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REVIEW OF LITERATURE ON VULNERABILITY AND RISK: APPLICATION TO THE CASE OF FLOOD

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ABSTRACT
Given the inherent discrepancies in definitions, concepts and measurements, these have contributed to growing prominence of vulnerability and risk terms in multidisciplinary fields such as disaster management, environmental science and geography. Generally, a common approach to measure vulnerability to floods is based on the extent of risk that communities have to face. In recent years, flood risk has been on the rise compounded by increasing physical, social, economic and environmental vulnerabilities across the globe. Due to prevailing flood characteristics in terms of the magnitude and frequency of the events and associated losses of human life and property, there is a need especially for the Asian developing countries to implement a systematic method towards assessing the multi-dimensions of flood vulnerability in a comprehensive manner. By employing the FVI methodology within a flood vulnerability assessment, this can enable proper measures to be prioritized for the flood risk response among the community leaders, populations at risk, decision makers and policy makers alike.

Keyword: Floods, Vulnerability, Economic and Environmental vulnerabilities

1. INTRODUCTION
Vulnerability and risk concepts have been increasingly adopted by various disciplines. As such, some of the covered disciplines are anthropology, conflict and war, disaster management, economics, entitlement, environmental science, food security, geography, health, nutrition, sociology and sustainable livelihoods (Alwang, Siegel & Jorgensen, 2001). Since there are no universal definitions of vulnerability and risk, the definitions greatly vary across different arrays of literatures up to the extent that the terms become almost useless in the interdisciplinary context without further specifications (Birkmann, 2007a; Füssel, 2010).
In the case of a natural disaster such as flood, flood risk has been on the rise compounded by increasing vulnerabilities across the globe. These include changing demographics, technological and socio-economic conditions, rapid urbanization, continued development within high-risk zones, agricultural activities expansion, environmental degradation, climate variability and the competition for scarce resources. By representing the root cause of a disaster, flood vulnerability serves as the key element of the flood risk assessment and damage evaluation notably in the physical, social, economic and environmental dimensions (Nasiri & Shahmohammadi-Kalalagh, 2013). Thus, there is a need for a country to implement domestically systematic records towards assessing the multi-dimensions of flood vulnerability and managing the reduction of flood risk as means to ensure the sustainable development of an area, district, state or nation. Accordingly,

through minimizing the severity of flood vulnerability, this can contribute to reducing the adverse impact of floods and resulting in the flood risk reduction.

2. THEORETICAL REVIEW

2.1 Concepts and Measurements of Flood Vulnerability

Firstly introduced by O'Keefe, Westgate and Wisner (1976) as cited in Li *et al.* (2013), the meanings of vulnerability have been accordingly categorized into three streams of ideology proposed by proponents from natural science, social science and a combination of both groups. Natural science proponents define vulnerability by primarily focusing on the physical system, thus leaving the socio-economic features to be out of the overall system. For instance, the Intergovernmental Panel of Climate Change [IPCC] (2001) interpreted vulnerability as the incapability degree to mitigate with the adverse impacts of climate change and sea level rise. Meanwhile, social science proponents assert vulnerability by prioritizing on the human's capacity to cope with hazardous events and recover from damages and losses. For example, Watts and Bohle (1993) examined the social vulnerability of communities on the coping, resistance and resilience capacities to the hazardous events. On the contrary, natural and social science proponents characterize a natural disaster as a complex system by integrating the physical and socio-economic characteristics into the overall system. In turn, this has led to increasing its significance in the scientific community over the recent years. One instance is that Cutter (1996) termed vulnerability as a hazard of place that contains biophysical risks, social response and action. Therefore, in the context of a flood event, flood vulnerability refers to the extent that a system is susceptible to the event due to exposure and perturbation in line with its ability or inability to cope, recover or adapt (McCarthy *et al.*, 2001).

Similar to vulnerability in general, there are also three distinct themes to specifically conceptualize on vulnerability to floods. The first theme is known as a risk or hazard exposure. Cutter (1996) examines the potential sources of flood hazard that encapsulate the hazardous conditions, human settlements in flood plain and flood prone areas and associated losses. The second theme underpins the social dimension of vulnerability that hinders the ability of an individual and the society to deal with floods whereas the third one, which is called as a hazard of place by Cutter (1996), encompasses the mixture of biophysical risk and social response but is geographically centred in a particular area.

