

# **Mapping Landslide Events in Vietnam Using the Global Landslide Catalog and GIS**

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**Key words:** mapping, landslide events, Vietnam, global landslide catalog, GIS

## **SUMMARY**

Landslides are mass movements that can lead to heavy losses of life, property and services. To understand and mitigate their adverse effects, landslide events in the world need to be reported, mapped and assessed with different methods. This paper presents a new mapping study of landslide events in Vietnam over the last decade, 2007-2017 using the global landslide catalog and GIS. The data obtained from the global landslide catalog and other sources were reviewed, edited and standardized to develop a landslide database for Vietnam's regions and provinces. The selected spatio-temporal analysis and mapping techniques were applied to derive and visualize new information on the past landslide events. This geospatial information is essential for landslide management in the country in the context of climate change. The applied GIS-based mapping model highlights the utility of the global, local data and GIS as effective tools for landslide studies at national, regional and provincial levels.

# Mapping Landslide Events in Vietnam Using the Global Landslide Catalog and GIS

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## 1. INTRODUCTION

Landslides are geographic phenomena with negative impacts on human and natural systems. In order to understand and effectively manage landslides for sustainable development, landslide events need to be reported, mapped and assessed using traditional and modern methods such as remote sensing and geographic information systems (GIS).

For global landslide mapping and modeling, the National Aeronautics and Space Administration (NASA) has developed a global landslide catalog (GLC) since 2007. The catalog contains information derived from various sources and is updated to become a specialized database with a global coverage that can be publicly accessed online (Kirschbaum et al., 2010, 2015). To date, the GLC data have been used for some global landslide mapping and assessment (Stanley and Kirschbaum, 2017; Kirschbaum and Stanley, 2018). However, no attempt has been made for country specific studies using the data and GIS.

GIS is a computer based system designed to capture, store, manage, analyze, and display all forms of geographically referenced information (Kennedy, 2001). This system allows users to perform difficult, time consuming, or otherwise impractical spatial analyses to support spatial planning and management. Thanks to its great power in data input, management, analysis and output, GIS has been widely used in landslide studies (Coppock, 1995; Chacón et al, 2006; Carrara and Guzzetti, 2013; Van Westen, 2013; Jaeger et al., 2015) in both developed and developing countries.

Vietnam is a developing country in SE Asia. It is highly vulnerable to landslides due to its geographic location and socioeconomic conditions. Landslides occur annually and are expected to become more frequent with more losses of life, property and services in different geographic regions and provinces of the country under a changing climate (Lê, 1997; McBean and Henstra, 2003; GSO, 2009). In such context, a sound knowledge of landslide events in Vietnam is highly needed and landslide mapping studies using geoinformatics have attracted an increasing attention of many scientists and managers for scientific research and disaster management (Bui et al., 2012; Hung et al., 2017; Dinh Minh, 2017; Long and De Smedt, 2019). However, no attempt has been made/there is a need to create landslide distribution maps covering the whole country and several years in the absence of a national database.

This paper presents a new study of mapping landslide events in Vietnam over the last decade, 2007-2017 using the global landslide catalog and GIS. It is intended to provide insight into the landslide events in Vietnam. The insight is useful for spatial decision making to mitigate adverse impacts of landslide for sustainable development in the country in the years to come.

## **2. DATA AND METHODS**

### **2.1 Data collection**

The main data collected for this mapping study include analog and digital data of landslide events, geographic regions and provinces in Vietnam in the form of archived and published documents. They were collected online and offline from a variety of sources, including the official web pages of NASA (<https://data.nasa.gov/Earth-Science/Global-Landslide-Catalog-Export/dd9e-wu2v/data>), education, research and management institutions under Vietnam National University (VNU), Vietnam Academy of Science and Technology (VAST), Ministry of Natural Resources and Environment, Ministry of Agriculture and Rural Development, Ministry of Transportation and Communication.

### **2.2 Database creation**

The collected data were reviewed, edited, imported and standardized to the ArcGIS software format to develop a landslide GIS database for Vietnam and its geographic regions and provinces. ArcGIS was adopted as it is an advanced GIS. It includes tools for data input, storage, management and output (Booth and Mitchell, 2001; Theobald, 2009). The created ArcGIS database consists of spatial and attribute data in the form of feature datasets and feature classes related to landslide events, geographic regions and provinces in Vietnam.

