

Review

Social Vulnerability Assessment for Landslide Hazards in Malaysia: A Systematic Review Study

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Abstract: Landslides represent one of the world's most dangerous and widespread risks, annually causing thousands of deaths and billions of dollars worth of damage. Building on and around hilly areas in many regions has increased, and it poses a severe threat to the physical infrastructure and people living within such zones. Quantitative assessment of social vulnerability in Malaysia is worrying because it has been given less attention than hazard-related studies. Therefore, this study's objective is to find out the indicators used for social vulnerability assessment in the context of a landslide in Malaysia. The analysis is critical for understanding the measures of social vulnerability, given that the incorporation of climate change and disaster risk mitigation issues in urban planning and management are considered priorities in ensuring a stable population growth and avoiding economic disruption. A systematic study on the Scopus and Web of Science repositories was conducted based on the PRISMA Report analysis method. This article concluded that there are six important indicators of social vulnerability in the context of landslide in Malaysia.

Keywords: social vulnerability assessment; landslide; social indicator; disaster risk reduction; Malaysia



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1. Introduction

In recent years, extreme events have increased in intensity and frequency globally, leading to rising economic losses and casualties. It is believed that these events will continue to accelerate in future climate scenarios. An accurate understanding of the physical and socioeconomic drivers of these extreme events is crucial and can ultimately enhance adaptive strategies. The frequency and intensity of geophysical events is increasing. This is the result of the interaction between humans and the environment. Climate change and increasingly aggressive human activities contribute to the vulnerability of catastrophic hazards to humans, their infrastructure, and the environment [1]. Faced with ever-increasing societal impacts arising from such events, a wealth of research and analysis has focused on understanding causal processes and outcomes [2]. Landslides are a type of geophysical event that plays a significant role in the evolution of a landscape [3]. However, landslides do pose a serious threat to local populations given that these events are being triggered increasingly by a changing climate and more unpredictable weather patterns. In recent years, it has become clear from previous research that the location, abundance, activity, frequency of landslides as well as the social and economic consequences are increasing over time and more people are exposed to the risks [4–10]. It was reported in [11] that geophysical

disasters such as landslides are the deadliest. The presence of humans, infrastructure, and other forms of vulnerabilities in one location will make things worse.

Historically, efforts to reduce landslides are physically oriented resulting in a proliferation of technocratic approaches in the literature, while financial losses and social vulnerability from the geophysical events continue to increase. Over time, this gave rise to an alternative explanation that mounting losses are related less to the dynamics of the events but more to the vulnerability of exposed human populations [2]. Although assessing the magnitude and intensity of disasters is critical, the nature of population demographics and various socioeconomic contexts may also lead to a greater risk of disasters. Understanding the complexities of vulnerability to disasters, including those caused by geophysical events, is at the heart of disaster risk reduction. Efforts to reduce disaster risk involve various disciplines and should be viewed from numerous perspectives to provide long-term benefits. A comprehensive disaster risk reduction strategy that incorporates physical and socio-economic aspects is the key determinant of vulnerability.

In spite of very high importance of socioeconomic data to assess landslide vulnerability, there are lack of social data documented for analysis and mapping in Malaysia. Therefore, the objective of this study is to find out the indicators that are used for social vulnerability assessment in the context of landslides in Malaysia. The analysis is critical for understanding the measures of social vulnerability, since the incorporation of climate change and disaster risk mitigation issues in urban planning and management are a priority for ensuring stable population growth and evading economic disruption.

2. Literature Review

The definition of vulnerability is “the quality of being vulnerable (able to be easily hurt, influenced, or attacked), or something that is vulnerable” [12]. Vulnerability means the risk of being vulnerable or easily hurt by something or someone. Vulnerability is a concept that has been used over a long period of time, and it has been recognised in much research covering various fields of endeavour [13], for instance, the social sciences, economics, psychology, and engineering. It should be noted that there is no consensus regarding how vulnerability is defined [14]. It has, in fact, been interpreted in many ways according to the subject area being investigated.

According to [15], vulnerability refers to situations where individuals and societies are exposed to social, economic, and cultural risks and in essence the dangers posed by harm to them. All people and all communities at some point cannot avoid risk or harm, so at best each individual needs to prepare for every situation. Moreover, stress that social vulnerability is partly the result of social difference or social inequality, which affects or forms the susceptibility of different groups to harm or at risk and regulates their capacity to react to a certain situation [16]. There is inequality in every society and the unequal distribution of wealth and resources is something that has permeated all of human history. For instance, in a farmer’s perspective, inequality can take many forms such as unequal distribution of wealth, water allocation, rights to land and water, taxation inequity, economic poverty, land tenure issues, and much more. The definition of climate vulnerability according to the Intergovernmental Panel on Climate Change (IPCC) is “... the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change” [17]. The concept of vulnerability has been refined over the decades so that people understand the disasters and hazards that occur in communities susceptible to this kind of situation. Vulnerability is something that can help people achieve a level of sustainable development realistically. Economic development or progress should be engaged with as long as the natural environment in which they occur can be sustained.

For this reason, vulnerability can be defined as individuals, households, or communities that are dealing with external shock from the outside and are unexpected [18]. Vulnerability is present in both internal and external factors that influence the lives of individuals and communities. Furthermore, vulnerability can be understood as the capacity of

individuals, groups or communities to reciprocate, cooperate, survive, and recover from the impact of environmental events that have happened around them [19]. Landslides are very indicative of how the characteristics of a social group can overcome this kind of disaster but also reflect the harsh realities of social vulnerability to natural events.