Given vulnerability to exist in any spatial level and is contingent upon various potential hazards (e.g. floods), there are many ways to measure vulnerability to floods. One way is that vulnerability is an *ex ante* notion, thus suggesting that any measure of vulnerability should contain a "predictive quality." By means, it is a complex set of characteristics for a particular group at-risk that cover a person's well-being, self-protection, social protection, social, political networks and institutions (Cannon, Twigg & Rowell, 2003). Another way is that the measures of vulnerability should reflect vulnerability in relation to a socially acceptable level of outcome (Alwang *et al.*, 2001).

Furthermore, vulnerability indicators should possess information on the causes of vulnerability and the relative importance of idiosyncratic and covariate risk (Günther & Harttgen, 2006). Moreover, the measures of vulnerability are generally considered as good if capable of referring to a given cause of vulnerability, i.e. be hazard-specific (Cannon, 2007). However, certain factors such as poverty, the lack of social network and inadequate social support mechanisms are acknowledged to aggravate vulnerability levels regardless the type of hazard. These factors are not well-suited to constitute as the factors of hazard-specific and deserve a different position in the interventions and risk management and adaptation processes (Cardona *et al.*, 2012). Additionally, a good measure of vulnerability should consider the dynamics of vulnerability ranging from before to during and after a hazard occurs (Birkmann, 2007b). Also, vulnerability is properly measured via undertaking the assessment on ways and means of a system's response to floods (Briguglio *et al.*, 2012).

Thus far, the developments in theoretical concepts have taken place in measuring vulnerability to floods. In the literature, a common approach to measure vulnerability is based on the degree of risk that a particular household, population, district, state or country faces following the flood events. Accordingly, various indicators are adopted in respective models to measure hazard potential (e.g. flood depth and flood damage) and flood vulnerability (e.g. economic growth or GDP, population density and sensitive environments). Hence, the selection of appropriate indicators hinges upon the accessibility and availability of appropriate data and the spatial level under study (Naudé, Santos-Paulino & McGillivray, 2012).

2.2 Concepts and Measurements of Flood Risk

Firstly discussed by Knight (1921) as cited in Balica, Popescu, Beevers *et al.* (2013), the term 'risk' in relation to disasters such as floods has been used thereafter in diverse contexts and topics within the literature. For example, risk is conceivably defined as the type and severity of the hazard and its frequency of occurrence (Blaikie *et al.*, 1994; Wisner *et al.*, 2004). Following the definition from the Office of the United Nation Disaster Relief Co-ordinator [UNDRO] (1979), risk is interpreted as the expected losses from a particular hazard to a specified element at risk in a particular time period. These losses may be estimated in terms of deaths, injuries, properties, livelihoods, disrupted economic activities or damaged environment as a result from the interactions between natural or human-induced hazards and vulnerable conditions (Sharma, 2012). Therefore, flood risk, which is in accordance with the European Floods Directive 2007/60/EC [EC] (2007) and the United Nations Environment Programme [UNEP] (2004), refers to the product of a flood event probability and the potential adverse consequences for cultural heritage, economic activities, environment and human health. In other words, flood risk relates to the probability of the event to occur which subsequently renders to inflicting consequences in physical, social, economic and environmental conditions.

With regard to a disaster, it is crucial to understand the nature of a risk by distinguishing between rare, more frequent less severe and catastrophic events. Specifically, in the flood management, flood risk is represented by the probability and consequence. Noticeably, high probability and low consequence events are differently treated relative to those of low probability and high consequence. When taking into account on the significance of flood risk, the reference is not only based on the numerical value of the probability multiplied by its consequence but also to consider the perceived risk to floods by a household or community. Hence, to conceptualize flood risk, perception and awareness are important since it requires the prior knowledge of flood hazard and flood vulnerability (Sharma, 2012). Also, perception and awareness represent the two major concepts of the effective disaster risk management (United Nations International Strategy for Disaster Reduction [UNISDR], 2004).

In most cases, disaster risk exists within social systems. For this reason, it is imperative to consider the social contexts whereby flood risk, in particular, occurs and affected populations do not necessarily share the same perceptions of risk and underlying causes. According to the UNISDR (2004), the ability to understand and assess risk to disasters (e.g. floods) hinges on many factors including the reliability of available information and the perceived perception of risk. While risk perception undoubtedly determines the effectiveness of the flood risk management as it influences the public behaviour, risk awareness plays a key role to minimize the variance between the perceived risk and the actual risk so that rational decisions of the flood risk management options can be potentially made among the community leaders, decision makers, policy makers and populations at-risk alike.

