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Unravelling the Complexity of Flood Hazards: A Comprehensive Review of Characteristics and Risk Assessment

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Understanding the characteristics of flood hazards is crucial since it is one of the basic indicators for determining the risk of loss level. The elements of a hazard are often interpreted with varying connotations, especially flood hazards. In fact, the characteristics and scales that measure a flood hazard level also vary from one study to another. Therefore, the aim of this paper is to understand the characteristics of flood hazards and their influence on the risk of loss level by reviewing previous research. Generally, the flood hazard level can be determined according to certain characteristics, such as depth, velocity, duration, amount of discharge, flood flow force, flood intensity and energy head. Based on these characteristics, the flood hazard level can be classified into three or four levels: low, medium, high; or low, medium, high and extreme. From the aspect of depth, for example, floods with a height less than 0.5 meters and more than 1.5 meters are categorised as low and high hazard levels, respectively. In terms of frequency, floods that occur less than 6 times a year are considered as low hazard level, while those that occur more than 11 times a year are classified as extremely hazardous. The higher the flood hazard level in an area, the greater the risk of loss. Therefore, understanding the characteristics of a flood hazard will aid in determining or assessing the risk of loss in any particular area.

Keywords: Hydrology; flood risk management; flood risk assessment; vulnerability; resilience

I. INTRODUCTION

Generally, the entire earth's surface has the potential of facing hazards or is at risk of facing hazards (Jafar *et al.*, 2022). The types of hazards experienced in each area are sometimes extremely diverse and can take the form of either biological, physical, chemical, natural, social-communicative or complex hazards (Dickinson & Burton, 2015). Floods are an example of a physical hazard since they commonly occur in floodplain regions (Jafar *et al.*, 2020; 2021) as well as in urban areas (Jafar *et al.*, 2012). Floods are frequent phenomena, especially during the monsoon season. Floods are not always dangerous, yet they carry a risk of loss in all circumstances. The risk of loss or a disaster will only exist in the presence of two main factors: vulnerability and hazard (Wisner *et al.*, 2003; UNISDR, 2004; Leon, 2006; Birkmann *et al.*, 2013). This indicates that with the presence of a flood hazard but with the absence of vulnerability, there will be no disaster or risk of flood loss. The opposite is also true.

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Disasters will not exist with the presence of vulnerability and the absence of a flood hazard. Therefore, the elements (hazard and vulnerability) must first be identified to efficiently manage flood risks (Jafar *et al*., 2022).

The element of vulnerability will only exist In line with the existence of human beings in an area that has potential for disasters, especially floods (Jafar *et al.,* 2022a). Humans are the subjects threatened by hazardous factors that create the risk of disaster (Chan, 2002). The focus of this paper is not on the elements of vulnerability but rather the characteristics of flood hazards. The diverse nature and characteristics of a flood hazard must be examined since it is an important indicator that influences the risk of loss level. Numerous studies on flood hazards have been previously published, such as the research of Kundzewicz *et al.* (2018), Biswas *et al.* (2018), Shah *et al.* (2020), Mudashiru *et al.* (2021a) and Mudashiru *et al.* (2021b). However, these articles did not consider the characteristics of flood hazards and their impact on the risk of loss level. Therefore, this paper examines the characteristics of floods since they are significant factors in determining the risk of loss level.

II. METHODS

This paper adopted the unsystematic narrative review method, as recommended by Green *et al.* (2006). We believe that this method is appropriate for revising the extensive range of available resources, utilising the 'best synthesis approach' to cover various sources, including (i) peer-reviewed journals, (ii) government documents, (iii) website articles and (iv) books. A Boolean search approach was conducted to determine the relevant literature, incorporating related keywords (such as flood hazard, flood hazard characteristics, etc.) into the search engines. The Google Scholar database was used to search through most materials and sources. Google Scholar was found to be suitable since it is an openly accessible database that provides a large volume of reading material.