2.1. Social Vulnerability to Disaster

Vulnerability is broadly defined as the potential to suffer loss or harm. The theory includes structural vulnerability of buildings, physical exposure of people, and places to natural events, while social vulnerability describes different kinds of susceptibility based on social, economic, and political factors [20,21]. Vulnerability and exposure are dynamic, varying in temporal and spatial scales, and depend on economic, social, geographical, demographic, cultural, institutional, governance, and environmental variables [22]. Analyses of vulnerability in the engineering context of landslide or slope (or any disaster) are quite common [23,24]. The study by [25] has described vulnerability as the characteristic of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard (an extreme natural event or process). Despite its importance in disaster risk reduction, there is still a lack of approaches that contribute to a better understanding of social vulnerability hidden in dynamic contextual conditions [26].

The definition of social vulnerability within the disaster framework was introduced in the 1970s when researchers realised that exposure included socioeconomic factors affecting group resilience [27,28]. Social vulnerability is useful as an indicator in determining the differential recovery potential from disasters. Social vulnerability normally employed individual characteristics of people such as age, race, health, income, type of dwelling unit, and employment [29]. Social vulnerability is a concept that can explain social imbalances that are happening in society in some parts of the world. It is one of the results of social inequalities that occur in many communities. Factors affecting social disparities evident in a society include: lack of resources such as information, knowledge, and technology; limited access to political power or representation; social capital; social networks and connections; beliefs and customs; building stock and age of infrastructure; and type and density of infrastructure and lifelines [30]. Next, the 18 social vulnerability indicators was introduced as follows: socioeconomic status (income, political power, and prestige), gender, race and ethnicity, age, commercial and industrial development, employment loss, rural/urban, residential property, infrastructure and lifelines, renters, occupation, family structure, education, population growth, medical services, social dependence, and social needs population [16].

The design of these indicators depends on their expected use, and it must be relevant to the hazard context, methodologies, and data availability [31]. However, social vulnerability exists based on the underlying characteristic of a population, and it does not rely on the hazard or susceptibility of an area. Apart from indicators, numerous indices have been developed in order to measure social vulnerability. Many pioneer researchers have devoted much effort to formulating the concept of social vulnerability. Social Vulnerability Index (SoVI) was introduced [32] to quantify social vulnerability through an empirical basis to compare social differences within a community regarding social variables selected to mitigate the disadvantageous effects of certain events. It was asserted that socially vulnerable communities are more likely to be adversely affected in disaster events because they are much less likely to recover from them and more likely to die [33]. Even though the SoVI was devised with the United States in mind, many studies have adapted SoVI for a variety of contexts, no matter the nature of the population or places being investigated.

2.2. Landslides: Malaysia's Experience

Malaysia is located in the south-east of Asia. It is divided into two archipelagos, Peninsular Malaysia and Borneo Island. Malaysia is a tropical country with a warm and humid climate throughout the year. Over a recent 20-year period (1998–August 2018),

Malaysia has witnessed 51 disaster events [34–43]. During that time, 281 people died, more than 3 million people were affected, and disasters caused nearly US\$2 billion in damage [44]. Flood, landslides, drought, and forest fires are common in Malaysia, while the annual rainfall is the main contributor due to two monsoon periods, i.e., South West (SW) and North East (NE) occurring between April and October and from November to March, respectively. These monsoons contribute to high annual rainfalls amounting to 2000–4000 mm with a maximum of about 200 rainy days [45]. The amount of rainfall varies from one rainy day to the next [46]. The rain and consistently high temperatures throughout the year lead to intensive and extensive weathering of features on the ground. These combinations of climate and geological conditions together with other causative factors such as slope angle, drainage conditions, geological boundaries, etc. [47] have led to landslides becoming one of Malaysia’s most common natural disasters.

The most common trigger for landslides is heavy or prolonged rainfall, but seismicity, river undercutting, freeze-thawing cycles, and human activity may also cause substantial and destructive landslides. As reported [48], Malaysia recorded 171 landslides between 2007 and March 2016, according to data from the US National Aeronautics Space Administration (NASA), making the country the world’s 10th highest in terms of landslide frequencies. In recent years, Malaysia has experienced several landslides resulting from extreme tropical rainfall. Landslides have occurred in several parts of the country, such as Paya Terubong (Penang), Highland Towers (Kuala Lumpur), Hulu Langat, and Pos Dipang (Perak). These landslides incur significant property loss and hundreds of lives. In 2017, 6000, people were severely affected by a flash flood and landslide in the Kundang, Selangor area, which left many stretches of roads, infrastructure, and assets badly damaged [49]. When the population density of towns increases, highland or hilly terrain development also increases and this puts more stress on the natural environment. Urban areas are then exposed to a high risk of landslides [50]. Significant landslides in Malaysia were recorded from 1993 to 2020 (see Table 1).

Table 1. Series of significant landslide occurrences in Malaysia.

| No. | Year | Location | Consequences |
|-----|------|--|---|
| 1 | 1993 | Highland Tower, Ulu Klang, Selangor | 48 deaths and 2 injuries. One building collapsed |
| 2 | 1993 | Pinggiran Bukit Segar, Kuala Lumpur | One family evacuated their house |
| 2 | 1993 | Pantai Remis, Perak | No record |
| 4 | 1994 | Taman Puchong Perdana, Puchong, Selangor | 10 families evacuated |
| 5 | 1995 | Taman Keramat Permai, Ampang, Selangor | No damage recorded |
| 6 | 1995 | Kuala Lumpur—Karak Highway | 20 deaths, 22 injuries, and ten cars damaged |
| 7 | 1996 | North-South Expressway (NSE) near Gua Tempurung, Perak | No record |
| 8 | 1996 | Pos Dipang, Kampar, Perak | 44 people were killed |
| 9 | 1996 | Ampang Jaya, Selangor | No record |
| 10 | 1999 | Puncak Athenaem Condominium, Ampang, Selangor | Minor landslide, road access to the hilly residential area affected |
| 11 | 1999 | Mutiara Condominium, Ampang, Selangor | No record |
| 12 | 1999 | North-South Expressway, Kuang, Selangor | Thousands of vehicles stranded. Road closure lasting one day |
| 13 | 2000 | Jalan Bukit Antarabangsa, Ampang, Selangor | No record |
| 14 | 2001 | Kampung Sungai Chinchin, Gombak, Selangor | A house partly destroyed |
| 15 | 2002 | Jalan Ipoh, Kuala Lumpur | Covering three-lane road leading from Selayang to Rawang |
| 16 | 2002 | Taman Hillview, Ampang, Selangor | Eight deaths and five injuries |
| 17 | 2003 | Taman Bukit Jaya, Ampang, Selangor | No fatalities |
| 18 | 2004 | Taman Melati, Gombak, Selangor | 1 death |
| 19 | 2004 | Jalan Seri Penchala 1, Kuala Lumpur | 24 houses evacuated |
| 20 | 2006 | Taman Zooview, Ampang, Selangor | Four deaths |
| 21 | 2006 | Taman Bukit Serdang, Seri Kembangan, Selangor | Damaged section of the road measured 50 m × 25 m |
| 22 | 2006 | Bukit Tunku, Kuala Lumpur | No record |
| 23 | 2006 | Taman Esplanad, Kuala Lumpur | Two houses damaged |
| 24 | 2008 | Taman Bukit Mewah, Ampang, Selangor | 4 deaths |

