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VALUE OF BUILDINGS IN VOLCANIC VULNERABILITY: A CALCULATION CONCEPT

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Abstract

Indonesia has diverse geographical conditions in each region that causes different impact in assessing real estate value, one of which is the active mountains especially in Ternate, North Maluku. This research discusses the experience of volcanic hazards that influences the model of cost valuation method in building. Drawing on technical calculation, the paper first examines the historical volcanic hazard at Mt. Gamalama, Ternate, Province North Maluku. This work also introduces in how volcanic vulnerability requires a specific approach to play complementary roles in appraising the real value of a building. Following cost approach method, by computing the specific formula to determine the characteristic of a building which directly related to its depreciation, this model predicts the implications of the expected value of a building which is typically located in the volcanic vulnerability.

***Keyword**: v*olcanic vulnerability, building, cost approach method

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INTRODUCTION

Called as “Pacific Ring of Fire”, the natural disasters such as earthquakes, floods, tsunamis, and volcanic eruptions are common threats to many countries, in the Asia-Pacific region including Indonesia (Primanti et al 2018). For the last decades in Indonesia,a volcanic hazard has been assessed at the regional scale and the assessment of volcanic vulnerability is a particular step within the real estate analysis at the specific region. Precisely, in order to conduct a valuation, specifically in the location of the volcanic eruption recorded, an appraiser needs to determine the effect, in terms of possible damage to buildings and other built facilities due to volcanic eruption (Spence et al 2005).

Characterized with four thematic areas as physical, social, economic and environmental, (Birkman and Wisner, 2006) the vulnerability which related to the physical aspects is usually described as the ‘degree of losses’ of an element or set of elements at risk resulting from the occurrence of a natural phenomenon. In this context, particularly for the structure of a building, an appraiser is expected to express a judgement in terms of volcanic vulnerability for the building constructions.

Indonesia has public appraisers that is officially appointed by the Minister of Finance through The Directorate General of State Asset Management (DGSAM)- with specific duty to conduct state asset valuation. Established at 2006, DGSAM answered the need of public asset management practice issues, one of its positive agenda is to identify the accuracy and reliability of existing value of Indonesian asset with up-to-date database. Written down in its mission to realize a fair value of the State Asset that can be used for various purposes, moreover, to achieve the target, then DGSAM need a new set of rules and regulations in valuation.

Several regulations as guidance for public appraisers in conducting valuation have been made, one of which is related to building valuation. Thus, the regulation must meet the necessity of a particular asset to be identified. Specifically in this research objective for assets located in a volcanic hazard, within the context of the impact of volcanic vulnerability towards building. Several indicators have set up to be considered in building valuation such as: (1) age of buildings; (2) construction materials; (3) building function; (4) number of floors. All of the indicators henceforth will be useful to assess building New Reproduction Cost when appraisers conduct a Cost Method approach.

In view of the lack of research in how to assess the fair value of a building at the potential hazardous location and its significance, based on technical calculation, this study analyses each volcanic action and describe their effects on the fair value of building at a regional scale, in the municipality of Ternate, located in the North of Maluku. The example is given by applying the model to part of the potentially affected area based on calculation output.

STUDY AREA

In reference to The Statistics Indonesia (2019), the study area is the municipality of Ternate (162,7 km2—Fig. 1), located in the Province North Maluku - Indonesia. Ternate City consists of 3 large islands and 5 small islands which consists of 8 sub-districts and 78 villages divided amongst the islands. The Government Center is on its largest island, Ternate Island. There are five (5) subdistricts within the Ternate Island, namely, Ternate, South Ternate, Central Ternate, North Ternate and West Ternate.