A total of 42 references were reviewed in this study (excluding the Methodology section). Thirty-three percent of these references (14 sources) were published in 2018 and onwards (within the past 5 years). Thirty-eight percent (16 references) were published over a period exceeding six years (2012 to 2017), while twenty-nine percent (12 sources) were published over ten years (2011 and earlier).

III. HAZARD

The understanding of hazards and their associated impacts has been steadily increasing for over 30 years (refer to Table 1). Several countries have coordinated meetings to establish frameworks for addressing hazardous events as well as their consequences. One such initiative was the International Decade for Natural Disaster Reduction (INDR), implemented in 1989. The Yokohama Strategy and Plans of Action and the Hyogo Framework for Action (2005-2015) are other equally important frameworks aimed at safeguarding the world from hazards. Most recently, the Sendai Framework for Disaster Risk Reduction (2015-2030) has been adopted as a more comprehensive framework for achieving a substantial reduction in disaster risk and loss of lives (UNISDR, 2015; UNDRR, 2020).

Table 1. International commitments to disaster risk reduction.

Year	International Commitments
1989	International Decade for Natural Disaster Reduction (IDNDR)
1994	Yokohama Strategy and Plans On Action
1999	International Strategy for Disaster Reduction (ISDR)
2005	Hyogo Framework for Action 2005-2015 (HFA)
2015	Sendai Framework for Disaster Risk Reduction 2015-2030

Source: Adapted from Aitsi-Selmi *et al.* (2015).

In general, a hazard is defined as a dangerous physical event that can result in casualties, injuries, property damage, social and economic disruptions, as well as environmental degradation (UNISDR, 2004; Jafar *et al.,* 2022). Tominaga *et al.* (2009) and the Yogyakarta Special District Disaster Management Agency (2013–2017) also defined hazard as the probability of the occurrence of natural phenomena or processes that have the potential to cause damage in an area at a given time. The occurrence of hazards is either due to natural factors or human activities (UNISDR, 2004; Mardiatno *et al.,* 2012; UNDRR, 2020, Sakke *et al.,* 2023). Tarbotton *et al.* (2015) categorised hazards into three parts:

natural hazards, technological hazards and environmental degradation hazards. Technological hazard, or anthropogenic hazard, is associated with technological accidents, industries, infrastructure failures or certain human activities that can result in casualties, injuries, property damage, social as well as economic disruptions or environmental destruction. Some examples of technological hazards are industrial pollution, nuclear and radioactive emissions, toxic waste, dam failure as well as transportation and industrial accidents (whether in the form of explosions, fires or spills). Environmental degradation is defined as a process caused by human activities that damage ecosystems or basic natural resources, such as deforestation, open burning and soil degradation. This results in biodiversity loss; water, soil and air pollution; climate change; rising seawater levels; and ozone depletion.

A natural hazard is a phenomenon or process that occurs in the earth's biosphere layer that is likely to lead to destruction. There are three main factors that cause natural hazards: hydrometeorological, geological and biological factors, as shown in Table 2. Based on the table, hazards caused by hydrometeorological factors include floods, tropical cyclones, storms, sandstorms, etc. The onset of such hazards is a result of natural phenomena such as atmospheric, hydrosphere and oceanographic processes. These types of dangers are caused by geological factors such as earthquakes, volcanic activity, landslides and others. Finally, biological hazards arise as a result of exposure to pathogenic microorganisms, toxins and bioactive substances that cause disease outbreaks in plants and animals.

Table 2. Categories of hazards or natural disasters based on their causes.

Causes	Phenomena
Hydrometeorology: natural phenomena or processes of the atmosphere, hydrology and oceanography	Floods, tropical cyclones, storm, rain, blizzards, droughts, extreme temperatures, sandstorms and landslides
Geology: Phenomena are endogenic or exogenic natural processes such as plate movement and mass movement	Earthquake, volcanic activity, landslide, tsunami and rock falls
Biology: Processes derived from organics or biological vectors, including exposure to pathogens, microorganism, toxins and bioactive substances	Disease outbreaks, infectious disease transmission from animal and plants

Source: Modified from Tarbotton *et al.* (2015).