Table 1. Cont.

| No. | Year | Location | Consequences |
|-----|--------------|--|--|
| 25 | 2008 | Ulu Kelang, Selangor | Four deaths and 15 injuries |
| 26 | 2008 | Kuala Kubu Bharu, Batang Kali, Selangor | Two sisters were buried alive when a landslide hit a bungalow |
| 27 | 2008 | Kemensah Heights, Ampang, Selangor | No fatalities |
| 28 | 2008 | Bukit Ceylon, Kuala Lumpur | One worker killed |
| 29 | 2008 | Pantai Dalam, Kuala Lumpur | One killed, 4 injured, and 19 families evacuated |
| 30 | 2009 | Taman Cheras Awana, Cheras, Selangor | Destroyed 3 cars and a motorcycle, 10 families evacuated |
| 31 | 2010 | Ukay Perdana, Ampang, Selangor | No fatalities |
| 32 | 2010 | Taman Bukit Mulia, Ampang, Selangor | No fatalities |
| 33 | 2011 | Puncak Setiawangsa, Kuala Lumpur | 88 residents of bungalows, shop houses, and double-storey terrace houses ordered to move out |
| 34 | 2011 | Jalan Semantan, Kuala Lumpur | Six cars were buried and five vehicles were damaged |
| 35 | 2011 | Pekan Batu 14 Hulu Langat, Selangor | 16 deaths |
| 36 | 2011 | Kampung Tengah, Puchong, Selangor | 5 houses affected |
| 37 | 2012 | Taman Desa Sentosa, Hulu Langat, Selangor | Endangered four occupants of the Perkid Welfare Home for girls |
| 38 | 2012 | Taman Mulia Jaya, Ampang, Selangor | Water seeped through the sewerage system. |
| 39 | 2013 | Putra Heights, Subang Jaya, Selangor | Several vehicles submerged in mud |
| 40 | 2015 | KM 52.4 of the Kuala Lumpur-Karak Expressway between Lentang and Bukit Tinggi, Pahang and Gombak-Bentong old roads | Lentang-Bukit Tinggi stretch of the expressway was closed to traffic |
| 41 | 2016 | Karak Highway | Blocked all lanes in both directions on the highway and four vehicles were trapped in the landslide |
| 42 | 2016 | Bau-Puncak Borneo, Sarawak | Comprising mainly Bidayuh settlements and Padawan Ring Road critically affected |
| 43 | 2017 | Tanjung Bungah, Penang Island | Killed 11 construction workers |
| 44 | 2018 | Jalan Bukit Kukus, Georgetown, Penang Island | Killed nine construction workers |
| 45 | 2019 | Taman Batu Permai | No record |
| 46 | 2019 | Jalan Lee Woon, Ampang, Selangor | A house evacuated |
| 47 | 2019 | Genting Highland, Pahang | Affected a portion of the Jalan Genting-Amber Court slip road and no access to the resort |
| 48 | 2020 | Taman Kelab Ukay, Bukit Antarabangsa | 40 residents were ordered to leave their homes |
| 49 | 2020 | Taman Silibin Indah, Ipoh | Killed one construction worker |
| 50 | 2020 | Sungai Penchala, Kuala Lumpur | 3 families ordered to leave their homes |
| 51 | 2020 | Jalan Gombak to Genting Highland | The main road was closed for repairs |
| 52 | 2020 | Ulu Beram, Jalan Lapok | Residents cut off due to damaged roads |
| 53 | 2020 | Tapah to Ringlet | Fallen trees blocked the main road |
| 54 | 2020 | Tapah to Cameron Highland | Fallen trees blocked the main road |
| 55 | 2020 | Jalan Simpang Pulai to Cameron Highland | The retaining wall suffered damage and part of the structure collapsed |
| 56 | 2020 | The Banjaran Hotspring Retreat, Tambun | Killed 2 guest house |
| 57 | 2020 | Jalan Lojing-Gua Musang | Closed half of main road |
| 58 | 2020 2021 | Jalan Keningau-Kimanis, Sabah Jalan Raub-Bukit Fraser | Two houses were damaged and no casualties Road closed and 13 vehicles trapped |
| 59 | 2021 | Taman Bukit Kempas, Johor | Tank water pipe broke, and 42 people vacated the residence |
| 60 | 2021 | Kemaman, Terengganu | The restaurant was hit by a rock, no casualties |
| 61 | 2021 | Jalan raya Timur Barat, Ipoh | One hallway closed |
| 62 | 2021 | Kampung Garong, Padawan, Sarawak | 2 houses were damaged, and a house half buried in the ground |
| 63 | | | |
| 64 | 2021 | Kota Kinabalu | 10 landslides were reported in seven villages, involving four districts, namely, Kota Kinabalu, Kota Marudu, Pitas, and Kudat. No casualties |

Source: [51–60].