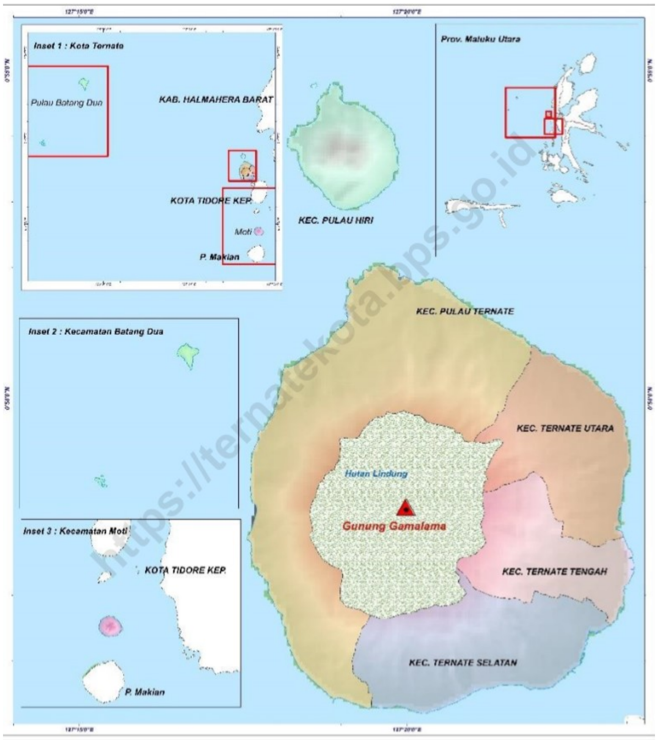

Figure 1: Ternate Municipality
Source: The Statistics Indonesia (2019)

Specifically, look into the geomorphological point of view, Ternate Island is estimated as the meeting area of the plates of which the Pacific Plate, Eurasian and Philippines and other small plates which was formed by an active volcanic mountain named Mt. Gamalama, an active strato-volcano with altitude of 1715m. Active volcanoes which in general seems flat on the coast, but becomes steeper as it reaches the top (Sinaga et al 2017). Compiled and hosted by Smithsonian's Global Volcanism Program at www.volcano.si.edu, named as The Volcanoes of the World database (Cotrell 2015 in Papale et al), the first eruption of Mt.

Gamalama was begun on 1500 to the latest one in October 2018. Based on historical observations, more than 80 Holocene eruptive periods have been confirmed (volcano.si.edu 2019).

According to the Statistics Indonesia (2019), it is reported that the climate in the study area concentrates during the summer and rainy, and the summer drought typically lasts up to 6 months. The average annual precipitation during 2018 was 212.75 mm with average temperature of 27.5 C. The main source of demographic data is population census that is conducted every 10 years, the latest census was held in 2010. The population of Ternate City is based on the population projection of 2018 as many as 228,105 inhabitants consisting of 115,891 inhabitants of men and 112,214 inhabitants of women, which population density in Ternate City in 2018 reached 1,407 people/km2. Compared to the projected population in 2016, Ternate residents experienced a growth of 2.24%. Eight volcanic earthquakes were recorded about an hour before volcano eruption (Program 2018), and the Statistics Indonesia (2019) reported the situation impacted to 2 subdistricts at Ternate Barat and Ternate Utara. There were no victims reported during the eruption.

THE METHOD

Combining the literature review and technical calculation, an analytical framework for expected value of buildings were developed. Figure 2 below illustrates this methodological flowchart framework that conceptualizes fair value of a building as a complex interaction between the capacities of actual inherent conditions at particular building and the result of hazard impacts as the volcanic vulnerability post-event at Ternate Municipality.

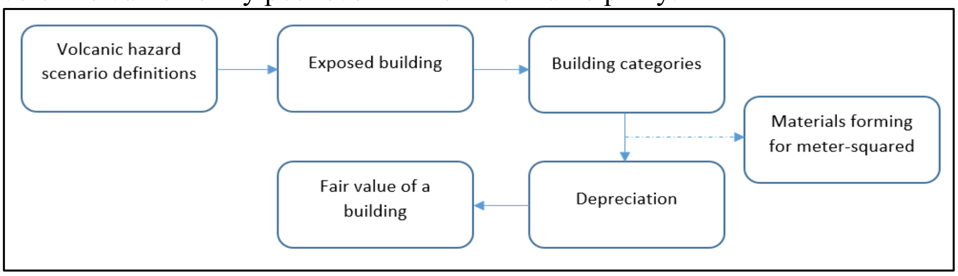

Figure 2: Research Flowchart
Source: Author

Volcanic Vulnerability and Exposed Building

Spence et al (2005) mentioned that the crucial factor trough volcanic vulnerability closely related to the terms of damaged state and the intensity level of the particular hazard. This includes the tephra fall, pyroclastic flow pressure earthquake ground shaking (Spence et al 2005), ballistic material and gas (Paton 2006).