### **2.3 Data analysis and mapping**

All landslide events in Vietnam were selected and then exported to shapefile format. The landslide layer was edited to contain the records between 2007 and 2017 for a decadal mapping and analysis.

For spatial mapping of landslide events in Vietnam, point in polygon analyses were performed to add regional and provincial information to landslide events. For temporal mapping, the date function was used to create the year and month attributes of landslide events. Summary statistics were obtained by summarizing the related field in the attribute tables. Charting and thematic mapping were implemented in Excel and ArcGIS. All the above mentioned operations allowed to derive and visualize new information on the geographic location, extent, causes of large floods and their health impacts in Vietnam between 2007 and 2017.

## **3. RESULTS AND DISCUSSION**

A GIS database of landslide events in Vietnam over the last decade, 2007-2017 was created and illustrated in Figure 1, consisting of spatial data layers and their associated attribute tables. The detailed information of each landslide event can be accessed with the Identify tool in Arcmap. The region layer shows 8 geographic regions and the province layer consists of 63 provinces and cities in Vietnam. However, some fields in the landslide attribute table are still empty and need to be filled with data. The field of Photo link is an example.

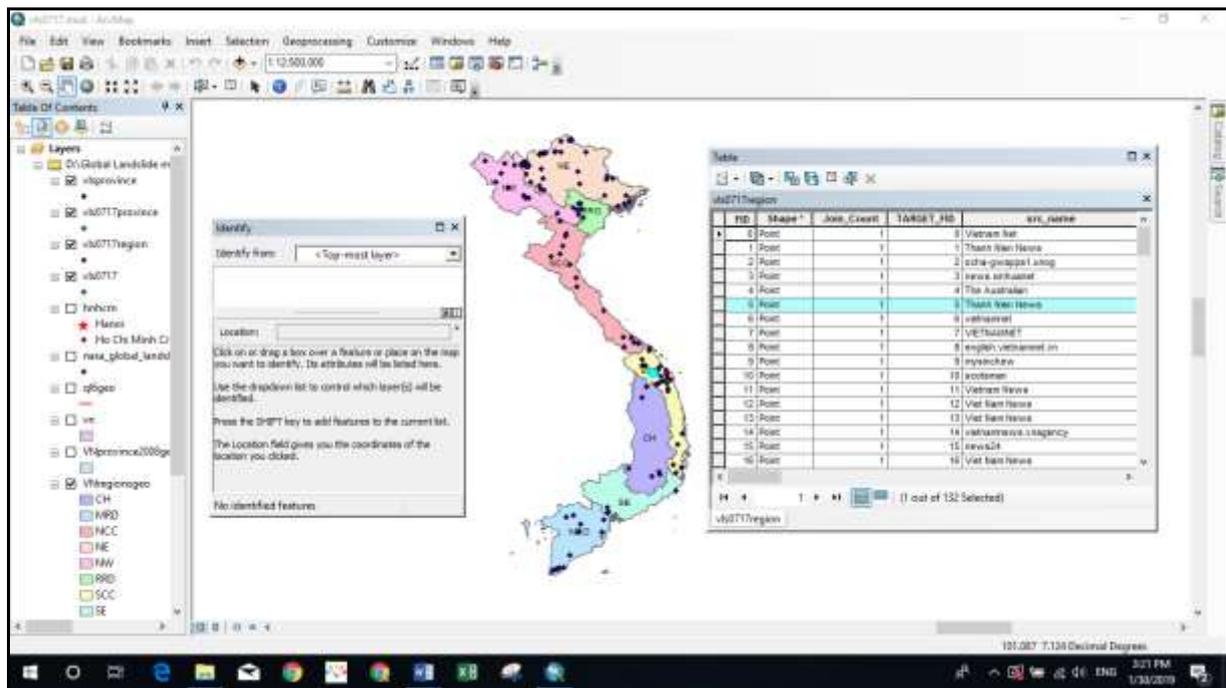


Fig. 1. An illustration of GIS database of landslides in Vietnam

At the national level, a total of 132 landslide events were mapped for the study period (Figure 2). This national distribution map of landslide events allows us to see the different patterns of landslide events in Vietnam.