In Malaysia, there have been numerous landslide events in the mountains, along the valleys, rivers, and coastal regions [61,62] but the most massive have generally been associated with rivers. Findings from the literature have shown that landslides occur frequently along hilly areas in the rainy season. There is a strong correlation between the density of drainage and distance to the river due to landslides in the mountainous region being triggered by erosion-related phenomena [63]. Development on hilly areas in Malaysia has increased the risk and likelihood of landslides [64]. Hilly areas are attractive for building residential areas, hotels, or resorts. This poses a severe threat to the physical infrastructure and population living within that area. This situation will lead to many casualties and significant financial losses if these hilly regions are struck by landslides [65].

Global landslides cause billions of dollars' worth of infrastructure damage and thousands of deaths annually. The estimated number of deaths is 1000 per year and destruction of property amounting to approximately US\$4 billion [66]. Meanwhile, losses due to landslides in Malaysia have cost more than US\$1 billion since 1973 [67]. Emergency preparedness plays a part in reducing the effects of disasters. The most effective preparedness at the initial stage was to make the right decision to reduce the number of deaths and damage to property in communities. The rescue team provided some emergency response and preparedness training for each member of the community so that their reactions were practical. In Malaysia, there are several agencies involved in dealing with landslides such as Malaysia Civil Defence Force (MCDF), Fire and Rescue Department of Malaysia, National Disaster Management Agency (NADMA), and others. Furthermore, the Ministry of Housing and Local Government has issued a guideline for any physical development on the hilly terrain area in Malaysia. Table 2 summarises the criteria of the biological effect based on the slope gradient, slope classification for engineering work, and the description of development activities.

Table 2. Malaysian Guideline on physical development in hilly terrains.

| Slope Gradient (α) | Slope Classification For Engineering Work | Description |
|-----------------------------|---|---|
| Below 15° | Class 1 | Compliance with: <ol style="list-style-type: none"> i. Development Guidelines in Hill Areas 1997 (issued by the local government) ii. Erosion and Dirt Control Guidelines, 1996 (issued by the Department of Environment) iii. Environmentally Friendly Drainage Manual 2000 (issued by the Department of Irrigation and Drainage) |
| 15–25° | Class 2 | EIA report prepared by EIA consultants registered with the Department of Environment for development exceeding 50 ha. For class 1 and II development projects only subject to section 34A, the Environmental Quality Act 1974 must be provided EIA. |
| 25–35° | Class 3 | Requires an additional environmental impact assessment study. Proposes the conduct of landslide vulnerability assessment, which may serve as an alternative tool to establish a sustainable development environment. |
| Above 35° | Class 4 | Development projects within this area are not permitted at all, except for road construction, which is inevitable. However, an environmental impact assessment is required. Proposes the conduct of landslide vulnerability assessment, which may serve as an alternative tool to establish a sustainable development environment data |

Source: [68].

Malaysia has its share of landslides and most of the landslide studies conducted focus on the engineering perspective. Socioeconomic aspects should be taken into account to evaluate the vulnerability of the community, especially one at high risk of experiencing such catastrophic effects, but previous research concentrated more on describing the disaster types [61,69], susceptibility, and risk assessment [70,71]. The level of quantitative

evaluation of social vulnerability in Malaysia is worrying due to the lack of social data documented for analysis and mapping. Therefore, the objective of this study is to find out indicators that are used for social vulnerability assessment in the context of a landslide in Malaysia. The analysis is critical for understanding the measures of social vulnerability, since the incorporation of climate change and disaster risk mitigation issues in urban planning and management are a priority for ensuring stable population growth and evading economic disruption.

The representativeness of Malaysia as an important case for research, though can be critical in other cases, is not an issue for his study. What we are trying to demonstrate is that in analysing landslide risk, the human part is an integral part and should be incorporated as detailed in this study. The methodology used in this study is a pioneer for landslide risk assessment. Assessing the landslide risk with the proposed methodology can be a crucial tool for engineers and policy-makers in developing a site, particularly in hilly areas, for population development. Thus, it must be done at its locality, per se, in order to assess the real risk of landslide. More importantly this methodology can serve to highlight the importance of public education to increase the level of knowledge of the population on the hazard and mitigation of possible landslide events in their area. Limited literature found on social vulnerability mapping to climate-driven disasters in the country. The socio-economic aspect is the most apparent after disasters as different patterns of damages, losses, and suffering may be experienced differently by certain groups of the population.

3. Materials and Methods

This section incorporates five significant sub-sections that explain the following: PRISMA, resources, inclusion and exclusion criteria, systematic review procedure, and data extraction and interpretation. The methodology technique to retrieve articles is the one suggested by [72].

3.1. PRISMA

The systematic review in this article was guided by the PRISMA method, and this abbreviation stands for “Preferred Reporting Items for Systematic Reviews and Meta-Analyses.” PRISMA has mainly been utilised by healthcare personnel to create systematic reviews and meta-analyses. As well as the medical field, PRISMA has been employed by environmental management experts to undertake systematic reviews.

3.2. Resources

This study used two primary journal databases, specifically Scopus and Web of Science (WoS). Scopus is a bibliographic database for journal articles and consists of abstract and citation sources. This database covers journals from scientific, technical, medical and social sciences and currently has more than 5000 publishers worldwide and more than 22,000 titles. Web of Science (WoS) is a database producing Clarivate Analytics, which includes articles from 256 disciplines such as science, social science, arts, humanities, etc. WoS offers full-text articles, reviews, editorials, abstracts, proceedings and book chapters. WoS includes more than 33,000 journals published from the year 1900 to the present day. Other databases like JSTOR and Google Scholar were considered for this research.

3.3. Systematic Review Process

The systematic review process includes four main stages to acquire relevant: identification, screening, eligibility, and data extraction.