Dickson *et al.* (2012) classified natural hazards into five main groups: biological, geophysical, hydrological, meteorological and climatological hazards, as shown in Table 3. The clustering of hazard types performed by Dickson *et al.* (2012) was not significantly different from the classification of Tarbotton *et al.* (2015). The only variation is that the grouping performed by Dickson *et al.* (2012) is more extensive than that of Tarbotton *et al.* (2015).

Table 3. Categories of natural hazards.

Biology	Geophysical	Hydro-Meteorology		
		Hydrology	**Meteorology**	**Climatology**
• Insert attacks • Epidemic - Viral infectious disease - Bacterial infectious disease - Fungal infectious disease - Prion infectious disease	• Earthquake • Volcanism • Mass movement (dry) - Rockfall - Landslide - Avalanche - Subsidence	• Flood - Regular flood - Flash flood - Coastal flood - Mass movement (wet) - Rock falls - Avalanche - Subsidence	• Cyclone - Tropical cyclone - Extratropical cyclone - Local cyclone	• Extreme temperature - Heatwave - Extreme winters • Drought • Forest fires

Source: Modified from Dickson *et al.* (2012).

According to Dickson *et al*. (2012), the hazard components of hydrology, meteorology and climatology constitute a major branch of hydrometeorological hazards.

IV. FLOOD HAZARD

Floods can be defined as an excess quantity of water that submerges a wide region, including properties (Hua, 2016). There are three main types of floods: riverine, coastal and pluvial (Bateni *et al*., 2022). Each type is triggered by different factors. Riverine floods, for example, occur due to an overflow from large rivers, while pluvial floods result from extreme rainfall where existing drainage systems cannot adequately handle the excess water (Yin *et al*., 2015). In contrast, coastal floods commonly take place when low-lying dry land is submerged by seawater. According to Maggioni and Massari (2018), riverine floods cause significant property damage, whereas pluvial floods tend to result in a higher loss of life.

A hazard is something dynamic with varied potential impacts (UNISDR, 2004). The potential impact of a hazard is influenced by the characteristics of that hazard. The level of flood hazard, categorised as a hydrometeorological hazard for instance, is assessed according to its characteristics, such as depth (Tincu *et al*., 2018), velocity (Schanze, 2006; Priest *et al*., 2008; Cancado *et al.,* 2008; Russo *et al*., 2013; Albanoa *et al.,* 2017), duration (Bhuiyan & Baky, 2014; Hammond *et al*., 2015), amount of discharge (Messner & Meyer, 2005), flood flow force and flood intensity (Kreibich & Thieken, 2009). Apart from specific flood characteristics, indicators that determine the flood hazard level can also be assessed based on the distribution of the amount of rainfall received in an area (Hai *et al*., 2018). This is due to the fact that distribution of rainfall received in an area will eventually affect the characteristics of floods or water discharge in affected regions.

V. CHARACTERISTICS OF FLOOD HAZARDS AND THEIR INFLUENCE ON THE LEVEL OF RISK OF LOSS

Each flood hazard characteristic will produce different types of impacts, as detailed in Table 4. Based on the table, five types of flood hazard characteristics are present: flood depth, flood velocity, flood intensity, flood flow force and *energy head*. Among the five characteristics, flood depth is the highest indicator of flood hazard, contributing to most of the negative impact results in various forms. This is because the flood depth strongly influences the damage caused to the structural integrity of residential buildings. Flood depth can also damage road structures, disrupt business activities and cause financial losses to residential buildings at a moderate level of impact. The *energy head* is the second stage of flood hazard indicators. It contributes to negative impacts that come in various forms. Similar to the flood depth indicator, the energy head indicator also has a significant effect on the structural damage of residential buildings. The only difference is that the energy head indicator does not have a strong negative influence as the flood depth indicator when it comes to business disruptions.