In general, the concept of flood risk encapsulates two components namely the likelihood of an adverse event to occur and the consequences if it happens. With that, the level of flood risk is resulted from the intersection of flood hazard and the economic or intrinsic value of the elements at risk across the multi-dimensions of vulnerability; physical, social, economic and environmental. Additionally, the analysis of flood risk must incorporate a variety of factors including property damages, system failures and economic losses. Altogether, these factors are consolidated in order to determine the appropriate level of risk to be parked either in a high, moderate or low classification (Sharma, 2012). Further, in terms of the levels of acceptable or tolerable economic risk to floods, such criteria are seen to widely vary over time notably under different circumstances and perspectives of a community member perceives them (Tyagi, 2009). For example, a community can tolerate the minor levels of flooding if it is not severe and only affects very few properties. However, the community is likely to be less tolerant of moderate to major flooding that inflicts serious disruptions in the socio-economic activities and irreversible damages. Therefore, through the theoretical point of view, there is clearly an inverse relationship between risk acceptability and risk controllability.

To measure the risk of flooding both qualitatively and quantitatively, a systematic task, which is called as the flood risk assessment, needs to be undertaken accordingly. By serving as the process to determine the nature and extent of flood risk, the assessment examines potential hazards besides evaluating the vulnerability and capacity conditions (Tyagi, 2009). The conditions of elements at risk are believed to may cause adverse consequences to populations, properties, livelihoods and the environment that a community lives in. Generically, there comprises of three different analyses of flood; flood risk, flood hazard and flood vulnerability assessments (Thakur, 2012). Flood risk assessment is aimed to study the characteristics of flood risk, possible consequences and specific effects on affected populations. This includes a risk evaluation, comparison of the risks and establishes the acceptable levels of associated risks. Meanwhile, flood hazard assessment is the study on the probability of a hazardous event (e.g. flood) to occur with a specific intensity and duration at a particular place and time faced by a vulnerable group of population. This includes the identification of underlying causes that may influence flood hazard, estimation on the probability of flooding and characterization of the flooding in terms of its depth, frequency, intensity and velocity. Flood vulnerability assessment is meant to evaluate the ability of an individual, community or element to absorb, cope, mitigate and recover from the impact of floods. For example, the vulnerability of a community is calculated by considering on the potential loss to populations (e.g. health and well-being), physical assets (e.g. building and infrastructure), socio-economic conditions (e.g. education levels and culture) and natural assets (e.g. forest and agriculture areas).

2.3 Relationship between Flood Vulnerability and Flood Risk

By and large, within the literature, it is highlighted that flood risk is the product of flood hazard and flood vulnerability (Blaikie *et al.*, 1994; Wisner *et al.*, 2004; Chauhan, 2012; Thakur, 2012). Accordingly, there will be no sign of flood risk if there is no flood vulnerability in the first place. For instance, a flood strikes a land whereby nobody lives in. Also, the higher the risk, the more urgent is that the vulnerabilities need to be addressed by mitigation efforts given the flood event itself is the realization of a hazard (Chauhan, 2012). More importantly, it is neither practical nor economical to eliminate all flood risk (Huntingdon & MacDougall, 2002). Therefore, the feasible approach to deal with a flood event must be to equitably manage flood vulnerability levels towards attaining the acceptable levels of flood risk.

The vulnerability levels to floods differ significantly among the countries and communities across the globe. Although associated risks of flooding can exist in both developed and developing countries, there is a prevalence of flood risk being more impactful in developing countries whereby respective institutional capacities are among the lowest, thus leaving many flood-hit populations in some parts of a country to be severely vulnerable (Sharma, 2012). Also, there prevail some evidences on floods that create seemingly equal risks in both developed and developing nations (Sharma, 2012). However, it is expected that the developed nations, which can capitalize on more resources for developing the counter-measures to floods e.g. to protect the buildings and manage the emergency response system, are able to protect their vulnerable communities at a greater scale than those of in the counterparts.