3.3.1. Identification

The first process of undertaking systematic reviews is identification. Identification means finding the most relevant studies, using keywords, dictionary terms, thesaurus, encyclopaedias, etc. The keywords used help to build the “search string” for the research (Table 3). Subsequently, 13 articles were found in JSTOR using the term “social vulnerability

index." From the Scopus database, in total, 147 articles related to the search string were discovered while a total of 69 items emerged from Web of Science (WoS). Meanwhile, 29 studies were found in Google Scholar search engine, where the data covers a huge range of subjects and is essentially a superset of WoS and Scopus [73].

Table 3. Search string.

| Databases | Keyword Used |
|----------------------|--|
| Scopus | TITLE-ABS-KEY (("socia* vulnerabilit* inde*" OR "soci* economi* vulnerabilit* inde*" OR "soci* vulnerabilit* inde*" OR "socia* vulnerabilit*" OR "SoVI" OR "SeVI" OR "SVI")) AND (landslid* OR rockslid* OR earthfal*) |
| Web of Science (WoS) | TS = (("socia* vulnerabilit* inde*" OR "soci* economi* vulnerabilit* inde*" OR "soci* vulnerabilit* inde*" OR "socia* vulnerabilit*" OR "SoVI" OR "SeVI" OR "SVI") AND (landslid* OR rockslid* OR earthfal*)) |
| JSTOR | (((((("socia* vulnerabilit* inde*") OR ("soci* economi* vulnerabilit* inde*")) OR ("soci* vulnerabilit* inde*")) OR ("socia* vulnerabilit*")) OR ("SoVI")) OR ("SeVI")) AND ("landslide")) |
| Google Scholar | ("social vulnerability") ("social vulnerability index") ("socio economic vulnerability index") (landslide) |

3.3.2. Screening

The second part of the systematic review process is screening. Here, it is necessary to gather all the articles related to the study topic and exclude all irrelevant items. Table 4 shows the inclusion and exclusion criteria that need to be followed in finding related articles. The total of 258 articles was screened using the inclusion and exclusion criteria including literature type, language, timeline, countries and territories, and the subject area. For the first criterion of the literature type, this study decided to focus on journal research articles and excluded papers resembling review articles, book chapters, and conference proceedings. Meanwhile, for language, the chosen one was English, and all other non-English articles were excluded. The criterion for publication was the period from 2010 to 2020 only, and the geographical criterion was Southeast Asia, Southwest Asia and Europe. Lastly, for the subject area, this study only chooses articles from social sciences, environmental science, science, and agriculture. From the inclusion and exclusion criteria, the number of articles that have been excluded is 199, in total (Figure 1).

Table 4. Inclusion and Exclusion criteria.

| Criterion | Eligibility | Exclusion |
|---------------------------|---|--|
| Literature type | Journal (Research articles) | Journals (review article), book chapter, conference proceeding |
| Language | English | Non- English |
| Timeline | 2010 to 2020 | <2010 |
| Countries and territories | Southeast Asia, Southwest Asia and Europe countries | Non-Southeast Asia, non-Southwest Asia and Non-Europe country |
| Subject Area | Social Science, Environmental Science, Agricultural | Other than Social Science, Environmental Science, Agricultural |

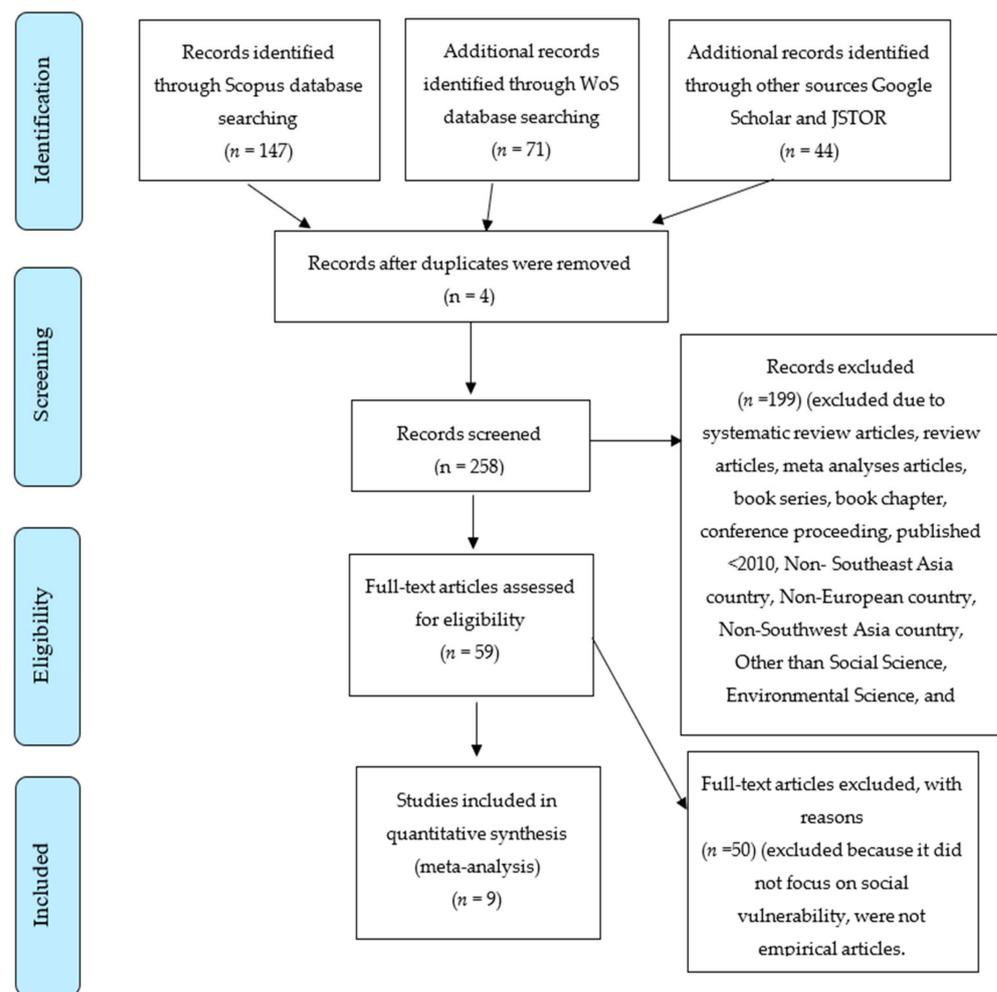


Figure 1. Literature searches based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) is guidelines (adapted from [74]).