Flood intensity, flood flow force and flood velocity are the characteristics of flood hazards in the third, fourth and final stages, respectively. All three indicators significantly influence road structural damage, but do not have a strong or moderate influence on other types of impacts. For example, flood intensity and flow force indicators do not have a significant impact of damage on residential building structures, while the flood velocity indicator does not have any damaging impact. The influence of these three indicators on the financial losses in the case of damages of residential buildings is only at a low level. When compared to the other two indicators (flood velocity and flood flow), only the flood intensity indicator contributes to business disruptions, but even that is at a low level.

Table 4. Influence of flood hazard characteristics on the type of impact.

Hazard Indicator	Type of Impact				
	Damage to residential building structure	**Damage to road structures**	**Financial loss to residential buildings**	**Financial loss to road structures**	**Business disruption**
Flood depth	Strong	Moderate	Moderate	No	Moderate
Flood velocity	No	Strong	Weak	No	No
Flood intensity	Weak	Strong	Weak	No	Weak
Flood flow force	Weak	Strong	Weak	No	No
Energy head	Strong	Moderate	Moderate	No	Weak

Source: Adapted from Kreibich & Thieken (2009) and Neto *et al.* (2016).

From the flood characteristics, the level of flood hazard can be classified into three levels: low, medium and high. The level is determined according to the threshold level value, as shown in Table 5. For the flood depth indicator, a depth level of 0.6 meters or below is categorised as a low hazard level. Flood levels at a depth of 0.6 meters to 1.2 meters or above are categorised as moderate and high flood hazard levels, respectively. The hazard threshold level for the flood depth and flood velocity indicators is similar. The only difference is the measurement unit. If the flood depth indicator applies a unit of measurement or meter measurement, then the flood velocity indicator applies a unit measurement of m/s (meters per second).

Other than that, a flood intensity with a capacity of 0.36 m^2/s is categorised as a low-level flood hazard. A flood intensity of 0.36 to 1.5 m^2/s is classified as a moderate flood hazard level, while a flood hazard level exceeding 1.5 m^2/s is considered as a high flood hazard level. The *energy head* indicator is categorised as a low flood hazard level when it measures less than a meter. It only reaches a moderate hazard level when its size is in the range of one to two meters. High hazard levels will only occur when the *energy head* measures more than two meters. The hazard threshold level of the *energy head* and the flood flow force indicators are the same. The only difference is that the *energy head* indicator is measured using a meter unit, while the flood flow force is measured using the m^2/s^2 unit.

Table 5. Threshold level based on flood hazard indicators.

Indicator	Low	Medium	High
Flood depth (m)	0.0-0.6	0.6-1.2	>1.2
Flood velocity (m/s)	0.0-0.6	0.6-1.2	>1.2
Flood intensity (m^2/s)	0.0-0.36	0.36-1.5	>1.5
Flood flow force (m^2/s^2)	0.0-1.0	1.0-2.0	>2.0
Energy head (m)	0.0-1.0	1.0-2.0	>2.0

Source: Modified from Neto *et al.* (2016).

According to Neto *et al.* (2016), measuring the flood hazard level is not limited to a single or separate indicator, as shown in Table 5. This is because the combination of flood depth and flood velocity indicators can also form new dangerous hazard values, as shown in Table 6. The hazard level values are determined using the arithmetic averaging method derived from the values of flood depth and flood velocity levels. The calculation result, obtained in the form of a decimal point, will be rounded to a whole number to the nearest large value. Subsequently, the results of combining the values of both flood velocity and flood depth indicators indicated a low flood hazard level, while the results of combining the values of two and three were classified as having moderate and high flood hazard levels, respectively.

Table 6. Determining the hazard index based on a combination of flood depth and velocity indicators.