When assessing diverse elements of vulnerability and risk together with a particular hazard, this forms the basis for understanding on the physical, social, economic and environmental issues that jointly integrate to shape the extreme flood events in various parts of the world. In particular, flood vulnerability demonstrates a reflection of physical, social, economic and environmental conditions at present that potentially increase susceptibility to hazards whereas flood risk combines this reflection with the probable size of the type and magnitude of the hazard (Sharma, 2012). Thus, to implement sound disaster policies in a country, it has been recognized that the relationship between flood vulnerability and flood risk is inevitably significant in the reduction aspects of flood risk and flood vulnerability analyses (UNISDR, 2004). Indeed, the aspects are important to constitute as essential instruments within the flood management portfolio. Ultimately, the objective of this portfolio is to bring the probability that associated damages to occur with specific hazards and with the risk posed by hazards and vulnerabilities following a flood event as possibly close to nil (Sharma, 2012). Given the type and magnitude of floods are beyond one's control, Sharma (2012) therefore suggested that the focus of a proper flood management should be to reduce flood vulnerability as much as possible so that flood risk is potentially minimized and this can be achieved via integrating with the developmental process. However, by separating the flood management from the development process, this will unavoidably contribute to increasing flood vulnerability and likely so to flood risk in the subsequent manner.

3. EMPIRICAL REVIEW

3.1 Measurements of Flood Vulnerability

On the factor of flood vulnerability, it represents the combination of exposure, susceptibility and resilience factors of vulnerability for a system at any spatial scale (e.g. river basin, sub-catchment, urban and rural areas). The similarity on the adoption of similar flood vulnerability factors exists among most of previous studies such as Balica (2007), Balica and Wright (2010), Balica *et al.* (2012), Kissi *et al.* (2015) and Karmaoui *et al.* (2016). Despite other names are used to characterize the vulnerability factors in some empirical studies, the main principle remains the same. Undeniably, the core factors of vulnerability feature exposure, susceptibility or sensitivity and resilience or adaptive and coping capacities. With reference to Balica (2007), the exposure factor refers to the predisposition of a system to be impacted by a flood event based on its location in the same area of influence. In other words, exposure means that the conditions of goods, infrastructure, cultural heritage, agriculture lands and affected people that are present at the location where floods can occur. The susceptibility factor refers to the extent of the exposed elements (e.g. people, property and infrastructure) within the system that leads to being harmed due to floods whereas the resilience factor describes a system's response to floods, amid maintaining significant levels of efficiency in the physical, social, economic and environmental, physical vulnerabilities (Balica, 2007).

Through empirical observations, a difference is prevailed in order to conceptualize the component of flood vulnerability. It can be assessed either along a thematic dimension or across the multi-dimensions. On one hand, authors such as Balica and Wright (2010), Kissi *et al.* (2015) and Karmaoui *et al.* (2016) categorized the dimensions of vulnerability to floods in a comprehensive way to become four components; physical, social, economic and environmental. According to Balica and Wright (2010), the physical vulnerability encompasses the estimable state of physical condition, i.e. whether natural or human-made activities, will contribute to increasing vulnerability to floods in a study area. While the social vulnerability exhibits the varying levels of vulnerability to floods among affected populations or social groups, the economic vulnerability indicates the income and wealth of affected populations in a study area. Accordingly, the environmental vulnerability measures the level of environmental damage due to floods that is attributed to a study area. For example, Kissi *et al.* (2015), who studied the flood vulnerability index (FVI) methodology on the eight villages in the counties of Togo with a total of 24 finalized indicators, found that some indicators such as the closeness of farmlands to the river, construction type, household size, lower education level, inadequate flood warning system and deficient emergency services were statistically significant to explaining the rise in vulnerability to floods among the communities.

On the other, there exist previous authors like Connor and Hiroki (2005), Balica *et al.* (2012) and Villordon (2015) who used four or five components of flood vulnerability, i.e. albeit in a comprehensive way, are conceptually different than those of conventional authors. Specifically, the different set of flood vulnerability components adopted by these authors include hydro-geological, socio-economic and politico-administrative. Specifically, the hydro-geological component refers to the natural river system that is expected to have a relationship with the environmental vulnerability (De Leon, 2006). In term of the socio-economic aspect, the socio component covers the related issues of human beings and the economic component relates to income issues notably among the affected populations. The politico-administrative component includes the authorities' development plans at the national, regional and local levels to oversee the coordinated actions that may affect a study area. For instance, Balica *et al.* (2012), who developed a Coastal City FVI (CCFVI) methodology for nine cities worldwide with a total of 19 finalized indicators, revealed that the city of Shanghai in China was the most vulnerable to coastal floods from the perspectives of hydro-geological, social and politico-administrative components, accordingly.