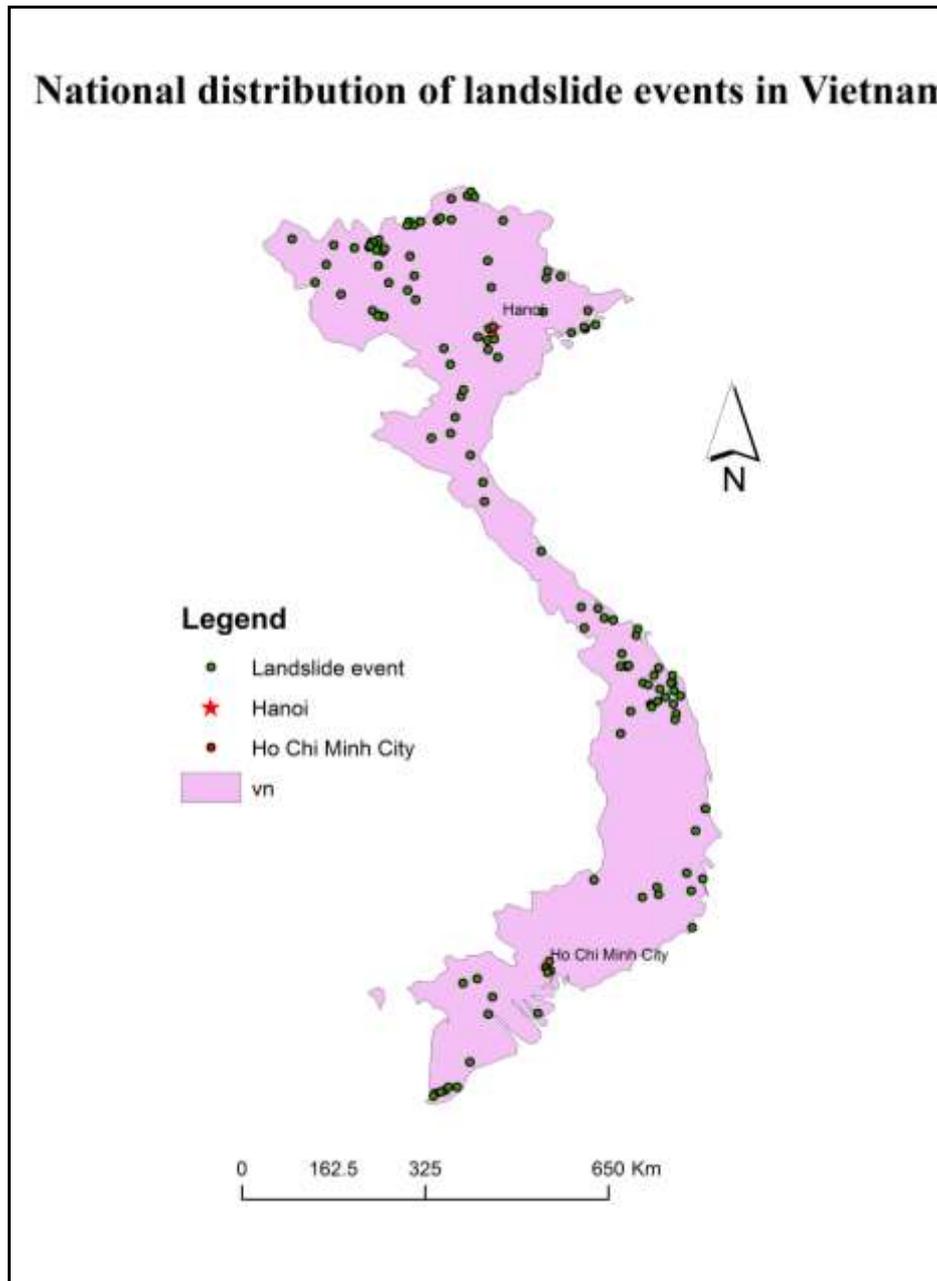


Figure 2. Map showing national distribution of landslides in Vietnam, 2007-2017

Landslide events were distributed in all eight geographic regions (Figure 3). The number of events varies from region to region (Figure 4). The North East region has the largest number of landslide events mapped. It is followed by the South Central Coast, North Central Coast, Mekong River Delta, and the Northwest.