3.3.3. Eligibility

For the third stage eligibility, a total of 59 articles were used. Title, abstract, and the content of each paper are important and need to be examined thoroughly to make sure it fulfils the inclusion criteria and review objective. In total 50 articles have been excluded because they did not fit this criterion. Therefore, the criteria of selected articles to be analysed is focus on the social vulnerability study and the empirical articles. It is because the purpose of this study is to define the indicators used to assess social vulnerability in the context of landslides in Malaysia. The research is important for understanding social vulnerability interventions, as the inclusion of climate change and disaster risk mitigation problems in urban/rural planning and management. More specifically, this approach will help to illustrate the value of public education in growing the population's level of awareness about the risk and mitigation of potential landslide events in their area. Even though the occurrence of landslides is different due to the climatic conditions among the countries for article analysis, however, due to the lack of research on the formation of social vulnerability indicators in Southeast Asian countries, alternatively, this study has expanded its study to Southwest Asian and European countries.

3.3.4. Data Extraction

After the remaining articles were assessed and analysed, the researcher started to extract the data. First, this was done by reading the abstract of the article, and then the researcher read the full text to start identifying themes and sub-themes related to the

objective. After that, themes and sub-themes were organised to establish a typology for the article.

4. Results

According to the results shown in Table 5, in total, 9 articles were chosen for this study. The nine authors of the articles include [75–83] in this study. Besides, the selected articles were published in the years ranging from 2011 to 2020. It aims to identify research trends on social indicators that are constantly being studied and considered for the purpose of forming a social vulnerability index for certain area and community. Next, with reference to countries covered, two studies are from Nepal, and the rest are one study each from Portugal, England, Italy, Pakistan, India, China, and Indonesia. It comprises the name of authors, the country of studies, title of articles, and the objective of the studies by scholars.

Table 5. List of articles analysed for systematic review.

| Author | Country | Year | Title | Objective |
|--------|-----------|------|---|--|
| [75] | Nepal | 2020 | A geospatial analysis of multi-hazard risk in Dharan, Nepal | Produce individual hazard assessment for the rapidly growing city of Dharam city and calculate its level of social vulnerability |
| [76] | Nepal | 2019 | An analysis of social vulnerability to natural hazards in Nepal using a modified social vulnerability index | To quantify social exposure at the local level using indicators relevant to Nepal's distinct social and physical landscape |
| [77] | Portugal | 2015 | Application of social vulnerability (SoVI) and delineation of natural risk | To go further into the biological risk analysis in the Greater Lisbon area using a multi-hazard approach |
| [78] | England | 2019 | Evaluation of social vulnerability to natural hazards: A case of Barton on Sea, England | The current study examines the social vulnerability of Barton-on-Sea by conducting a survey-based analysis |
| [79] | Italy | 2016 | Mapping social vulnerability to natural hazards in Italy: A suitable tool for risk mitigation strategies | The study aims to define a social vulnerability index (SVI) for Italy by applying an inductive approach |
| [80] | Pakistan | 2018 | Socioeconomic determinants of landslide risk perception in Murree hills of Pakistan | The aim is to assess the determinants of landslide risk perceptions in the Murree Hills of Pakistan |
| [81] | India | 2020 | Study of integrated social vulnerability index SoVLint of the hilly region of Uttarakhand, India | This study focuses on producing a map for the hilly district of Uttarakhand showing the vulnerabilities measured by natural, social, and economic indicators |
| [82] | China | 2011 | Social vulnerability assessment of natural hazards on county-scale using high spatial resolutions satellite imagery: A case study in the Luogang district of Guangzhou, South China | This study examines the social vulnerability assessment of natural hazards on a county-scale using high spatial resolutions satellite imagery |
| [83] | Indonesia | 2018 | Quantitative assessment of social vulnerability for landslide disaster risk reduction using GIS approach (Case study: Cilacap Regency, Province of Central Java Indonesia) | To examine social exposure for landslide disaster risk reduction using a GIS approach |

Sources: Author analysis, 2020.

4.1. Indicators Used to Measure Social Vulnerability in a Landslide

There are 14 indicators serving to measure social vulnerability when a landslide occurs. Included here are age, gender, ethnicity, built environment, income, family structure, education, employment, occupation, urban or rural, disability, migration, medical, and population (Table 6).

Table 6. List of indicators use as social vulnerability index.

| Indicators | Variables | Reference |
|--------------------------|---|------------------|
| Age | The elderly population (>65 years), children under 5 years old, dependency ratio, elderly index, resident population aged 5–14, resident population aged 15–19, mean age (years) of the resident population | [77,79,80,82,83] |
| Gender | Females, a household that is run by a woman, a household with land owned by females | [75,77] |
| Ethnicity | Population by ethnic, minority population | [75–77] |
| Built Environment | A household without piped water connection, electricity, reinforced cement concrete (RCC) foundation, sewage water, and the population lived in a home with quality external walls. | [76] |
| Income | The income per capita, the ratio of high income to low income | [80] |
| Family structure | Female-headed household, the average number of people per household | [75,78] |
| Education | People cannot read and write, high level of education, low level of education | [76–81,83] |
| Employment | Female labour force employed, labour force employed, unemployment rate | [78,81,83] |
| Occupation | Employed in agriculture, forestry, fishing, mining and quarrying; employed in manufacturing and construction; employed in transportation, communication and other public utilities; employed in accommodation and food services | [75] |
| Urban/Rural | Population density | [77] |
| Special Needs Population | Population with disabled person (auditory, visual, motor, or mental disability), the person who is disabled and/or unemployed or without any economic activity, a person with disability that is more than 60%, a person who is disabled, and under 4 or above 65 years of age, permanently disabled and unable to work | [75–77] |
| Migration | Foreign population, absentee population | [77,81] |
| Health | Medical services, health problems, distance from the hospital | [77,81,82] |
| Population | Population growth | [79,83] |

Sources: Author analysis, 2020.

