/window is totally damaged	Complete (C)
4	Building still standing	Structure collapsed mostly	Wall partially collapsed	Roof/tile cover cannot be separated	Broken ceiling	Electrical installation is not damaged	Door/window is not broken	Moderate (M)
5	Building still stands	Structure/beam column is not damaged	Wall does not crack	Roof/tile cover cannot be separated	Ceiling is not damaged	Electrical installation is not damaged	Door/window is not broken	None (N)

And then an object of assessment calculated depends on probability which has difference damage states use equation 1, as in Table 2.

**Table 2.** Probability of Damage States

Slight (S)	Moderate (M)	Extensive (E)	Complete (C)	None (N)
0.17308	0.41346	0.36538	0.03846	0.009615385

And then criteria of damage states, are calculated depends on damage states using Equation 1, as sample as in Table 3.


**Table 3.** Sample of scoring Damage Criteria from Building Conditions (X1)

X1	Building Conditions				
	Slight (S)	Moderate (M)	Extensive (E)	Complete (C)	None (N)
P (Building is remains standing) =	1	1	0.3421	0	1
P (Building is totally collapse) =	0	0	0.0263	1	0
P (Building is incline) =	0	0	0.6316	0	0

To calculate the highest rank/the most type of damage states of damage probability of decision damage state use Equation 2, as in Table 4.





**Table 4.** Discrete Probability of Decision Damage State (NBC) in Kertosari Village

Number	Photo	Coordinate	Discrete Probability of Decision Damage State (NBC)	
			Highest Rank	Categories
1		7°13'21.068"S109°40'12.551"E	1.0000	Extensive Damage (E)
2		7°13'899"S109°40'026"E	1.0000	Extensive Damage (E)
3		7°12'758"S109°40'673"E	1.0000	Extensive Damage (E)

4		7°12'006"S109°40'263"E	0.9777	Slight Damage (S)
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In Table 4 the most damage states in Kertosari village is Extensive Damage, which have a difference result to a preliminary survey [8] and BPBD Banjarnegara data [13] in year 2018 as Table 5.

**Table 5.** Damage data based on a preliminary survey and BPBD Banjarnegara in Kertosari village

Number	Photo	Building	Latitude	Longitude	Damage State
1		House 1	-7.21415	109.67872	Complete Damage (C)
2		House 2	-7.22300	109.67012	Complete Damage (C)
3		House 3	-7.22333	109.66958	Complete Damage (C)
4		House 4	-7.22232	109.66930	Complete Damage (C)

In Table 5 the most damage state in Kertosari village is complete damage, and the values of cumulative damage probabilities summarized is moderate damage [8].

## 5. Conclusion

The results from determine the probability of damage processing using the NBC methodology in Kertosari Banjarnegara that most of damage state is extensive damage. There is a difference with 2018 research data, where the most damage states is the moderate damage, and there is also a difference with the BPBD Banjarnegara data, which has the most damage states is the complete damage. The difference is caused by the criteria in determining the damage conditions are still too general and the uncertainty value is high. Therefore, it is necessary to improve and detailed the building type model and damaged condition criteria for Indonesian buildings, based on the assessment and suggestion of experts who have good and long experience in earthquake risk management and understand the state

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