Depth	Velocity	Combination	Hazard Level
1	1	1	Low
2	1	2	Medium
3	1	2	Medium
1	2	2	Medium
2	2	2	Medium
1	3	2	Medium
3	2	3	High
2	3	3	High
3	3	3	High

Source: Modified from Neto *et al.* (2016).

Ristya (2012) also categorised hazards into three levels: low, medium and high. According to Ristya (2012), the flood hazard level can be measured using three types of parameters: flood depth, flood time period and annual flood frequency. Floods with a depth of less than 70 cm are categorised as low hazard levels. When the flood depth reaches a height of 70 cm to 140 cm or more, it will be categorised as medium and high hazard levels, respectively (Table 7). Regarding the flood duration, if the flood occurs in less than a day, it is classified as a low level hazard. Medium and high-level flood hazards will only occur when the time period of the flood event lasts for one to two days or exceeds two days. In terms of flood frequency, floods that occur less than six times a year are categorised as low hazard levels. If floods reach a frequency of six to eleven times a year, they are considered to be at medium hazard level. Floods that occur more than eleven times a year are categorised as high-level flood hazards.

Table 7. Determining the flood hazard index based on depth, duration of flood and frequency of floods in a year.

Hazard Indicator	Criteria	Hazard level	Index
Flood depth	<70 cm	Low	1
	70cm to 140cm	Medium	2
	>140 cm	High	3
Flood duration	<24 hours	Low	1
	24 hours to 48 hours	Medium	2
	>48 hours	High	3
Flood frequency in a year	<6 times to 11 times	Low	1
	6 times to 11 times	Medium	2
	>11 times	High	3

Source: Modified from Ristya (2012).

Several studies further categorised the flood hazard level into four stages. Komi *et al.* (2016), for example, used a depth indicator to categorise flood hazard levels into four levels: very low, low, medium and high, as shown in Table 8.

Table 8. Classification of flood hazard level based on flood depth indicator.

Depth (m)	Hazard Level	Definition of Hazard Level
0-0.2	Very low	• Estimated property damage is very low.
0.2-0.5	Low	• Number of flood victims suffering casualties or injuries are not significant. • Estimated property damage is low.
0.5-1.0	Medium	• Number of flood victims suffering casualties or injuries are significant.
1.0-2.0	High	• Number of flood victims suffering casualties or injuries are quite high. • Widespread property damage.

Source: Modified from Komi *et al.* (2016).

A flood depth level is considered very low when its height is less than 0.2 meters. Estimates of property damage occurring at this stage would be very low. When the flood depth range is between 0.2 and 0.5 meters, the flood hazard level is categorised as low. At this stage, the casualty or injury rate of flood victims is insignificant. Only at a moderate flood depth range of 0.5 to 1.0 meter will there be a large number of casualties suffering from significant injury. Flood depths of 1.0 to 2.0 meters have a more prolonged effect and are classified as high hazard levels.

Table 9. Classification of flood hazard levels based on flood depth and velocity indicators.

Hazard Level	**Characteristics of the Nature of Flood**		**Impact**
Extreme	Depth Velocity	D > 1.5 m H ≥ 2.0 m/s	• All buildings are likely to be destroyed, high probability of casualties.
High	Depth Velocity	D > 1.5 m 1.5 m/s < H < 2.0 m/s	• Evacuation by truck is unlikely, minor structural damage to the house frame and high risk to life.
Medium	Depth Velocity	0.5 m < D < 1.5 m 0.5 m/s < H < 1.5 m/s	• If the velocity is high, action to wade through water is not possible and there is a risk of drowning.
Low	Depth Velocity	0.1 m < D < 0.5 m 0.1 m/s < H < 0.5 m/s	• Flooded areas are accessible to adults

Source: Modified from Cancado *et al.* (2008).