Moreover, Spence et al (2005) defined the tephra fall as the damage state of collapse, meaning “the failure of a major structural element” such that “the roof covering and the structural members supporting it will fall inwards along with the thick tephra layer above”. The focus is on this damage state because it is only roof collapse which leads to significant casualties. Related to pyroclastic flow pressure, Spence et al (2005) notices four specific variables started from the occurrence of first damage state when glazed openings start to fail, allowing pyroclastic flow materials to invade building interiors. A second damage state occurs when shuttered openings and solid doors fail. As pressure further increases, wall panels without opening may begin to fail, third damage state. As pressure increases further, roofs and whole buildings may fail, which is the fourth damage state. And taking into account to the hazard concerned in volcanogenic earthquake, categorized by two types as collapse and partial collapse of a building.

Thus, even though the hazard contributes to building resilience both in times of quiescence, during a disaster, and after a disaster (De Terte et al 2009), this study focusses on the post disaster impact on the buildings which is related to the Perceived risk and adaptability to hazards that are especially significant in measuring local resilience.

Building categories and meter-squared material forming

In the way due to lack of comparable market transaction information, many instances of buildings opinion about its value are required even though no market activity took place (Scarrett 2008). To solve this situation, the replacement cost method seeks to estimate the usual costs associated with the constructing of a building rather than exchange price (Wyatt 2007). In details, the DGSAM, based on the Director General Decree 12/2019, stated, in order to find the new replacement or reproduction cost, appraisers must multiply the identified total area of building with meter-squared cost of building. Specifically, there are 4 categories of meter-squared cost of a building such:

a. 1st Category is a building that is generally known and well-functioned as a residential building. Buildings of this category usually consist of many rooms separated by permanent walls for residential activities such as bedrooms, living rooms, family rooms, kitchens and bathrooms. To be more specific, the 1st category can be divided into three sub-categories with characteristics below:
    1) Char 1.1
       Building functioned as a place for housing activities which has simple structure with dimensions of columns are no more than 18 cm squared or flattened with walls, and more than 50% of distance between columns that is less than 6 m in which the overall construction does not require special construction/structural design.

2) Char 1.2
   Building that is built as a place for housing which has medium structure with several dimensions of columns are 18cm^2, more than 50% of distance between columns that more than 6 m and there are several rooms with special construction.
3) Char 1.3
   Building functioned as a place for housing activities which has complex structure or has multi-storey structures with or without shear wall/core wall. This building specification requires more than 50% of distance between columns are more than 6 m and there are several rooms with special construction.

b. 2nd Category is a well-known as business (commercial) building. Building of this category is functioned as a place of business or a combination between place of business and residence. Generally, buildings of this category only have a few spaces that separated by permanent walls. However, the separation between spaces sometimes can be insulated with non-permanent walls or consist of a collection of small spaces of common size area and these spaces are corridors-connected. To be more specific, the 2nd category could divide into three sub-categories with characteristic below:
   1) Char 2.1
      A rectangular less-space simple building structure with smaller width than the length. This building specification requires more than 50% of distance between columns that less than 6 m with overall no require special construction.
   2) Char 2.2
      Building functioned as a commercial place with multi-storey structures without shear wall and core wall. This building specification requires more than 50% of distance between columns maximum 6 m with no rooms with special construction.
   3) Char 2.3
      Building functioned as a commercial place with complex structure and had two-tiered portal which combined with shear wall and core wall structures. This building specification requires more than 50% of distance between columns that more than 6 m with no rooms with special construction.

c. 3rd Category are buildings that are generally used for industrial activities such as warehouses, workshops, and factories. These buildings has a saddle-roof construction and has a single space that covers at least 80% of the building area. To be more specific, the 3rd category could divide into two sub-categories with characteristic below:

1) Char 3.1
   There is only 1 permanent room without mezzanine. Building has unidirectional horse-span for 12 to 16m with main supporting pillar at 5m height.
2) Char 3.2
   Building has less space with mezzanine. Building has unidirectional horse-span for 16 to 22m with main supporting pillar more than 7m in height.

d. 4th Category is a building that does not represent particular function; however, this category has special structural characteristics due to its function, even for such as a simple structure or through a complex structure. To be more specific, the 4th category could divide into three sub-categories with characteristic below:

   1) Char 4.1
      Building has a simple structure with lightweight building materials and the building has a maximum width of 7 m.
   2) Char 4.2
      Building has a simple multilevel portal building structure with parallel space with relatively equal area in each space that is connected by a corridor.
   3) Char 4.3
      Building has a complex structure, wide span between column, a very large spaces the likes of a hall, meeting place, or place of worship. Several buildings of this category have a special construction specific such as a dome or a high steep roof.

