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A GIS-based approach for assessing social vulnerability to flood and debris flow hazards

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A B S T R A C T

Owing to the escalating environmental hazards caused by climate change, the mitigation of disaster becomes extremely important. The investigation of social vulnerability is a prerequisite for formulating a mitigation plan to environmental hazards. This research applies a GIS-based approach with the Social Vulnerability Index (SoVI) to investigate and quantify the social vulnerability to environmental hazards in Yilan County, Taiwan. In order to construct the SoVI, the literature review was conducted, and 12 variables were selected. Through Principal Component Analysis (PCA), the 12 variables were reduced into four principal components. In order to explore the spatial pattern of SoVI, the spatial autocorrelation analysis was applied. The result showed that there were 26.5% of communities in Yilan County with a high level of SoVI, and most of these communities were mainly located in mountain areas. The unfavorable topography features cause the distributions in mountain areas. On the other hand, there were 37.3% communities with a related low level of SoVI, and these communities were located in plain areas. The inaccessibility caused by topography creates an incapability, resource-lacking environment and lead to a high value of SoVI. In addition, this research applied Geographically Weighted Regression (GWR) to validate SoVI, and the result of the R^2 value was 0.769. Also, the standardized residuals showed no spatial autocorrelation, meaning the SoVI had the adequate explanatory ability. This research provided a set of valid indicators to explore the social vulnerability for decision-makers to formulate the mitigation plan of environmental hazards. Besides, SoVI is a suitable tool for visualizing and quantifying the potential loss to environmental hazards.

1. Introduction

Since the late 20th century, the frequency of extreme climate events has increased dramatically, and also augments the intensity and damage to flood and debris flow [1–3]. As a result, environmental hazards reduction and mitigation have become a critical task for the government. Therefore, one of the most important requisite analysis is the potential loss caused by environmental hazards. Over the last two decades, vulnerability is becoming one of the essential terms for the analysis of potential losses caused by environmental hazards. Visualizing and quantifying vulnerability enable the decision-maker to recognize the vulnerable areas and forecast potential losses.

According to Refs. [4,5], the vulnerability composes of social vulnerability and biophysical vulnerability and can be represented as potential losses to environmental hazards [4–7]. The social vulnerability can be regarded as the partial outcome of social inequalities [4]. In other words, social factors have shaped, influenced, or govern the ability of susceptible groups to respond when they face environmental hazards. Social factors include a lot of variables, such as gender, ethnicity, age, socioeconomic status, and education, etc [4–7]. General speaking, environmental hazards do not randomly affect society [8,9]. Usually, the groups that already marginalized by unfavorable socioeconomic status are the most likely to be jeopardized by environmental hazards [10]. When encountering environmental hazards, these groups are susceptible to the impacts [4,11–13]. Most of the researches apply the concept of social vulnerability to environmental hazards to quantify and investigate the susceptible groups [14–19]. On the other hand, biophysical vulnerability represents the geographic context of an area [5]. Based on the different locations, the biophysical vulnerability will also differ from place to place. For example, due to the topographic characteristics, the coastal areas are often affected by storm surges and floods. As a result, two of the most common factors affecting the biophysical vulnerability are the storm surge and flood in coastal areas under climate change [20–24]. Although the geographic context varies

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