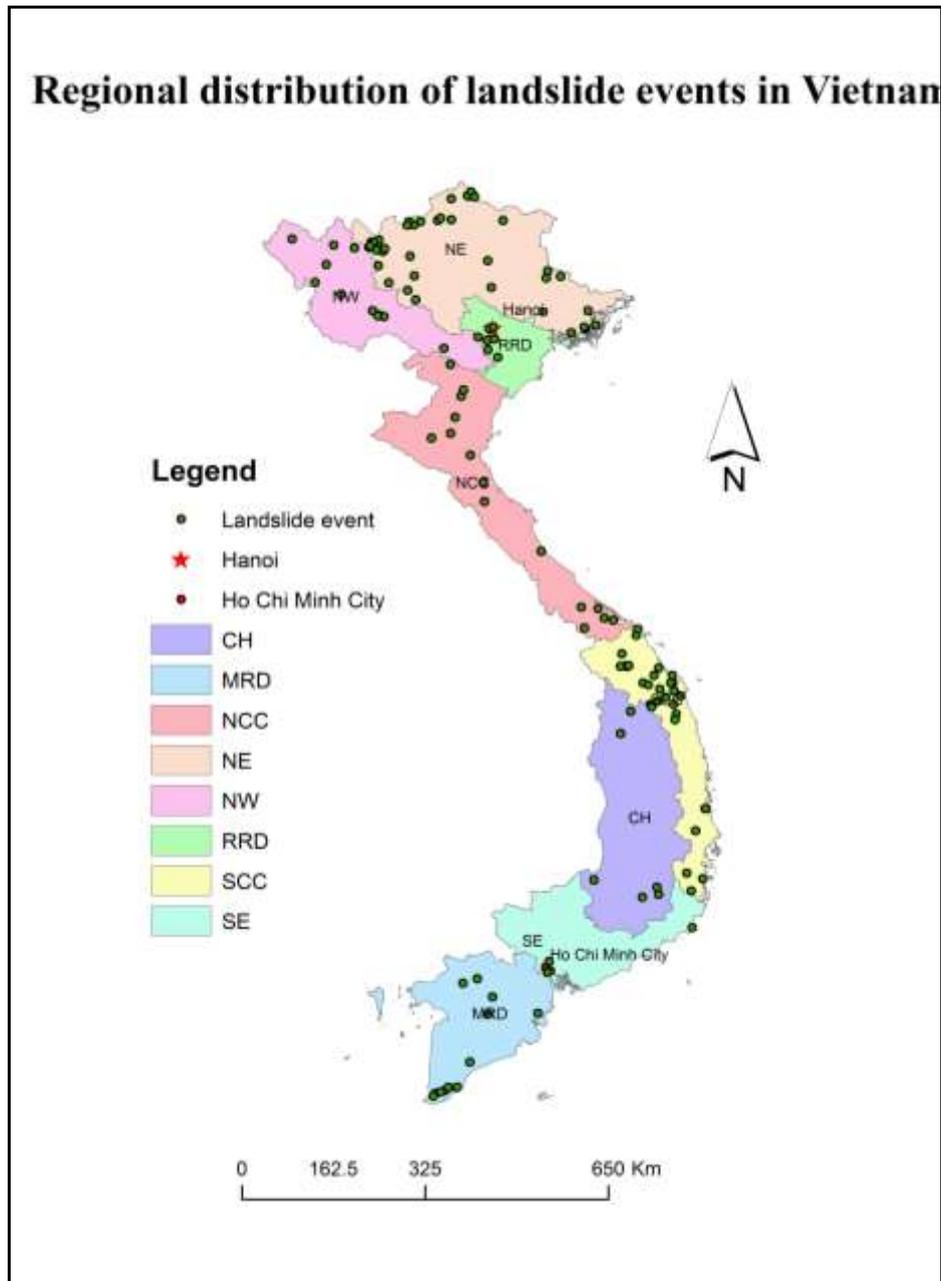


Figure 3. Map showing regional distribution of landslide events in Vietnam, 2007-2017. The eight geographic regions include Central Highlands (CH), Mekong River Delta (MRD), North Central Coast (NCC), North East (NE), North West (NW), Red River Delta (RRD), South Central Coast (SCC), and South East (SE).

