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Assessment of Building Damage Hazard Caused by Earthquake: Integration of FNN and GIS

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Abstract

The objective of this research is to develop an integrated system that implements FNN and GIS to evaluate the building damage hazard caused by earthquake and to calculate the economic losses of damage. This research comprises of four steps which is the development of building damage hazard zones, the development of building database, the assessment of building damage hazard and the impact of economic losses in of damage. The result of the analysis showed that more than 97 percent of the functions of buildings in research location is a low hazard of building damage, where residential/commercial type and educational/religious facilities majority is in moderate to high hazard zone of building damage. The direct economic loss due to building damages caused by earthquake in Banda Aceh city Indonesia is estimated around 1,518,831,150,000 in Indonesia rupiah (168,759,016 in US Dollars).

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Keywords: Building damage; hazard assessment;earthquake; FNN; GIS

1. Introduction

Indonesia is one of the countries with high intensity of earthquake which is the main characteristic of tectonic islands that reside between three main plates which is Eurasia plate at the North, Indo-Australia plate

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at the South and Pacific plate at the Northeast. The earthquake with high intensity in this decade apart of causing casualties it also caused building damages in Banda Aceh City that reached 35 percent as the impact of Sumatra Earthquake in 2004 (Irwansyah, 2010), more than 140,000 units experienced a total damage caused by Yogyakarta earthquake in year 2006 (Miura et al, 2005) and more than 300,000 as an impact of West Sumatra in 2009 (AusAID, 2012).

Realizing the fact that the high building damage figure as a result of earthquake and with the objectives to reduce casualties it is required to have an assessment method that include damages assessment on buildings and assessment of economic damages directly (direct assessment). The assessment method can be used as the base of a spatial decision support system related to the building damage hazard caused by earthquakes generally conducted in the assessment domain of building damage only (Alam et al, 2013; Aghataher, et al, 2008) as well as the assessment on the building damage hazard and the impact on economic loss directly. (Tang and Zhao, 2012; Motamed et al, 2014; Duzgun et al, 2011; Hashemin and Alesheikh, 2011; Molina et al, 2010; Tang and Wen, 2009; Bo et al, 2009; Rosyidi et al, 2008; Yeh et al, 2006).

The method which is used mostly by researchers to assess building damages as well as the impact on economic loss directly is using GIS whereas some researchers are using an integrated system such as integrates risk assessment tools and SIG (Alam et al, 2013), artificial intelligent and SIG (Tang and Zhao, 2012; Choun and Elnashai, 2010; Tang and Weng, 2009) and also Fuzzy-AHP and SIG (Aghataher et al, 2008). The objective of this research is to develop an integrated approach that implements fuzzy-kohonen clustering network (FKCN) algorithm from the FNN model with GIS to assess the building damage hazard caused by earthquake and to evaluate the impact on economic loss of building damages directly using seismic data and building inventory in Banda Aceh.

2. Assessment of Building Damage Hazard Caused by Earthquake

Based on the assessment domain, in general, the earlier assessment about the building damages caused by earthquake is conducted to assess building damages only as conducted by Aghataher, et al , 2008 and Alam et al, 2013 or as a unit of assessment on the direct economic loss impact in building damages as has been conducted by Yeh et al, 2006; Rosyidi et al, 2008; Tang and Wen, 2009; Bo et al, 2009; Molina et al, 2010; Duzgun et al, 2011; Hashemin and Alesheikh, 2011; Tang and Zhao, 2012; Motamed et al, 2014.

Aghataher et al, 2008 and Alam et al, 2013 researches concentrated on the assessment on only building damages caused by earthquakes and a spatial decision support system (SDSS) in two different cities which is Kelowna, Canada and Teheran in Iran, using seismic data and building inventory that is organized by combining the databases that has been verified with the result of filed survey. Both researchers used GIS as the main tool to analyze where each is combines using different methods, which is Risk Assessment Integration tools (RADIUS) by Alam et al, 2013 and GIS tools is useful in the special analysis process as the base in an effective decision support and identifying risk area.

In contrast to the earlier researchers, Yeh et al, 2006; Rosyidi et al, 2008; Tang and Wen, 2009; Bo et al, 2009; Molina et al, 2010; Duzgun et al, 2011; Hashemin and Alesheikh, 2011; Tang and Zhao, 2012; Motamed et al, 2014 conducted assessment on building damages and assessment on the economic loss as a direct impact of earthquake.Taiwan Earthquake Loss Estimation System (TELES) based on GIS is developed by Yeh et al, 2006 to integrate several inventory data and seismic module analysis, assessment of damages and a module of social economic loss estimation which is a developed as an enhancement of HAZUS model with an additional module that allows automatic estimation of disaster scale and distributed soon after a large scaled earthquake incident. TELES mode is replicated in Indonesia as IELES by Rosyidi et al, 2008 and implemented as a decision support and recommended to become part of a complete system to handle the disaster at Bantul city West Java, Indonesia. A similar model is also suggested by Bo et al, 2009 with a