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FLOOD RISK FOR RESIDENCE = HAZARD X CONSEQUENCE: THE PARAMETERS INVOLVED

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Abstract
Evidently, the world has experienced devastating floods which affected millions of people and caused untold hardship to the affected population. Flooding is one of the leading devastating hazards worldwide. The most vulnerable population are the poor who are the majority in most human settlements. Social perception in risk taken play a crucial role, which could lead to adverse or positive outcomes in risk conditions. The risk involved in flood occurrence affects human properties, social, geological and economic systems, in extreme cases it results to loss of lives. Hazard parameters which could be measured to quantify direct flood hazards are majorly volume, depth, volumetric flow rate, velocity, temperature, density and salinity. Increase in flood losses are the aftermath of risk taken. The research aims at creating more awareness regarding flood risk with emphasis on the consequence and the parameters to be considered. To realize this data was collected from books, journals and internet. The finding revealed that there is need to minimize taken risk so as to reduce loses of lives and properties especially in flood prone areas.

Introduction
Risk which is mathematically a product of hazard and its consequence should be treated with caution. Sayers *et al.* (2002) point out that two calculated risks with equal values may not necessarily be equivalent because a risk dominated by a high hazard probability has different management needs than a risk dominated by high vulnerability. With these provisos in mind, a quantitative definition of risk suitable for this research focus on residence vulnerability to floods may be sought. Caution is warranted because, paraphrasing Helm (1996), this product does not describe the totality of the real risk but is appropriate as a basis for comparing risks and for risk management decision-making. Lewis (1999) warns that "focus on risk of a given magnitude may cloud our perception of a reality which might in fact be lesser or partial".

Considering UN DHA (1992) definition in conjunction with other authors' definitions, a clear, adaptable definition is provided. A straightforward, generalized equation for the definition's core is:
Risk to one residence for one hazard event defined by one hazard parameter value
= (probability of the hazard parameter value being equaled or exceeded at the residence within a specified timeframe) X (physical vulnerability of the residence to that hazard parameter value)

This equation resembles that of risk as a product of hazard and its consequence. The calculation of risk = (hazard parameter value exceedance probability) X (vulnerability to that hazard parameter value) must be summed over all possibilities within the bounds set bythe problem. In this study, the bounds are that the hazard is a flood hazard parameter and theelements deemed to be physically vulnerable to the flood hazard parameter are residences.
Residences are discrete but flood hazard parameters are continuous yielding the risk equation:
risk = ΣAll residences ∫All values of the hazard parameter
[(hazard parameter value exceedance probability)
X (vulnerability to that hazard parameter value)]
integrated with respect to the hazard parameter.

Using the UN DHA (1992) definitions, the reported risk is dimensionless but is defined on monetary basis. Assigning monetary values to residences is not as fraught with difficulties as assigning monetary values to invaluable elements such as life, health, culture, and ecosystems or to intangible elements such as aesthetics and emotions. Residences hold invaluable and in tangible qualities, but analyzing the monetary values of residences tends to be more substantial and less controversial than for other possible losses.

The difference between the property insurance company point of view and the disaster mitigation point of view clarifies this issue. The goal of disaster mitigation tends to be to reduce casualties while the goal of property insurance companies tends to be to reduce property losses. Protecting property often protects occupants, but design strategies for natural disasters exist which sacrifice the structure in order to protect the occupants (e.g. Harris *et al.*,1992). If a conflict arises between these two objectives when selecting a flood management strategy or when assessing vulnerability, the preferred point of view should be identified. The specific flood hazards and physical vulnerabilities to explore, and to quantify, with respect to residences examined.

Vulnerability to disasters describes the degree to which a socio-economic system or physical assets are either susceptible orresilient to the impact of natural hazards (Birkmann, 2006). UNDRO (1991) defined it as "the degree of loss to a given element at risk or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total damage)". Blaikie et el (1994) on the other hand define vulnerability as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from impacts of ahazard"

Natural hazard refers to a characteristic of or phenomenon from the natural environment which has the potential for causing damage to society. Society includes residences. Examples of natural hazards are wind, tornadoes, flood water, soil in floods, rain, hail, tigers, kiwi birds, rickettsia, cosmic rays, asteroids, earthquakes, lava, rocks, and tsunami. This research focuses on flood hazards. Flood hazard is often quantified by selecting a measurable parameter, such as depth, velocity, or maximum flow rate. Probabilities of exceeding a specific value of this hazard parameter in any given timeframe are determined through observation, experimentation, modelling, or a combination. In this case flood hazard quantification by calculating probabilities of the sea's/river 's extreme water level exceeding a certain value at the studied area is carried out.