In this study, there are five main indicators that are focused on, these being age, ethnicity, education, disability, and health. These are the variables that most scholars measure when investigating landslides. They are explained in more detail below.

4.1.1. Age

The first component that has been discussed in [77] is “urban, age (elderly), and gender.” Variable for age includes the proportion of resident population aged 65 and over, proportion of resident population aged 4 and younger, proportion of residents aged 5–14, and proportion of resident population aged 15–19. The study shows a negative result for elderly people, which means they are more susceptible to vulnerability. There was reported [79] that focuses more on four component indicators—age, employment, population growth, and education. He also stated that aging index is one component that represents the age indicator.

The variables include population of people aged 65 and above and those aged 15 and younger. The aging phenomenon that is very evident in Italy has resulted from the depopulation of people in mountain areas, people leaving the land, migration, and the lure of promising jobs in the industrial and service sectors. Italy’s people are generally living longer and the average birth rate has declined. According to the study by [80] there are five main indicators affecting the landslide risk perception: age, income, education level, location, and experience. In addition, the study shows that age of respondent yields an effect on the perception of landslides.

4.1.2. Ethnicity

According to [76], the ethnicity indicators focus on the Dalit population and minority population such as Muslims and Sikhs/Punjabis. They found that this group was less than 5% of the total population in Nepal, and it is considered as disadvantage groups. In [77], “nationality and ethnicity” is one of the five main indicators in that particular study. The variables for ethnicity indicator include person of African origin living in the country, foreign nationality, and resident who was born outside the country as a marginal group. Like age, ethnicity can be an indicator in the social vulnerability index and help assess what is happening in a given society.

4.1.3. Education

Education has always been regarded as one of the key vulnerabilities all communities have to deal with. Educated people are more likely to have advantages in everything they do compared to people without or with little education. There are three main variables relating to education as follows [75]: percentage of the population who can read and write, percentage who completed school certificate (SLC), and percentage who completed a college or university degree. In the study by [77], one of the indicators “development and education” included variables such as the proportion of illiterate people. The community can be very vulnerable when the proportions of literate and illiterate are dangerously disproportionate.

Furthermore, the level of education and qualification can affect vulnerability in one community. The higher the qualification in education that someone has, the more unlikely it is that they will experience vulnerability from any hazards. According to [78], an individual who has enough education and knowledge regarding about a certain issue will generally better understand the nature of a hazard and its likely effect on them. Not only can education affect individuals’ knowledge of certain issues but it also helps to reduce poverty, improve health, get more and better job opportunities, higher salaries, etc.

4.1.4. Special Need Population

The population with special needs is usually much more vulnerable than people without a disability. Disability can be a huge factor for assessing vulnerabilities, especially when disasters or hazards occur. As mentioned by [76], this factor is closely linked to socioeconomic status, education and built environment, and ethnicity—all components of vulnerability assessment. It is shown by the variance for socioeconomic status (45.12%), education and built environment (19.74%), ethnicity (10.98%), and disability (10.78%).

4.1.5. Health

Health is one of the major indicators of this study. Variables such as medical services, health problems, and distance from the hospital are important factors of measuring social vulnerability as mentioned by [77,81,82]. Being healthy and having a good public healthcare system is important for communities that are more vulnerable to a disaster or hazard. Poor public health systems can simply make problems worse, and lead to more accidents and disruptions.

5. Discussion

There are not many studies concerning the Social Vulnerability Index (SoVI) with reference to landslides. Based on the research undertaken, articles regarding landslide in the context of social vulnerability index usually consider other types of hazard or where landslides are bracketed with other natural disasters. Articles based only on social vulnerability and landslides are difficult to locate. Social vulnerability or the social vulnerability index has many types—not only SoVI but also referred to as SEVI or SVI. Even though the focus is only on SoVI in this paper, the researcher has taken note of other types of social vulnerability index.

There are 14 indicators that have been employed to measure social vulnerability in the context of landslide including (see Table 5): age, gender, ethnicity, built environment, income, family structure, education, employment, occupation, urban or rural, disability, migration, medical, and population. Based on the analysis, the researcher only focuses on five main indicators that have been used by many scholars: age, ethnicity, education, special needs population, and health. These were chosen because they are very relevant to the more vulnerable in society, especially where inequalities and imperiled areas are very evident.

5.1. Education

There are a few factors that affect social vulnerability including lack of access to: resources such as information, knowledge, and technology; social networks and connections with other individuals; social capital; and infrastructure [83]. In this study, education emerges as a major indicator employed in other studies regarding social vulnerability and landslides. Education is a bridge to success for many people, and it can refer to both formal and informal education. Education can also mean information, knowledge, and technology regarding the scope of discussion. The importance of education is to help people achieve more success and status in society, get a better job and understand the issues involved in a hazard or disaster. Furthermore, it helps individuals to be prepared for any circumstances. According to [84], people who have better response mechanisms, always prepare and constantly recover from a disaster, and this is certainly the case for those individuals, households, and societies with better and more widespread higher education outcomes compared to others.