Additionally, there exist considerable numbers of authors who are motivated by the developments in a particular thematic dimension of vulnerability. For example, the Social Vulnerability Index (SVI), which was developed by Dwyer *et al.* (2004), is an urban SVI methodology to identify the social conditions of individuals at risk to natural hazards. In their works, the SVI can be assessed from four different scales namely individual, community, regional or geographical and administrative or institutional. On the selection of indicators, 13 vulnerability variables (e.g. socio-economic indicators characterized individual characteristics) and two hazard variables (e.g. indicators characterized the impact of hazard) were chosen by Dwyer *et al.* (2004) based on a literature review, researchers' discussion and relevance to the research framework. As such, some hypothesized indicators to affect individual vulnerability include emergency services, local government policies and political climate.
Another example is the Environmental Vulnerability Index (EVI), which was developed by Kaly, Pratt and Mitchell (2004), measures a country's vulnerability to environmental degradations. In their works, resilience was treated as the opposite side of vulnerability whereas vulnerability was defined as the potential characteristics of a system, human or natural to adversely deal with the hazardous events. A total of 30 indices and indicators were evaluated based on four major categories namely ecological footprint, state of the environment, sustainable development and vulnerability. By incorporating the so-called "SMART" (Specific, Measureable, Achievable, Realistic and Time-Bound) indicators into the analysis, the involved conditions and processes were believed to operate well in the system, thereby minimizing the requirements of data. Hence, one benefit of the EVI is that a country can assess own corresponding level of vulnerability to environmental degradations via using the readily available data. Also, the transformation to scales is proven to be useful since individual vulnerability scores seem more relevant than the comparative ranking.

3.2 Measurements of Flood Risk

Flood risk assessments are empirically undertaken by many authors in order to determine the likelihood of particular hazards to occur and the possibility of having the biggest impacts on an individual or a community. By serving as a data combination of the two analytical flood hazard and flood vulnerability analyses, the flood risk analysis helps in estimating associated damages, losses and consequences as stemmed from one or more flood disaster scenarios in the future.

Danumah *et al.* (2016) performed a flood risk analysis within the Abidjan district in the southern Cote d'Ivoire of the West African region as means to identify and map particular areas that were potentially exposed to flood risk. In the study, the multi-criteria decision approach (MCDA) for flood risk mapping of vulnerable areas can be employed given there was an integration of flood hazard map (e.g. slope, drainage density, soil type and isohyet) and flood vulnerability map (e.g. population density, urban structure types and drainage system). One finding of Danumah *et al.* (2016) is that the Analytic Hierarchy Process (AHP) flood risk map indicated about 34 percent of the study areas were highly and very high exposed to the risk of flooding. In this regard, eight out of 13 municipalities within the Abidjan district were expected to be at a high risk of flooding.

Apel *et al.* (2006) conducted a flood risk assessment in the Rhine River basin of Germany. In constructing a probability modelling system, hazard alone was seen to be insufficient to characterize as a flood defence system. Instead, the combination of flood hazard and flooding consequences under a more comprehensive risk-based design was accordingly pursued. Apart from hazard and vulnerability, another key element in the risk assessment measures is exposure. The term 'exposure' is defined as the presence of populations, livelihoods, socio-economic, infrastructure and culture conditions as well as environmental services and resources in places that may be adversely affected (Gain *et al.*, 2015). In another circumstances, De Moel and Aerts (2011) and Gain *et al.* (2015) , who carried out the flood risk assessments in the Netherland and the Dhaka City, focused on the hazard, exposure and vulnerability elements in which the integration of these elements can provid e a better estimate of damages and losses associated with flood risk.

Samantha *et al.* (2016) handled an inland flood risk analysis via the use of MCDA in the Papua New Guinea notably within the lower part of Markham River basin in Morobe Province. In the study, a flood risk map was produced given the availability of four distinct geospatial data variables such as distance to river, elevation, land use and slope of the basin. Since MCDA and GIS techniques have been commonly known as key tools in spatial data analysis and mapping, the integration of those techniques can constitute as reliable instruments in the flood risk analysis and mapping of vulnerable areas (Scheuer, Haase & Meyer, 2011; Solin, 2012). However, the applicability of MCDA method can be further enhanced via the inclusion of significant indicators such as rainfall, river discharge and surface runoff. From their findings, the areas that were in proximity to the Markham Bridge including the parts of Lae city and Bulolo town were disclosed to be at high risk of flooding.