The objectives of the study are:

i. To examine risk in respect to flood in residence.
ii. To determine hazard as a result of risk in residence.
iii. To examine vulnerability of flood in residence.

Literature review

In the scientific community, it is widely agreed that risk is the product of a hazard and its consequences. Where there are no people or values that can be affected by a natural phenomenon, there is no risk. In a similar way, a disaster can only occur when people are harmed and/or their properties destroyed. For instance, a very strong flood water in an uninhabited region without human property cannot lead to disaster. Similarly, a strong flood water in a well-prepared region will not be disastrous. In a poorly prepared region, however, even a moderate flood water may cause a devastating effect. The flood water hazard is clearly highest in the first case, while the flood water risk is highest in the third case. Hence, three components determine the risk:

1. the hazard**:** the threatening natural event including its probability of occurrence;
2. the values or values at risk: the buildings/items/humans that are present at the location involved;
3. the vulnerability: the lack of resistance to damaging/destructive forces.

In its most simple form, the risk is computed by multiplying these three components. If values at risk and vulnerability are combined to form the variable C denoting the consequences resulting from a single event with the probability P, the risk from only this one event can be written as;

$$R = C \cdot P \quad (1)$$

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Usually, however, natural hazards do not manifest themselves in one single event with a given probability of occurrence, but in many different forms with an almost infinite number of variations. In the case of the hazard being flood discharges *Q*, Equation 1 must therefore be written in an integral form

$$R = \int_{Q_a}^{\infty} C(Q) \cdot f(Q)\ dQ \qquad (2)$$

where *C(Q)* is the costs/losses caused by a given discharge *Q* and *f(Q)* is the probability density function of the discharge. The integration must be performed for the whole region above the flood value *Qa*, for which losses start to occur. In general, this integration cannot be done analytically, except for certain specific combinations of *C(Q)* and *f(Q).* For example, if a linear function of *C(Q)* is chosen for*Qa*<*Q*<*Qb* with values *C(Q)* = 0 for *Q* < *Qa* and *C(Q)* =*Cmax* = const. for *Q* > *Qb*, and the one-parameter exponential distribution is chosen for the discharge probability density function (see Figure 1)

$$f(Q) = \lambda\, e^{-\lambda(Q - Q_o)} \qquad (3)$$

Equation 2 can be integrated directly and written as

$$R = \int_{Q_a}^{Q_b} \frac{C_{\max}}{(Q_b - Q_a)} \cdot (Q - Q_a) \cdot \lambda\, e^{-\lambda(Q - Q_o)}\ dQ + \int_{Q_b}^{\infty} C_{\max} \cdot \lambda\, e^{-\lambda(Q - Q_o)}\ dQ \qquad (4)$$

After some calculations the following equation is obtained (Kron, 1993)

$$R = C_{\max} \cdot \frac{e^{-\lambda Q_o}}{Q_b - Q_a} \left[Q_a e^{-\lambda Q_b} - Q_b e^{-\lambda Q_b} + \frac{1}{\lambda}\left(e^{-\lambda Q_a} - e^{-\lambda Q_b} \right) \right] + C_{\max} e^{-\lambda(Q_b - Q_o)} \qquad (5)$$

In practice, such analytical calculations for assessing the risk are seldom possible, mainly because the data base usually is very thin. Instead, simplified procedures are applied (Munich Re, 1997).