Cancado *et al.* (2008) classified flood hazards according to depth and velocity. Flood hazards can be categorised into four levels: extreme, high, medium and low, as shown in Table 9. Each flood hazard level will produce different outcomes or impacts. Low flood hazard levels are characterised as floods with a depth of 0.1 to 0.5 meters and a velocity of 0.1 m/s to 0.5 m/s. Most adults can wade through a flood of low hazard level. Flood depths exceeding 0.5 meters and reaching 1.5 meters, combined with a velocity level of 0.51 m/s to 1.49 m/s, are categorised as medium hazard levels. At this stage, the flood depth with low velocity can cause damage to buildings. However, large trucks can still be used for the relocation process. When the flood velocity increases to and approaches the value of 1.5 m/s, then it is not possible to wade through the water and there is a risk of drowning.

If the flood depth exceeds 1.5 meters with a speed ranging between 1.5 m/s and 2.0 m/s, it will cause minor structural damage to buildings along with a high risk of casualties. The use of trucks or any mode of transfer would be almost impossible. The velocity and depth characteristics of such floods are classified as high flood hazard levels. The only variation between high and extreme flood hazard levels is the velocity indicator. If the flood velocity movement has already exceeded 2.0 m/s, then the flood hazard level is categorised as extreme. At this stage, buildings located in the flood route are likely to be completely destroyed, with a high probability of casualties.

Priest *et al.* (2008) combined two indicators, the flood depth and flood velocity variables, to determine the flood hazard level. This is in contrast with Cancado *et al.* (2008) who applied the two indicators as separate readings. Priest *et al.* (2008) combined the two variables to form flood intensity, with a unit reading of m^2/s. Five hazard levels are present based on the flood intensity values: low, medium, high, extreme and very extreme (refer to Table 10). An extremely high hazard level is further grouped into two levels: floods with intensity values ranging between 2.5 (m^2/s) and 7.0 (m^2/s) and floods with intensity values exceeding 7.0 (m^2/s). At this stage, a high risk of casualties is present. The collapse of buildings is likely if exposed to flood currents.

Flood hazard levels are classified as low when the flood intensity has a value of less than 0.75 m^2/s. At this stage, the flood flow is shallow, yet people should still be on alert. When the flood intensity value exceeds 0.75 m^2/s and reaches 1.49 m^2/s, it is categorised as a medium flood hazard. At this stage, communities vulnerable to floods will face the risk of casualties. The flood hazard level with a flood intensity exceeding 1.5 m^2/s and approaching 2.5 m^2/s falls under the high-level category. In such conditions, the flood currents will affect a large number of people who will likely face a high risk of casualties.

Table 10. The risk threshold level based on the combination of depth and velocity.

Depth x Velocity (m^2/second)	Hazard	Description
< 0.75	Low	Being cautious Shallow flood flow.
0.75 - 1.49	Medium	Harmful to vulnerable communities Deep or fast flowing. Casualty usually occurs in vulnerable communities or is caused by human behaviour.
1.5 - 2.49	High	Dangerous to most people Deep or fast flowing. The main factor of casualty is due to exposure to hazard.
2.5 - 7.0	Extreme	Dangerous to all Too dangerous due to very deep flood level and having flows that are too fast. Casualty is caused by exposure to hazard.
> 7.0	Very Extreme	Dangerous to all Too dangerous due to very deep flood level and having flows that are too fast. Causes risk to building collapse.

Source: Modified from Priest *et al.* (2008).

Priest *et al.* (2008) formed a matrix based on flood depth and velocity. According to the matrix, three classifications are present according to the potential hazards likely to affect humans (refer to Figure 1). In short, a flood depth as high as 2 meters and above (with any velocity value) will be considered dangerous to all human beings within the vicinity. On the other hand, a flood depth of 0.1 meters or below (with any velocity value) will be considered dangerous to only a few people. At a depth of 0.2 to 1.5 meters, it has the potential to be a danger to most people in accordance with the flood velocity level.