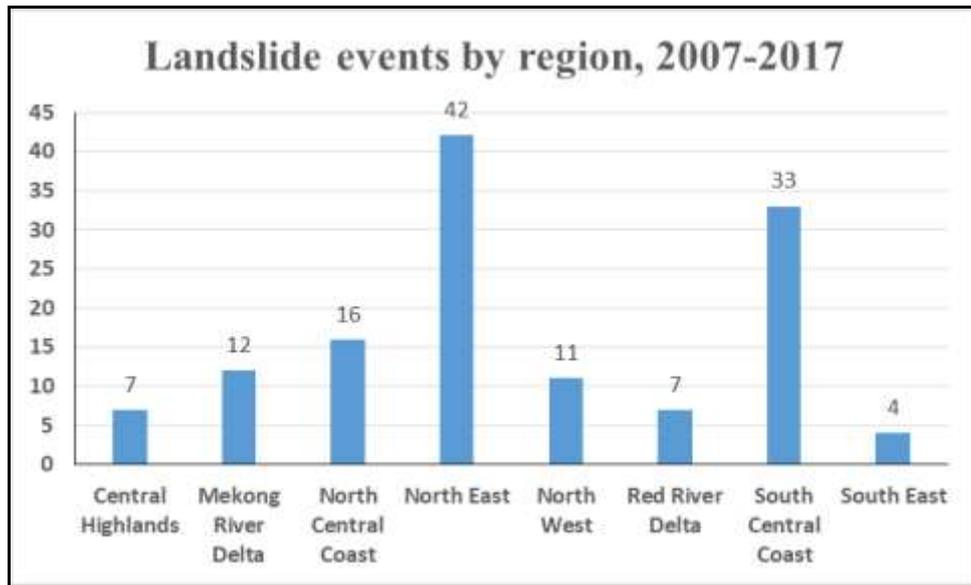


Figure 4. Number of landslide events by geographic region in Vietnam, 2007-2017

The provincial distribution of landslides is shown in Figure 5. Out of 63 provinces in Vietnam, 36 provinces were affected by landslide events during 2007-2017. The top 7 affected provinces include Ha Giang, Quang Ngai, Lao Cai, Quang Nam and Ca Mau, Hanoi, Thua Thien Hue (Figure 6).



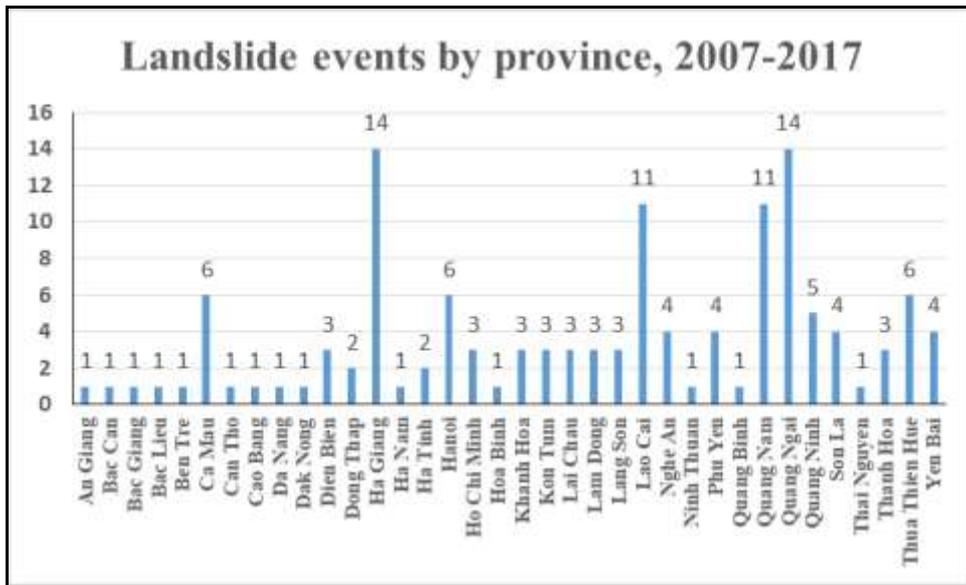


Figure 6. Number of landslide events by province in Vietnam, 2007-2017

The yearly distribution of landslide events is shown in Figures 7 and 8. The most eventful years include 2010, 2008, 2013 and 2015.