Material forming and depreciation

Defined as the measure of wearing out, consumption, or other reduction in the useful economic life of a fixed asset, whether arising from use, effluxion of time or obsolescence through technological or market changes (Scarrett 2008), depreciation could be caused from deterioration as the wearing out of the building fabric (Isaac 2001) and obsolescence (Wyatt 2007). Related to depreciation, DGSAM has implemented by following the Circular Letter 4/KN/2013 from Director General as guidance for public valuer to appraise a building by using cost approach method.

In estimating the depreciation, firstly, to identify in cluster the physical condition of building into 5 categories which are estimate the depreciation, firstly, by clustering the physical condition of a building by 5 categories as very good condition, good condition, average condition, bad condition and very bad condition. These 5 categories, which were captured during the field survey by appraisers, must consider the real condition of building at the stipulated time. Due to the impact of volcanic vulnerability, appraiser should define clearly this physical condition as deduction. Precisely, Spence et al (2005), notified there are seven classes of construction materials of the vertical load-bearing structure to be considered as shown in Table 1 below:

Table 1: Classes of construction materials

	Type	Other Descriptive Notes
1	Reinforced concrete, infilled frame	
2	Reinforced concrete, shear wall	
3	Masonry, block/squared/cut stone	unreinforced
4	Masonry, confined or reinforced	reinforced
5	Masonry, rubble	
6	Steel Frame	
7	Timber	with lightweight cladding

Source: Spence et al (2005)

Secondly, after the physical condition of a building has been defined, we need to estimate the effective age of a building, even the building is with or without renovation, and even the building has been changed in overall dimension and physical structure (restoration).

Next, estimation should be based on the condition of building and the affective age of building, DGSAM has implemented specific formula in order to obtain the depreciation (number of percentage) which this percentage particularly different in each characteristic of buildings.

And lastly, the formula to calculate the total depreciation could be written as

$$\% \text{ of Total Depreciation} = PD + \{FD * (100\% - PD)\} + \{ED * (100\% - PD)\}$$

Where PD defined as physical depreciation, FD as functional depreciation of building dan ED defined as economic depreciation of a building.

SAMPLE CALCULATION

This section demonstrates case sample calculations relate to cost method valuations for rating. Case 1 shows the value of residential purpose, while Case 2 applies the commercial building to newly built premises. Both of this sample case includes the impact of hazard scenario which corresponds to a real condition of building when appraiser conduct a survey.

1. Case 1
   A 100 m2 simple residential house located at Ternate City, no specific reference thereto, no specific rooms and construction, no multi-storey, was erected in 1990 and has renovated at 2012. At the date of field survey,

building was in well maintained with good condition should be calculated as Table 2 below:

Table 2: Calculation Case 1

		Area coverage (m2)	Cost per Meter squared (IDR)	Value (IDR)
A	New Reproduction cost of building	100	3.316.171	331.617.100
B	Effective age	13 Yrs		
C	Depreciation	32%		106.117.472
D	Fair value			225.499.628
E	Roundings			225.500.000

Source: Author's calculation

2. Case 2
A simple multi-storey building with basement and the rest of its two-story used for office which located at Ternate City. When the valuation officers conducted the physical survey of the building, they found the building were in average condition. This office was erected in 2001 with 3000 m2 of the total area and no renovation has been made. The calculation should be as Table 3 below:

Table 3: Calculation Case 2

		Area coverage (m2)	Cost per Meter squared (IDR)	Value (IDR)
A	New Reproduction cost of building	3000	4.952.106	14.856.318.000
B	Effective age	17 Yrs		
C	Depreciation	49%		7.279.595.820
D	Fair value			7.576.722.180
E	Roundings			7.576.722.000

Source: Author's calculation

DISCUSSION AND CONCLUSION

Prior to exploring the challenges in state asset management in Indonesia, it is clear that there is a notion for the DGSAM to accelerate implementation in valuation practices for state asset management due to specific condition of the asset itself.