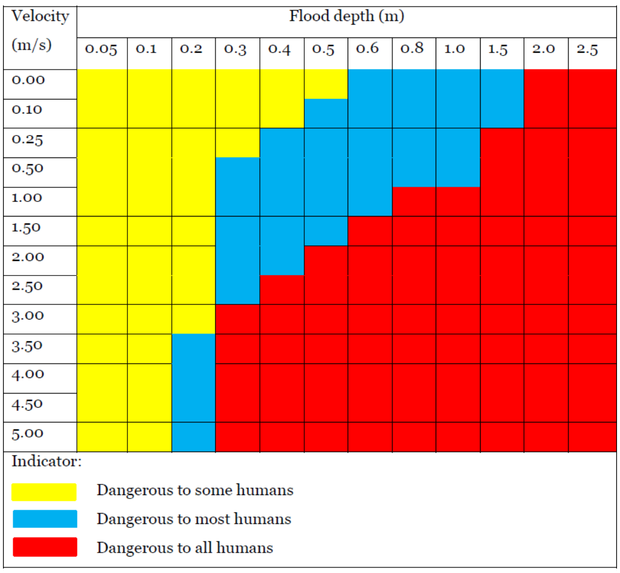

Figure 1. Determining the danger to humans according to the depth-velocity matrix.
Source: Modified from Priest *et al.* (2008).

In Barcelona, Spain, Russo *et al.* (2013) evaluated the influence of flood velocity on the stability of pedestrian movement in flooded road areas. The hazard level to pedestrians is determined according to the flood velocity. The three hazard levels are categorised as: high, medium and low, as shown in Table 11. Based on the figure, flood velocity values of 1.88 m/s and above are categorised as high hazard levels, while flood velocity values of less than 1.51 m/s are considered as low hazard levels. Floods that flow with a speed of 1.51 m/s to 1.87 m/s are categorised as medium hazard level. These three classifications are only adopted when the flood depth value is between nine and 16 cm.

Table 11. Hazard level based on velocity parameters of flood flow in pedestrian areas.

Hazard level	Conditions of flows
	(Only for flood flow depths between 9 and 16 cm)
High	Velocity ≥ 1.88 m/s
Medium	1.51 m/s ≤ Velocity < 1.88 m/s
Low	Velocity < 1.51 m/s

Source: Modified from Russo *et al.* (2013).

The Australian Government (2006) classified flood hazards into four levels: major flood level, moderate flood level, minor flood level and sub-minor flood level. As shown in Figure 2, the four flood hazard levels are categorised according to the index values and flood characteristics.

Problems caused by

floods will only begin after the existence of the first report, which is at the beginning of minor flood levels. At this stage, several situations will be present, such as the flooding of areas nearby rivers and low-rise bridges, as well as alternative roads being closed. However, population evacuation is no longer taking place. Population evacuation only occurs at moderate flood danger levels. This is because at this stage, some floors within buildings will become flooded. In addition, major traffic routes, crops and livestock will also be affected. The situation becomes more serious when flood levels reach a significant level where the size of the flood stagnation area is so large that it results in a larger-scale population evacuation compared to the moderate flood level. It also leads to major traffic and railway route closures, which simultaneously cause the disruption of utility services.

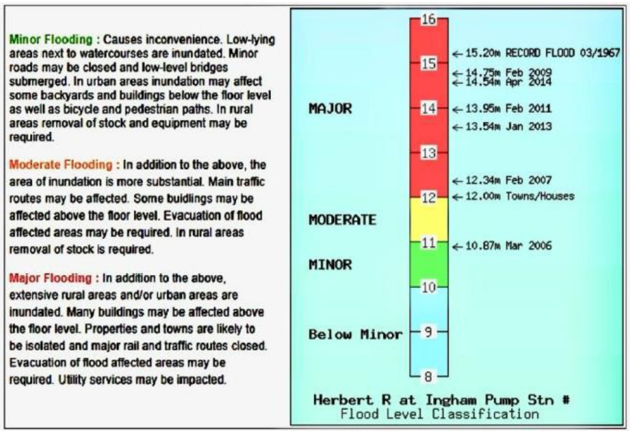

Figure 2. Classification of flood hazard levels
Source: Australian Government Bureau of Meteorology (2006).