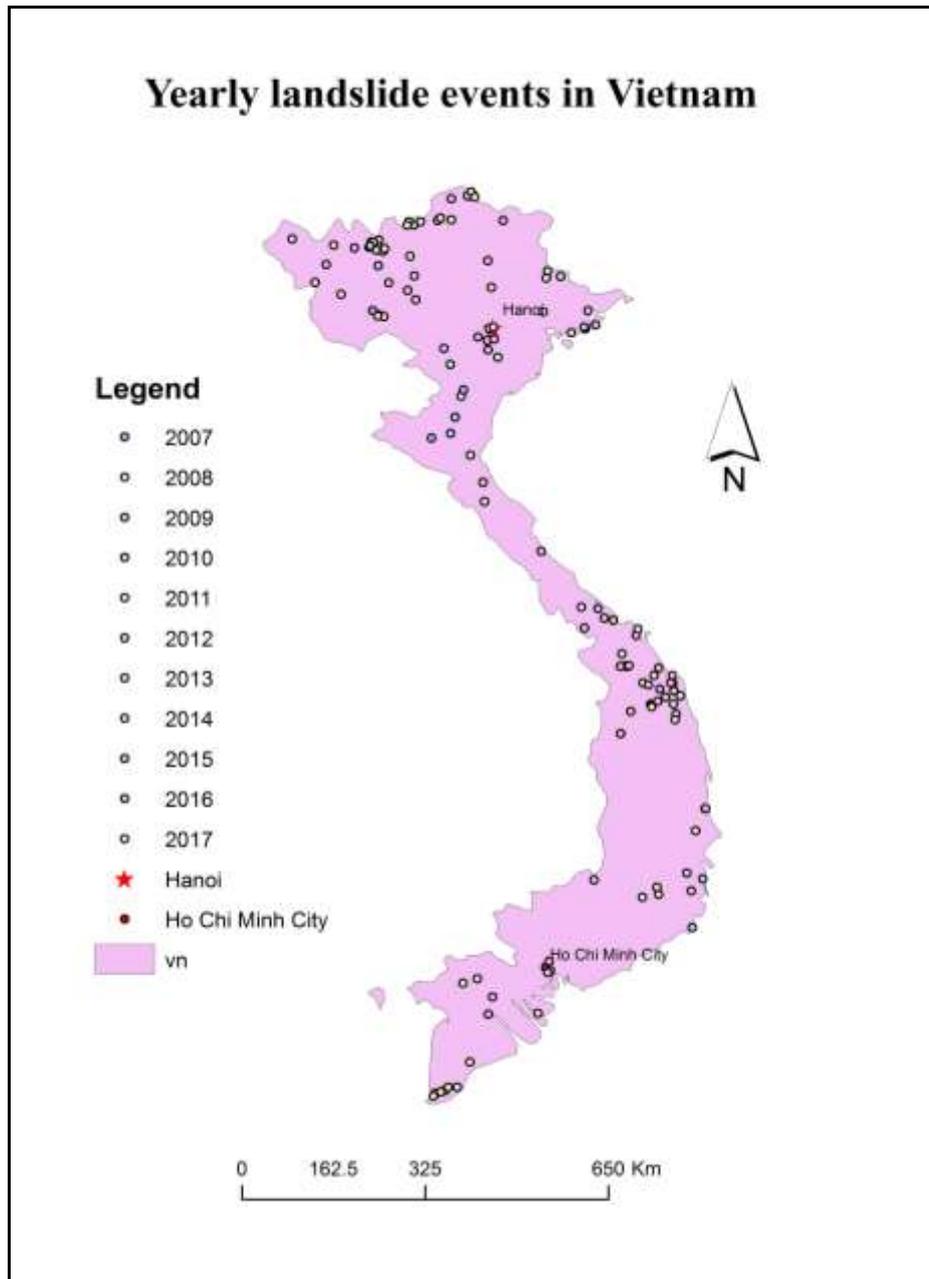


Figure 7. Map showing yearly distribution of landslide events in Vietnam, 2007-2017.

