

GIS and Geodatabase Disaster Risk for Spatial Planning

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Abstract. The spatial planning in Indonesia needs to consider the information on the potential disaster. That is because disaster is a serious and detrimental problem that often occurs and causes casualties in some areas in Indonesia as well as inhibits the development. Various models and research were developed to calculate disaster risk assessment. GIS is a system for assembling, storing, analyzing, and displaying geographically referenced disaster. The information can be collaborated with geodatabases to model and to estimate disaster risk in an automated way. It also offers the possibility to customize most of the parameters used in the models. This paper describes a framework which can improve GIS and Geodatabase for the vulnerability, capacity or disaster risk assessment to support the spatial planning activities so they can be more adaptable. By using this framework, GIS application can be used in any location by adjusting variables or calculation methods without changing or rebuilding system from scratch.

1. Introduction

GIS is the tool to store, organize, analyze and display spatial data very well. Today GIS is commonly used in various fields in solving problems related to nature and human activities [1]. Many aspects of life can't be separated from GIS such as social, economic, geography, computer, information system, education, health, science, and disaster, especially in spatial planning.

A lot of researches using GIS and Geodatabase for disaster and spatial planning have been done. They show how GIS and Geodatabase can be used very well for visualizing, organizing, analyzing and calculating vulnerability, capacity and disaster risk [2]. They examine what variables are used in disaster risk assessment and what method is suitable for calculating each different type of disaster. Surely each disaster study has a different variable and may be using different calculation method. In general, the factors considered in the disaster assessments are nature, social, economy, physical, resources, environment and special needs [3]. Most of these models or researches are limited to discussing or implementing the specific study area; they are rarely or not suitable for other locations.

This paper will review and develop the concept that can improve the use of GIS and Geodatabase for calculating the vulnerability, capacity and disaster risk to support the more adaptable spatial planning activities. Disasters researches are needed for spatial planning in Indonesia because by the Indonesian law on disaster assessment must be included in spatial planning activities [4].

2. GIS and Risk Assessment

GIS has the capability of storing, retrieving, processing and analyzing multi-source spatial or temporal datasets. GIS plays as a tool for spatial analysis to become easily accessible and develop. GIS can solve problems in many sectors including in disaster risk and spatial planning. GIS, as the tool, has



numerous tasks such as site selection, plan assessment, management of urban activities, public participation, integration of planning with strategic environmental assessments, assessment vulnerability, and assessment risk [5]. To make the implementation successful, there must be an integration of spatial planning with disaster risk management in all relevant dimension required by researcher and stakeholder.

Geodatabase technology can be a potentially more effective solution to the continuing challenge in storing and retrieving spatial data effectively. Geodatabase enables the integration of diverse information sources, and also supports the management, storage and analysis. Geodatabase supports spatial and non-spatial data: vector, raster and attribute, as well as temporal and time series data. The time series and temporal data are ones of important factors in disaster and spatial planning [6].

Study of disaster vulnerability and risk assessment is a complex problem which uses a number of variables and method. Basic natural disaster is classified into three procedures: hazard analysis, vulnerability assessment, and risk assessment. Each procedure has different parameters or operation models according to the purpose and the studied location.

Zhao Ming et al. in his research used GIS method to make geoprocessing tool for risk assessment. That geoprocessing workflow models are for hazard, vulnerability and risk assessment which integrate into automatic GIS tool. The tool is successful for guiding emergency and urban planning. The geoprocessing workflow refers to a program that calls the sequence of geoprocessing tool to perform the geospatial task. This geoprocessing automates the operations required: data processing, severity calculation by hazardous sources, vulnerability, and risk mapping. This geoprocessing uses meteorological, demographic and spatial data for data processing. The numbers of vulnerability indicator are identified and quantified such as population density, population structure, and accessibility of emergency facilities [7].

Moreover, Rahman Naima et al. used GIS for mapping vulnerability to earthquake and fire hazard. This research has three assessments: earthquakes vulnerability assessment, fire hazard vulnerability assessment, and social assessment for combining the result of the composite vulnerability assessment. Earthquakes vulnerability indicators are building type, number of storey, vertical irregularity and plan irregularity. Fire hazard vulnerability indicators are construction material type, number of storey, floor area, fire sources in the building, fire source around the building, and accessible of the road. Social assessment vulnerability indicators are population density, gender, age below 5 and age over 65, disability and illiterate [2].