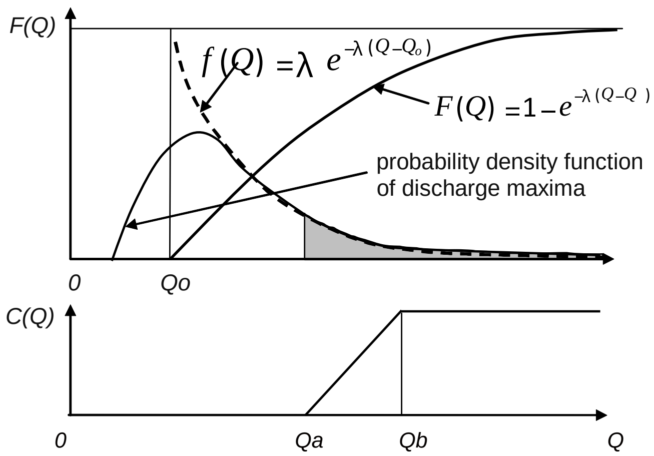

Figure 1**.** "True" probability density function of discharge maxima, approximated probability density function, *f(Q),* cumulative distribution function, *F(Q),* and consequence function, *C(Q)*
Source: Wolfgang(2005).

Other scholars defined risk based on their understanding, which includes:

- ✓ Smith (1996): "Risk is the actual exposure of something of human value to a hazard and is often regarded as the combination of probability and loss".
- ✓ Crichton (1999): "'Risk' is the probability of a loss, and this depends on three elements, hazard, vulnerability and exposure". If any of these three elements in risk increases or decreases, then risk increases or decreases respectively.
- ✓ Alexander (1991): Total risk = Impact of hazard X Elements at risk X Vulnerability of elements at risk
- ✓ UN DHA (1992): Risk is "Expected losses (of lives, persons injured, property damaged, and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability". Hazard is "A threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period and area". Vulnerability is "Degree of loss (from 0% to 100%) resulting from a potentially damaging phenomenon".
- ✓ Granger *et al.* (1999): "Risk (i.e. 'total risk') means the expected number of lives lost, persons injured, damage to property and disruption of economic activity due to a particular natural phenomenon…Total risk can be expressed in pseudo-mathematical form as:
  Risk(total) = Hazard X Elements at Risk X Vulnerability

This approach is not only elegant; it is also very practical. Given the complexity of urban communities and the degree to which the various elements of risk are interdependent, the 'total risk' approach is considered mandatory. Further, it also lends itself to quantitative, qualitative and composite analytical approaches"

- ✓ Blong (1996): Risk = Hazard X Vulnerability
- ✓ Helm (1996): Risk = Probability X Consequences, although "this simple product is not sufficient in itself to fully describe the real risk, but...it provides an adequate basis for comparing risks or making resource decisions".

These references indicate that risk is fundamentally a combination of hazard and vulnerability. In order to mathematically combine hazard and vulnerability to quantify risk as mathematical expectation, quantitative descriptions of hazard and vulnerability are necessary.

UNDP (2004) said that vulnerability is "human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard". It is determined by a combination of several factors, including awareness of hazards, the condition of human settlements and infrastructure, public policy and administration, the wealth of a given society and organized abilities in all fields of disaster and risk management. Recent studies especially in developed countries have emphasized the significance of people's vulnerability to hazards, rather than retaining a narrow focus on the hazards themselves (Mitchell (ed.), 1999; Twigg & Bhatt,1998). It is particularly important to operationalize the term vulnerability. In addition, it is equally vital to crucial to recognize that vulnerability is balanced by peoples' capabilities and resilience, and that if they are perceived only or mainly as victims then the problem of what causes vulnerability may be evaded (Cannon, 2000). Vulnerability analysis is developed from arange of socio-economic approaches to hazards and what we could call 'the disaster of everyday life' (Blaikie et al, 1994; Cannon, 2000). Social vulnerability is a set of characteristics of a group or individual in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood is at risk by a discrete and identifiable event in nature or society (Blaikie et al,1994). Vulnerability, according to Cannon (2000) can be considered in terms of five components:

Initial well-being: This appraises the initial nutritional and health status (both physical and mental) of people in everyday life (or before the impact of a hazard). It is indicative of their capacity to cope with illness and some types of injury resulting from a hazard such as flood.

Livelihood resilience: It is a measure of the capacity of an individual and/or their household to cope with the aftermath of given hazard impact, and to reinstate their earning or livelihood pattern. This might include their likely continued employment, level of savings, loss of welfare benefits, loss or injury of supportive family members, hazard damage to their normal livelihood activity (for example in floods this might include damage to agricultural land by sediment deposits, seawater incursion, toxic or sewage contamination, loss of dwelling place etc.).