The Hawkesbury-Nepean Floodplain Management Steering Committee (2007) found that the flood depth level that generally floods houses (modern single-storey houses) affects the loss level from the financial aspect (refer to Figures 3 and 4). Losses in the form of property (carpets, furniture items and electrical appliances) are mostly affected by flood events. Losses in the form of house structures, including the cost of repairing damage to floors, ceilings, walls, windows, kitchens, etc., are also strongly influenced by flood depth. Forms of external losses (gardens, fences and garages) were found to be the least affected by the increase in flood levels.

The loss levels are classified into five categories: insignificant, minor, moderate, major and catastrophic. The total losses of less than ($)5,000 and $5,001 to $10,000 Australian dollars represent insignificant and minor levels of loss, respectively. The total losses of $10,001 to $25,000 are categorised as the intermediate level, while $25,000 to $50,000 are considered as the major level. The loss level classified as catastrophic is $50,001 to $150,000. When the flood depth level reaches a height of 0.5 meters, the risk of property and house structural losses will reach a major level. After the loss value is summed, it can be classified as catastrophic (refer to Figure 3).

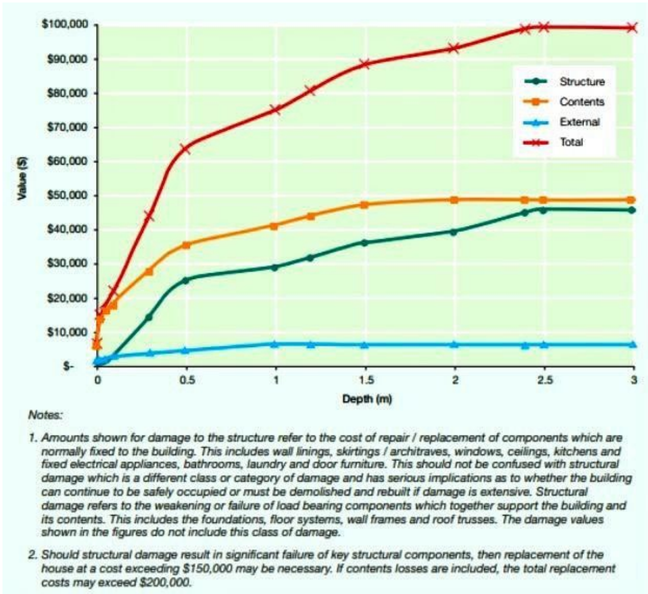

Figure 3. The relationship between flood depth and risk of financial loss.
Source: Hawkesbury-Nepean Floodplain Management Steering Committee (2007).

Figure 4. Value of financial loss based on flood depth levels. Source: Modified from Hawkesbury-Nepean Floodplain Management Steering Committee (2007).

VI. CONCLUSION

To conclude, floods are hazards caused by hydrometeorological factors. They are classified as natural hazards but can be triggered by human activities. The direct impact of floods can result in the loss of human life, injuries, damages to properties, social and economic disruptions and environmental degradation. Ironically, the level or extent of destruction and losses caused by flood hazards are highly influenced by their characteristics. Moreover, the flood hazard level for a particular flood event is influenced by the characteristics of that specific flood.

Various flood characteristics can be used to determine the level of flood hazard, such as the distribution value of annual rainfall, flood depth, flood velocity, intensity and flow. The number of available flood characteristics also varied from one study to another. Some studies only apply one characteristic to determine the flood hazard level, while other research used more than one. However, to determine the flood hazard level, the most frequently used flood characteristics are flood depth and velocity. Discussions on the characteristics of flood hazards and their influence on the risk of loss are important since the occurrence of floods is common in most countries. Understanding flood hazard characteristics will facilitate the process of determining or assessing the potential risk of loss in an area.

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