Farin Fatemi et al. described the variable of vulnerability in five general factors: gender, demographic attributes, socio-economic status, public resources, and disability and special needs. According to Soma Sarkar et al., the variables of vulnerability are wetland conversion, population density, population growth rate, infrastructure status, livelihood, social status, and road proximity [2]. Based on PERKA BPNP there are social, economic, physic and environment vulnerabilities [8]. Over time these variables will increase by the location conditions of the study area.

3. Discussion

There are two important things that must be considered in risk assessment and spatial planning using GIS. The first is data as it is very important for successful disaster risk assessment and spatial planning. Data represent condition in the studied location. In this study, data are modeled as a variable, used to display the real condition of a region in the assessment of disaster risk. There have been many descriptions of vulnerability over the last decades, but what is still lacking is a comprehensive definition that will meet the required needs of various and humanistic disciplines. The recognition grew of the importance of fundamental characteristic of environmental, economy, social and politic cause of vulnerabilities [2]. Vulnerability is the conditions determined by physical, social, economic and environment factors, which increase susceptibility to the impact of hazards [9].

The second is a method for the analysis or calculating vulnerability and risk assessment that is integrated with GIS tool. The most commonly used methods for the analysis of vulnerability and risk assessment were Analytical Hierarchy Process, Principal Component Analysis, Simple Multi Attribute

Rating Technique, Fuzzy and other Multi Criteria Decision Making (MCDM) Method [2]. The Multi Criteria Decision Making method introduced the defined relationship between the variable or indicator, that has the weighting for calculation.

Most of these models or researches are limited to discussing or implementing the specific study area; they are rarely or not suitable for other locations. Thus, they are not general and rigid to adaptable assessment of the variable of vulnerability, capacity and disaster risk assessment. However, we know that the study of disaster risk assessment can use different variables and methods for several studies. This happens because the concepts associated with vulnerability and risk assessment are complex. Different research communities have different concepts for vulnerability and risk assessment data and method. Thus, it is often difficult to find empirical evidence about vulnerability and establish viable metrics for measuring it, and it is difficult to estimate the methodological reasons for social vulnerability. These differences in definitions are confusing. The indicators are always indirect numerical surrogates of real phenomena, and quantitative assessments of qualitative are subject to generalization to achieve computation and comparability, which may be inaccurate and inapplicable. Despite these constraints, few researchers tried to produce valid indicators of vulnerability by applying some methods.

By these restrictions, the use of GIS and Geodatabase technology can increase the adaptability of vulnerability and risk assessment model for spatial planning. Importantly, the GIS and Geodatabase are more effective for vulnerability, capacity, and risk assessment without changing the application from the beginning. This model can accommodate various variables that can be added or remove based on the specific studied location which has different characteristics.

GIS has played a big role in constructing geospatial information system in many fields over the past years. GIS is a powerful tool which manages analyzing spatial data for disaster risk and spatial planning. GIS has geoprocessing that is convenient and using flexible technology for automating complicated task, and it has been used for solving many spatial problems including disaster risk and spatial planning. The main idea of geoprocessing is to provide a framework and toolkits to perform analyzing disaster risk for spatial planning. Basic GIS method can create a framework that can solve the problem with the adaptation of variables and methods. The application of disaster risk assessment based on that framework can be used in any locations by adjusting variables or calculation methods without changing or rebuilding the system from the beginning, and this framework can be implemented in various GIS and Geodatabase software.