5.2. Age

Indicators such as age can also mean susceptibility to social vulnerability. Older and very young people are more vulnerable to hazards and disasters than people in the middle. A higher proportion of senior citizens means that a society is at greater risk of disaster and the strategies needed to repair any given situation, simply because older people are more vulnerable to hazards than other age groups. Older people normally need a lot of physical and emotional care and support services. They can also be more disadvantaged compared to other age groups. The indicators that have been collected from previous studies do not represent the population or the place.

5.3. Ethnicity

Racism or ethnic discord is one of the factors of disaster risk, and especially for minority groups such as migrants and/or non-residents in a given location [85]. They are also known as marginalised groups, considered to be inferior in terms of their economic status, health, social relationships, and environment. If this situation continues, it will result in lasting social, political, and economic losses [86]. Although a mixture of socio-spatial and biophysical influences forms people's susceptibility to environmental hazards, race/ethnicity, and class have been central to understanding social dynamics during hazard events [87].

5.4. Special Needs Population

Special needs populations such as people with a disability are the most-at-risk persons when a disaster occurs. Disability means that the person with a physical or mental condition has limited movements, senses, or ability to participate in activities. Characteristics that are considered to be a disability are deafness, blindness, diabetes, autism, epilepsy, depression, and HIV. According to [88], disability emerges from the connection between people with health problems, such as cerebral palsy, Down syndrome, depression, as well as personal and environmental influences, including negative attitudes, limited transport facilities, public service facilities, and insufficient social support systems. They are generally the first victims of natural disasters. Indeed, early warning systems that alert the public may not

actually reach the disabled individuals in time. The death toll from a disaster is two to four times larger than for those who are not disabled [89].

5.5. Healthcare Accessibility

Those with health problems are particularly vulnerable to landslides. They require constant attention and healthcare services to ensure their safety and good health. Therefore, access to health services such as hospitals, healthcare clinics, and pharmacies is an important need for this community. One of the principal components of emergency management is healthcare management to cope with disasters [90]. In disaster prevention activities, well targeted healthcare supply chain management can function effectively and efficiently. A substantial number of disaster casualties or even fatalities could be absorbed as long as healthcare services are up and running when a disaster occurs [91].

All the variables are listed above give an essential role in determining the security of a community based on social inductors. However, the results of the author's study found that income indicators and social capital are less emphasised. Income indicators referring to those with low incomes and belonging to the group below 40% of Malaysia's income are very vulnerable to disasters. For example, the floods that occur every year have caused suffering because they cannot work, and the worst consequences, they will lose their jobs. The study [92] found that the income sub-domain is the largest contributor and gives high value to the index of endangered livelihoods of rural communities in Pahang in 2014. Low-income conditions will also affect the period for them to recover after a catastrophic event. The results of the author's research found that there are no studies that explore social asset indicators. Social assets carry meaning as resources available to individuals and groups through membership in social networks. If the household has a higher position in a group or social institution, he or she will produce higher social strengths and resources [93]. Longer membership history as well as more participation in other social groups make it easier for access to information, business opportunities, social strength, and influence. The ability to access other assets is also simpler [94]. The evolution of social capital through the interaction of relationships between people and groups in community social networks [95,96]. Social networking means the interaction of an individual with other individuals, organisations, and groups to obtain information and assistance on something related to their livelihood [96,97]. The lack and absence of these elements within the social life environment of an individual will contribute to their vulnerability factors, as emphasised by [98,99]. Social capital influences, the sustainable life they possess significantly to strengthen the ability to develop a network of cooperation between groups both internally and externally and through enhancing the institutional capacity of community groups to improve the well-being of society.

State government agencies, local governments, and community leaders are the most familiar with the people in their communities. The social vulnerability index's importance is design to assist them in ensuring the security and well-being of their population. The SVI components can help the state and local people involved in all phases of the disaster sequence, in particular, landslides. Knowledge of locations and community information that is vulnerable to landslides can help planners in identifying target groups and accelerating assistance in efforts to reduce and impact property damage and loss of life, as well as prepare for disaster events. The stakeholders and management planners can setting the evacuation centre to places in secure condition to those are needs emergency assistances such as elderly people, single mothers with kids and infants, no transportations people and migrants whose are not influent in local language. In the recovery process, local governments may recognise communities that may require additional funding for human services or as a mitigation gauge to avoid a need for more costs due to the post support [100]. The slower to recover are those with the socioeconomically low-income community with hazardous areas of landslide occurrence. Therefore, the analysis results show that there are seven indicators as outlined that should be used as a social vulnerability index in measuring the level of susceptibility of landslides events. It consisted of education,

age, ethnicity, special need population, healthcare accessibility, income, and social asset indicators. Future research will examine how SoVI can be used in the planning and mitigation processes to help target disaster management interventions as part of the system. Besides, the SoVI outcome can lead to geological mapping of disaster risk management in Malaysia's decision-making systems based on specific zones.

6. Conclusions

In this study, we have reviewed a selection of socioeconomic vulnerability components. At the searching stage, 258 articles were found in key databases, and after inclusion and exclusion criteria using the PRISMA guideline, only nine articles were chosen as being valid to this research. Fourteen variables were listed, and five variables of social vulnerability, which were typically used by scholars, proved to be relevant to Malaysia. Not all places or locations have the same experiences of landslides, and so the level of social vulnerability will differ and how these are measured. Although people may experience the same hazard or disaster, it does not mean that all individuals go through the same processes of destruction, recovery, evaluation, etc., as others. There are individuals who experience much higher social vulnerability than others, and it depends on which indicators are employed. As a climatic condition and the landslides occurrences in Malaysian context, there are seven indicators underlined which are education, age, ethnicity, special needs population, health accessibility, income, and social capital. These are the important indicator to measure the social vulnerability index to the high-risk communities towards landslide hazard. The result of these indicator measurement should be useful to authorities to include it as a complementary data to their geological mapping of disaster risk management based on the location of the landslide events. Furthermore, that is why, this study is important for understanding the social vulnerability index in the context of landslides in Malaysia.

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