Self-protection: This is concerned with the ability or willingness (readiness) of an individual and/or household (with a given level of knowledge of apparent risks) to provide themselves with adequate protection, or to be able to avoid living or working in hazardous places. It will be influenced by the level of knowledge of physical measures, and the capacity of people to implement them.

Societal protection: This refers to the ability or willingness of social and political structures at political or social levels above the individual or household, to provide protection (especially structural and technical preparations) from particular hazards. This might include local government, state government, national government, relevant organizations (e.g. fire department,

civil defense, NEMA, NGOs), or community-based initiatives.
Social capital: This involves the 'soft' security provided by group or community capacities to enhance (or reduce) a person's resilience. This may include the degree of cohesion or rivalry that might affect rescue and recovery. There are various forms of social capital that may enhance or hinder recovery such as support networks (belonging to a church or other group), some of which may provide mutual aid in times of hardship.

It is important to note that each one of these is crucially linked to the likely severity of impact of a given hazard, and yet primarily they are all determined by political, economic or social processes. They also contain the possibility of both vulnerabilities and capabilities, with these varying over time (as individuals and groups subsist and compete within given livelihood possibilities), and being affected in regard to different types of natural hazards. The concept of vulnerability is oriented towards the perception of disaster risk and has a wide range of interpretations. Multiple definitions and different conceptual frameworks of vulnerability exist because several distinct groups have different views on vulnerability (Birkmann,2006).

Capobianco *et al.* (1999) and Klein and Nicholls (1999) define vulnerability for only the natural environment. Their definition is pertinent to both residences and other aspects of society. For example, in considering the property insurance industry, susceptibility may be interpreted as exposure, the accumulated value and proximity to hazard of insured residences (after Crichton, 1999).

Vulnerability refers to a characteristic of society which indicates the potential for damage to occur as a result of hazards. Vulnerability (after Capobianco *et al.*, 1999 and Klein and Nicholls, 1999) is a function of:

- ✓ resistance, the ability to withstand change due to a hazard;
- ✓ resilience, the ability to return to the original state following a hazard event;
- ✓ and susceptibility, the current physical state, without taking into account temporal changes.

Methodology

The study adopted the secondary source of data collection by exploring previous works on the subject matter using internet, journals and books.

Social perception in disaster risk reduction

Any understanding of how people perceive natural hazards should take into consideration the context within which natural hazards are experienced (Renn et al,2000). According to social scientists specializing in the study of social perception, people's perception or understanding of natural disasters is socially constructed(Boholm,2003). The context may include unique socio-economic and religious factors, direct and indirect experiences, and political characteristics that have influenced the formation of a community's risk perception. Disaster researchers have developed what may be called elements of social perception in risk analysis. According to Figueire do et al. (2009), social perception of natural hazards is subjective because the risk associated to a particular natural hazard may differ within and across communities depending on the socio-economic dynamics of those involved. In Taiwan, for example, victims' (most of whom are rural dwellers) perception of risk associated with floods and landslides differs from that of the general population (most of whom are urban dwellers) (Ho et al,2008). The former has been directly exposed to floods and landslides, and as a consequence they perceive such events as carrying more risk than the general population who have had little exposure to it. Also, compared to male victims of flood and landslides in Taiwan, female victims consider such natural hazards to carry more risk than their male counterparts. This is because the women are largely exposed to it duet the impact it has on their domestic activities. Another element of social perception in risk analysis is that it is value-laden because natural disasters are perceived or understood according to local values, beliefs and other cultural factors. Boholm (2003) argues that culture is crucial to social perceptions of risk or natural hazards. As an example, among the Hima tribal group, Bantu-speaking people in south-western Uganda, women are not expected to come into contact with cattle as this is believed to cause death and sickness among the cattle (Boholm,2003).