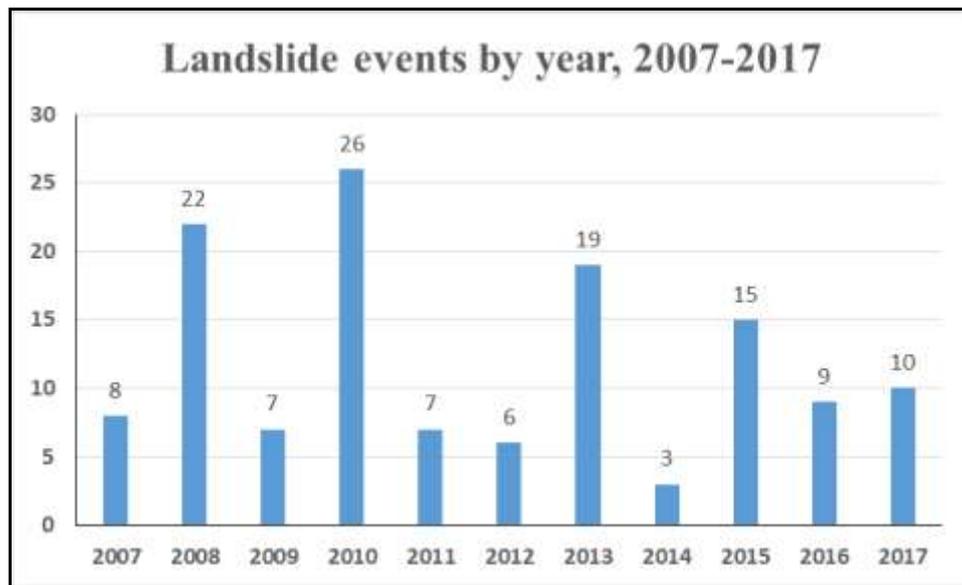


Figure 8. Number of landslide events by year in Vietnam, 2007-2017

The monthly distribution of landslide events in Vietnam is presented in Figures 9 and 10. The most eventful months are November, September, August, July, and October. This distribution is linked to the rainy season in different regions of the country.