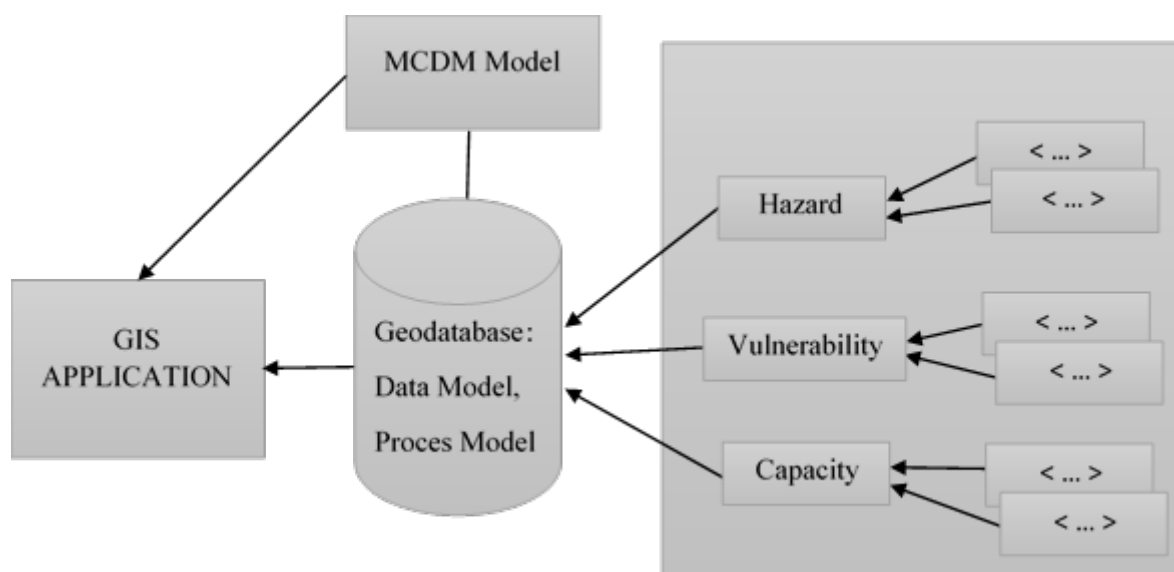


Figure 1. Framework GIS and Geodatabase tool for disaster risk and Spatial Planning.

The framework explains the concept of GIS as an application tool for calculating disaster risk, which consists of four major components: data input variables (hazard, vulnerability, and capacity), MCDM Model, Geodatabase, and GIS Applications.

3.1. Data Input Variable

Data input variable is the most important thing in this framework. Data input represents real condition indicator or component of hazard, vulnerability, and capacity. One thing to be aware of is that the component variables or indicators are not specified with certainty and can be added or removed in calculation. Variables are stored in spatial data (vector or raster) and they can also be stored as attributes or tables. By storing data component or indicator in a geodatabase, the disaster risk calculation becomes generic, not rigid, and can be adjusted by the availability of data for the location.

3.2. MCDM Model

MCDM Model contains several methods of Multi Criteria Decision Making for calculation. One studied location can choose or use more than one models. It makes it possible to compare and find the best model applied in a given location. Each location has certain characteristics that may have different output when using other methods despite using the same data. MCDM Model in the framework can be applied in two steps. First, the model is applied and stored in a geodatabase as a procedure or routine in the geodatabase. MMCDM Model can also be stored in a table as attributes and operations of calculations. Second, a model is applied or inserted into a GIS application itself as a function in a code program in the GIS application.

3.3 Geodatabase

Geodatabase technology can be an effective solution to store data and model used for disaster risk assessment and spatial planning. Geodatabase enables the integration, management, storage and analysis of data. Geodatabase has a comprehensive information model for representing, managing of data and model. These data and models are implemented as a series of tables or spatial data (raster and vector). The Geodatabase can provide the logic application for GIS application which can access various files or formats of geographic data. Moreover, geodatabase enables us to work with a number of spatial analysis. If the MCDM model is stored in the geodatabase, the model can be stored as procedure of code program or in the tabular data that holds the operation and weighting data.

3.4 GIS Application

GIS provides a consistent visualization of the environment for displaying the input data and model, and it creates a particularly useful aid in a processing data and model. GIS has geoprocessing which provide a framework and toolkits for performing analysis and managing data and model. Geoprocessing has a large spatial analysis method and allows us to customize a task or function for calculating risk and spatial planning. Collaborating GIS application with geodatabases can give modeling, automate disaster risk calculating and offer the possibility to customize the variables or operations on the fly without changing the code program.

4. Conclusions

A lot of researches using GIS and Geodatabase for disaster risk and spatial planning have been done. These researches examine what variables are used in disaster risk assessment and the suitable method for calculating each different type of disaster risk assessment. Most of these models or researches are limited to discussing or implementing the specific study area as they rarely or not suitable for other locations. The framework can be adopted by various GIS and Geodatabase applications to enhance the adaptability of the system in any studied locations by adjusting variables or calculation methods without changing or rebuilding system from scratch.

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