Presently, it is an accepted practice within international disaster management that before embarking on any disaster risk reduction project in a community, differing perceptions should be recognized and targeted. Many scholars have argued that people's perception of risk, although varying, is a crucial component of community risk assessment as it provides a venue to come to common understanding of risk scenarios. More importantly, the World Disaster Report of 2014

suggests that the "missing link" in current vulnerability analysis is culture. Risk perception is the main driver of citizens' actions and hence good source of information for determining behavioral outcome space(BOS) where BOS refers to the set of all individual behaviors in the face of a natural hazard (Pennings et al 2008). Policymakers rely on BOS when making major decisions in disaster situations (Pennings et al 2008). Unfortunately, to date, local understandings and perceptions offload risk have not been integrated in a substantial and proactive way in either policy or implementation processes (Figueiredo et al.2009). However its inclusion, generally, adds legitimacy and effectiveness to social processes in the management of disaster, strengthens risk communication, and can serves a stepping stone in efforts to adjust social behavior (Ho et al,2008;Figueiredo et al.2009).Although many studies of risk perception have been carried out and a large body of literature exists, limited research has been conducted on social perceptions regarding the causes of natural disasters, such as floods, and their implications for disaster-risk reduction in local communities.

In addition to individuals and communities' perception of flood, during the last few decades many flood plains have been occupied by residential areas and residential parks. The nearby rivers have been tamed and confined

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in narrow strips by dikes, cheap and attractive land has been reclaimed. Towns and villages have declared these areas residential areas and many potential buyers of properties counted on there being no flood hazard to be feared. The movement of political, social and other refugees, the increased mobility, and the attractiveness of areas that have beautiful natural environment and a mild climate leads to people settling in places whose natural features they do not know. Worst still they are not aware of what can happen and they have no idea how to behave if there is flood. These critical issues complicate flood risk with its ugliest consequence.

Flood hazards parameters

Examples of hazard parameters which could be measured to quantify direct flood hazards includes;

- ✓ Volume.
- ✓ Depth.
- ✓ Volumetric flow rate.
- ✓ Velocity: average and "gusts" (measures of spatiotemporal variation).
- ✓ Temperature.
- ✓ Salinity.
- ✓ Density.
- ✓ Percent not water by mass or by volume (e.g. debris and contaminants including silt, stones, sewage, oil, paint, and collapsed residence material) along with specific characteristics of non-water parts such as size, mass, density, velocity, miscibility with water, corrosiveness, and flammability. Without a substantial portion of water in the flood, the hazard would have labelled with another term, such as lahar, debris flow, mudflow, landslide, avalanche, or rockfall.
- ✓ Wave height, length, and frequency.

Each parameter is a function of three-dimensional space (x,y,z) and time (t).
Although this research focuses on direct flood hazards, the wider context can rarely be ignored.
Examples of water hazards in combination with other hazards are:

- ✓ Wind-driven rain.
- ✓ Wind and low atmospheric pressure augmenting the tide level to produce a storm surge and large waves.
- ✓ Wind causing waves during a storm after flooding has turned a residential area into a "lake".
- ✓ Biota's range expanding due to the flood or flood-induced dampness. For example, jellyfish or whales swimming through a residential area or fungus or algae growing on a residence wall.
- ✓ Rainfall- or water flow- induced landslides.
- ✓ Storm- and wave-induced coastal erosion.

A linear sequence may occur in which one hazard event causes a structural weakness meaning that the residence cannot act at the design level for the next hazard event. Time may not be available for maintenance or repair work between the two events.

To determine the effect of a hazard on a residence, the hazard parameter must be translated into a form which indicates an effect on the residence. For example, forces, pressures, and energy transfers may be calculated from flood depth and velocity characteristics. Collectively, such impacts on residences due to hazard parameters are termed "actions"

In interpreting and recording the hazard parameters, the presence of the residence may be important. For example, flood velocity would change direction, possibly with augmented vertical components, upon encountering a residence. Flood flow parallel to non-failing residence yields a boundary layer in the fluid, altering the velocity profile. Furthermore, as the flood water flows around the residence's corners, eddies are formed, substantially altering the fluid's velocity and flux profiles(Ilan,2002).