In this work, we explored two components that are crucial to analyze volcanic vulnerability: the vulnerability itself and the value of exposed elements.

However, this contribution only focuses on the single type of exposed elements: buildings. One of the innovative contributes of this study was supported by very detailed component materials in order to develop the precise cost per meter squared that allowed the appraisers to calculate the reproduction cost for each single building within the study area. Such information was used to evaluate the buildings condition bases on physical survey conducted based on empirical data which supported by expert opinion.

In this study, we assume a unique value for every single of building in the municipality. Value of a building was obtained for each single building taking into consideration the construction cost, the area, the building characteristic, location and its age.

The complete information regarding buildings in the volcanic hazard was aggregated into a geodatabase that may be explored in future work in order to improve the estimation of magnitude values for other types of volcanic vulnerability in the study area. We believe that this methodology may be exported to other areas with similar building characteristics. However, the application of this method to large cities appears to be very difficult because it implies the data collection for each individual building.

REFERENCES

Birkmann, J. & Wisner, B. (2006). Measuring the un-measurable. The challenge of vulnerability. *Studies of the University: Research, Counsel, Education—Publication Series of UNU-EHS*, No. 5/2006.

Cotrell, E. (2015). Global Distribution of Active Volcanoes. In: Papale, P. *Volcanic Hazards, Risks, and Disasters*. Elsevier.

De Terte, I., Becker, J., & Stephens, C. (2009). An Integrated Model for Understanding and Developing Resilience in the Face of Adverse Events. *Journal of Pacific Rim Psychology, 3*(1), 20-26. doi:10.1375/prp.3.1.20.

Directorate General of State Asset Management (2013). Surat Edaran Nomor SE-4/KN/2013 tentang Penyusutan/Depresiasi pada Penilaian Bangunan

Directorate General of State Asset Management (2019). Keputusan Direktur Jenderal Kekayaan Negara Nomor 12/KN/2019 tentang Perubahan Kedua atas Keputusan Direktur Jenderal Kekayaan Negara Nomor 246/KN/2017 tentang Petunjuk Teknis Penilaian Tanah, Gedung dan Bangunan, Jalan, Jembatan, Bangunan Air, dan Penyusunan Laporan Penilaian Dalam Rangka Penilaian Kembali Barang Milik Negara.

Global Volcanism Program. (2018). Report on Gamalama (Indonesia). In: Venzke, E. (ed.). *Bulletin of the Global Volcanism Network, 43:11*. Smithsonian Institution. https://doi.org/10.5479/si.GVP.BGVN201811-268060. https://volcano.si.edu/volcano.cfm?vn=268060, accessed on 18 Oct 2019

Isaac, D. (2002). Property Valuation Principles. Palgrave-McMillan.

Paton, D. (2006). Disaster resilience: Building capacity to co-exist with natural hazards and their consequences. In D. Paton & D. Johnston (Eds.), *Disaster resilience: An integrated approach* (pp. 3–10). Springfield, IL: Charles C Thomas.

Primanti, IN., Roeslan, F. & Hastiadi, FF. (2018). The Economic Development Impact of Natural Disasters in APEC Countries (1999-2013). *Journal of Economic Cooperation and Development*, 39(2) pp. 1-28.
Scarrett, D. (2008). Property Valuation-The Five Methods. 2nd Edition. Routledge.
Sinaga, GHD., Zarlis, M., Sitepu, M., Prasetyo, RA. & Simanullang, A. (2017). Coulomb stress analysis of West Halmahera earthquake mw=7.2 to mount Soputan and Gamalama volcanic activities. *IOP Conference Series: Earth and Environmental Science*, 56-012005.
Spence, RJS., Kelman, I., Calogero, E., Toyos, G., Baxter, PJ., et al. (2005). Modelling expected physical impacts and human casualties from explosive volcanic eruptions. *Natural Hazards and Earth System Science, Copernicus Publications on behalf of the European Geosciences Union*, 5(6), pp.10031015.
The Statistics Indonesia. (2009). Ternate Municipality in Figures.
Wyatt, P. (2007). Property Valuation. 2nd Edition. Wiley-Blackwell.

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