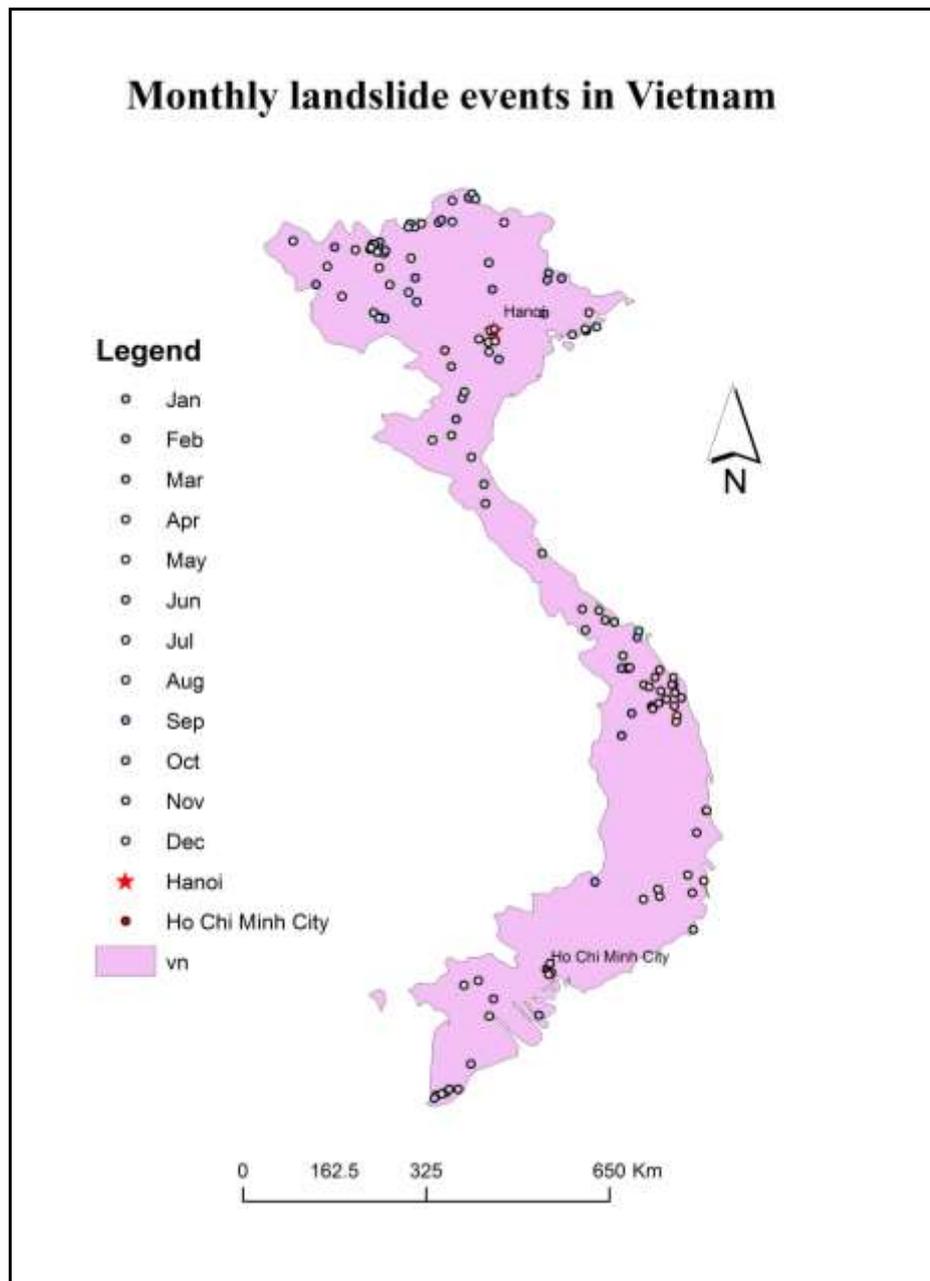


Figure 9. Map showing monthly distribution of landslide events in Vietnam, 2007-2017.

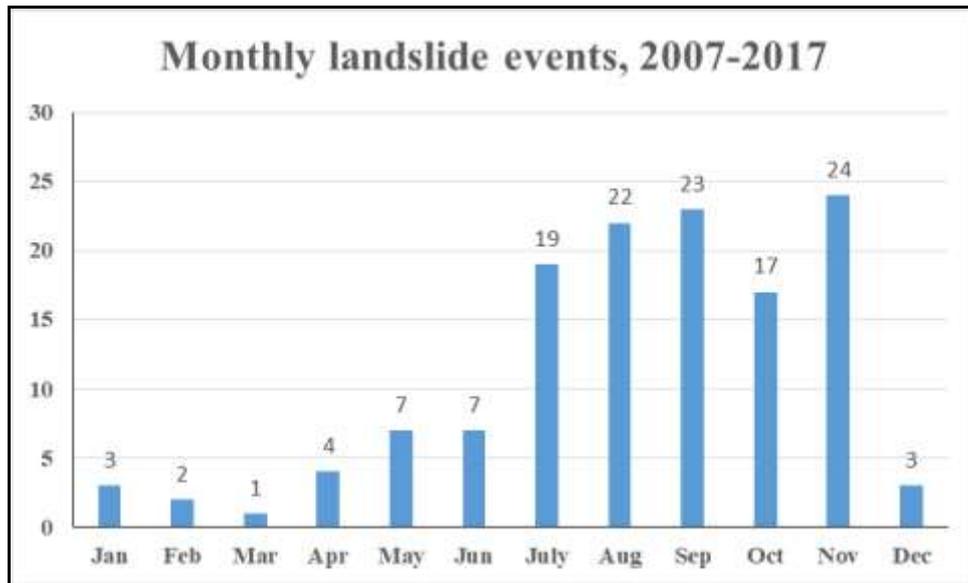


Figure 10. Number of landslide events by month in Vietnam, 2007-2017

#### 4. CONCLUSION

With the Global Landslide Catalog and GIS, we could develop a GIS database of landslide events in Vietnam. Based on the created GIS database, we could spatially and temporally map landslide events in a robust, consistent, affordable way.

The created ArcGIS database can and should be exploited, updated and enriched as new data and techniques become available. The spatial and temporal distribution maps of landslides help to communicate, better understand landslide events in Vietnam over the last decade, 2007-2017.

The landslide events formed uneven spatial and temporal distributions due to regional, provincial differentiation and seasonality in Vietnam. This information is essential to planning and management of limited resources to prevent and mitigate future adverse impacts of landslides.

Further studies are needed for quantifying landslide patterns, landslide susceptibility, hazard and risk using remote sensing and GIS in combination with ground investigations. The approach used in this study could be applied in other parts of the world, especially in developing countries for scientific advancement and landslide disaster management for sustainable development.

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## **BIOGRAPHICAL NOTES**

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Dr. Nguyen Dinh Minh received his PhD degree from Vietnam National University (VNU) and MSc degree from Asian Institute of Technology (AIT). He is currently an associate professor of geography at VNU University of Science. His main research interests include applications of remote sensing and GIS in natural resources, environmental and hazard management for sustainable development.

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