Jiang *et al.* (2009) undertook a flood risk analysis in Malaysia particularly in the state of Kelantan. As such, seven districts of the state; Bachok, Kota Bharu, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, and Tumpat, which represent the state's main flood-prone areas, were chosen as the cases of study. For the study, three techniques namely fuzzy comprehensive assessment (FCA), fuzzy similarity method (FSM) and simple fuzzy classification (SFC), which are feasible in the flood risk evaluation, were employed accordingly. Data variables such as the flooded area, paddy area, residential area, urban area and refuges were included in the analysis as means to validate on the accuracy of flood risk. Their findings disclosed that the flooded areas, i.e. ranging from 70 to 75 percent, are located within the higher and highest risk zones. As such, these riskiest zones, which cover paddy, built-up and residential areas, are more likely to be susceptible to potential damages following the episodes of flood disaster. In addition, more refuges, which will be equipped with proper risk mitigation plans, have to be built in the higher and highest risk zones to meet rising accommodation requirements in the future.

3.3 Relationship between Flood Vulnerability and Flood risk

In general, the commonly used equation of a disaster risk is represented by $Risk = Hazard \ x \, Vulnerability$ whereby risk is the convolution of hazard and vulnerability. Therefore, in the context of a flood event, the equation is converted into $Flood \ Risk = Flood \ Hazard \ x \ Flood \ Vulnerability$ in which flood risk is seen as the product of flood hazard and flood vulnerability. Since flood hazard and flood vulnerability tend to be different with respect to region and time, flood risk similarly varies by region and time and it can be responsibly altered by rational human actions. Thus far, it is believed that the implementation of effective flood-control measures not only can potentially reduce the risk of flood events on one hand, but also able to minimize the vulnerabilities to floods faced by an individual or a community on the other.

Balica *et al.* (2013) undertook both flood vulnerability and flood risk assessments on the Budalangi settlement, which is located at the district of Busia in Western Kenya, within the Nzoia River Basin. In the study, both physical (e.g. computer-based inundation mapping) and parametric (e.g. FVI model) approaches were employed to evaluate vulnerability and risk levels to floods. From their findings, the physically-based technique has high capability for prognosis and forecasting, thus strategically fitting for more focused studies whereas FVI model is deemed useful in a vulnerability assessment at a large scale albeit less physically rigorous. Also, FVI model contributes to enabling the flood risk assessment to capture other important aspects such as social, environmental damage and infrastructure resilience although the FVI model does not directly assess flood risk.
Zhu *et al.* (2012) commenced a flood vulnerability analysis notably in the Guangdong province of China. By employing both subjective and objective methods, they disclosed that the mean vulnerability index (VI) as calculated via subjective method was 0.35 with the standard deviation of 0.10 versus the mean VI as estimated by objective methods that was 0.31 with associated standard deviation of 0.08. In turn, both statistical methods indicated reliable and consistent results of VI. As a rule of thumb, districts with subjective VI that is greater than 0.50 and/or objective VI that is greater than 0.40 should give a close attention to floods, including the coastal and basin areas along the Beijiang River, Dongjiang River and Pearl River. Among others, their findings claimed that the Dapu district of Meizhou (0.55/0.45) and Dianbai and Maogang districts of Maoming (0.54/0.48) were the most vulnerable to floods. Due to the varying levels of flood vulnerability being successfully identified across the regions in the province of Guangdong, flood-prone areas should become the province’s utmost priority to be closely monitored especially in the prevention and control of floods. Therefore, lowering vulnerability to floods contribute to effectively reducing the risk to floods and ensuring the sustainable development of an area.

4. LITERATURE GAP

From the conducted literature review activities, it is further observed that there is a prevailing gap in the disaster literature notably in the developing countries. This is with regard to the applicability of a systematic method for capturing the broader picture of adverse consequences of floods in a comprehensive manner. By and large, there seems to be less popular among the authors in the Asian region to employ the FVI methodology within the flood vulnerability assessments since the method capitalizes on the use of readily available data and requires a thorough investigation across the multi-dimensions of vulnerability. By comparison, the increasing use of computer-aided applications (e.g. remote sensing and Geographic Information System) represents a huge breakthrough and pushes the conventional boundaries within the body of literature but is highly dependent on the sophisticated techniques and expertise of users.

5. CONCLUSION

Due to prevailing flood characteristics over recent years in terms of the magnitude and frequency of the events and associated losses of human life and property, there is a need especially for the Asian developing countries to develop a systematic method towards assessing the multi-dimensions of vulnerability to floods in a comprehensive manner. Given the applicability of the FVI methodology within a flood vulnerability assessment, this can enable proper flood control measures to be prioritized for the flood risk response among the community leaders, populations at risk, decision makers and policy makers alike.

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