Residence physical vulnerability to flood hazards

Damage and losses from floods are categorized as either direct, resulting from the physical contact of flood water with damageable property, or indirect, resulting from the interruption or disruption of social and economic activities. Damage and losses from floods are also either tangible, for which a monetary value can be easily assigned, or intangible, for which a monetary value cannot be easily assigned. Examples of damage in these four categories are:

- direct, tangible: food, appliances, residence structural collapse.
- direct, intangible: photographs and negatives, heirlooms, an archaeological site, drownings.
- indirect, tangible: days absent from work, changed spending patterns.
- indirect, intangible: quality of life lessened due to stress, delays in formal education.

In focusing on physical damage to residences, this research considers direct, tangible damage. Assigning a monetary value is relatively easy when choosing a method for quantifying vulnerability, as discussed in "Risk as a loss function"

Measuring vulnerability

To measure vulnerability at different scales, hazard researchers have used numerous strongly correlated variables, such as the physical, social, economic, and political condition of the area of occurrence. Some of the major factors which tend to increase the vulnerability of cities to urban flooding, especially in developing countries, are poverty, poor housing and living conditions, lack of preparedness and management of flood defenses, increasing population growth, development of squatter settlements in hazard prone regions, poor maintenance of drainage structures, lack of awareness among the general population, and limitations in early warning system.

Global trends suggest that flood risk is expected to increase substantially in subsequent years as a result of both climate change and continued socio-economic development. However, the consequences of flooding can be mitigated by appropriate behaviors and actions. Successful flood risk management is dependent upon the active support of all on whom the effects of flooding may impact, those directly at risk, the civil authorities and the wider community and its leaders.

A study conducted on privacy, vulnerability and the impact of flooding in the Limpopo province in South Africa argues that while disasters may affect everyone and play an important role in increasing vulnerability, poor people are made more vulnerable from a web of circumstances that make them prone to the effects of disasters (Khandihela and May 2006). They established that the varying impact of floods on households and the community at large showed that vulnerability to the effects of a flood disaster is indeed an outcome of the interaction between socio- economic and political process. Adamson (1983) also observed that extreme events such as floods over southern Africa have resulted in loss of life, massive damage to property, crops, livestock and disrupted communications. The Laingsburg flood disaster of January, 1981 was also described as South Africa's greatest natural catastrophe. The flood washed away a considerable part of the town with a loss of 100 lives. In addition, extensive damages were largely on bridges and irrigation schemes. The heavy rains of January 1974 had a disastrous effect on the agricultural economy of the central regions of South Africa.

Vulnerability exposure factors

These includes the following.

- Individual house hold level of education, age, gender, race, income, past disaster experience; social vulnerability: poverty, race, isolation, lack of social security service.
- Institutional vulnerability: ineffective policies organized and non-committed public and private institutions economic vulnerability; financial insecurity, GDP, source of national income and fund for disaster prevention and mitigation.
- Physical vulnerability: This includes the location of settlements, building materials, maintenance, forecasting and warning systems.
- Environmental vulnerability: poor environmental condition, unprecedented population growth and migration system vulnerability which affects utility and services in the community such as health services that make for a resilient system.

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Conclusions

Flooding has been a devastating phenomenon globally with large scale threats on humans, human properties, geological system, economic system, social lives as well as loses of lives. In addition to individuals and communities' perception of flood, during the last few decades many flood plains have been occupied by residential areas and residential parks. The nearby rivers have been tamed and confined in narrow strips by dikes, cheap and attractive land has been reclaimed. Towns and villages have declared these areas residential areas and many potential buyers of properties counted on there being no flood hazard to be feared. The movement of political, social and other refugees, the increased mobility, and the attractiveness of areas that have beautiful natural environment and a mild climate leads to people settling in places whose natural features they do not know. Worst still they are not aware of what can happen and they have no idea how to behave if there is flood. These critical issues complicate flood risk with its ugliest consequence.

To mitigate any risk associated with flooding, all human activities that are prone to risk must be addressed, which includes, adherence to flood warming and acting appropriately as advised by flood experts. In event of observed flooded road, caution must be applied. Water may be deeper than it appears and can hide hazards such as sharp objects, washed out road surface, chemicals, and electrical wires. All flooded related drownings occurs when a vehicle is driving into hazardous flood water. The force and power of water should not be underestimated. Never drive around the barriers blocking a flooded road. It is not wise and safe to drive or walk into flood waters especially when the water is still moving.

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